UNIVERSITY OF SOUTHAMPTON

REDEFINING THE CONCEPT OF SUSTAINABLE DEVELOPMENT;

UPLAND RURAL RIVER CORRIDOR MANAGEMENT IN ENGLAND AND WALES

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ABSTRACT

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REDEFINING THE CONCEPT OF SUSTAINABLE DEVELOPMENT;
UPLAND RURAL RIVER CORRIDOR MANAGEMENT IN ENGLAND AND WALES

by Kristina Jacqueline Richards

This research redefines Sustainable Development into workable best practice for River Managers in the Environment Agency of England and Wales through:

1) The redefinition of sustainable development in a clear and simple form through practical management targets;
2) Translation into operational best practice and identification of local and national implications (with particular regard to Flood Defence); and,
3) Review of the institutional and infrastructural implications.

Section one of this research is a critique of what Sustainable Development aims to achieve. This section investigates the present theoretical debates and considers why the concept has not reached the success it aspired to at its inception in the mid-1980s. This debate is placed within the context of upland rural river corridor management in England and Wales. The Upper Wharfedale Best Practice Project is introduced as the case study by which the growth of the sustainable management philosophy and understanding may be developed. The Environment Agency (which has sustainable development as its principal aim) is identified as the mechanism by which a concept of Sustainable Management may be developed, with the objectives of: minimum intervention; let-erode; flooding; and, metastability.

Section two explores potential tools for the appraisal of Sustainable Management. It is suggested that many tools for pragmatising the concept are in existence in other disciplines but that this is not explicitly recognised in either the literature or by policy. This section follows the conceptual and absolute design of a tool which utilises existing databases for the assessment of the sustainability of upland rural river corridors in England and Wales.

Section three considers techniques which may be used to implement sustainable management. This section highlights the need for the tools developed in section two to be set within the wider social metagoals of society if their utility is to be realistic and practical. Awareness raising and public participation are suggested for reconciling the social and economic sacrifice which sustainable management implies, along with relevant economic incentives and market mechanisms.

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Upland rural river corridor management in England and Wales

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Chapter 0

Foreword

The aim of this research is to translate the concept of Sustainable Development into operational guidelines, specifically in terms of river corridor management, within the remit of the Environment Agency of England and Wales.

Undertaking such a massive task as translating a global argument to the scale of the river corridor has necessarily involved a complex and broad way of thinking. This may sometimes appear confusing to the reader. For this reason, chapter 0 aims to encapsulate this process, which often follows the chronology of the thinking at the time. Through doing this, the key principle of this thesis resting on the *preliminary development of a theory* through holistic applied science is illustrated.

This thesis has necessarily focused on the spatial scale of the river corridor. Within the present data availability and integration, there are real constraints on achieving a widening of the sustainability remit from channel and corridor to the catchment. It must be acknowledged however that it is hoped that this will stimulate further research which will continue these discussions within the context of the wider floodplain and catchment scale. Where appropriate, potential scaling issues have been highlighted and justified to aid this process.

The conceptual progress of the following nine chapters is illustrated well by an hour-glass shape. Through illustrating the theory of this shaping in the following paragraphs, it is hoped that the reader will follow this progress with more clarity than would otherwise be possible.

Chapter 1 introduces the global concept of Sustainable Development, and begins to introduce how this concept has been variously translated. How it might be translated to the local scale is then considered, with regard to the river corridor. The difficulties of doing this are highlighted within chapter 2, where the Environment Agency is identified as an Institution through which this might be challenged as part of this research. This is set within the spatial and temporal scale of the Best Practice Project (specifically the Upper Wharfedale Best Practice Project), and concentrated around the issue of flood defence.

Chapter 3 and 4 newly define Sustainable *Management*, where thresholds of more or less sustainable management and/or states are identified through a bipolar spectrum of measurement. Optimal fluvial geomorphological functioning is identified as vital if long-term sustainable management is to be achieved.

The middle-body of this research narrows from the initial discussions to identify the potential of Decision Support Tools for helping to articulate the above arguments. A pilot expert system is trialled to illustrate the potential for such a tool within further research. Further, an evaluation matrix (similar to the principles of Environmental Impact Assessment) is developed to complement this tool. Both of these tools are expected to help the River Manager in assessing a) the most sustainable present management option; and b) movement over time to more or less sustainable states.

Having compressed and validated earlier discussions through chapters 4 – 6, chapters 7 and 8 then broaden the discussion once again, towards the wider implementation of these concepts and tools, within the present social and economic issues and opportunities in England and Wales. Both chapters have far wider application than the river corridor, and are indeed suggested as catchment wide initiatives to complement the above.

The broad principal to be followed within the following chapters is the inter-linkages that exist. These are always highlighted where appropriate.

SECTION 1
TARGETS FOR SUSTAINABLE MANAGEMENT
What does sustainable management achieve?

Chapter 1

'Sustainable Development' - the moral ideal

Environment and Development in a moral framework

1.1 What *is* Sustainable Development?

'Sustainable Development...

'Sustainability...

'Sustainable Management...'

Inherently attractive sounding terms, and ones which have become the aspiration of many over the last two decades. Yet the concepts which lay beneath them are arguably some of the most ambiguous and misunderstood of modern day endeavours.

Libraries abound with a diverse multitude of texts incorporating 'sustainable development' into their titles. One only has to enter the phrase into any information network to appreciate its seemingly infinite nature. For example, a keyword search on the WWW for 'sustainable+development' generates over 2,000,000 hits (Netscape Net Search, April 2000). A similar search on the Bibliographical Information Database System generates almost 700 hits since the system's inception in 1981. Broken down over time, we see a noticeable rise in the number of articles on the subject, particularly through the latter half of the 1980s and into the 1990s (box 1.1). This mirrors the political history of the concept at this time.

The term 'Sustainable Development' was first *defined* by the World Commission on Environment and Development (the ***Brundtland Commission***) in 1987. The commission produced a report, ***'Our Common Future'***, which defined the concept as,

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

(World Commission on Environment and Development, 1987).

Number of articles generated by keyword search 'sustainable+development', (BIDS, 2000)

Year	**Number of hits**	**Percentage increase**
1981 - 1985	14	N/A
1986 – 1990	53	378%
1991 – 1995	276	520%
1996 - 2000	423	153%

Box 1.1

The next 'landmark' in the history of the concept was at the United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro, June 1992. The most notable output of this summit (often referred to as the 'Rio Summit') was the formulation of *Agenda 21*. Agenda 21 was essentially a list of activities that ought to be followed to give sustainable development. It has been suggested that this was composed of little more than a list of good intentions and estimated budgets with no commitments (O'Riordan, in Turner (eds.), 1993) with a distinct lack of how these activities would be monitored or assessed. In June 1997 Rio II was held in New York. Less encouraging than the first summit, Rio II saw a lack of evidence that many countries were implementing the frameworks of the first conference (Ball and Bell, 1996).

Various other significant strategies have occurred since Rio II including the EC Fifth Action Programme on the Environment, ***Towards Sustainability***, and ***'This Common Inheritance'***, the first White Paper on the environment, produced by the UK Government in 1990. ***'Sustainable Development: The UK Strategy'*** was published in 1994, reiterating the Fifth Action Programme.

1.11 Common definitions of Sustainable Development

Most strategies and conventions on sustainable development aspire to set their own list of deliverables and concurrent definitions of the concept. The following is a short summary of the most significant interpretations to date. This summary is headed by the world perspective, and followed by European, UK Government, UK Institutes and Councils and Non-Governmental Organisations. A number of frequented source texts are also quoted. The concluding summaries begin to introduce the concept within the context of river management.

World Bank objectives for environmental sustainability reflect a common interpretation, consisting of the following diagram (figure 1.1).

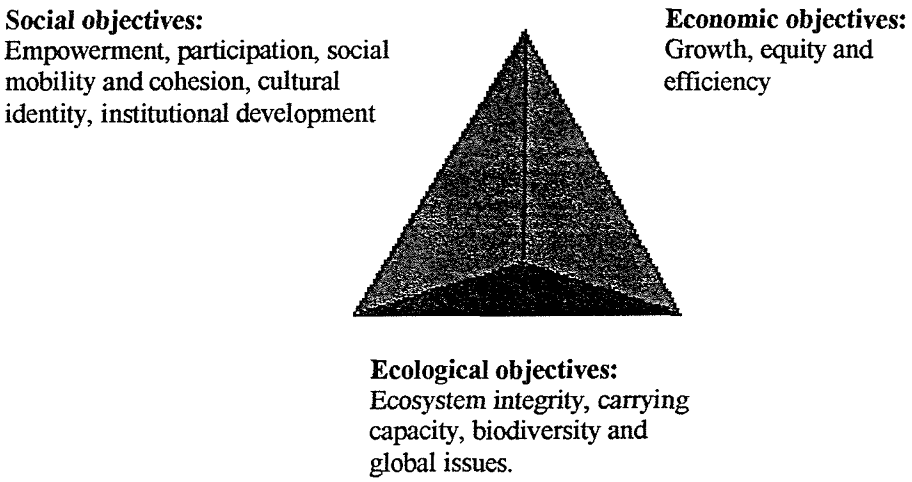


Figure 1.1: World Bank objectives for sustainability (After Mehra, 1997)

A further framework, which is often used to integrate environmental factors with those inherent to Sustainable Development is the pressure-state-response concept (UN Division for Sustainable Development, 1996) (see figure 1.2, below). The UN modify this approach to a ***DSR Driving Force-State-Response framework***. They see the term 'Driving Force' as accommodating more accurately the addition of social, economic and institutional indicators and allowing in that impact on Sustainable Development may be both positive and negative, encompassing human activities, processes and patterns that impact on Sustainable Development. 'State' indicators refer to the state of Sustainable Development and 'Response' indicators highlight policy options and other responses to changes in the state of Sustainable Development (UN Division of Sustainable Development, 1997). As time-series data and experience grows then the expectation is that so then too will causal relationships emerge so that interactions between the indicators are highlighted and perhaps utilised more efficiently by policy-makers (UN Division of Sustainable Development, 1997).

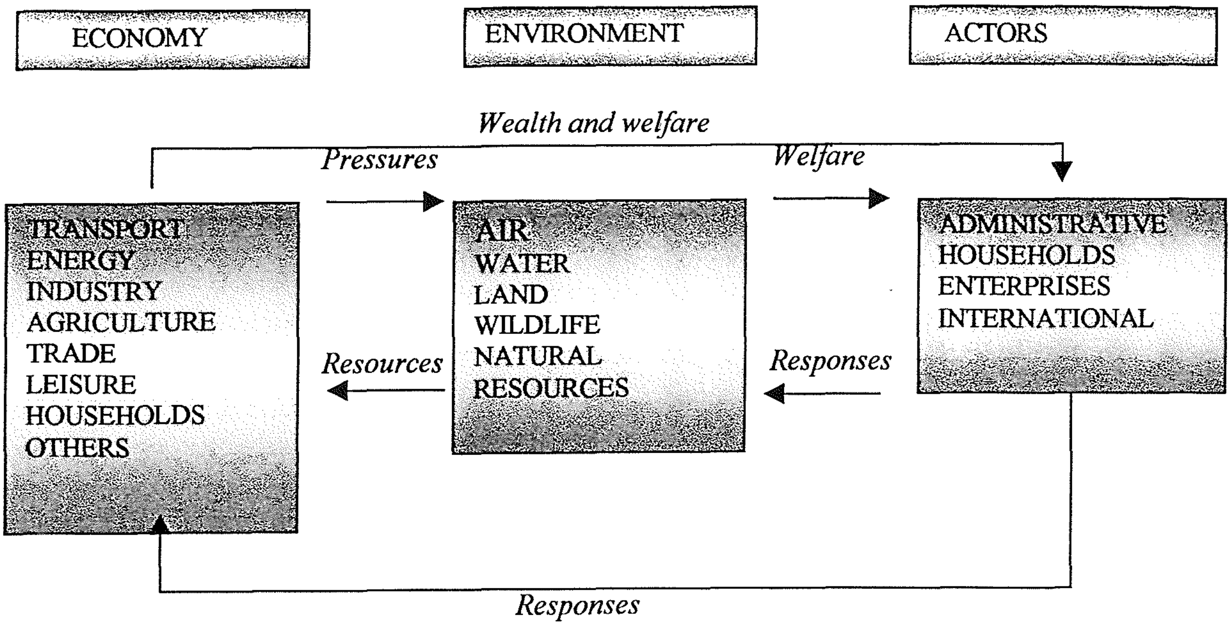


Figure 1.2: The pressure-state-response framework (DOE, 1996)

The UN further state that for successful sustainable development, *"unifying economics and environment in decision making may be the key"* (UN Division for Sustainable Development, 1996).

The European Commission see sustainable development as representative of the fact that, *"the integrity of natural systems – soil, water, air and biological diversity – should be preserved and, where possible, restored"* (European Commission, 1993-1996, in Mehra, 1997).

The European Environment Agency proposes a Four-Capital Model based on 'New Economics':
"A healthy society balances/maintains all four capitals of:

1) *ecological (natural) capital;*
2) *human capital (knowledge, shills, health, motivation);*
3) *social and organisational capital (law, government, community, companies, organisations, family);*
4) *Manufactured capital (tools, machines, infrastructure)"* (Mehra, 1997).

European Sustainable Cities suggests that sustainable urban management involves:

- *"Environmental limits: applying the precautionary principle so as not to exceed the Earth's carrying capacity;*
- *Demand management: managing demands rather than meeting them;*

- *Environmental efficiency: reducing the use of natural resources, increasing durability;*
- *Welfare efficiency: obtaining the greatest human benefit from each unit of economic activity;*
- *Equity: social solidarity and equitable distribution of wealth"*

(European Sustainable Cities, 1996 in, EA, 1997n).

UK Governmental statements again closely follow the international perspective, but with preceding targets reflecting the national scale of implementation.

For example, the Government's Advisory Panel on sustainable development states that the concept envelopes, *"the need for the country to maintain and even to quicken economic growth and to protect international competitiveness while decisions throughout society are taken with proper regard to the environment"*(Government's panel on Sustainable Development, 1996).

The Local Government Management Board follows this with the definition of, *"improving the quality of life while living within the carrying capacity of supporting ecosystems"* (Local Government Management Board, 1995).

Local Agenda 21 summarises the commonly held definition, *"sustainable development tries to integrate the three processes of development – 1) economic (or capitalist) development; 2) community development (equity); and, 3) ecological development"* (Local Government Management Board, 1995).

The UK Round Table on Sustainable Development (UKRTSD) was established in 1995, and aims to encourage discussion on major sustainable development issues and to build consensus between people who have different perspectives and different responsibilities. The UKRTSD publish an annual report to provide review on current progress and recommendations. Interestingly, they 'deliberately avoid attempting to produce a specific definition of sustainable development…nor does the Round Table regard it as necessary for it to advocate a specific model of sustainable development' (UKRTSD, 1997). The group continue, 'members believe that the important factor is that they should have a common view of the main components of sustainable development, these being:

- *The integration of economic, environmental and social elements; and*
- *Minimising the trade-offs that have to be made between those elements'*

(UKRTSD, 1996).

Further, and of most pertinence to this research, from the UKRTSD's 'definition', a sequence of evaluations to establish the significance of an issue for sustainable development are presented. These are in a *key* form (see box 1.2).

1. Has the particular development caused, or will cause, an adverse environmental or social change? [By definition, development will cause economic change.]
   Yes...2)
   No..**sustainable**
   (strongly sustainable if there is an irreversible beneficial change)
2. Is the change irreversible?
   Yes...3)
   No...4)
3. Will it compromise the ability of future generations to have the same benefits, even taking into account the possibility of substitution?
   Yes...**strongly non-sustainable**
   Future effects may be mitigated by substitution or other technological fix
   ....**moderately non-sustainable**
4. The change is reversible; it reduces environmental quality, economic opportunity or social equity in relation to essential resources..**weakly non-sustainable**

Box 1.2: Key for evaluating the significance of an issue for sustainable development (UKRSD, 1996).

The full objectives set by the Government for the Round Table are:

- To help identify the agenda and priorities for sustainable development;
- To develop new areas of consensus on difficult issues of sustainable development and where this is not possible, to clarify and reduce difference;
- To provide advice and recommendations on actions to achieve sustainable development;
- To help evaluate progress towards objectives; and
- To inform and involve others, building wider support for emerging consensus (UKRTSD, 1996).

The British Government Panel on Sustainable Development (GPSD) was appointed by the British Prime Minister in 1994 to advise the Government on strategic issues arising from the Sustainable Development Strategy set by Government and other post-Rio reports on climate change, biodiversity and forestry. The panel's remit is:

- To keep in view general sustainability issues at home and abroad;
- To identify major problems or opportunities likely to arise;

- To monitor progress; and
- To consider questions of priority.

The Government consults the Panel on issues of major importance (GPSD, 1996). Since 1994 six annual reports have been produced each spring. It is interesting to note the development of the panel over time. Most notable of the changes is the increasing identification of environmental accounting, pricing and economic instruments to successful sustainable development (see chapter 7).

With regard to the Environment Agency of England and Wales, Ministers' statutory guidance on sustainable development states that the Agency should:

"i) take a holistic approach to the protection and enhancement of the environment;

ii) take a long-term perspective;

iii) conserve and where practicable enhance biodiversity;

iv) protect the global atmosphere;

v) partner regulated organisations adopting improved technologies and management techniques;

vi) strive to develop a close and responsive relationship with the public, local authorities and so forth;

vii) provide high quality information and advice"

(EA, 1997a).

Various other organisations and Institutes offer their own interpretations.

"The need for policies that would seek to secure equity within society and wider public participation in the policy process" (Royal Town Planning Institute, in Reid, 1995).

"A process that partially discounts present market values and recognises a need for society to improve its well being rather than seek material accumulation" (National Trust, in Reid, 1995).

"Sustainable development means meeting development needs within environmental carrying capacities. This will require lifestyle changes through reduced consumption to deliver a higher quality of life for all. This reduced consumption is to come through demand management to help ensure that development is focused on real needs and is of the appropriate type and location in order to meet these needs within the ECCs" (English Nature in Reid, 1995).

The Natural Step (TNS) is a completely different approach to promoting sustainable development, albeit only focused on the business community in the UK at present. TNS was originally conceived by a Swedish oncologist, Dr Karl-Henrik Robert, and is said to 'refer back to the fundamental sciences of thermodynamics and cellular biology' (TNS, 1998). At the heart of the concept there are four 'system conditions' which collectively define the conditions that must be met by a sustainable society. These are as follows:

1. *Substances from the earth's crust must not systematically increase in the Biosphere.*
2. *Substances produced by society must not systematically increase in nature.*
3. *The physical basis for the productivity and the diversity of nature must not be systematically diminished.*
4. *We must be fair and efficient in meeting basic human needs*

(TNS, 1998).

The case of TNS is an interesting one. It has eminent people at its forefront – Jonathon Porritt as Chairman, endorsement of the King of Sweden – and yet its firm scientific basis, which it repeatedly refers to in its promotion, is actually only loosely related to the issue of sustainability. The perspective that TNS takes is a noble one and indeed reiterates what other advocates of sustainability believe in, but despite its claims TNS is nothing more than another redefinition. TNS cloaks itself in overly long, often ambiguous, scientific language, and yet at its heart is still Brundtland's message (WCED, 1987). As one article in the Business and Environment section of the Financial Times contends,

> *'Some experts, while praising TNS' moral purpose, doubt that the fourth system condition has anything to do with science, and argue that the first three unravel as soon as they are closely scrutinised*
>
> *'Clive Hambler, an Oxford University ecologist, says they are 'too ambiguous' to mean anything in ecology. 'Cost-benefit analysis itself is in its infancy, particularly for full life-cycle and long-term costing,' he says. 'Ecological cost-benefit analysis is even less developed.'*
>
> *'Mr Hambler fears that at some stage TNS could be used to avoid hard but necessary choices: 'We may have to consider increasing the human changes made to some systems in order to prevent irreversible changes such as species extinction in others' he warns'*
>
> (Henderson, C, 1998).

A number of texts have been written on the subject of sustainable development. A particularly common interpretation of sustainability, especially in the economic literature, is summarised by Reid,

> *"Weak sustainability implies no diminishment of total stock of capital from generation to generation. It allows for substitution. Strong sustainability implies no perfect substitution. There is a need therefore to make specific provision for natural capital"*
>
> (Reid, 1995).

Turner similarly labels the two extreme polar positions of sustainable development as very strong sustainability (VSS) and very weak sustainability (VWS). These reflect respectively the ecocentric perspective of extreme deep ecologists who seem to come close to rejecting even the sustainable utilisation of nature's assets, and the technocentric perspective, that the concept contributes little new to mainstream approaches to intertemporal choice (Turner, RK in Turner (ed.), 1995).

The safe minimum standards (SMS) concept is proposed by Turner as being representative of the strength of sustainability. A socially determined dividing line between moral sustainability imperatives and the freeplay of resource trade-offs for example is illustrated graphically as SmSm (figure 1.3). Supporters of the technocentric paradigm might favour line StSt, whilst ecocentrics would follow a line similar to S (Pearce and Turner, 1990 in Turner (ed.), 1995) (figure 1.3).

Such an absolutist concept of sustainable development as strong sustainability has been described by one author in economics as 'morally repugnant. Given the poverty and environmental degradation in which many of the world's population live, it is not possible to justify using up vast resources in an attempt, say, to preserve every single one of the millions of species that exist' (Beckerman, 1995 in Corkindale, 1998). In weak sustainability, Beckerman continues that, 'in the attempt to rid the original 'strong' concept of sustainable development of its most obvious weaknesses, the baby has been thrown out with the bath water. For it appears now that what society should aim at is not 'sustainability', but the maximisation of welfare. In other words it should pursue the old fashioned economist's concept of 'optimality'' (Beckerman, 1995 in Corkindale, 1998).

Other commonly given definitions are summarised by the following.
"Sustainable development's central concept is that of shared responsibility (government, industry and consumers)" (Ball and Bell, 1997).

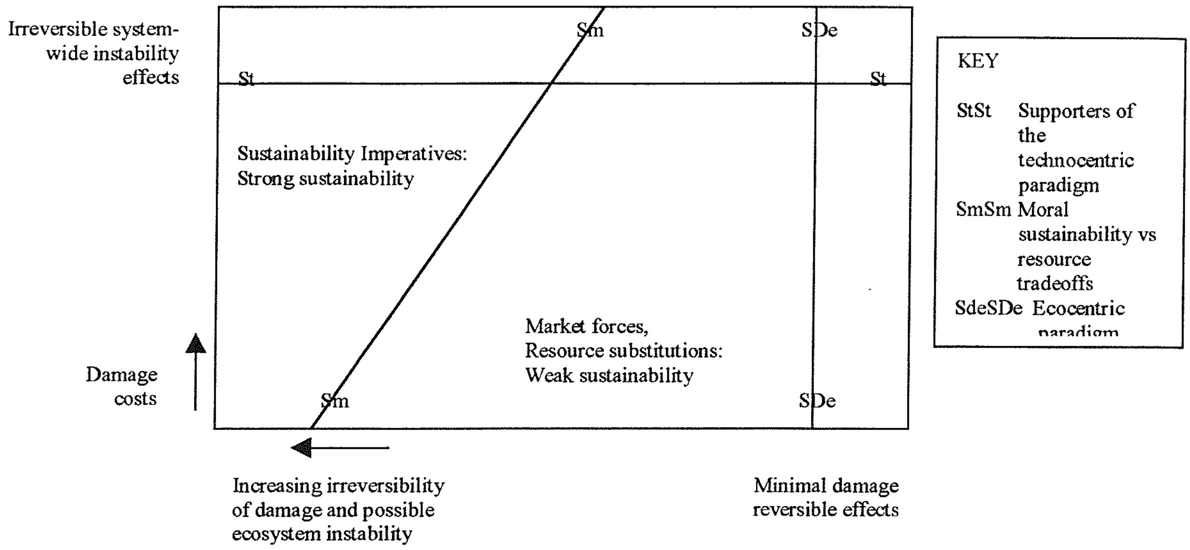


Figure 1.3: Safe minimum standards approach to sustainability (Adapted from Norton, B in Turner, (ed.), 1995).

"The concept is deeply entwined with the notions of futurity, environment, quality of life and equity" (Bruff and Wood, 1995 in Otterstad, 1996).

"An operational definition of sustainability is:

- *a requirement that environmental assets are not to be damaged;*
- *inclusion of full environmental costs in economic decision making;*
- *a requirement for environmental impact assessments for development"* (Hel, D, in Reid, 1995).

Finally, in the context of river management and the aims of this thesis,

"Sustainable development of river basins requires acknowledgement of:

1) *the natural system (the water system consisting of the components water, beds, banks and shores with their physical, chemical and biological aspects);*
2) *the socio-economic system (the water users);*
3) *the administrative system (the water management)"* (Meijerink, SV, 1995).

"Sustainability for river basin development and management would encompass:

1) *use by those developing resources of space and time scales appropriate to the optimum functioning of river basins as natural systems;*
2) *assessment, using these scales, of the impact of both technical and policy developments;*
3) *monitoring the state of both pristine and developed basin systems and of both channel and catchment processes"* (Newson, 1992).

"calls for sustainable development imply that land use should be rationally planned and result from public consultation on appropriate environmental limits;
"the Best Practicable Environmental Option (BPEO) is a minimum sustainability area criteria which links the interests of conservation in CMP and flood (non-) protection and water quality protection" (Newson, 1992).

"In order to obtain sustainability in water resources management projects, public participation must be considered from the very inception, and followed by the building up and strengthening of the local organisation" (Mirghani, M, 1995).

What this suite of definitions hopes to illustrate is the sheer diversity of the Brundtland definition when interpreted by different audiences at levels varying from policy to implementation. Despite such diversity, as Levett summarises, 'there seems to be no mystique or obscurity about the central meanings of Sustainable Development. They are rooted in perennial themes of responsibility for others, providing for the future and dependence of life on the natural environment since time immemorial' (Levett, 1993 in Reid, 1995). Reid follows, 'the concept has a somewhat beguiling rhetorical quality, appealing to our guilt and deep-rooted desire to ensure our children's future are provided for not just materially but aesthetically too. It supplies us with an alluring sense of social justice and ecological health which can only provide hope and encouragement for our future situation' (Reid, 1995). Further, 'the objective of sustainable development is really no different from other kinds of decision-making that one does every day ... The idea of long-term sustainability is a perfectly natural thing: the human race has evolved to do it rather well' (Biotechnology and Biological Sciences Research Council in SCSD, 1995).

Before the concept is researched in further detail, definite steps must be taken to draw a distinction between two very different, but often erroneously paired terms. ***Sustainable Development*** is an socio-economic concept and ***sustainability*** essentially an ecological notion (Royal Town Planning Institute, in SCSD, 1995). Leaving future generations equally able to meet their needs is not the same as leaving them an identical stock of ecological assets. According to John Bowers, Reader in Economics at the University of Leeds, sustainability means accepting constraints on current activities in the interest of future generations. Sustainable development is development which is compatible with those constraints (Bowers, in SCSD, 1995). The distinction between the definitions Sustainable Development and Sustainability, if explicitly recognised and applied by the Policy makers, might well go some way to resolving the debate over strong versus weak sustainability. The UK Environment Agency use the terms interchangeably, and by so doing add an ambiguous edge to their principal aim (see chapter 2).

A similar dilemma in terminology involves the pragmatisation of the concept. For the redefinition of sustainable development in the context of environmental management, and more specifically, river management, there is a need to develop the notion of ***Sustainable Management***. This would recognise more explicitly the need to pragmatise the larger political notions of the concept within the reality of environmental management decision-making. This transition is discussed fully in chapter 3.

In further need of clarification is the ambiguity in the literature over the often mutual use of the word ***'conservation'*** with sustainable development. The two are often spoken of in the same vein and yet should perhaps be accorded a rather more concrete distinction. Conservation implies the state of environmental *preservation* in contention with the notion of sustainable development, which still represents a commitment to *growth* (Ball and Bell, 1997). Yet despite this distinction those defining characteristics of sustainable development still share the ideals of conservation but in a manner that offers more opportunity for compromise than the traditional Conservationist's ecocentrism.
It is an easy misconception to make that Sustainable Development is a new brand name for the world's conservation movement – a way of superficially throwing off the baggy jumper, long-haired hippie image to try and gain a few extra votes. This is not the case. In today's world of aspiring economic growth, there are few environmental systems in society which are not affected by development. Sustainable Development recognises this and works with society to come to environmental states that are attainable for all. Agencies now recognise that environmental change and development are unavoidable and an approach based on preservation and resistance to change is neither practical nor desirable (CAG and LUC, 1997). With sustainable development there is a need, at least in principle, to distinguish between major life and planet threatening concerns, on the one hand, which merit imperative action, and, on the other hand, more modest or local concerns, which may be capable of negotiated trade-offs. As the Select Committee on Sustainable Development

suggest, the notion of sustainable development could easily become devalued if this fundamental distinction is ignored, even if the categories prove difficult to determine (SCSD, 1995).

One further commonly taken approach to sustainable development is the concept of carrying capacity. At any one time there are limits to the capacity of the environment to host particular forms of development (SCSD, 1995). The RSPB, the CPRE and Friends of the Earth all embrace this notion of ***limits to capacity*** of the environment to accommodate some forms of development. FOE added an injunction upon society to maintain a minimum capital ***stock*** of environmental ***assets*** (SCSD, 1995). Related to this is the Countryside Commission's urge to recognise the concept of critical environmental capital. Environmental capital is a complex of environmental assets deserving the most rigorous protection. The RSPB are concerned that the definition of some capital as critical should not undervalue the rest, but they accept that nothing in a democratic society can actually be inviolable (SCSD, 1995).

The interesting challenge, as emphasised from this short resume of current opinions, rests in the ambiguity of the concept with regard to its implementation. It seems that sustainable development is "a good idea which cannot sensibly be put into practice" (O'Riordan, 1988 in Reid, 1995) or at least not as easily and successfully as it was first envisaged.

1.2 Interpreting a moral concept

From the preceding discussion it is clear that the question has to be asked as to whether the emotive appeals of sustainable development are enough for en masse acceptance as a way of life. Various authors consider the limitations of the concept.

Redclift for example, describes the concept as, "moral convictions as a substitute for thought" (Redclift, 1987 in Reid, 1995), whilst Smith states that the concept does little more than illustrate "how to destroy the environment with compassion" (Smith, 1991 in Reid, 1995). As De Vries conjectures, sustainable development has more of the character of a moral principle than a precise definition (de Vries, in Reid, 1995).
Otterstad sees the concept of Sustainable Development as a typical ***consensus product***, formulated in sufficiently vague terms to make international agreements possible, while at the same time precise

enough for implementation procedures to be agreed. It leaves much to the interpretation and priorities of the practitioners of Sustainable Development (Otterstad, 1996).

A far more damaging and deeper criticism is highlighted by Beckerman. This is centred round the concept's inherent characteristic of combining the technical characteristics of a particular development path with a moral injunction to pursue it. Beckerman considers that a definition of whether any particular development path is technically sustainable does not, by itself, carry any special moral force. Beckerman reiterates by stating that the definition of a straight line does not imply that there is any particular moral virtue in always walking in straight lines, but most definitions of sustainable development tend to incorporate some ethical injunction without apparently any recognition of the need to demonstrate why that particular ethical injunction is better than many others that one could think up (Beckerman, 1995). Beckerman continues that a sustainable development path should be defined simply as one that can be sustained over some specified time period, and whether or not it ought to be followed is another matter. In other words, it should be treated as a purely technical concept. In other words, immediately we make the distinction between sustainability, defined as a purely technical concept, and optimality, which is a normative concept, many economic activities that are unsustainable may be perfectly optimal, and many that are sustainable may not even be desirable, l*et al.*one optimal (Beckerman, 1995).

Further, with regard to futurity but also the concept of need, Beckerman (1995) believes that the Brundtland definition is useless since 'need' is a subjective concept. People at different points in time, or at different income levels, or with different cultural or national backgrounds, will differ about what needs they regard as important. Hence, the injunction to enable future generations to meet their needs does not provide any clear guidance as to what has to be preserved in order that future generations may do so (Beckerman, 1995 in Corkindale, 1998).

Gladwin argues that Sustainable Development is still most often conceptualised as an eco-efficiency problem largely involving pollution prevention and resource conservation. The eco-efficiency challenge of sustainability appears to be the easy part of the necessary transformation, while "the socio-economic challenge may be infinitely more intractable" (Gladwin *et al.*, 1995 in, Otterstad, 1996).

Based upon this suite of opinions the uncomfortable question of *why* such a virtuous concept as Sustainable Development has not reached its high ideals on a universal scale, begins to be resolved.

With regard to Otterstad's quote, the fact that sustainable development is a consensual product should not be seen as a negative aspect, but a *different* one. Present day culture does not regularly encounter 'concepts' that must be interpreted, but this is not good reason to remain unchallenged. What this statement does introduce, as with Beckerman's critique, is that a missing key to the implementation of the concept seems to be the understanding and shifting of deeper ***societal metagoals***. It is naïve to suggest for example, that the 'technical' rung of sustainable development will be taken up if not paralleled by change in the deeper social and economic aspirations of society. It is now increasingly recognised that apparently unambiguous 'realist' representations of environmental phenomena tend also to embody significant tacit social and cultural assumptions. These in turn may frequently give rise to unpredicted difficulties of social acceptance when such descriptions come to be applied 'innocently' in real world situations (Buttel and Taylor, 1994; Grove-White and Michael, 1993; Thompson *et al.*, 1986; Wynne, 1994 in, Macnaghten, P *et al.*, 1995).

So how is the current situation to be rectified? Sustainability, if it is to be implemented successfully, is the recognition and management of a universal suite of factors which affect societal quality of life today in a manner which will maintain the resource or valued subject for future generations tomorrow.

Even when the theoretical basis of the concept and the current arguments are grasped, yet another hurdle is knowing how the practices that are advocated and implemented in the drive to Sustainable Development are in fact Sustainable. How does society know if it is becoming more sustainable? The qualitative nature of the Brundtland definition makes this particularly problematic.

What is needed is a set of universally objectifiable or quantifiable criteria of all those factors that are affected or have an effect on Sustainable Development. Here the difference between the two terms must be defined. The design of definable criteria essentially ***objectifies*** the concept of sustainability. This may, in its course, involve the ***quantifying*** of some themes, but it must be recognised that some criteria do not merit from quantification, and in fact may lose some of their whole by so doing. For example, landscape aesthetics and public perception are inherently subjective. Various exercises in measuring these subjects have been problematic. Some areas, for example economics, are obviously easier to quantify than others, but in the realm of river management, criteria to ascertain 1) the sustainable option; and, 2) the level of sustainability of a given environment are sadly lacking.

Many believe that sustainable development could, in many instances, be made operational simply by requiring that economic decisions take environmental costs into account. Pearce, for example, sees sustainable development to be a situation in which future generations would be left the same 'capacity' as now for improving human well being. Capacity, he determines, is the sum of all human, man-made and environmental assets. Decision making would have to incorporate a full analysis of environmental costs and benefits and the aggregate value of environmental assets should not be allowed to fall, that is to say that any environmental damage in one area must be compensated for by improvements in others. A set of "green" accounts might be used to support the second part of the definition (SCSD, 1995).

1.3 Summary

This chapter has introduced the need for a 'demystification' of the concept of Sustainable Development if it is to overcome the problems in implementation experienced over the last decade. To this end, throughout this thesis and in concordance with the preceding discussion, the reader is asked to bear in mind the following underlying objectives to the research. Ultimately, these are elementary to the practical implementation of the Sustainable Development concept:

1) ***What does Sustainability achieve;***
2) ***How is Sustainability achieved;***
3) ***What does Sustainability mean in practice; and,***
4) ***How do we sell the concept of Sustainability?***

In other words, how can the theory of sustainable development be most successfully positioned to influence the principle and practice of river management?

Chapter 2

Sustainable Development: the 'reality'

2.1 The Institution and Sustainable Development

> *People are sceptical as to whether government or business can be 'trusted' genuinely to promote sustainability. Government and business are commonly perceived as part of 'the system', with tendencies towards self-interest and short-term goals* (Macnaghten, P *et al.*, 1995).

The statement above is presented at such an early stage to highlight how problematical, both socially and institutionally, a concept like Sustainable Development is to introduce on a grand scale. There is a wealth of research into the deeper problems embodied by this statement, and indeed, it is suggested that for a truly *sustainable* sustainable development policy in any institution or agency, this needs to be of parallel importance to the tools and techniques for sustainable development. Indeed, many of the tools and techniques will have to face this issue directly.

A graphical representation of this problem has been proposed (Shiau, H, 1998)(figure 2.1 below). Here, this is modified to include the social metagoals and consensus building which, it is argued, are implicit at policy level, but perhaps not recognised as such, and are definitely not *explicit* in the Environment Agency policy goals. Rather, it is suggested that there is a massive bias on the Agency's behalf towards the pragmatic, which is where the Agency is excelling at present. However, the Agency now needs to channel more research into recognising those underlying social metagoals which could, by so doing, greatly enhance their drive to sustainable river management. Public participation and consensus building should be seen more as second order metagoals. There is a need to recognise the first order, to look beyond the more explicit levels, and to the underlying drivers and constraints to sustainable management. One point which is particularly pertinent to these objectives is the idea of understanding first and foremost *why* degrading practices come about and how they are able to achieve their own social and political legitimacy.

Drummond and Symes suggest that the theory and practice of sustainable development could be better progressed by turning to two theories - ***Realism*** and ***Regulation theory***. These, they claim, could be the bases for understanding causality of unsustainable events, and, concerning ourselves with the contradictions and crises which emerge within capitalist economies and the ways these are addressed by society (Drummond and Symes, 1996).

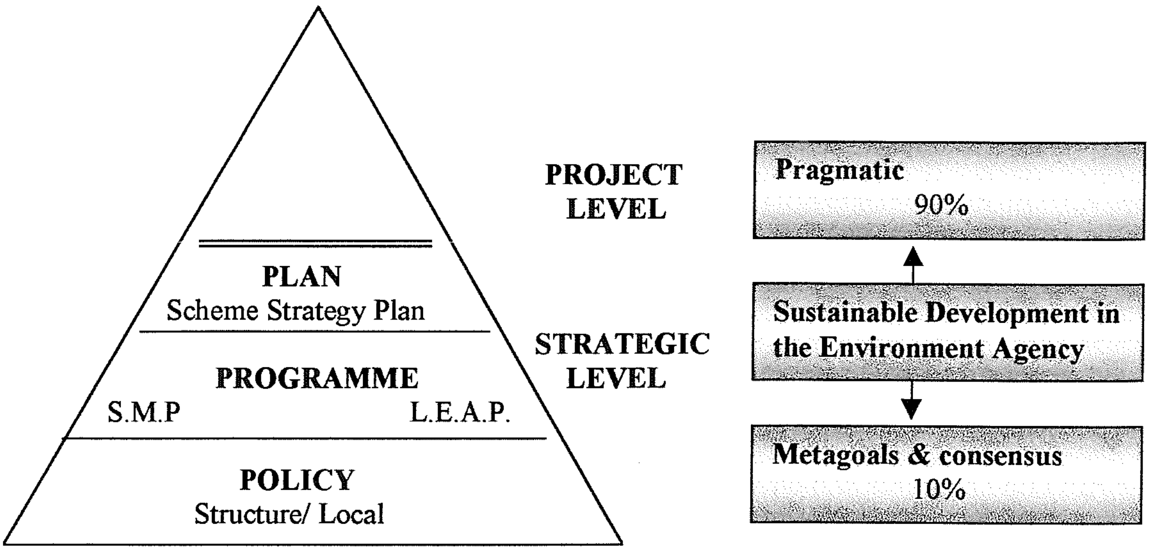


Figure 2.1: The institutional structure of sustainable development (modified from Shiau, 1998)

Realist theory is claimed to provide a multi-level conceptual framework, which elucidates a range of moments where policy might be targeted. There are two possible approaches in the realms of sustainable development according to Drummond and Symes. One can intervene at the level of contingency although this already happens but rather than preventing an event happening any place, any time, it only limits that specific place and time. In other words the unsustainable activity will simply be redirected elsewhere. Alternatively, one can address the tendency involved rather than outcomes but for this approach there is a need to know what the objects and structures, which give rise to the unsustainable tendency are, and then how the tendency can be moderated (Drummond and Symes, 1996).

Regulation Theory suggests alternatively, that despite pushes away from Capitalism, it survives through a mode of social regulation - an ensemble of norms, institutions, organisational forms, social networks and patterns of conduct. Current modes of social regulation tend to make unsustainable practices the norm. Regulation theory suggests that the emergence of contradiction, dysfunction and *unsustainability* is an inherent feature of the capitalist dynamic. Drummond and Symes postulate that instead of unsustainability being seen as conjunctural crises which require minor adjustments it should instead be seen as crises resulting from fundamental contradictions in the capitalist mode of production itself. In other words, the unsustainability inherent in socio-economic formations can be postponed, but in practice only through measures which tend to involve other forms of unsustainability. This scenario leads to the previously mentioned line always having to bear a certain pressure, a pressure for the threshold to be transgressed as new and more profound contradictions will tend to emerge.

People display a pronounced degree of fatalism and even cynicism towards the country's public institutions, including national and local government. Macnaghten states, 'seeing officialdom and experts speak as if they know what sustainability means and what it demands of society, but then finding in practice that few clear proposals or initiatives are advanced (even if they would find some of these unpalatable – that is another issue), it would not be surprising to find that people were suspicious, or that some reacted to this sustainability discourse as another elite conspiracy' (Macnaghten, P *et al.*, 1995).

Based upon this statement and the discussion of chapter 1, the Environment Agency of England and Wales provides the ideal mechanism by which to investigate the current attitudes and approaches to sustainable development, and also a forum for developing a more pragmatic redefinition of Sustainable Development. The Agency already has the goal of Sustainable Development whilst having the geographical and institutional flexibility to allow field-testing, policy uptake and financial support.

2.2: The Environment Agency

2.2.1: Statutory objectives towards Sustainable Development

The Environment Agency (also referred to as the EA and the Agency) is a Public Body Corporate, which was set up on 8 August 1995 under the Environment Act 1995. It took over the powers and functions of HMIP and the NRA, together with the waste regulation duties of the Local Authorities on 1 April 1996 (EA, 1996i).

The Agency has a range of functions which it has to carry out in accordance with the Government's overall environment strategy set out in the 1990 white paper, 'This Common Inheritance' and the 1994 UK Strategy for Sustainable Development. The basis of that strategy is the commitment to the goal of sustainable development, seeking to reconcile the dual objectives of achieving economic development and of providing effective protection and enhancement of the environment.

Section 4 of the Act defines the Principal aim of the Agency (box 2.1),

> *"In discharging its functions so to protect or enhance the environment, taken as a whole, as to make the contribution towards attaining the objective of achieving Sustainable Development that Ministers consider appropriate"*

Box 2.1 (EA, 1996h).

Together, statutory guidance to the Agency from ministers and the 1996 Management Statement set the broad framework within which the Agency operates. Ministers have given the following statutory guidance on objectives -

That the Agency should:

i) *adopt, across all its functions, an integrated approach to environmental protection and enhancement which considers impacts of substances and activities on all environmental media and on natural resources;*

ii) *work with all relevant sectors of society, including regulated organisations, to develop approaches which deliver environmental requirements and goals without imposing excessive costs (in relation to benefits gained) on regulated organisations or society as a whole;*

iii) *adopt clear and effective procedures for serving its customers, including by developing single points of contact through which regulatory organisations can deal with the Agency;*

iv) *operate to high professional standards based on sound science, information and analysis of the environment and processes, which affect it;*

v) *organise its activities in ways which reflect good environmental and management practice and provide value for money for those who pay its charges and taxpayers as a whole;*

vi) *provide clear and readily available advice and information on its work; and,*

vii) *develop a close and responsive relationship with the public, local authorities and other representatives of local communities, regulatory organisations and public bodies with environmental responsibilities*

(EA, 1996h).

With regard to sustainable development, ministers have set a number of statutory contributions that the Agency should make towards the objective, relating primarily to conduct (box 2.2).

Unfortunately, within the Agency, as in other organisations trying to implement Sustainable Development into environmental management, there has been a high degree of confusion as to what this all means for each of the Agency Functions in practice. Despite there being a Sustainable Development team in the Agency Headquarters in Bristol, there is a perception that little seems to trickle down to those who need firm guidelines to adhere to, so that each project seems to have its own ideas of what 'sustainable' means.

The Agency should,

i) *take a holistic approach to the protection and enhancement of the environment;*
ii) *take a long-term perspective;*
iii) *conserve and where practicable enhance biodiversity;*
iv) *protect the global atmosphere;*
v) *partner regulated organisations adopting improved technologies and management techniques;*
vi) *strive to develop a close and responsive relationship with the public, local authorities and so forth;*
vii) *provide high quality information and advice.*

Box 2.2: Statutory contributions to sustainable development (EA, 1996h).

At present, river managers in the Agency are being presented with a Brundtland-style definition and then asked to apply this to their river - a formidable task, and one which begs the question of a need for a ***sustainable management*** perspective rather than pure sustainable development.

2.2.2 Language as a facilitator of confusion

The Agency is in essence a regulatory body and as such, the legislation surrounding its duties and functions is of utmost importance. This considered, there are a number of ambiguities and potentially confusing figures of speech and terminology within the EA documentation, which go a long way to explaining the lack of clarity in many of the statutory aims and objectives.

Considering the Principal aim first, the level of legally enforceable obligation upon the EA is more than a little uncertain. The term "***taken as a whole***" although introduced with the aim of ensuring that the decision making process was not overburdened by detailed consideration of impacts on individual environmental media, could perhaps be used to justify attaching less weight to any one individual factor (Ball and Bell, 1997).

The confusion created by introducing a Principal Aim which is not legally enforceable is further illustrated by the declaration that it will "only take precedence over other statutory objectives where there is a direct conflict between the two" i.e. in a decision to act where both objectives cannot be met the Principal Aim would take precedence. However, the Principal Aim is stated to be "subject to" other provisions of the act, which would include the other objectives.

Similarly, the Agency must have regard to guidance issued by the Secretary of State when discharging its functions. Guidance on the Principal Aim is likewise expressed in very general senses. As Ball and Bell state, "one of the inherent dangers of using such guidance to flesh out such a statutory provision is that it is capable of change without recourse to legislation" (Ball and Bell, 1997). In other words the Agency could carry out its functions without the scrutiny which is afforded to legislative proposals. The real issue, which needs to be clarified, is the way in which the principal aim is taken into account with regard to individual decision making and the setting of strategic aims.

Additionally "***having regard***" to the guidance will mean that the Principal Aim is little more than a statement of intent which will not be subject to judicial scrutiny (Ball and Bell, 1997).

The statutory objectives towards Sustainable Development itself are similarly open to interpretation on a number of points. If each is considered in turn then some common themes begin to emerge, thus:

i) ***"The Agency needs to take a holistic approach to the protection and enhancement of the environment"*** (EA, 1996h)

Ministers continue, "it should therefore strive through its actions to optimise benefit to the environment ***as a whole***, taking proper account of all likely costs and benefits. Where practicable and permissible, the Agency should seek to ***exercise its functions in combination***, so as to contribute to sustainable development ... [and] the Agency should make use of integrated catchment management planning or other integrated geographic planning tools where appropriate. Many of the Agency's functions may, depending on local and regional circumstances, have implications for the quality of the water environment and for downstream uses" (EA, 1996h).

Central to this objective then is the optimisation of benefits to the environment 'as a whole' through the 'proper account of all likely costs and benefits'. Again, one must ask what this terminology means in practice. Costs are defined in section 56 (1) of the Environment Act 1995 as including costs to any person (which also means organisations) and to the environment. Legal requirements (such as the implementation of water quality objectives) remain unaffected by the duty; they must still be observed. But the general duty with regard to costs and benefits will apply wherever there is more than one way of achieving the legal requirements, and if the agency retains discretion as to how they should be achieved (EA, 1996h).

This objective contains a number of other loosely phrased and ambiguous terms of speech. As Ball and Bell state, '***Taking account***' in relation to cost and benefit does little more than raise an evidential presumption that they will be considered. In the legal context it does not prescribe the weight to be attached to such costs and benefits and thus any decision based on such an analyses would be difficult to challenge (Ball and Bell, 1997).

Similarly, costs are defined as "to any person ... and to the environment" but ***benefits lack any form of definition***. How then, bearing in mind their mutual partnership in the literature, are the two to be compared in any quantitative form? Likewise, if "there is no requirement for the agency to value the environmental benefits it delivers" but the "cost of applying the duty should be proportionate the potential benefit to be gained" (EA, 1996f) then how does the agency estimate the proportionate cost?

The extent to which the duty could be used to challenge a decision of the agency on the basis that the benefits of a proposed action or strategy could not be shown to outweigh the costs is controversial.

One further ambiguous phrase is... "***where practicable and permissible***". This implies a high level of discretion regarding the degree of 'holism' followed in relation to the combination of the various agency functions - once again, a point of contention if legal action were to be taken against negligence of certain functions.

Similarly, the duty does not apply if it would be 'unreasonable'. It does not affect agency mandatory obligations and legal requirements are unaffected.

The objective makes considerable reference to "*Holism ...taken as a whole ...[and] integrated management*". Bearing in mind the central position of these terms to the agency sustainable development goals, the question has to be posed as to what holism means to the agency? Document SD1, page 5, states,

> *"In order to achieve a holistic approach these areas [those described above] will need to be developed in the agency. Integrated planning will have to be delivered at corporate, policy and operational level. Local EA Plans (LEAP's) are seeking to achieve these aims by integrating planning at the operational level"*
>
> (EA, 1996d).

It is problematic to identify whether integrating at the "policy ...and operational level" means in terms of river management for example, the integration not only of the various components of sustainable development but also the complex physical interrelationships at the river channel level. The argument over holism is a complex one. Dictionary definitions of "Holism" variously occur as,

> *"holism (also wholism) 1. Philos. the theory that certain wholes are to be regarded as greater than the sum of their parts (cf. REDUCTIONISM). 2. Med. the treating of the whole person including mental and social factors rather than just the symptoms of a disease."*
>
> (Concise Oxford Dictionary, 1990)

> *"holistic App. to the view that in nature functional organisms are produced from individual structures which act as complete 'wholes'. Geography is said to have this holistic approach,*

whereby phenomena are viewed not as individual entities but as interrelated complexes. Hence holism, the doctrine itself."

(Monkhouse, 1976)

"holism, any of a wide variety of theses that in one way or another affirm the equal or greater reality or the explanatory necessity of the whole of some system in relation to its parts ...holism with respect to some system maintains that the whole has some properties that its parts lack. In the context of explanation, holism with respect to some object or system maintains ...that all the variables that constitute the system interact with each other. Holism is sometimes understood as the theses that with respect to some system the whole has properties that interact "back" with the properties of its parts."

(Audi (ed.), 1995)

So perhaps with regard to Agency objectives holism could be redefined as box 2.3, below.

> *"A complex system which gains something from the study of the inter-relationships of a number of component parts, which, in turn, retain their own ability to act as complete wholes and which should be viewed in terms of more than just the symptoms they convey."*

Box 2.3: Agency definition of holism

ii) "the Agency needs to take a long-term perspective"

The guidance further states, *"taking into account longer term implications and effects, particularly those which appear likely to be irreversible, reversible only at high cost over a long timescale or which would raise issues of inter-generational equity"* (EA, 1996h).

It would be interesting to discover what the threshold level is at which the future becomes "long term" for not only the Agency but also others aspiring to implement sustainable development. At present, long-term in a flood defence capacity is usually taken to be the 50 year life. Policy is not as yet ready for such a lengthening in its aims and objectives. Similarly the Agency's approach to discounting is not mentioned (which possible should have been in either one of these first two objectives). This is a particularly valuable tool for evaluating the future costs and benefits and the effects on inter-generational equity.

iii) "conserving and where practicable enhancing Biodiversity and Protecting Natural Heritage

"...the Agency should pay particular attention to its statutory obligations with respect to conservation. The need to protect species, habitats and ecosystems is in accordance wit Government policy and the obligations of the Biodiversity Convention and other international nature conservation laws and agreements..." (EA, 1996h).

The Sustainability/Biodiversity link is critical, not least because of international agreements on Biodiversity which could support the use of Sustainable Development as a management goal, and Geomorphology as a scientific discipline. This objective is therefore suggested as the one which could include the use of Geomorphological principals in its actions. It is argued at this point that biodiversity and geomorphology are inextricably linked and that neither can be fully optimised without the other. This will be discussed in chapter 4.

As with objective (i) this guideline uses the phrase "where practicable" and, as with the Agency's Principle aim, the goal is to "enhance" biodiversity. One needs to ask the question as to who decides that the biodiversity is being enhanced in the correct direction, and similarly, whether enhancing biodiversity is sustainable in the long-term without respective shifts in Geomorphology.

Searching for the geomorphological context into which the above rests, it seems that the Agency do speak of biodiversity and geomorphology as one mutually inclusive package. However, at times the two also contradict each other, particularly if the natural metastability of the river is very dynamic and certain species are not well adapted to the continuation of this natural adjustment.

vi) "the Agency should strive to develop a close and responsive relationship *with the public, local authorities and other representatives of local communities, regulated organisations, and public bodies with environmental responsibilities. It should also strive to work in partnership with all such groups, for example in developing integrated catchment plans"* (EA, 1996h).

vii) "high quality information and advice *on the environment is an important element in taking forward strategies for sustainable development. The Agency should therefore strive within its areas of responsibility: a) to become a recognised centre of knowledge and expertise, and b) to provide and promulgate clear and readily accessible advice and information on its work and on best environmental practice"* (EA, 1996h).

Both of these objectives stress the importance of communication between the Agency, public and organisations. Not unlike the preceding objectives there seems to be little legally binding terminology within them but the Agency is encouraged to "strive" towards these goals. However, these are important objectives, and ones which are considered in considerable detail in chapter 8.

2.2.3 Present practice in the Environment Agency

At the outset of a Research Project of this kind it is apparent that if a review of the current state of sustainable development is to be defensible and valid, extensive discourse with the various players in that quest is essential.

For this reason, at the inception of research, a formal set of interviews were held with Agency employees around the country (table 2.1) to assess the present day attitudes to the Environment Agency's Principle Aim. Excluding a meeting with the Sustainable Development (SD) team in Bristol the interviewees were chosen on the basis of their inclusion in one document, **SD*9: Case Studies*** (EA, 1996g), where their projects were included by the SD Team as exemplifying good practice in Sustainable Development. Further contacts were made on the recommendation of these people.

The purpose of these discussions was to:

1. Gauge present-day Agency reactions to the concept of Sustainable Development;
2. Identify why the concept has the reception it has and consider the suggestions of those at ground level;
3. Critique the social context of sustainable development in the Agency (see chapter 8 for results);
4. Identify possible case studies for development within the research project, and most importantly,
5. Identify potential opportunities and constraints to the guidelines that will be developed as part of this research project.

Prior to the consultations, a list of 'discussion prompts' (Table 2.2) were mailed to the respective parties for familiarisation with the aims and objectives of the meetings. These prompts were developed on the basis of the definitions and arguments presented in chapter 1, and the theories behind the concepts of chapters 7 and 8. They were compiled in a manner which aimed to emphasise the key components of successful sustainable management:

1) how the concept is quantified;
2) how this is effected by the political and legal framework;
3) how the concept is optimised in both policy and practice to the community; and,
4) how the Environment Agency structure facilitates (or constrains) these initiatives.

At this stage of research, economic mechanisms were also identified as key facilitators to the implementation of more sustainable practices, and the discussion prompts were designed to provide a forum for discussion on the practicality of utilising market mechanisms in a more successful drive to sustainable development in environmental management. Geomorphology is also seen as an important key attribute of sustainable environmental management (see Chapter 4), and again, the discussion prompts aimed to raise awareness to this, and to identify opportunity for implementation.

A preliminary schedule and summary of the PhD were also enclosed in the package. Depending on the bias of each project, the prompts were modified accordingly. The views expressed may not be those of the Agency as a whole, although it is suggested that a number of the views are widely held.

Following the period of discussions, a number of interesting points emerge. The section following the list of prompts is a short summary of the most widely expressed views. This section is included so that a comparison might be sought with the recommendations which will be made towards the end of this research project.

Date of Meeting	Location	Name of Participant/s	Job Title/s	Project/s Discussed
December '97	HQ, Bristol	Chris Newton Richard Howell	Head of SD Biodiversity	Policy
28 January '98	Bath EA	SD Team: Chris Newton Ronan Palmer Jim Kersey Richard Howell Mary Cassell Andrew Brookes	 Head of SD Chief Economist SD Policy Manager Biodiversity Secretary, SD NCRAOP	Policy
25 February '98	Lincoln EA	Phil Smith	Conservation and Recreation Officer	• Horncastle Enhancement Scheme • LowerWitham Scheme • Nene Valley • Various washlands
11 March '98	Newcastle EA	Colin Blundell Alistair Laferty	Conservation and Recreation	No specific project
7 April '98	York EA, Clifton Moor	Dr Liz Chalk	Team Leader, Collaborative Projects: Fisheries, Ecology and Recreation	Upper Wharfedale Best Practice Project
8 April '98	Darlington; Field Visit	Olivia Clymer	Recreation Officer and Project Leader	River Skerne River Restoration Project (RRP)
1 October '98	Sustainability Working Group meeting, Yorkshire Dales National Park Authority (YDNPA), Grassington, Yorkshire.	Clive Kirkbride Ian Cuthbert Sylvia Jay Eleanor Robinson (and colleague) Gill Travis	YDNPA (Joint Chair) Kettlewell Parish Council Yorkshire Wildlife Trust Conservation Officer, EA Farming and Rural Conservation Agency (FRCA)	Upper Wharfedale Best Practice Project
10 March '99	Sustainability Working Group meeting, Yorkshire Dales National Park Authority (YDNPA), Grassington, Yorkshire.	Clive Kirkbride Ian Cuthbert Sylvia Jay Eleanor Robinson (and colleague) Gill Travis	YDNPA Kettlewell Parish Council Yorkshire Wildlife Trust Conservation Officer, EA Farming and Rural Conservation Agency (FRCA)	Upper Wharfedale Best Practice Project

Table 2.1: Consultees in Discussions

1.0 **Sustainable Development**

1.1 ***Quantification of,***

1.1.1 Would you say, either on your own behalf, or that of the Agency that **weak** or **strong** sustainability are the way forward to improving our present day problems in the UK? ...and which would you say, is the Agency implementing or aspiring to?

1.1.2 Do you see the Agency as taking a primarily **proactive** or **reactive** role?

1.1.3 Has there been any attempt to identify **quantifiable indicators** of Sustainable Development in any division of the Agency but with especial reference to rivers/coasts?

1.1.4 Does Agency monitoring of sustainability include both **physical <u>and</u> economic indices**? Can these be calibrated?

1.1.5 How do we know if we are becoming more sustainable? (...indices?)

1.1.6 In what ways can you justify that the Agency is moving closer towards its goals of sustainability, if indeed it is?

1.1.7 Does the Agency have a list of sustainability indices or targets which it uses to **monitor performance**?

1.1.8 How much importance does the Agency place on **Research** (Universities and Research Institutions), say in monetary terms?

1.1.9 What provisions has the Agency put in place for the **attitudinal revision** of its staff to more sustainable practice/s?

1.1.10 The Agency's Principle aim is to "protect or enhance the environment". How does the Agency propose to quantify "enhance"? Is this in purely physical terms or more qualitative terms? If it is the latter, have **perception** studies been implemented?

1.1.11 What form does **Post-project appraisal**/monitoring take in the Agency and over what time period?

1.2 ***Legislation/Politics of,***

1.2.1 Is the Agency aspiring to more **enabling legislation** in the UK or is the present position acceptable? (esp. re: land use/management)

1.2.2 To what extent does **EC legislation** affect the Agency's sustainability agenda?

1.2.3 To what extent does the Agency look towards the experience of our foreign counterparts?

1.2.4 Being a Non-Departmental-Public-Body (NDPB) is the Agency subject to the overriding **politics** of 'keeping the electors happy'? If financially able, do private regulators have more freedom?

1.3 ***Selling Sustainability/Public Education***

1.3.1 How does the Agency plan on **remedying the vagueness and ambiguity** of the sustainable development definition?

1.3.2 What do you see as the principle tasks in selling sustainability? Are these ideals financially constrained?

1.3.3 What are the **major hurdles** to be crossed in **selling** sustainability?

1.3.4 How much importance is the Agency placing (in practice) on the **awareness raising** and education of the public with regard to the goal of sustainability?

1.3.5 How successful are the Area Environment Groups proving to be?

1.3.6 Does the Agency see itself as the medium by which the public can be educated in the key meanings of sustainable development (without the jargon!)?

1.3.7 One 'measure of success' in the Agency's 1996 flood defence strategy (unpubl.) is "an informed public". How does one know if the message is getting through? Will there be a form of **social monitoring** programme?

1.3.8 At present what do you believe the **public image** of the Agency to be? ...and who monitors this?

1.4 ***Interconnectivity of,***

1.4.1 Is discharging the Agency's functions working so far, with regard to the inherent inter-connectivity of the various components of the environment and sustainability?

1.4.2 What does the term 'holistic' mean?

1.4.3 Does the Agency's agenda work on the principle of coupling its 'State of the Environment' data onto a regional scale for practical implementation or does each project (regarding rivers) work relatively independently of others?

2.0 **<u>Economics</u>**

2.1 How does the Agency define the **criteria** to be adhered to with regard to cost-benefit analysis/environmental valuation?

2.2 What **methods** does the Agency use to cost out the likely ramifications of implementing Sustainable Development in their management?

2.3 What form does the Agency's assessment of **intangibles** take?

2.4 How does the Agency stand on meeting the needs of the present whilst not compromising the future? Has the Agency found it economically viable and practicable so far?

2.5 How does the Agency approach the philosophy of **'discounting'**?

2.6 Will discount rates vary within a single project and between different localities?

2.7 Is there now greater emphasis on discounting than before the sustainability era? The DoE states that "for most applications in Central Government a discount rate of 6% per annum in real terms is used for discounting costs and benefits which can be expressed in money terms" (DoE, 1991, Policy Appraisal and the Environment, HMSO). Will the Agency strive towards a similar figure in its valuation methodology?

2.8 In the 1996 EA publication 'Sustainable Development: taking account of the likely costs and Benefits' it is stated that "there is no duty for the Agency to demonstrate quantitatively that likely benefits exceed likely costs before it acts, as long as it can be shown that the Agency took account of the likely costs and benefits in reaching its decision". How does the Agency avoid the inherent difficulty involved in valuation of projects if costs and benefits are not quantified?

2.9 If "there is no requirement for the Agency to value the environmental benefits it delivers" but the "cost of applying the duty should be proportionate to the potential benefit to be gained" (SD3: Taking Account of the likely Costs and Benefits) then how does the Agency estimate the proportionate cost?

2.10 Do each of the Agency functions have separate budgets and if so, how does the Agency tackle the challenge of taking them all into account when only one function is paying, but also to take action which may be difficult to justify in terms of one function alone?

2.11 How does the Agency plan to "secure an adequate level of investment in flood defence and prevention"? (flood defence strategy, 1996)

2.12 Is there a sound basis in place for the economic appraisal of using Geomorphology? If not, why?

3.0 <u>**Geomorphology**</u>

3.1 Why has Geomorphology not got any further than it has?

3.2 What are the key goals and objectives identified be the Agency with regard to sustainable development of the river system and <u>geomorphology</u>?

3.3 Will the Agency publish **national standards** (calibrated and thus quantifiable) which can permit comparability of assessment standards (also economic and social)?

3.4 Are Geomorphologists given enough freedom to implement their discipline to the full and most effective level or are they constrained by economics and/or other interests?

3.5 If Geomorphology is an aspiring goal of the Agency then river based issues comparable to coastal **managed re-alignment** will need to be considered. Have these been considered so far, and if so, how does the Agency propose to tackle the socio-economic and political factors involved?

3.7 Is the Agency aspiring towards the production of a **data base** on floodplain limits for

	floods of varying magnitude and do these take into account predicted changes in climate?
3.8	Does the Agency have or is it developing a clear order of priority for action to restore system carrying capacities?
3.9	Is the Agency considering 'Stream Reconnaissance Surveys' for the cost effective collation of riverine data?
3.10	Will the Agency's goal towards Catchment Management tend towards 'control and command' or 'incentives' with regard to the accommodation of rival interests?
3.11	Is or has the Agency considered Pollution taxation as a way of funding its initiatives and compensating those affected by land loss etc.?
3.12	How interrelated , in Agency terms, is biodiversity and geomorphology?

Table 2.2: Discussion prompts

2.2.3.1 Policy level: Quantification, legislation, awareness raising and interconnectivity of Sustainable Development

From the discussions it is clear that the Agency tends towards the stronger pole of sustainable development but within socio-economic thresholds of tolerance. It is more successful than most in implementing sustainable development, but this is still set within a culture which has an inherent commitment to growth. The important integration of environment, economics and social issues in the commonly used venn diagram, is part of a hugely political concept, and one which is not readily made practicable. These factors make the implementation of a principal aim with sustainable development at its core, a problematic one.

Operationally the Agency is still reactive in its approach to sustainable development. There is no formal education or information programme in place for Agency employees on the concept. Attempts have been made at running road-shows, sustainable development documents and newsletters. However, few people have encountered any one of these tools. The reliance instead rests upon good results in projects promoting good practice. This style of reactive management is unfortunately resulting in the SD team receiving requests on how projects may be made more sustainable, in line with the corporate plan. This epitomises the lack of integration of the concept as a way of thinking rather than a separate, and often concluding, element of practice. Similarly, promotion to the public has met with little success. The message that sustainable development is not hugely complex still needs to be emphasised to as many people, both within and outside of the Agency, as possible.

Acknowledgement of catchment scale floodplain management means that this Function is more proactive than many in the EA. Despite this, progress towards sustainable development in Flood Defence is generally measured through figures on the numbers of people protected from flooding. Many argue however, that flood defence is cloaking the real issue. An analogy of the health service was used, in that more health services do not make people healthier – the problem is being controlled but not addressed.

There seems to be consensus that the Agency *is* becoming more sustainable in their emphasis on working with natural processes and moving towards softer engineering on the river. This is considered to be a good proxy for more sustainable practice. Similarly, Research and Development (as with this PhD) is addressing the issue, but there is a distinction to be made between commissioned work and that of the Academic institutions. New modes of dissemination need to be found if projects like this are to be afforded the level of interest which they need to adjust well-founded preconceptions and practices.

Despite the Agency's holistic aim there are still no 'River Management Bylaws" but rather bylaws stemming from the Agency predecessors are meant to come together under the Principal Aim. A number of laws also act in conflict with holism. These constrain the power that the Agency has to implement sustainable management widely. For instance:

> *"erosion of river banks is the responsibility of the riparian landowner;*
>
> *"the Agency has no responsibility of liability for erosion of river banks;*
>
> *"where bank erosion could effect the river regime, threaten flood defences or result in deficient drainage then action can be taken by the Agency but each case must be judged on its merits;*
>
> *"where the Agency or its predecessors have carried out works in the channel or on the banks and accepted responsibility for future maintenance then future maintenance can include erosion repairs."*

(University of Newcastle-upon-Tyne, 1998).

A major constraint on sustainable management in the Agency is the lack of cohesion between Functions. Each of the Agency Functions has a separate budget which raises the question as to how the Agency tackles the challenge of taking them all into account when only one Function is paying, but also how it takes action which may be difficult to justify in terms of one Function alone. This does not complement integrated and holistic management. As Gardiner states: "words such as 'integrated' and 'total' commonly fail in practice, usually because the institutional arrangement do not facilitate such co-ordination" (Gardiner, 1997, in Haycock *et al.* (ed.), 1997). Consultees however, do not believe that functionalising the Agency has precluded integration and holism. *"For example, flood defence has more money than any other function so this is used to rectify previous flood defence mistakes or to fund a project if flood defence is an integral part of the scheme. Beyond this the respective function has to pay"* (undisclosed, 1998).

The long-termism of sustainable development is particularly problematic. The major dilemma rests with the statement "meeting the needs of the present whilst not compromising the future". The time period that is chosen as the 'future' is left undefined. MAFF for instance, works on 'development lifetimes', discounting for a) justification of schemes and b) ranking schemes. However, discounting, once further than approximately 50 years, is blind to 100 or 1 billion years and yet if an object or scheme is still existing then obviously it still has a value or liability. Additionally, and most important to preservation and conservation, and the long-termism of sustainable development, it is uncertain as to how society will value in 50 years from now. Society places different values on different things whether they be cultural, socio-economic or environmental. The Agency does not approach the philosophy of discounting nor therefore the variation of rates within and between different projects. It is suggested that this is due to lack of understanding and the size of the task. The discount rate is simply taken as 6% as with the Department of the Environment, Transport and the Regions.

In the 1996 EA publication *'Sustainable Development: taking account of the likely costs and Benefits' it is stated that "there is no duty for the Agency to demonstrate quantitatively that likely benefits exceed likely costs before it acts, as long as it can be shown that the Agency took account of the likely costs and benefits in reaching its decision"*. There is an inherent difficulty involved in valuation of projects if costs and benefits are not quantified. Concerns exist on the Agency's behalf, over monetising all benefits. Emphasis instead is placed on costs whereas benefits are assumed. In the case of flooding the Agency uses 'House Equivalents' to identify costs under the assumption that flooding is damaging and that stopping flood is beneficial - in direct conflict with the goals of Sustainable Floodplain Management. The 'Multi-Attribute Approach' also helps to proportionate the cost/ benefit attributes. The Agency's widely banded phrase, *"taking account of"*, despite its legislative weakness, is seen as useful in the appraisal of for instance, option 'a' versus option 'b'.

If working from geomorphological principals is an aspiring goal of the Agency then issues comparable to coastal managed re-alignment will need to be considered. This is a key component of the Sustainable Management package (see chapter 3) and yet is not formalised in any part of the Agency's goals and objectives. This is also where legislation is arguably most needed. Consultations brought attention to the Danish legislation on land take where the state buys the land, negotiates and restores. Discussions also highlighted a public meeting held days before where a riparian landowner had professed an interest in a co-operative fund with other riparian land-owners over river issues. This is a particularly interesting notion and one which is not utilised in the UK to date (see chapters 7 and 8 for development of this concept).

2.2.3.2 'Ground-level'

Regarding the internal infrastructure of the Agency and the promotion of the Principal Aim, at few points have 'ground level' staff (those implementing the concept in the field) seen any trickling down of information from the SD Team in Bristol. It is widely appreciated that superiors may be familiar with the SD publications but a fuller provision and greater accessibility is needed. Similarly, staff have come across few provisions for the attitudinal revision of staff to the Agency's principle aim in general,

> *"it's lurking and banded around... It's implicit... there are no bulletins"* (undisclosed).

To receive budgets and funding for projects, much reference is made to the Corporate Plan to further chances. This is the most oft-cited reference point for those involved in the discussions of this research project.

There appears to be a widely held view that sustainable development is a *"bit of a giggle"*. Ground level staff express the need for a clear definition of what it all means to them when they are implementing a project on-site. The fact that the Agency has no method of measuring the success of sustainable development is seen as an important link to be researched. The Agency is seen by many to be moving closer towards its goals of sustainability through Integrated River Basin Management and LEAPs. Some believe that the Agency should gauge whether they are becoming more sustainable *"from the way a project is started to the very end result. More holistic and interdisciplinary practice and getting it right first time with a fuller understanding of the environment incurring less maintenance, are all signals of Sustainable Management"* (undisclosed). Similarly, no formal assessment of cost and benefit exists except in the field of flood defence - often costs and benefits are based upon subjective judgement. Targets are identified as especially important in the drive towards sustainable development, as presently any project which can be worked with in a way which is understood to be a sustainable is taken, opportunity and resource allowing. Best Management and Geomorphological targets are considered as being very important to parallel the awareness raising to the concept.

The concept of sustainable development is again perceived to be reactive, often being implemented in response to collaborative projects. It is rarely initiated freely and tends to be seen as a separate practice to everyday project work. Apart from the increase in the mention of the term in the office no quantifiable evidence exists of the Agency moving closer to its goals. The term 'Best Practice' illustrates less ambiguously what the concept of sustainable development aspires to achieve. 'Best *Practice' "would be more accessible, transparent and accountable to landowners, and would imply less of a global concept that has little application in more localised reality"* (undisclosed).

Similarly, with regard to image and room for improvement in customer service and promotion, there is notable confusion external to the Agency of their function in the Public domain. The NRA are still widely believed to be functioning, and the Agency as a form of Environmental Health/Water Board/pollution body. Consultees note that the public image of the Agency is too much that of *"white vans and prosecutions ...and very disjointed"*. Area Environment Groups and Regional Development Groups (community based participatory and partnership groups set up by the Agency) could be useful mechanisms for 'selling' sustainability more effectively in the public domain.

It is often the unfortunate case that the hydrological suitability, in terms of seeing the river as a continuum and in its wider catchment context, is not the most influential factor with regard to what deems a site suitable for sustainable management. Land ownership is the key. The Agency's lack of enabling powers is a major player in the constraint of successful implementation of large-scale sustainable development. Despite the best of intentions, the Agency are *"just pricking at the surface. In one case, of 12 hydrologically suited sites only 1 site was chosen due to land-ownership constraints. It is therefore difficult to link the longitudinality of the river. Powers of consultation and negotiation come into their own"* (undislosed). Unfortunately, enabling legislation is lacking and tends to be very focused on Function, with Flood Defence being a prime example. Funding schemes further complicate this situation. Enabling powers are seen as a major hurdle to be crossed in the drive to Sustainable River Management. There are few present powers and again, powers of persuasion and liason with the Farming and Wildlife Advisory Group (FWAG) are central to its success. It is very difficult to compensate due to the dependency on the land-owner.

Due to these inhibiting factors, the Agency should be assigning more research to sharing, collaboration and participation both within the Agency and externally. A best practice project on the Upper Wharfe, Yorkshire (discussed further in section 2.3, and the case study which will be referred to in chapter 6) has championed this style of management with collaboration between the Countryside Commission, the National Trust and various others *who "often have untapped potential until information is shared".* Area Environment Groups are particularly important and powerful in this drive. Potential of these groups is perhaps not recognised universally because of the regional diversity of the Agency offices nation-wide.

FWAG play a large part in the process of reconciliation of flood defence and environmental needs. *"If it were not for the combination of compensation from Countryside Stewardship Schemes and the open sympathy and presentation of the conservation benefits of sustainable management by FWAG to Farmers, land take and more sustainable options of management would not occur"* (undisclosed). The intangible benefits to the farmer, for instance the *"prestige ...peace of mind ...and idealism of sustainability"* (undisclosed) are simply not enough to instigate action on the land-owners part without this mix of incentive and awareness raising. On a personal level, many Agency staff are great believers in public involvement They are,

"aware of the need for locally oriented awareness raising and 'advertising' of biodiversity and Sustainable Development but feel they can't afford it ...school visits and so forth. And yet, we can see good mileage from Public Involvement, "

"The Area Environment Groups are going too strategic and losing the ground level approach for which they were intended. It seems now that smaller groups still are now needed to fulfil the Agency's preliminary intentions" (undisclosed).

Funding is a major constraint to the long-term goals of Sustainable Development and compensation schemes such as the Stewardship payments. After 10 years of compensation to land-owners the payments are harnessed and *"after often having to lower their inputs and being compensated for doing so for the 10 years, they still ultimately lose out"* (undisclosed). A longer-term scheme is needed which sees further into the future. In the present culture, 10 years is perceived as long term. However, occasionally, and especially by the older farmers and land owners, commitment to sustainable schemes runs over and above the stewardship life, which illustrates that there is a will to lengthen this period. As one Consultee states, *"the Agency needs to be less half-hearted in its approach to incentives and so forth"* (undisclosed).

Related to financial constraints to more successful implementation, Consultees refer to the lack of baseline data due largely to the constraints of the financial year - *"time and money have to be spent by x point in time"* (undisclosed). PPA is included in this funnelling of expenditure and man-hours. *"The opportunity is there but need to take it is dictated by other pressures"* (undisclosed).

Central to combating the confusion and ambiguity of the implementation of sustainable development, for the concept to be more widely utilised as a management tool it needs to be demonstrated that it works. *"Case studies need to be circulated to the engineer and catchments need to be looked at and defined and the question posed as to what we want to achieve. At the bottom of it all is the risk for the Engineer"* (undisclosed). However, before successful implementation is publicised a new form of information sharing is needed. SD Officers would be more readily utilised if spread throughout the Agency Offices and not only in the EA Headquarters.

One consultee believes that *"the way forward in the Agency is through strong sustainable development, otherwise it will not happen, but at present we are at the bottom of the learning curve with regard to community understanding of the issue. We therefore need to pass through the preliminaries of awareness raising and information provision before we begin climbing this curve. The Agency thinking is also not seen as complete. Presently the Agency is functional and statutory. They are not looking holistically, and even though LEAPs go some way towards integrated management it is still not truly integrated - they do not go right back to first principles of community involvement"* (undisclosed).

In summary, ground level staff view sustainable development as being led by opportunity rather than strategically. *"A new NVQ is to be introduced in the near future on River Management"* (undisclosed, 1998) - this could be seen as a potential avenue for raising awareness and information provision. A 2-day Geomorphology and Engineering Workshop run by Malcolm Newson has also been widely acclaimed by Consultees. This could again be utilised as a tool which raises awareness, perhaps more explicitly in the realms of Sustainable Management.

A number of recommendations may be made therefore, which are central to the increased success of the concept of sustainable development both internally and externally:

1. Increased coherence of information provision and sharing between the sustainable development team and those implementing the concept;
2. The definition of clearer guidelines (preferably measurable) to Agency staff who are required to implement the principle aim;
3. The redefinition of sustainable development, so that its core aim of 'best practice' is explicitly recognised;
4. The fuller uptake and utilisation of Area Environment Groups, Regional Development Groups and Community Leader Days to translate the message more effectively to those external to the Agency;
5. More imaginative solutions, such as co-operative land-ownership between riparian land-owners, and more proactive use of incentives;
6. More enabling powers especially with regard to land-take and compensatory mechanisms;
7. Long-termism through softening the 'blow' of the financial year, extending financial pay-outs and stewardships and, more effective PPA;
8. Increased training in the relevant functions;
9. A more strategic approach with the respective resources; and
10. A stronger approach to sustainability.

These principles have far reaching implications for a new and innovative approach to sustainable river management. They also provide the context out of which a research framework may be built based upon the identification of opportunity within the present structure of the Environment Agency.

2.3 Identifying a pathway for research

2.3.1 Constraining the holism – Flood Defence as the constructive Function

Defining Sustainable Development in a way that is relevant to a particular situation and applying the principles of the concept to existing situations are two fundamental problems with the concept

(Bruff and Wood, 1995 in, Otterstad, 1996)

To review the state of sustainable development in the Agency today, whilst identifying possible new modes of implementation, there is a need to constrain the breadth of research into a more specific theme. To review the whole of the Agency would provide a superficial coverage of too many issues. To review one function allows the in-depth investigation of the relevant issues, and subsequent inference.

Flood Defence, as illustrated in the previous section, is the major integrating Function of the Environment Agency and therefore perceived to be the most suitable for this purpose. If the potential of sustainable development is to be illustrated within the criteria suggested in the previous discussion, then flood defence offers the mechanism by which this may be carried out, with regard to standards that need to be met. To date, advances in the understanding of the river channel system in the context of the catchment as a whole suggest that it is possible to design management interventions which maintain or enhance the channel in a sustainable fashion. Management interventions in the Agency often take the form of flood defence. Similarly, 'maintaining or enhancing' suggests the implicit inclusion of geomorphology.

Further, an ideal operational case study is provided in the Wharfedale Best Practice Project. This project, identified in the consultations of section 2.2.3, provides a focus on upland rural river corridor management. This focus constrains the need to detail the lengthy socio-economic arguments which would apply in a more urban, lowland catchment. With regard to site-specific issues to the Wharfe parallel to flood defence, holistic research must also consider the issues of fisheries, conservation recreation, and, land-use planning. The latter is recognised as a key concept in flooding and mitigation. Similarly, elements which are in common with coastal zone management may also be identified, and paths of commonality and transferability suggested.

Box 2.4 is a summary of the flood defence legislation to be adhered to by the Agency and to be found in the Agency publication, 'Policy and Practice for the protection of floodplains'(EA, 1997j). It has been included to provide a background legislative framework and general introduction to the Agency's current policies on floodplain protection

It is more widely appreciated now than ever before that continuing pressure for new or improved flood defences from floodplain development is incurring maintenance costs which are increasingly unsustainable in the long-term (EA and FEMA, 1995). As Gardiner and Perala-Gardiner (1997) observe, *"the direction of river management is now toward integration of the river channel with its floodplain. The principles of fluvial geomorphology show that allowing wider floodplains free from permanent development can repay us richly in safety from hazards and diverse landscapes for our* *benefit as well as that of other species. Soil bioengineering used in riverbank stabilisation has demonstrated that working with inherent river process is less costly than trying to command the flood"* (Gardiner JL and Perala-Gardiner C, 1997 in Haycock *et al.* (eds.), 1997).

Further, Gardiner and Perala-Gardiner (1997) continue that, *"more land given to river processes will repay us economically with multiple functions and benefits integrated into the floodplain land use. A brief inventory of these functions includes affordable flood defence, water quality improvements, groundwater recharge, increased water supply, provision for the increasing demand for recreation near settlement, aesthetic landscapes, wildlife habitat, safe fisheries, navigation, irrigation, food and fibre extraction, mineral resource extraction and so on"* (Gardiner JL and Perala-Gardiner C, 1997 in Haycock *et al.* (eds.), 1997).

Flooding of floodplains is thus the desirable objective environmentally, but in practice, due to the historical development on and around floodplains, often not implementable because of the risk to human life and livelihoods. This contradiction in goals exemplifies one of the most influential barriers to sustainable development - balancing sustainability of the natural environment with the sustainability of that environment's economic and social mechanisms. The dilemma of *who* pays, in the broadest sense of the term, socio-economically, and indeed more importantly *how* they pay, if strong environmental sustainability is pursued, is an interesting one.

Britain has traditionally followed the development trap of developing on floodplains installing flood defence measures, and then having to reinforce or maintain these defences, often at considerable cost, into the future. The British public expects flood defence and pay higher housing prices in justification of this willingness to pay and live on flood risk zones. Indeed, as the consultations defined, *"why should the public not demand defences if there is this flood defence mechanism in place?"* (undisclosed, 1998).

The issue of floodplain management is well summarised by Penning-Rowsell and Tunstall (1996),

> *"Human floodplain processes often result from poor understanding or decision making about the consequences that may ensure if flood-affected areas are developed. Individual floodplain occupants are taken by surprise when the floods come. Governments, faced with a mayor flood disaster, are also surprised that local and regional authorities have given permission for such developments. The agencies responsible often think that someone else is to blame: the*

water agencies blame the land-use planners and the land-use planners blame the politicians. After the inevitable flood has subsided, and the damage and disruption have been forgotten, the process of development begins again"

(Penning-Rowsell, EC and Tunstall, SM, 1996).

The Environment Agency has a duty under the Environment Act 1995 (Section 6 (4)), "to exercise a general supervision over all matters relating to flood defence (which includes land drainage) throughout England and Wales. The main flood defence powers duties and responsibilities of the Agency are mainly set out in the Water Resources Act 1991 and the Land Drainage Act 1991. The flood defence role largely relates to main rivers, sea defences works and flood warning.

Local Authorities and Maritime District Councils have certain statutory powers and duties in relation to ordinary water-courses and protection of land from coastal erosion and encroachment respectively but the Agency has permissive power to construct new works and to undertake improvement and maintenance work on, or in connection with, main rivers and sea defences. The Agency has permissive powers to carry out sea defence works except where defences are privately or local authority owned. The Agency's prior consent is required for works in over or under main rivers and for culverting works, dams, weirs or other obstructions in ordinary watercourses. In addition, the Agency's land drainage bylaws control certain other limited activities in relation to main rivers and floodplains. Decisions under the Town and Country Planning Acts generally over-ride many of these bylaws.

The Agency is empowered to take enforcement action for unconsented works and can require works to be undertaken to maintain the flow of watercourses.

The Agency's general environmental and recreational duties are also to be applied whenever the Agency exercises any of its powers.

Box 2.4: Summary of flood defence legislation

The institutional context of floods and flood management in Britain is underlain by two crucial principles. First, it is dominated by a legal tradition emphasising common law, which places the first and basic burden of responsibility for the management of floods upon the riparian owner, not government (Wisdon, 1975). Secondly, floods and floodplain management are tackled using a range of policy instruments, rather than a single approach. Thus there exist economic instruments in the form of grant aid from central government to local organisations, and regulatory instruments in the form of land-use control exercised by local authorities over development in flood risk locations (Penning-Rowsell, EC and Tunstall, SM, 1996).

Penning-Rowsell and Tunstall express the relationship between flood vulnerability and a number of factors (socio-economic; property and infrastructure; flood characteristics; warning variables; and response variables)(box 2.5). In turn these factors are broken down into a number of variables, which research over a period of some 20 years has shown to be important in affecting the vulnerability of householders to the floods that they might experience (Penning-Rowsell, EC and Tunstall, SM, 1996).

This is where concepts of land ownership and property rights emerge, and a point returned to in section 3 of this research ('Techniques for sustainable management').

$$\begin{array}{l}\text{Household} \\ \text{Vulnerability}\end{array} = f\overset{\text{Social/Economic Variables}}{\left[\frac{A}{H,S,I,C,F}\right]} + \overset{\text{Property \& infrastructure Variables}}{\left[\frac{Sc,Sb,It}{St,Ro}\right]} + \overset{\text{Flood characteristics}}{\left[\frac{De,Dt,SD,St,W,V,Pl,R}{}\right]} + \overset{\text{Warning variables}}{\left[\frac{}{Wo,Wt,Wa}\right]} + \overset{\text{Response variables}}{\left[\frac{Tr,Ra,Rq}{}\right]}$$

A= age profile of household	De= depth of flooding
H= health status and/or mobility of household	Dt= duration of flooding
S= savings of household	Sustainable Development= sediment concentration
I= income of household	St= sediment size
C= cohesiveness of local community	W= wave/wind action (i.e. coastal or not)
F= flood knowledge	V= velocity
Sc= susceptibility of building contents to damage	Pl= pollution load of flood waters
Sb= susceptibility of building fabric	R= rate of water rise during flooding onset
It= time taken to restore infrastructure (especially sewerage, electricity and telecommunications)	Wo= warning given or not
	Wt= warning time provided
	Wa= advice content of warning
St= number of storeys	Tr= time taken for assistance to arrive after or during event
Ro= robustness of building fabric (density)	Ra= amount of response (number of people assisting)
	Rq= response quality

Box 2.5: The definition of flood hazard vulnerability as applied to households (Source: Penning-Rowsell and Fordham, 1994 in, Penning-Rowsell, EC and Tunstall, SM, 1996).

To begin to address these issues the Agency's floodplain policy perhaps goes some way to reconciling the needs of humans and nature. The five bullet-pointed objectives of the Agency's policy make definite efforts to meet the Agency's goal of sustainable development (box 2.6):

These objectives could be summarised by stating a goal of accepting that it is within the characterising nature of rivers to flood and that rather than fitting flood to development one should strive towards accepting flood risk and developing accordingly to lower danger to life, property and capital.
The Agency's declaration in accordance with the principles of SD follows,

"sustainable flood and coastal defence schemes are defined as those which take account of natural processes and other defences and developments within a river catchment or coastal cell, and which avoid, as far as possible, committing future generation to inappropriate options for flood defence"

(EA, 1997j).

- *development should not take place which has an unacceptable risk of flooding, leading to danger to life, damage to property and wasteful expenditure on remedial works;*
- *development should not create or exacerbate flooding elsewhere;*
- *development should not take place which prejudices possible works to reduce flood risk;*
- *development should not cause unacceptable detriment to the environment;*
- *natural floodplain areas are retained and where practicable restored in order to fulfil their natural functions.*

Box 2.6: Floodplain policy in the Environment Agency

Once again the terms "take account of" and "inappropriate" are open to interpretation but none the less show the agency's recognition of the need increasingly to work with nature rather than against it and also illustrate the potential shifts in Agency thinking from traditionally reactive to more proactive floodplain management. Despite this positivity very little practical guidance is included to suggest how these proactive ideals are to be implemented. Indeed the "Policy and Practice" document contains a number of statements of the type,

"a balance has to be struck between maintaining and supporting natural floodplains, and reducing flood risk,"

and yet not on how this potentially problematic goal will be achieved. The document continues,

"floodplains should be safeguarded to protect their natural role in allowing for the storage and free flow of flood waters..."

"inappropriate development within floodplains should be resisted and,"

"where appropriate, run-off source control measures which may also improve water quality should be incorporated into the development proposal" (EA, 1997j).

Apart from the Agency addressing the need for "comprehensive floodplain land use planning" to this end, and the need for "collation of information on development impacts" and "views of those people whose land or property will be affected," no clear guidance exists on how those directly affected i.e.

the riparian land-owner, are to be informed or indeed compensated in the pursuit of this goal. Without legislative and/or economic measures and the involvement of the public it may prove massively difficult and indeed unfeasible to impose these Agency policies upon the landowner and community at large. A system needs to be developed for including these factors into the decision and policy-making process.

2.3.2 Identifying the principal environment for evaluation –Wharfedale, Yorkshire.

The Upper Wharfedale Best Practice Project (UWBPP) provides the means to nestle the debates of the preceding discussion within a real-life situation. This experience may then be utilised to expand and develop theories on the applicability of Sustainable Development to upland rural river corridor management in England and Wales. Further, the research may then proceed to consider the transferability of this theory to other landscapes, particularly more lowland catchments.

The UWBBP is being run as the first ***Upland Rural River Restoration Project*** (RRP) with specific emphasis on the integration of Sustainable Management. The Upper Wharfedale is the dale within which the River Wharfe has its headwaters and upper reaches. It is located in the district of Craven, within the County of North Yorkshire (see figure 2.2 for location).

The project structure is based upon the emphasis that all decisions are steering group decisions, and not solely those of the Agency. Leadership is by the Project Officer, Mr I Ingles, and the Project Manager, Dr L Chalk, both of the Environment Agency, Dales Area, York. Technical expertise is called upon when appropriate (Chalk, 2000). The project is based upon seven working groups under the stewardship of the project Steering Group. The working groups are:

1. Sustainability
2. Pollution control
3. Erosion control and habitat creation
4. Water resources
5. Livestock farming and forestry
6. Preservation of local services, and
7. Education initiatives

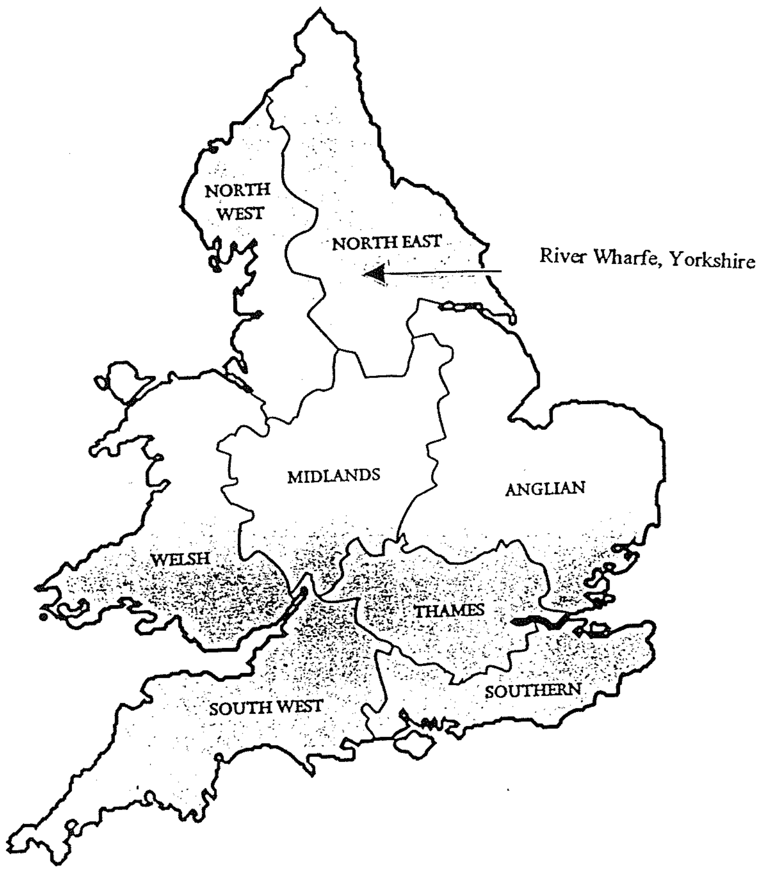


Figure 2.2: Location map for the Upper Wharfedale (modified from EA, 1997e)

The project structure is presented below (figure 2.3). Interestingly, the Sustainability objective group is seen as the umbrella group for all others, setting the targets, monitoring and disseminating for the other groups to act upon, and contribute to. The partners in the project are vast and diverse, and set within the framework of figure 2.4. The Steering Group is composed of:

1) The Environment Agency;
2) The Yorkshire Dales National Park Authority;
3) English Nature;
4) University of Newcastle-upon-Tyne;
5) National Trust (a major landowner in the Wharfedale);
6) Kettlewell Parish Council;
7) FRCA;
8) FA, and,
9) YWS (Chalk, E, 1998).

The partnerships are composed of:

1) The Environment Agency;
2) FWAG;
3) FRCA;
4) Commercial Forestry;
5) CDC;
6) Schools, colleges and Universities;
7) YWT;
8) Parish Councils;
9) Shooting Interests;
10) Community;
11) Landowners;
12) RDC;
13) YDNPA;
14) EN;
15) Farmers;
16) NT;
17) RSPB; and,
18) Angling clubs (Chalk, E, 1998).

The timetable of the project is presented in box 2.7.

1998/99	**Stage 1** – Project structure in place, baseline studies, detailed planning and design, external funding bid made and secured, implementation starts.
1999/2000	**Stage 2** – Implementation and monitoring.
2000/2001	**Stage 3** – Implementation, monitoring and audit (evaluation of need for further stages).

Box 2.7: Timetable for UWBPP (Chalk, 1998).

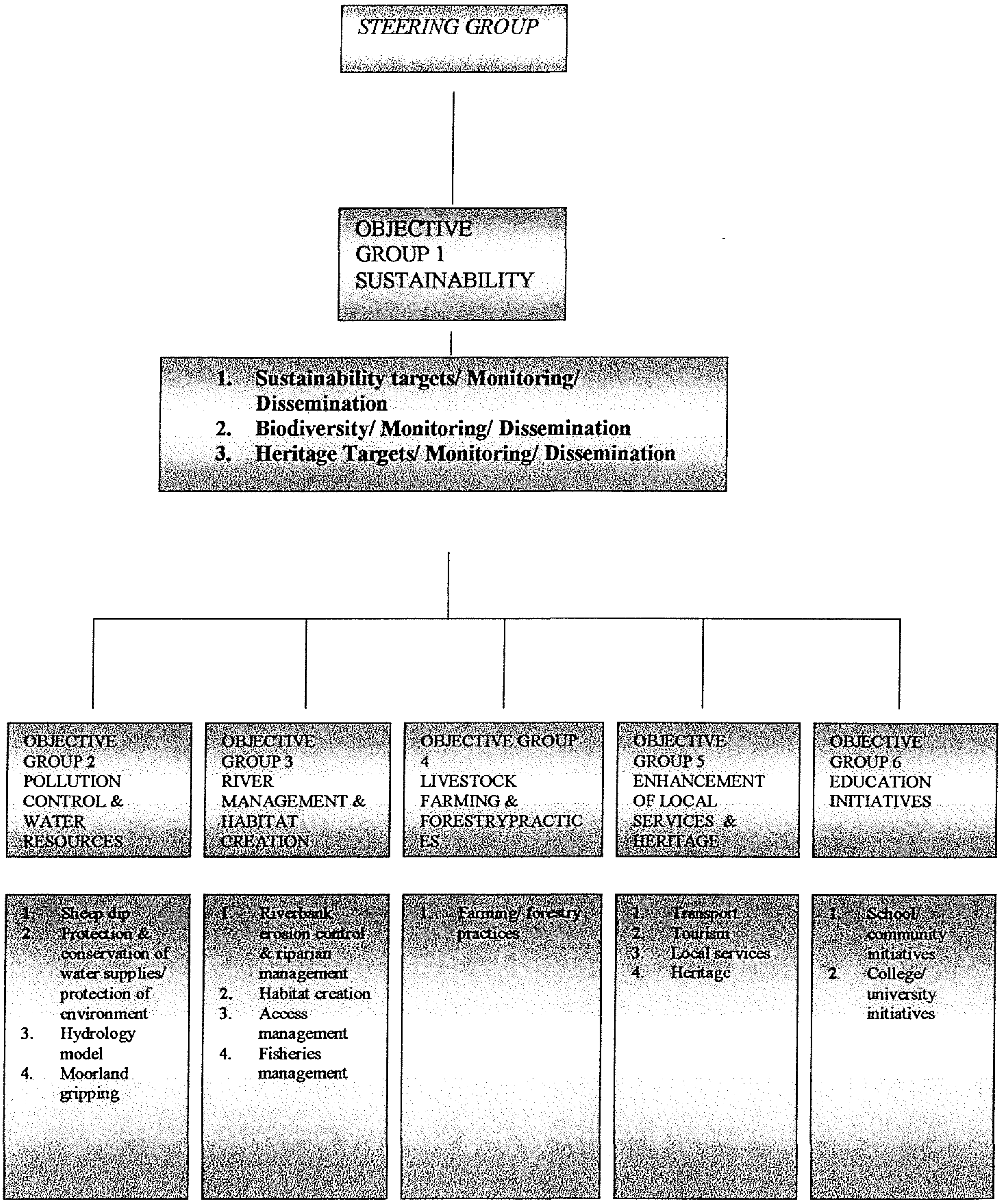


Figure 2.3: Upper Wharfedale 'Best Practice' project structure (Chalk, 1998).

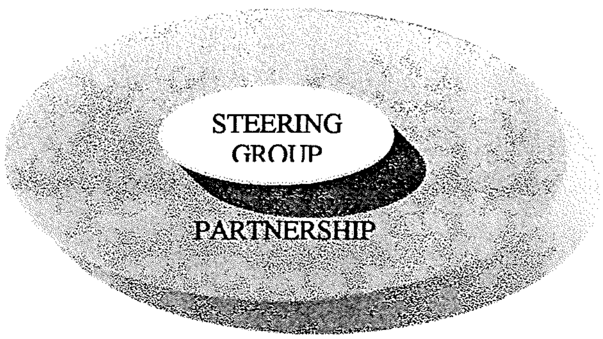


Figure 2.4: UWBPP Partnership concept (Chalk, 1998)

The guiding principles of the project are:

1) To focus on a community based approach;
2) Involve local people;
3) To provide opportunity for partnership;
4) Consensus decisions on where and when changes are needed;
5) Recognition of the need to reconcile the natural environment with the socio-economic;
6) An opportunity to influence wider strategy and policy making; and,
7) Flexibility of the project over time (modified from Chalk, 1998).

These guiding principles envelope 13 key objectives specific to the sustainable management of Wharfedale, ranging from positive changes in upland livestock farming to protecting ground water supply. Those most pertinent and relevant to the river are:

1) To strengthen river banks to manage erosion by developing 'natural' techniques of protection and by land management practices;
2) To assess the potential for and, if appropriate, create wetland areas on the valley floor; whilst protecting the hay meadows;
3) To set and achieve biodiversity and sustainability targets; and,
4) To carry out education initiatives with schools, colleges and the wider community (Modified from Chalk, 1998).

The UWBPP is an interesting one in that Upper Wharfedale has, to the untrained eye, a minimal need for management. The catchment comprises an upland, rural area typical of the Yorkshire Dales. Its environmental value is particularly notable, with six Sites of Special Scientific Interest, as well as part of the Pennine Dales Environmentally Sensitive Area. The majority of the catchment is upland livestock farmed (RKL-Arup, 1998). Box 2.8 highlights specific locational, hydrological and geological characteristics of the catchment.

The Catchment

The Upper Wharfe river commences as two tributaries, Oughtershaw Beck to the north and Greenfild (or Langstrothdale) Beck to the south. These two tributaries join at Beckermonds (NGR SD 874802) at an altitude of just over 300mAOD. The river falls 100 metres between this point and the confluence with the Skirfare (24km distance), which is the downstream boundary of the UWBPP (AKL-Arup, 1998).

The gradient of the Upper Wharfe can be divided into the steeper headwaters with gradients in excess of 1 ion 100 leading to the valley bottom between Hubberhome and Kettlewell where the gradient averages approximately 1 in 300 (RKL-Arup, 1998).

Carboniferous limestone and shale alternate in the catchment. Much of the channel upstream of Hubberholme displays a Limestone bed, however fluvio-glacial deposits fill the valley downstream of Hubberholme Bridge masking the effect of the geology (Heritage, GL and Newson, MD, 1997).

Kettlewell receives 1710mm of rainfall per year on average, this compares with an actual evaporation rate of 433mm annually. Flooding used to be very frequent with overbank flows in excess of 20 times a year in the Buckden area, a flood relief scheme has reduced this frequency to less than once every 6 months (Heritage, GL and Newson, MD, 1997).

The soils in the catchment are peaty and suitable for good quality grazing of sheep and cattle. The flood relief scheme at Buckden further improved the land for these practices. Subsequent changes in land management practices and conservation measures have resulted in one stretch of river designated as an SSSI and an Environmentally Sensitive Area. The majority of farmers have joined the ESA initiative (Heritage, GL and Newson, MD, 1997).

Box 2.8: Catchment characteristics of the River Wharfe

Upper Wharfedale is wholly within the Yorkshire Dales National Park and contains some of the most spectacular scenery in the Dales. The area is remote yet well visited by tourists and day-trippers. It is estimated by the Park Authority, that 60% of visitors go to Wharfedale. It is of interest both because of the landscape, its famous upland hay meadows and ancient semi-natural woodland but also because of its rich heritage (RKL-Arup, 1998). The Dales Way runs through the catchment, and the Pennine Way skirts the western edge of the catchment. There are two angling clubs with fishing rights in the catchment. Various other recreational users visit both the river and wider catchment (RKL-Arup, 1998).

Despite the unspoilt picture that this brief overview provides, the Upper Wharfe is not without its problems. The 1997 RRP report made the following summary statements concerning the major issues and causes for concern in the area:

- There is a strong connection between the management of land within the river catchment and the management of the river itself. For instance, at Buckden, embankments have been built to reduce the frequency of out of bank floods so that adjacent meadows can be more productively farmed
- The river is reacting to the containment of floods with apparent changes in the patterns of erosion and deposition of sediments. Attempts have been made to regulate this process, but the costs involved have proved prohibitive, leaving what is essentially, an unmanaged situation. Ultimately this can only lead to the breaching of embankments, collapse of riverside trees and increasing difficulties for those farming the floodplains. The attraction of the river to people walking the Dales Way will also be increasingly marred
- The evident erosion of peat in the high moors and the impact on the regime of Oughtershaw Beck, impacts on the Wharfe through changes in flow rates, sediments and water quality. It is known, for instance, that peak flow rates in several Dales rivers have markedly increased in the last decade
- The physical link between land and river is fundamental to wider interests. Landscape and tourism, flora and fauna, etc. are equally dependent upon informed management of the physical environment that *is* Wharfedale
- The RRP inspection supports the view that the physical environment is threatened by piecemeal land and river management practices. The development of an integrated management plan offers a rational way forward
- Land management issues are the priority area for review

The RRP recommends that:

- Flooding of adjacent land may need to be re-introduced in conjunction with river works that reduce hydraulic capacity and restore appropriate GM processes.
- Due to lack of upland experience, it would be wholly inappropriate to speculate on likely measures (RRP, 1997).

Together with these broader issues, the RRP made the more detailed recommendations in box 2.9, below.

Based upon the potential for a more sustainable approach to river management than would perhaps occur had the RRP not made these recommendations, further work was instigated. In October 1997, Dr Liz Chalk, Team Leader for Collaborative Projects, EA, York, addressed a variety of local people with interests in the Upper Wharfedale, at Buckden Village Hall. Dr Chalk stated that the EA was *'interested in exploring the possibility of a partnership in integrated environmental management in Upper Wharfedale to co-ordinate activities and resources for better environmental and community benefit, demonstrate 'best practice' to others and influence policy'* (Chalk, 1997). This meeting was the first in many more subsequent talks and participatory exercises.

"Ideas for enhancing Upper Wharfedale without reducing the areas of high conservation value and compromising flood defence, whilst recognising the need to protect the farming economy include:

- *Strengthening riverbanks to control erosion by developing and using 'natural' techniques including trees and shrubs and sympathetic stone pitching.*
- *Managing existing trees and plant new trees and shrubs along the river corridor and gill sides to benefit fish and other wildlife.*
- *Assessing the potential to create wetland areas in the valley floor, whilst protecting the hay meadows, to attract new wildlife.*
- *Seeking ways of upgrading sheep dips.*
- *Seeking changes in upland livestock farming practices to prevent overgrazing and damage to riverbanks; recognising the need for an environmental foundation to economic farming.*
- *Investigating the impact of gripping of fell tops on water run-off and identifying any resultant action needed.*
- *Protecting and restoring footpaths vulnerable to river erosion.*
- *Preserving heritage and local services.*
- *Involving local people in protecting, improving and enhancing their knowledge of the environment"*

(RRP, 1997)

Box 2.9: Recommendations of the RRP

The reason that the Wharfe has been chosen as a case study site for this research project over others, is the wealth of information that will be generated *because* of the UWBPP and RRP. There is considerable potential to examine most aspects that have an effect on, or are effected by the Wharfe river corridor. The production of reference material and data that at the outset were non-existent, has again been stimulated by the larger project, having a positive effect on this research. Similarly, and perhaps of even greater importance, the existence of the UWBPP has opened up a variety of doors for discussions in public participation and sustainability (especially useful to the EA). It also provides the forum by which the practices presently considered 'sustainable' by the Agency may be considered and appraised.

Throughout this research project, the Wharfe will be repeatedly referred to as the reference point for translating theory to practice in river corridor management. The practicality of the concepts and ideas that will develop will be considered in the context of the Wharfe, and indeed, the practices and theories that will be exercised on the Wharfe by the UWBPP throughout the period of this research project will also be fully engaged and discussed. In the closing chapters however, an attempt will be made to assess the limits of generalisation of the concept and appraisal.

2.4 Summary

This chapter opened with an introduction to the political and institutional constraints to Sustainable Development, including the perceived lack of trust in these elements by the 'public'. It is suggested that this is just as an important issue to be faced as the development of tools and techniques for implementing the concept. The Environment Agency of England and Wales is identified as the mechanism by which this might be progressed.

Consultations within the Environment Agency with both Policy level and 'Ground' level have highlighted a number of recommendations that should be made towards optimising the success of sustainable development, both internally and externally. The Function of Flood Defence is highlighted as the key facilitator of this process. The Upper Wharfedale Best Practice Project further provides the means and capability to appraise the recommendations and guidelines that will be developed.

These recommendations, together with the arguments of chapter 1, now need to be set within the context of river management.

Chapter 3

Placing Sustainable Development within the context of river management
Translating 'sustainable development' to 'sustainable management'

3.1 Introduction

Chapters 1 and 2 have defined the common characteristics that need to be considered in assessing Sustainable Development. These now need to be utilised and transferred into the realms of Sustainable *Management*.

To facilitate this modification there is a need to:

1. Redefine Sustainable Development in the context of the fluvial environment;
2. Identify specific goals that are indicative of optimising a sustainable riverine environment;
3. Identify a framework within which the key goals and objectives can be set;
4. Utilise, as far as possible, existing data collection and collation tools in the Agency and beyond; and,
5. Develop a *system* for defining thresholds to sustainable practices.

3.2 Redefining Sustainable Development in the context of the riverine environment – Introducing the bipolar model of sustainability

In this thesis sustainability is defined in terms of a bipolar entity, with ***Sustainable Development*** at the one end and ***Sustainable Management*** at the other. The Brundtland definition was largely a political message - a Politician presented it *to* politicians and addressed development issues often not explicitly related to the reach or even catchment level. 'Think global, act local' is a commonly coined phrase in Sustainable Development, and Sustainable Management is an important aid in putting this scale of implementation into environmental best practice. Similarly related to the concept of scale is the target 'audience' for the new approach to sustainable management. This so-called 'new' approach is in reality, and at the most basic level, a redefinition of ***best practice*** – something that in an ideal world all practitioners aspire to. The practical guidelines developed in this research are indeed most suited to the ***Best Practice Project*** illustrated by the Upper Wharfedale Best Practice Project introduced in chapter 2 (section 2.3.2). However, the context within which these are set is applicable to all upland, rural river corridor management.

This new approach is also centred on the ***strategic level*** of management, whilst providing practical guidelines at the level of ***implementation***. The definition of the strategic approach involves four attributes; it is proactive, it takes a long-term view, it requires co-ordinated decision making embracing all principal interests, and it is flexible and adaptive (Penning-Rowsell and Tunstall, 1996).

The development of the new approach and the evaluative system that it provides is targeted to combat statements of the following nature:

> *"The development of a more strategic approach in England and Wales requires greater central co-ordination than has hitherto been the case. Policies and procedures need to be standardised, or at least co-ordinated, and an overall methodology needs to be adopted. A number of problems need to be tackled which act as impediments to this process, including the absence of data, disagreement as to communication processes, and the inadequacy of existing legal instruments"*
>
> (Penning-Rowsell and Tunstall, 1996).

The new approach of sustainable management is part of a larger theoretical structure based upon the level to which the concept of sustainability is considered. This structure involves a ***baseline*** of the environmental assets on a reach together with likely ***impacts*** on that environment. This is then set within the context of a spectrum of sustainable management, so that ***criteria*** might be used to assess the likely level of sustainability relative to the pre-impacted state.

Three 'indicators' of sustainability pertinent to this research are being actively considered in the UK at the moment. Associated research illustrates this framework, and indeed completes a complementary four-tier model for the more successful assessment and appraisal of sustainability in environmental management (figure 3.1).

The focus of work by Newson, M, University of Newcastle-upon-Tyne illustrates the concept of ***Natural Capital*** and forms level 1. At its core is the calculation of the attributes and services that a resource exhibits at the outset of a project or proposal. These do not change, but may be eroded. The initial calculation provides the ***baseline*** on those assets that should be preserved.

The focus of research supervised by Arnell, N, University of Southampton illustrates Level 2 through the concept of ***Net Negative Impact***. Net Negative Impact exists at the strategic planning level. It is concerned with balancing out ***effects*** of a project or proposal on the environment so that there is a net negative impact on that environment. It is closely related to combating erosion of natural capital.

Level 3 is where the concept of ***Minimum Intervention*** exists (the focus of work supervised by Clark, MJ, University of Southampton). Minimum Intervention provides ***criteria*** by which degrees of sustainability might be assessed. It aims to provide a day-to-day guideline for practical sustainable environmental management. At its core it aspires to maintain natural capital and minimise net negative impact. It is concerned with the ***components*** of management, and the ***mechanisms*** towards this aim.

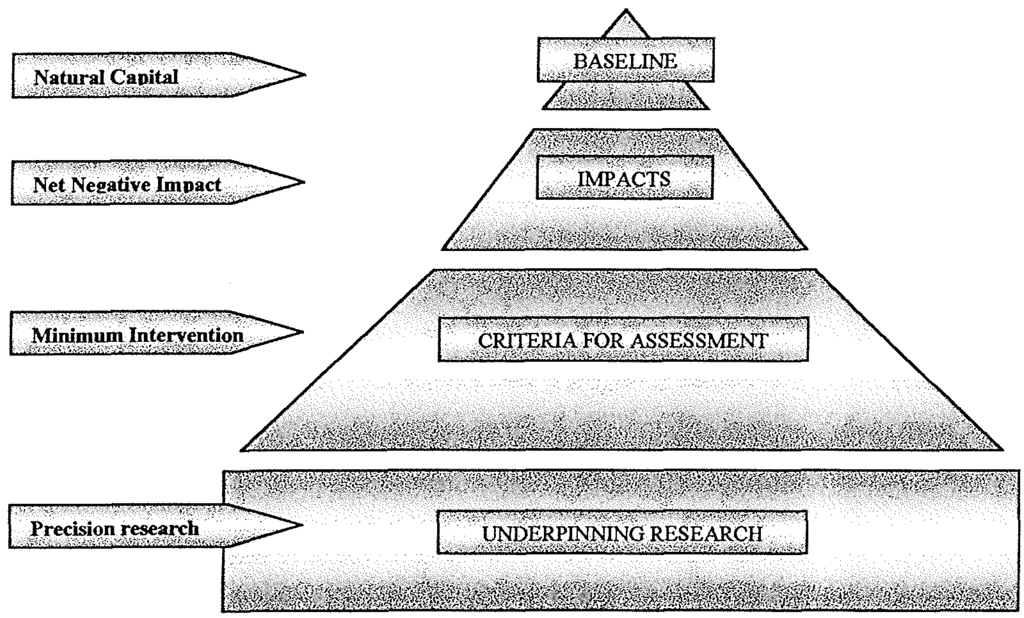


Figure 3.1: Four-tier Integrative model of sustainable environmental management

Beneath this three-tier model there is a level of process research which underpins the sustainability principles. This process research allows the continual improvement and refinement of the generic principles of sustainability, through the more explicit acknowledgement of the thresholds to sustainable practice. These levels of precision are to be acknowledged, but not to be the endeavour for this research project. The concept of sustainable management and minimum intervention, and the assumptions made, need to be necessarily ***generic***. Following these levels of precision would be at the price of generalisation, and thus effective management. Further, the 1990s and into the 21st century are seeing continued admiration by the generations of that period in indeterminancy and non-linear science. This thesis follows this trend, one that is also followed by Wilson (PhD Researcher, University of Southampton, at the time of writing).

Minimum intervention is identified here as the key indicator of sustainable management practice. The concept of minimum intervention allows the river to function more naturally, so that levels of ***erosion and channel migration*** might well increase and ***flooding*** will occur in a fashion more akin to its perceived natural state. Maintenance would still be needed because of the needs of the river user, but costs are foreseen to be lower and investment would be in ***'greener'*** practices that perhaps increase habitats and do not constrict flow. These objectives could be summarised in four key characteristic statements (box 3.1).

The 4 key characteristics of Sustainable River Management

- ***Minimum intervention as a metric against which, accepting:***
- ***Flooding***
- ***Erosion, and***
- ***Change or 'metastability' may be considered***

Box 3.1

Geomorphology has two distinct foci which contribute to it being the underlying mechanism for optimising sustainable management. These are its value as a science and skill base (including the way Geomorphologists work, and the space and time scales at which they work), and geomorphology as a set of interrelated biophysical attributes of a channel corridor. Upstream/downstream interactions, channel stability and instability, and flood and sediment conductance are all implicitly linked to the four key characteristics of sustainable management, and are encapsulated in the science of geomorphology. Understanding geomorphology leads to the more likely uptake of appropriate long-term management intervention that works with the natural system and not against it. Similarly, and in common with biodiversity and conservation which are also seen as vital to sustainable management, geomorphology is assumed to be inextricably linked with habitat. It is argued that if the geomorphological functioning is improved, then so to is the habitat of that environment. Chapter 4 considers the role of geomorphology in sustainable management in detail.

Although the term minimum intervention is proposed, this intervention still has to be appropriate and effective for its purpose, but just at the ***minimum needed to sustain the system***. Thus, it must be emphasised at this stage that minimum is not synonymous with *non-intervention*. Non-intervention does not allow for sustainable management except in the unlikely situation of no constraints on management. Generally, if a sustainable management plan is required this has been instigated by some type of management problem or need. Therefore, we may still need to manipulate feature, process and/or drivers and we may need to intervene in the mass or energy budget, but with good scientific understanding as our baseline.

The need to assess the minimum level of intervention needed to sustain the system introduces a further concept. Sustainable management begs the need for ***sustainability audit***. This is to be not only formulated in fiscal terms, but social and economic (see chapter 5). There is a requirement explicitly to recognise at definable phases in the sustainable management plan, the sustainability, in social and economic terms, of proceeding to relative levels of sustainability. For instance, the natural system should not be pushed to a degree of 'natural state' that will incur long-term and costly supported sustainability. There is, in essence, a need to develop a system which has at its core, an equivalent to the 'minimum flows' method calculated in low flow water management (i.e. the minimum flow that is acceptable before the threshold is crossed to a less sustainable state).

Sustainable management may be of two forms: supported and self-supporting. ***Supported sustainable management*** occurs where a) the natural system has moved beyond the threshold where it might be expected to return to its natural state if left to natural adjustment; or b) where initial supporting of the system is needed before a threshold is reached where natural adjustment takes over. ***Self-supporting sustainable management*** occurs where the system requires little intervention. Once constraints to natural adjustment are removed, the system recovers rapidly. The implications of these two forms of sustainable management are interesting. Obviously the fiscal cost of supported sustainable management of the system is likely to be far higher than if it were able to support itself. Intervention is likely to be more long-term, and in the case of (a) unlikely to be feasible in cost-benefit analysis. Similarly, the intervention that would be needed in a supported system is likely to be relatively high compared with self-supporting system. This therefore begins to contradict the *minimum* intervention approach. A mid-way point is therefore needed between the often unlikely scenario (due to the cost of land-loss and community tension) of self-supporting sustainable management, and supported sustainable management.

3.3 Identifying the key goals of Sustainable Management

The identification of the more specific key concepts and goals of sustainable management is thickly cloaked in the multitudinous literature existing on the various ideas of what sustainability means to differing audiences (see chapter 1). To design a set of criteria in as credible a manner as possible, it is necessary to bury into this literature from the geomorphological end of the spectrum through ecological limits, legality and economics, to the use and background understanding of social science and public participation. From this investigation it is possible to design a table containing the vital elements variously considered in the conceptualisation of Sustainable Development. These may be split into two themes:

1. Targets that sustainability achieves if successful;
2. Criteria/ tools that are used to work towards sustainability.

Table 3.1 illustrates these elements, with criteria and tools being presented in shaded format.

DEFINING GOALS OF SUSTAINABILITY	SUB-GOALS SPECIFIC TO SUSTAINABLE RIVER MANAGEMENT		
	PHYSICAL	ECOLOGICAL	SOCIO-ECONOMIC
SOUND SCIENCE			
	geomorphology for design	carrying capacities	demand management
	system dynamics	ecological/ environmental limits	multi-criteria decision making
	reach dynamics and sediment budget	environmental efficiency	high quality information and advice
	appropriate bed and bank sediments	wetland creation	
	channel morphological diversity		
	preservation/restoration of integrity of natural system		
	sustainable flow management, integral chain management, source management		
	understanding of bio-physical relationships		
	appreciation of chaos theory		
	upstream thinking		
	system thresholds		

PRECAUTIONARY APPROACH			
	prevention rather than cure	conservation better than recreation	polluter pays
		protecting natural heritage	rationally planned land use
MINIMUM INTERVENTION			
	ability of environment to continue its natural functions	ecosystem integrity	
	self-cleansing channel		
	favour natural channel and catchment processes		
	favour natural features and functions of floodplain		
	'optimal' funtioning of natural system whilst still developing		
	Using natural/ traditional techniques		
	soft engineering		
	establish natural stability		
LONG-TERMISM PAST AND FUTURE			
	channels change	sustained or increased environmental stock	market mechanisms to internalise environmental costs
	dynamic equilibrium/instability	conserving and enhancing biodiversity	discount rate
	spatial controls		CBA - do not degrade natural assets
			maintenance of natural and built assets
			protecting built heritage
			institutional development & adaptivity to change
HOLISM			
	catchment overview	reconciling environment and development	change should be incremental with adaptive management
	catchment yields		
	upstream/down-stream interactions		
	source control		

METASTABILITY			
	change as key to metastability	Biodiversity enhances ecological stability	assessment in space and time of policy and technological developments
	sustainable river is a mobile river		limited bank erosion
	sustainable river needs to flood		reducing nutrient and sediment loads
	sediment transport continuity		flood and sediment conductance
	continuum concept		erosion stabilisation
	transience of sediment		
	dynamic equilibrium		
	channel stability and instability		
CONSENSUS			
		river 'enhancement'	consensus building
		aesthetic quality and landscape	conflict resolution
		attractiveness	public participation
			fairness & equity
			social mobility/cohesion
			sharing/partnerships
			close and responsive relationships
			community
			local planning for self-organisation
			easy access to resources
			welfare efficiency
			cultural identity
			rural community development
			quality of life increased peace and quiet etc.
			economic development growth, equity, efficiency

Table 3.1: Key principles of Sustainable Development

It is unfeasible to present table 3.1 as individual targets and tools for the purpose of guidelines in sustainable management. Instead they need to be categorised into themes that reflect the transferability of sustainable development into the ***sustainable management*** context whilst still including the breadth of the approach in the previous diagram (figure 3.2 below). For wider understanding within the Agency these themes need to be further defined in the language of the Agency. Therefore figure 3.3 identifies the translation of figure 3.2 into a more Agency compatible context.

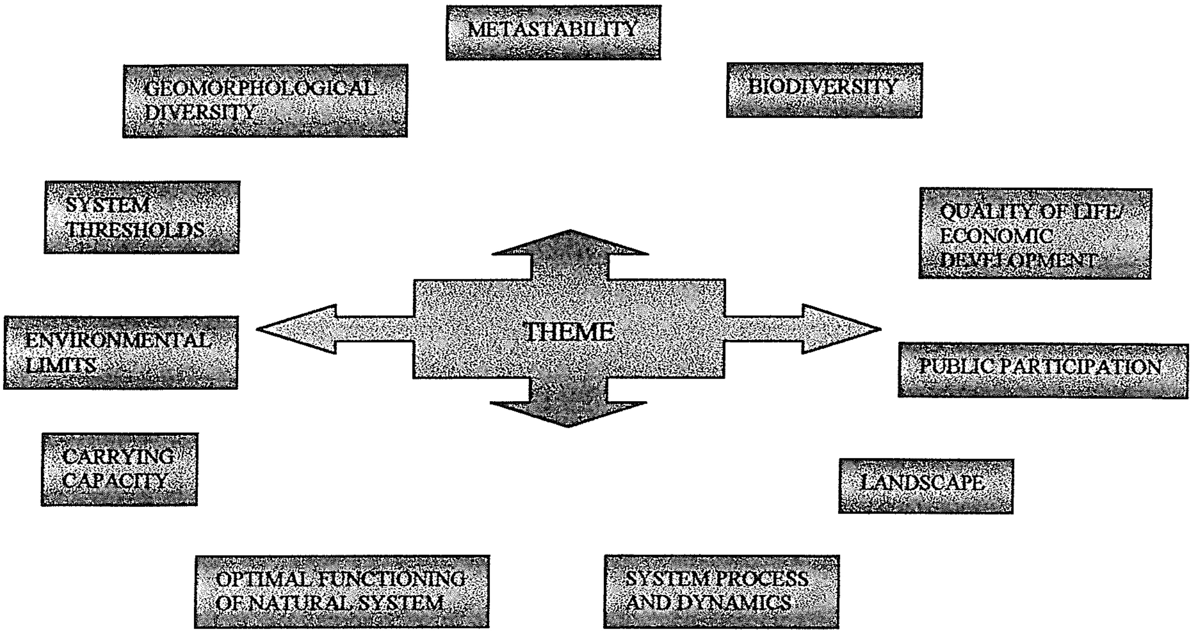


Figure 3.2: Key themes of Sustainable Management

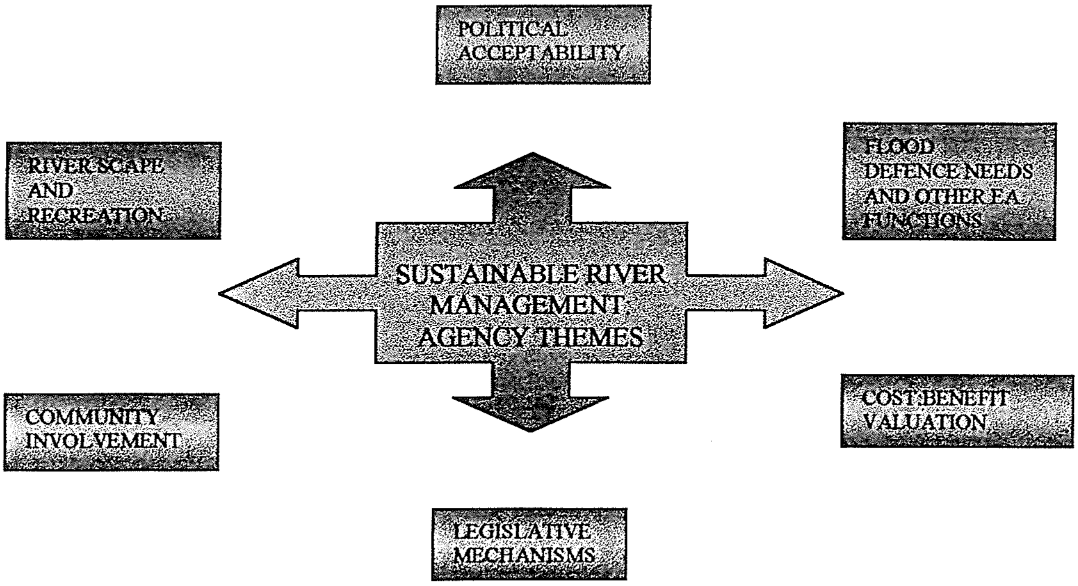


Figure 3.3: Placing of the key themes of sustainable river management within the structure of the Environment Agency

Essentially, sustainable river management should be seen to include the ***riverine environment***, by which all natural resources and the processes acting upon them are considered, the ***market*** environment, which is taken to include more than only fiscal mechanisms, and very importantly, ***community***, which includes public choice, participation and perception (figure 3.4). Other models place 'community' and 'economics' in separate sectors, but it is argued that each is mutually exclusive with the other. Fiscal or 'market mechanisms' are far more easily distinguished. It must be assumed that the environment will not be undertaking a truly sustainable approach unless these three factors are optimised together (figure 3.4).

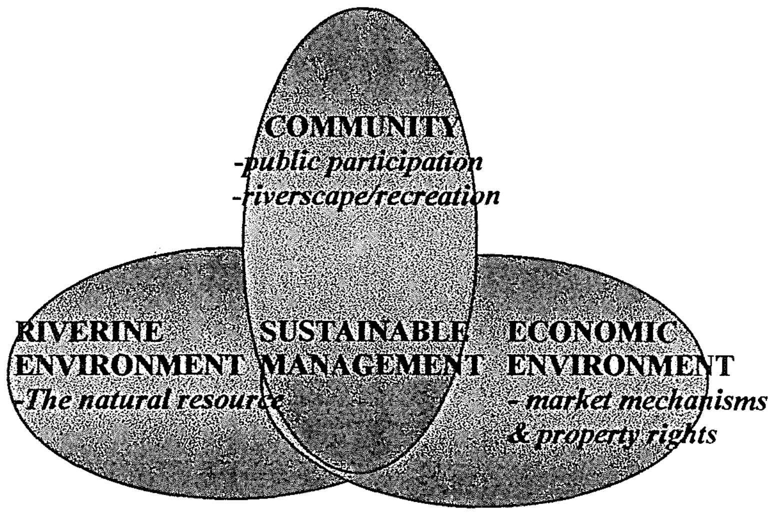


Figure 3.4: A conceptual model of Sustainable Riverine Management

Following the earlier argument for the increased consideration of fluvial geomorphology as a key driver of the habitat of the river, recommendations, if to be taken seriously and of practicable use, will need to complement those in biodiversity.

In January 1994 the UK launched 'Biodiversity: The UK Action Plan'. The Biodiversity Action Plan came in response to the UK's commitment given at the Earth Summit in Rio de Janeiro in 1992, and in accordance with the convention on Biodiversity. It draws together existing instruments, programmes and information on a range of habitats and species. It also provides the overall framework programme for actions related to UK Biodiversity over the next 20 years, key components of which are:

- The development of costed targets for the most threatened and declining habitats and species;

- Improving accessibility and co-ordination of biodiversity data, including that required to monitor progress towards agreed targets;
- Increasing public awareness and involvement through the targeting of key sectors (UKRTSD, 1998).

The Biodiversity Action Plan is implemented at regional level through Local Biodiversity Action Plans. These interpret the main plan through a local review and will therefore take into consideration local geographical variation (UKRTSD, 1998). At present, as the UKRTSD state, 'many organisations and companies attempting to address biodiversity are confused by the UK Plan. Other initiatives needing consideration (e.g. LEAPS) seem to aggravate the situation' (UKRTSD, 1998). In suggested remediation of this problem, the UKRTSD recommend that those involved with the plan ensure that all stakeholders are informed of, and invited to participated fully in, the development and implementation of the Plans (UKRTSD, 1998).

3.4 Identifying a framework within which the key goals and objectives may be set

The theoretical basis of what needs to be achieved in a 'sustainable river' may be agreed, but how is it known whether the management practices implemented are in fact sustainable? How is it known whether the environment is becoming more sustainable? The qualitative nature of the Brundtland-style definition, makes such questions particularly problematic. A more (not necessarily wholly) quantitative methodology needs to be developed to offer amore defensible and objective approach to assessing sustainability.

In the first instance, a methodology needs to be developed for the recording of variables pertinent to sustainability. With a concept such as sustainability and the uncertainty surrounding its formative parameters, it is inappropriate to use a dichotomous scale of measurement which aims to predict whether a proposed project, or existing environment is sustainable or unsustainable. As Drummond and Symes (1996) observe, policies which attempt to address unsustainable states, events and practices directly will degenerate into what they term 'Environmental managerialism' consisting of different methodological techniques, each of which enables the environment to be better managed. This, they warn, is *"the shallow end of the 'deep' ecological swimming pool. Approaches of this type fail to respect either the multi-dimensional nature of sustainable development or the need for truly integral solutions, which this implies. They tend to conceptualise the situation in terms of a line – on one side* *lies sustainability, on the other unsustainability. This line will vary through time and tends to be crossed whenever it is drawn"* (Drummond and Symes, 1996).

Because of the holistic nature of the sustainability debate, trade-offs between some attribute/s of the river with others will probably be needed to attain a ***meta-sustainable*** state. As the Select Committee on Sustainable Development state: 'the debate over sustainable development is often about where the line should be drawn between the two positions of a) insisting upon the need to establish and maintain a minimum environmental stock or capacity (even if their definitions of capacity or minimum stock might alter with social, economic or technological changes); and, b) accepting the inevitability of trade-offs between social and economic preferences and environmental resources' (SCSD, 1995).

In assessing sustainability, this research identifies benefit in the use of a bipolar 'less or more' approach to sustainable management, where a river may be placed on the spectrum and its movement plotted on that spectrum over time (figure 3.5). In addition, once the concept of thresholds to which the river should move before given levels of intervention are needed in the system is introduced, a useful quantitative and objective management tool begins to develop.

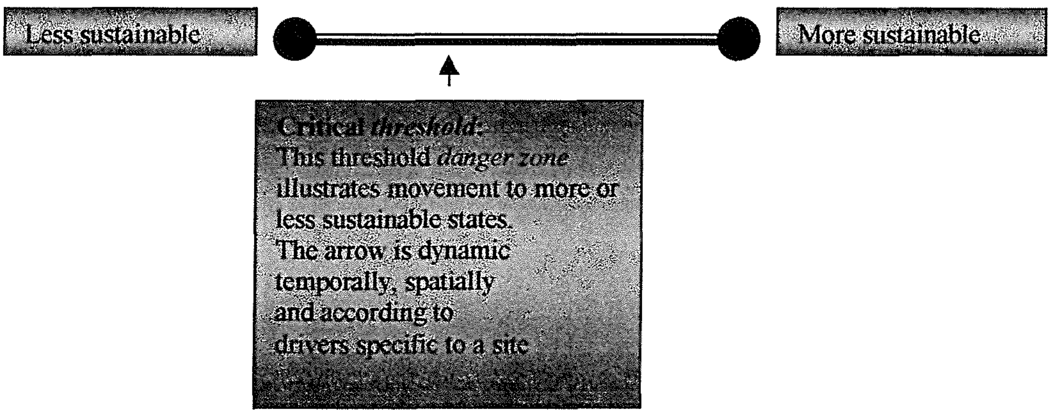


Figure 3.5: The bi-polar spectrum of sustainable management

To proceed from what is, at present, a largely theoretical model of 'measuring' sustainability, to one which will provide an effective management tool requires a number of underlying steps based upon good science and robust philosophy. A set of universally specifiable and preferably quantifiable criteria, which fully acknowledge those elements highlighted in table 3.1are required, but in a manner that surpasses all other attempts at measuring sustainability. A system is needed that proffers more than merely measuring separate indices in the hope of coming to some 'holistic' measure. As has been seen, holism implies the sum being more than the parts. Some facets may be additive in the riverine system, and some trade-offs may be needed. *This can not be fully represented within the traditional indicators approaches introduced in chapter 1.*

Similarly, some areas, for example economics, are obviously easier to quantify than others. This should not be seen as an excuse for not including those that are not. To be truly sustainable there is a need to include all factors that are involved in the system, including geomorphological research and proven sustainable river and management practices, and the social, legal, political, economic and institutional context of Sustainability.

It is proposed that five stages are involved in the pragmatisation of Sustainable Development into Sustainable Management (box 3.3).

CONCEPT/AIM → OBJECTIVE → DIAGNOSTIC → ATTRIBUTE

ITERATIONS

Box 3.3: The 5-stage model of pragmatising the conceptual
(see below script for detailed explanation)

To clarify, the *concept* or *aim* refers to the key characteristics of sustainable river management, for example within the broad statutory objectives of the Agency toward Sustainable Development as set out in the Agency publications. The *objective* is the tangible output or target that the Agency can use as an indicator of movement toward this more broad ranging aim, and the *diagnostic* seeks to define those objectives into the measurable so that multiple *attributes* can then be measured against targets set initially.

For instance, *metastability* is a *core aim* of sustainable river management i.e. the river should be seen as a naturally dynamic and migratory system both in time and space. An initial assumption might therefore be made that the *key objectives* or underlying principles of this aim are to be defined within the realms of *morphology* and *process*. These are implicit in the understanding of metastability. But to measure progress towards predetermined targets or objectives there is a need to produce a set of diagnostics, which are measurable. Thus, *diagnostics* in this case might take the form of *sediment budget* and *flow type* for morphology and process respectively. Specific attributes or criteria are then developed to measure how sustainable the environment is relative to the opportunities open. This is the stage at which extensive iterations and refining are needed. The most important part of the criteria design process, if the end product is going to be a success as a new tool, is the validation of the previous four stages by the expert. The tool developed needs both ***professional and scientific ownership*** if it is to succeed, therefore interview and dialogue with river managers, policy makers, geomorphologists and the various other players who exist in this new holistic form of management is of prime importance.

A number of general conclusions from the existing indicators approaches may be lifted to validate and improve the present more criteria-based approach. The UK Round Table on Sustainable Development recommend that it should be possible to ***aggregate national indicators with local indicators*** being prepared under Local Agenda 21 by local authorities and others. This is pertinent to the new system. A hierarchical approach would allow the expression of river character at a variety of temporal and spatial scales, and provide the most useful data for management planning on a broad variety of projects, from local management to catchment planning. This quality would also fulfil the statutory objectives within the Agency towards functions '*working together, in a clear and accountable way*'. A particularly efficient method for utilising surveys for management would be to develop the capacity for GIS transferability.

The UK Round Table also suggest that further consideration should be given to

- the way in which indicators are presented
- the need for different sets of indicators for different audiences
- the thresholds below which particular indicators should not be allowed to fall without corrective action, and
- the areas where indicators are constrained through lack of data

(UKRTSD, 1995).

Indeed, with regard to presentation, criteria will be most valuable and successful in as easy and accessible format as possible, which, like the second point would involve tailoring the methodology and data interpretations to the audience for which it is intended. The criteria should not be blanketed in specialist language but succinct and directly related to each objective. The final point is probably that most central to the lack of quantifiable sustainable indices in water based management - lack of information and thus *lack of understanding as to what indicators should be measuring to reach the goal of sustainability.*

The UK 'Working Group on Sustainable Development' put forward some interesting points on using indicators. They recognise a set of criteria, which an ideal indicator should meet. "They should be:

- representative
- scientifically valid
- simple and easy to interpret
- show trends over time
- give early warning about irreversible trends where possible
- be sensitive to the changes in the environment or the economy it is meant to indicate
- be based on readily available data or be available at reasonable cost
- be based on data adequately documented and of known quality
- be capable of being updated at regular intervals
- have a target level or guideline against which to compare it" (HMSO, 1996).

These points are again pertinent to sustainable river management, and the system that will be developed.

Three further issues must be considered and are indeed vital to the success of applying such an approach. These are:

1. the extent to which existing databases and tools are utilised;
2. Spatial scale: choosing appropriate land units for classification; and,
3. Temporal scale: how 'long-term', both past and future, should a rule-base of sustainability be?

3.5 Utilising existing databases and tools

> '...*Most writings on sustainable development start from scratch and some proceed to get things hopelessly wrong. It would be difficult to find another field of research endeavour in the social sciences that has displayed such intellectual regress'*
>
> (Dasgupta and Maler in Beckerman, 1995)

If the developed system is to be integrated successfully into the Agency river management mechanism then it is not sufficient to simply utilise the principles of sustainable development in a *new* way. Language must be converted into that of the Agency. This is especially true for a 'metric' or 'scale' of assessment such as that proposed. The three factors introduced in the conceptual model of sustainable management of community, market mechanisms and natural environment (figure 3.4), need to be placed firmly in the domain of the Agency and its functions. Therefore, the indices need to be placed within the three areas of: ***the physical, ecology***, and ***economics***.

Further, the point at which the new system is seen to contribute to Agency databases influences heavily the choice of methodology. What is widely apparent from discussions with river managers and policy makers in the Agency is the lack of agglomeration or resolution of all the databases that are in existence, in conflict with one of the strongest defining characteristics of Sustainability – holism. A need exists in utilising, to the most appropriate level, management tools that already exist in the Agency and beyond. ***River Habitat Survey (RHS)*** (EA, 1999e) is regarded as the most appropriate tool to utilise. The ***River Channel Typology study (RCT)*** (Universities of Southampton and Newcastle, 1998) is a considerable database of river information and photographs and is an invaluable inventory for this research (see chapters 4 and 5).

Based upon these factors, it therefore seems appropriate to develop a tool that has the following key attributes:

1. to take the existing relevant information providing tools and to agglomerate them;
2. to provide a tool that will be capable of using these to determine how relatively sustainable any site is; and *will* be with regard to options appraisal; and,
3. to produce a tool that is capable of being updated or tailored as new developments or databases are contrived, different environments assessed or different targets introduced.

Further, a considerable amount of research is also needed into intervention vehicles for change, not just the attributes to be measured. ***Social vehicles*** to be used in the drive to more successful sustainable management need to be specifically targeted, and the implications that these carry (chapter 8). Possible new socio-economic methods and the use of ***market mechanisms*** in managing the riverine environment need to be considered, which have sustainability as a core characteristic (chapter 7).

3.51 Utilising River Habitat Survey for Sustainable River Management

RHS is an outstanding database with regard to its potential use in a new approach to assessing sustainability. Its title is a little misleading, as far more can be gained than a simple picture of 'habitat' from the data it compiles. The most suitable location for a new evaluative system within the RHS structure would be at the point where it could utilise the newer outputs of RHS (figure 3.6). In this way, modification to habitat and the quality of the habitat might be ascertained. However, a number of limitations have been proposed following the investigation of the utility of RHS for this research project.

What the RHS includes in breadth it misses in depth at some levels, at least for the utility of the present system. To measure true propensity to change for instance, there is a need for localised data, with ***local slope*** (not as large scale as is currently given), and ***local velocity*** so that the stream power of the channel and therefore the ability of all the above parameters to resist or propel change may be calculated. Actual substrate size rather than the categorical measure which is presently supplied would also be of more benefit to resistance equations. The land use within 5m of banktop provides a level towards assessing the value of riparian land, although again, not really in enough detail to base robust cost/benefit judgements, even crude ones, in the evaluative system. Instead, a logging of house equivalents would be useful which would allay the present necessity to use these in addition to the RHS. The land use within 50m of banktop section would also benefit, in terms of flood defence, with an additional (or alternative) section on land use within, for instance, the 1:50 year flood zone. This is now far more achievable with the new flood estimation handbook produced by the Institute of Hydrology (1999).

The Natural Assets Register for the Sankey NOW River Valley Initiative (TEP, 1998a,b) provides a modern example of how the above recommendations may be incorporated successfully into a wide range of surveys. Most importantly, at its core the Sankey NOW River Valley Initiative combines very similar data to that which will be used in the new sustainable management approach, with RHS. This initiative is the closest analogy and example of how this present project needs to utilise RHS and merge it with other tools (for example, aspects of landscape, access, wildlife and water quality).

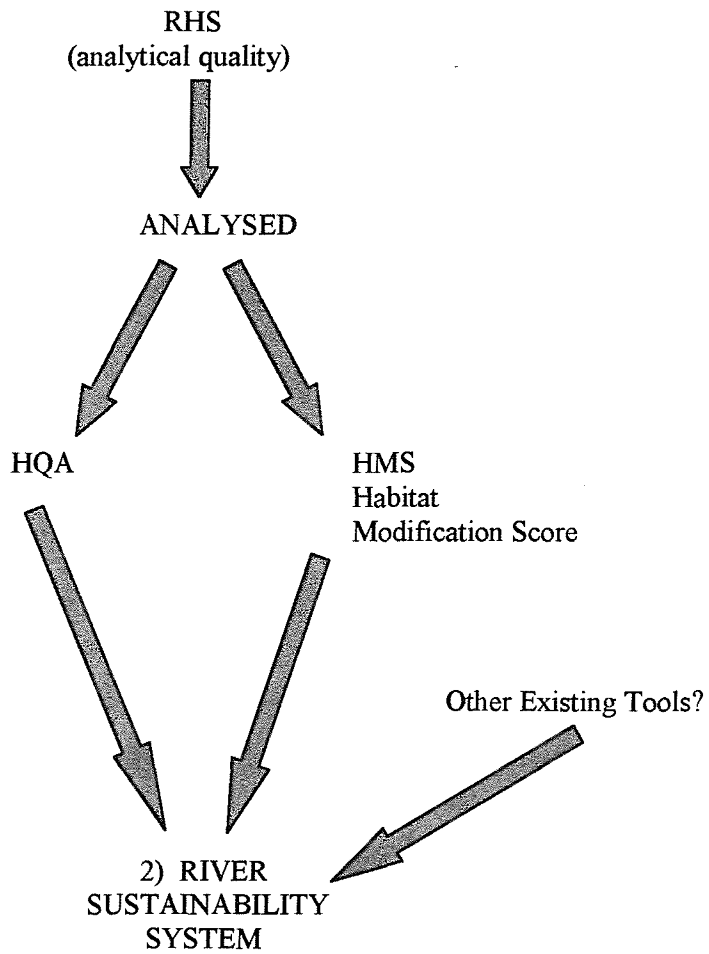


Figure 3.6: The location of a river sustainability evaluation system (Modified from EA, 1998).

As the authors state,

"The RHS method is a powerful tool for appraisal of watercourse and catchment quality and is becoming widely adopted by the Agency for baseline study in project impact appraisal nationally. It also offers the opportunity to compare a sample section, or a watercourse, or a catchment against a national database of reference sites"

(TEP, 1998a).

The Sankey NOW River Valley Initiative consists of five aspects:

- Landscape assessment: This used pre-existing landscape assessments of the catchment and field survey by a Chartered Landscape Architect.
- RHS.
- Questionnaire: sought data on wildlife, water quality and access concerns. Sent to LAs, major landowners' representatives, central government initiatives active in the catchment, local interest groups and the Agency.
- Desk study: various relevant plans and records studied.
- Interview: the questionnaire was used as the basis for discussion with key individuals involved in management.

These five aspects were used to gain the data shown in figure 3.7. The topics covered under these five 'aspects' are very similar to those covered in this research project. Similarly, the use of questionnaires, consultations, desk study and other tools parallel the conceptual framework of the sustainable management approach. This will become apparent in the following chapters.

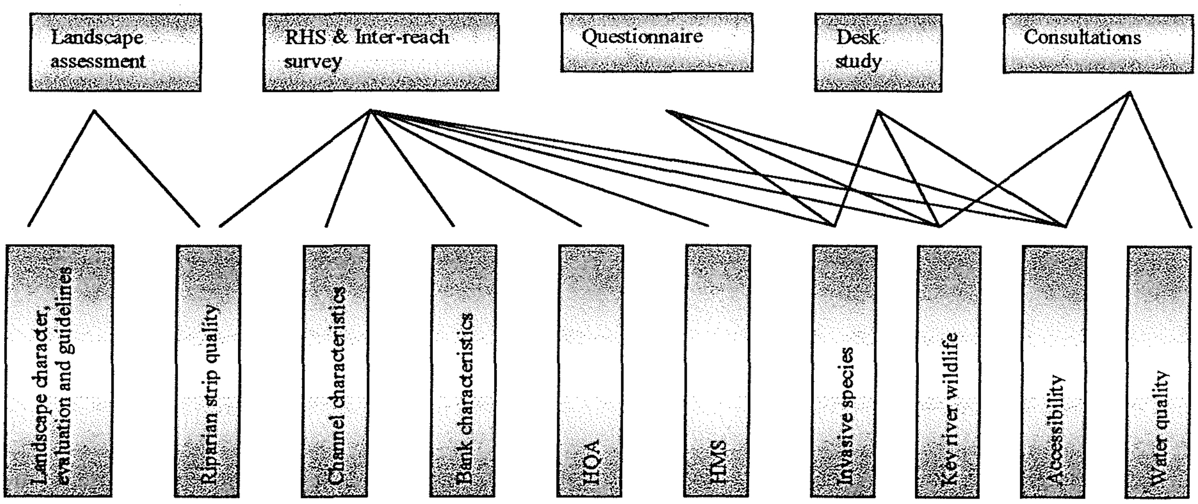


Figure 3.7: The five aspects of the Sankey NOW River Valley Initiative (TEP, 1998a)

The Sankey NOW River Valley Initiative incorporates three scales of landscape assessment. These are:

- **Catchment landscape areas**: broad areas, encompassing both river valleys and other land, with recognisable patterns of filed boundary, topography, settlement, building materials, woodland species cover.

- **Macro river landscape types**: the patterns of landscape and land-use of the immediate valley or vicinity of each watercourse.
- **Micro river landscape types**: the visual appearance of the watercourse and its channel and banks.

Again, this form of classification is a useful one for sustainable river corridor management. Any tool used to assess sustainable management should be seen to rest primarily in the Macro river landscape type, where land to 500m of the watercourse gains from the availability of data from RHS, and land-use is just as important as vegetation in determining landscape character (TEP, 1998a).

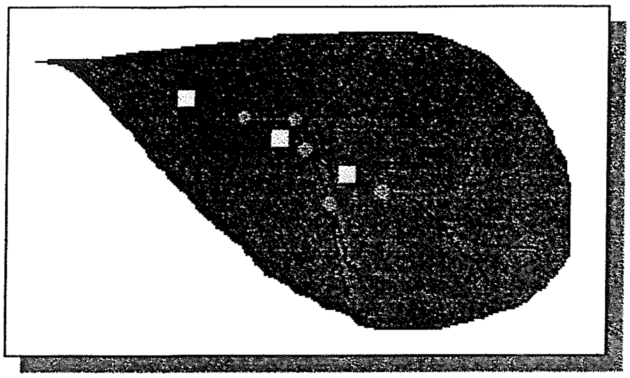
Any new evaluation system should not endeavour to reinvent the wheel or ignore vital and important information and methods that may exist already, or are in the development stages. The Sankey NOW River Valley Initiative is an example of a project that has seen its inception within the period of this PhD, and in so doing, incorporates and shares a number of key principles:

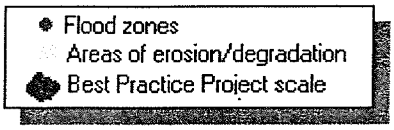
1. The utility of taking RHS data one step further and utilising it with other tools;
2. The need to incorporate public involvement in any assessment of the river;
3. The need to classify the riverine environment to best target tools to specific scales of interest, and further aid appropriate management strategies.

3.6 Spatial Scale - choosing appropriate land units for classification

Because of the various interests on the river, and indeed implicit in sustainable management, the consideration of the choice of land unit for applying a new sustainable management evaluation system should be somewhat problematical. However, the system, largely guided by the choice of the UWBPP as a case study, is nested within the spatial and temporal scale of ***the best practice project*** (BPP) approach. Therefore, this is largely resolved.

The best practice project approach takes a longer-term view at the catchment scale of consideration. Therefore, rather than more traditional symptomatic and 'at-point' solutions, the BPP looks towards resolving these at source. Thus, if there is severe seasonal flooding of point locations within the catchment, or recurrent channel degradation, the BPP looks towards remediating these as a whole (box 3.4).





Box 3.4: Hypothetical catchment problems

The utilisation of the Upper Wharfedale Best Practice Project (UWBPP) supplies this research project with this scale of data availability. However, it is not within the realms of this research to conduct a catchment scale 'fits all', but rather to acknowledge that the reach scale approach taken is within the wider catchment context.

This 'reach scale' is more specifically the RHS reach of 500m length. Further, and hopefully fully encompassed by the 50m to either side of the river channel, this scale of approach follows the 'streamside management unit' approach introduced by Swank (Swank, 1990). This approach considers, "the stream and an adjacent area of varying width where practices that might affect water, quality, fish and other aquatic resources are modified as necessary to meet water quality goal for each class of stream" (Swank, 1990).

The second decision to be made concerns the distance from the river across which the river channel classification is considered to be applicable to its surrounding area. The catchment as a whole has an important affect on the hydrology of the channel, but this is often difficult or impossible to quantify, especially with constrained resources.

It is at this point that the difference between recognising the multitude of factors that need to be taken into account to classify geomorphologically, and those that rest outside the physical attributes of the river needs to be highlighted. This research project is focused on sustainable river management with a predetermined focus on geomorphology, and as such, this must be taken as the basis for classification.

This is not however, the only reason for beginning with geomorphology. The influence of the river permeates all aspects of the basin, and considering that geomorphology is the primary control of that influence through its determination of process, morphology, habitat and landscape, it must be seen as the first level of consideration.

Research is often strongly influenced by the limitations of data availability. This should not, especially in the case of Wharfedale, be seen as a universal constraint. This research is fortunate in the existence of the UWBPP as it has stimulated a good quantity and quality of data. Central to this PhD in utility, and suggested starting points for other management projects, are the following data sources:

1. Dynamic assessment of unstable reaches (RKL-Arup, 1998);
2. Nidd and Wharfe LEAP (EA, 1997e);
3. River Restoration Project appraisal (RRP, 1997);
4. Geomorphological Audit (Heritage and Newson, 1997);
5. Upper Wharfedale Best Practice Project – Feasibility study: final report (RKL-Arup, 1998);
6. RHS database version 3.1 (EA, 1999e); and,
7. River Corridor Survey (Ecoscope Applied Ecologists Ltd., 1999).

Based upon this data and the preference to test a simple subset of rules on a known length of river, the area to be utilised on the Wharfe needs to be a section that has sufficient overlap of these information sources.

In terms of distance from channel to which the assessment area should be taken, there are five choices:

1. First significant break in floodplain slope;
2. Field or land-ownership boundaries;
3. A predetermined flood return period zone e.g. the 1:50 year flood zone;
4. To the point to which the river is expected to erode in the next x number of years, based upon current estimates; and,
5. The 'within 50m (or 5m) of banktop' prescribed by RHS and RCS.

A distinction needs to be made between the land area considered for flood and that for erosion or bank instability. This will need to be developed as implicit in the system. With regard to flood, it is far more defensible and consistent with promoting desk rather than fieldwork, to use the flood-zoning method (option 3) (box 3.5). There is definite potential in this in terms of the path that current Agency research is taking (the Agency's Indicative Floodplain Map; Institute of Hydrology's Flood Risk Map for England and Wales, 1999).

With regard to bank stability and land-loss it is again more defensible and robust to utilise data already at hand. Despite the decision of the US Army Corps of Engineers to take land at risk to be that based upon an existing erosion rate (US ACE, 1998), it is unlikely that in the long-term (e.g. 20 years) that rate will continue. Similarly, in terms of the present system, this would start to de-emphasise the ease by which any evaluation should be completed. As current erosion rates are rarely known for UK rivers their completion would have to be stipulated as a precursor to full evaluation. This may inhibit the system's widespread use.

For these reasons and within the present data availability, land and structures to 'within 5m of banktop' (EA, 1999e) will be considered for bank instability (box 3.5).

STREAMSIDE UNITS FOR RIVER SUSTAINABILITY EVALUATION	
Flood Risk	Flood Zoning (Institute of Hydrology, Flood Risk Map for England and Wales; EA, 1999 Indicative Floodplain Map)
Erosion Risk	Within 5m of banktop (EA, River Habitat Survey Guidance Notes)

Box 3.5

3.7 Temporal scale - choosing an appropriate time-scale for Sustainable River Management

Choosing the time-scale to which system sustainability must not only be working towards, but with regard to historical natural adjustment, working with, is a central characteristic of sustainable management.

Similar to spatial scale, the temporal scale of the actual management is largely dictated by the scale of the best practice project. As figure 3.8 illustrates, the sustainable best practice project should aspire towards the project time-scale of approximately 3 to 4 years, depending on funding and partnership opportunities (Sear, D, personal communication).

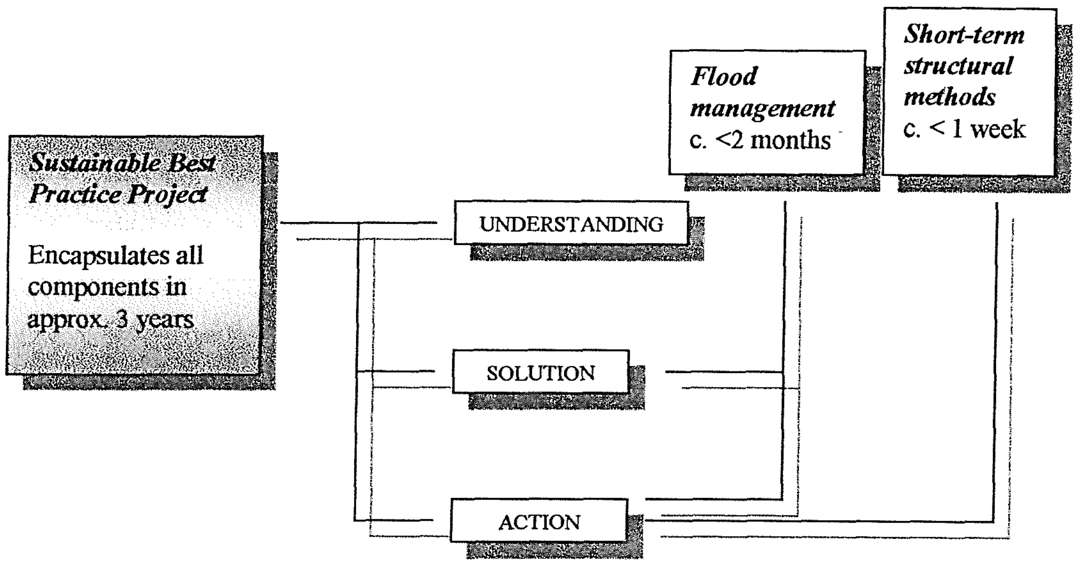


Figure 3.8: The temporal scale of sustainable management (Modified from personal communication, Sear, D)

As box 3.6 illustrates, documentary evidence for extended time periods may be used to identify potentially destabilising phenomenon (PDP) (NRA, undated) that are presently occurring. Box 3.7 indicates sources of information on river channel change that will help to identify the spatial and temporal context of PDPs. Further information on the use of historical data is provided in the NRA R&D report 661, and chapter 5 of this thesis. For a truly sustainable river there is a need to look into the past as well as the present when considering natural features and process.

There are various institutional mechanisms that conflict with the 'long-term' management that true sustainable management implies. As highlighted in the previous chapter, the Agency, like many other large companies and institutions, is largely governed by the financial year., so that project funding is often not consistent over longer periods. Similarly, different functions receive disproportionate levels of funding, so that flood defence for instance regularly receives larger sums than other functions, and not always to the advantage of 'sustainable design' (NRA, 661). As Pearce (1995 in, Gardiner and Perala-Gardiner, 1997) states, "*The longer-term economic analysis, which would allow the longer-term view to be counted, is missing from most if not all current benefit/cost analyses which typically might take only a 30-year term of discounted benefits and costs, associated with a discount rate of 6%,* *as in the UK. Many social and environmental costs and disbenefits are thus visited on future generations, in direct opposition to the principle of inter-generational equity articulated by Brundtland*" (Pearce, 1995 in, Gardiner and Perala-Gardiner, 1997).

Increase sediment supply	Decrease sediment supply
Catchment scale	
• Climatic change (>rainfall)	• Climate change (<rainfall)
• Upland drainage	• Dams/regulation
• Afforestation	• Reduction in cropping
• Mining spoil inputs	• Cessation of mining
• Urban development	• Vegetation of slopes/scars
• Agricultural drainage	• Sediment management
• Soil erosion	
Reach scale	
• Upstream erosion	• Upstream deposition
• Agricultural runoff	• Sediment trapping
• Tributary input	• Bank protection of erosion
• Bank collapse	• Vegetation of banks
• Tidal input	• Dredging (shoals/berms)
• Straightening	• Channel widening upstream
• Upstream embanking	• Upstream weirs

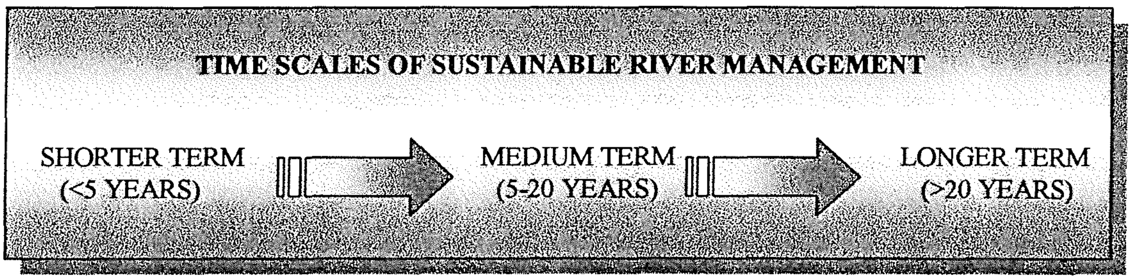
	Source	**Time-scale**
Maps	Estate	C16 +
	Enclosure	C18-19
	Tithe	1840s
	County	
	Ordnance survey	
	1:10560 county series	1853-1923
	National grid series	1948+
	Drift geology 1:50000 series	Map survey date
	Soil survey 1:50000 series	Map survey date
Remotely sensed imagery	Aerial photographs	1930+
	Satellite coverage	1970+
Documents	Estate papers	C16+
	Local newspapers	C19+
	Court of sewers records	C15-18
	Catchment Board Records	1930+
	River board Records	1946+
	Water authority records	1973+
	NRA reports (all functions)	1989+
	Scientific publications	C19+

Box 3.6 (above): Examples of PDPs (Sear *et al.*, 1994) and, Box 3.7 (below): Sources of information for river channel change (Sear *et al.*, 1994).

Just as 'long-term' is often difficult to implement within the Agency because of these factors, the practicality of long termism in the light of other existing market mechanisms has to be considered. For instance, MAFF project lengths are often x years, which could perhaps be viewed as in contention with the lengths we are considering here.

Similarly, if market mechanisms (see chapter 7) are considered, then uncomfortable questions like where financial incentives will come from, on what basis, over what time periods, and at what, if any, extra cost, will need to be asked.

It becomes clear as the debate continues that in reality a ***spectrum of time-scale*** needs to be utilised, dependant upon those factors above (box 3.8). Short term goals and objectives that are prone to adjustment by annual budgeting (e.g. 5 year) still need to be considered but additionally to the aspiration of the longer term of more than 20 years based upon the engineered life of structural solutions. It may be that a medium term needs to be inserted, readily fluctuating according to human and/or natural changes and drivers on the river system.



Box 3.8

3.8 Summary

The discussions in this chapter are illustrative of the breadth of factors that will have to be considered for the development of a system of sustainability appraisal that will be credible and robust enough for practical utility in the Environment Agency.

In summary, the new approach recognises and acknowledges:

1. The Best Practice Project spatial and temporal scales of implementation;
2. The strategic level of management, whilst providing guidelines for practical implementation;

3. The utility of complementing other current research;
4. The concept of minimum intervention, self-supporting versus supported sustainability, and the importance of geomorphology;
5. That a new evaluative system will need to utilise the key goals and themes of sustainable management;
6. Present political and management recommendations;
7. That sustainable management must be appraised on a bipolar spectrum model; and,
8. That a new evaluative system will need to utilise existing databases and tools, particularly RHS.

Utilising the key objectives and framework that has been developed in this chapter, the methodology by which the position on the bipolar spectrum of river sustainability will be ascertained now needs to be developed.

SECTION 2
TOOLS FOR SUSTAINABLE MANAGEMENT
How is Sustainable Management evaluated?

Chapter 4

Geomorphology as a key driver of Sustainable River Corridor Management

4.1 Geomorphology as a system driver

Geomorphology has already been emphasised as a key driver of fluvial environmental sustainability and thus the sustainability model. Geomorphology complements the Best Practice Project scale of management, providing the necessary information to support strategic policy decisions regarding the level of management on 'problem' river reaches. This thesis argues consistently for robust science and philosophy as a basis for management evaluation. Improving geomorphological functioning must therefore be seen as the essential foundation on which this framework can be built.

It could be argued that if geomorphology is to be afforded particular research attention, then why not also the other perceived components of fluvial environmental sustainability (e.g. Ecology; Recreation, Conservation). Here, a fundamental difference must be emphasised. Geomorphology is *the* holistic and driving force to the physical, and therefore social and economic riverine system. It is *the* ***independent*** variable, influencing rather than being influenced by the other components. The morphology of landform and the processes acting upon it are implicit in the stability and character of the river. Geomorphology is an ideal mechanism for assessing change through its time ***transgressive*** nature. Further, socio-economic value is predetermined by this physical dimension. If the geomorphological system is understood and respected then truly holistic management of the *system* is within the grasp of the environmental manager. It is often open to management intervention.

To summarise, of all fields of river classification, Angould emphasises geomorphology as the most important *"because it reflects a response to the water and sediment discharge regime as it is moderated by local rock type and topography, and it provides a control on a wide range of aspects of* *the character of the stream environment including substrate, water depth, flow velocity and water temperature variations, which in turn influence the biotic character of the river*" (Angould, undated).

As stated in the River Channel Typology project, *"to shift the management focus towards longer-term, sustainable solutions which may be flexible to changing environmental conditions requires an appreciation of the reality of channel change over time"* (Universities of Southampton and Newcastle, 1999). Geomorphology has the capacity to fulfil this objective.

The RCT project further emphasises the utility of geomorphology to the EA as:

- providing a practical basis for the assessment, protection and enhancement of the physical environment in river channels;
- enabling the Agency to take a holistic approach, by providing the appropriate tools for integrated geographical planning of the physical environment;
- supporting geomorphologically aligned channel design and management strategies which are effective, cost-efficient, sustainable and avid committing future generations to inflexible solutions or expensive channel maintenance
- identify situations where changes of channel morphology are liable to destroy valuable natural or man-made resources due to natural evolution, current instability or through being unduly sensitive to destabilisation by minor changes in flow regime, sediment supply or river management;
- consider viable alternatives to traditional forms of river management that work with rather than against natural processes when dealing with river stability problems: that is, geomorphology provides a useful tool in options appraisal;
- allow accurate assessment of the costs, benefits and sustainability of achieving desired engineering, morphological and biodiversity aims, particularly with regard to flood defence, fisheries, recreation, navigation and conservation functions of the Agency

(Universities of Southampton and Newcastle, 1999).

In summary, geomorphology provides the first level at which the drivers, thresholds and dynamism of the river may be categorised or quantified within the context of sustainability.

There is a preliminary need to identify the particular characteristics of geomorphological research that further the goal of sustainability and long-term management of the river system. According to Knighton (1998), factors influencing bank erosion, which is a central issue in sustainable fluvial management, are those presented in table 4.1. The majority of these factors are illustrated through the geomorphological audit and dynamic assessment procedures at either channel or catchment scale. Those that are not are either largely dependent upon the geomorphology (e.g. Biology) or largely reflected in geomorphological indicators (e.g. climate, man-induced). They are also elements that will be represented (often through surrogates) in the evaluation system to be developed in the following chapter. Table 4.1 emphasises that by taking geomorphology as the basis of the sustainable management approach, within the constraints of the research project, a good proxy will be provided.

Factor	**Relevant characteristics**
Flow properties	Magnitude-frequency and variability of stream discharge Magnitude and distribution of velocity and shear stress Degree of turbulence
Bank material composition	Size, gradation, cohesivity and stratification of bank sediments
Climate	Amount, intensity and duration of rainfall Frequency and duration of freezing
Subsurface conditions	Seepage forces, piping Soil moisture levels, porewater pressures
Channel geometry	Width, depth and slope of channel Height and angle of bank Bend curvature
Biology	Type, density and root system of vegetation Animal burrows, trampling
Man induced factors	Urbanisation, land drainage, reservoir development, boating, bank protection structures

Table 4.1: Factors influencing bank erosion (Knighton, 1998)

Similarly, a certain degree of existing material must be assumed at the outset of this research. It is not the role of this research to conduct the geomorphological audit, dynamic assessment, or any of the other surveys suggested by table 4.1, but as highlighted in the previous chapter, to illustrate instead the utility of existing tools, methodologies and knowledge on the subject and to place this within the larger sustainable system framework.

4.2 Sediment and channel adjustment

This research project is primarily concerned with the sustainable management of flooding and channel instability, whilst explicitly acknowledging the trade-offs that need to be made between these (often natural) processes and the socio-economic environment. What is of primary importance is the need to draw a distinction between localised adjustments and those that affect entire fluvial systems. The former, such as scour and fill may only occur over hours or days, whereas the latter represent systematic changes in bed elevation, through upstream progressing degradation, downstream aggradation, channel widening and narrowing and changes in the quantity and character of the sediment load over a period of years (Mackin, 1948 in Simon, 1995). Therefore, there is a need to locate bank stability or flood problems within the context of the whole nature of the river system both in space and time.

An effective approach to sustainable river management needs to optimise the acknowledgement of this holism, whilst retaining a level of specificity at the spatial and temporal scale of the riparian corridor. Guidelines need to be generic, but also practicable and developable. For this reasoning, the system of evaluation to be developed in this research considers explicitly the smaller spatial framework of the river channel, and associated riparian corridor. However, this is set implicitly within the wider context of that channel's catchment. It is the endeavour to develop criteria which are as generic as possible, so that future research will be able to extend these statements to the catchment scale in a more explicit and quantifiable manner.

Identifying methods or models to simulate width adjustment provides a significant portion of the robust science base of a river channel and corridor sustainability evaluation system. Present channel attributes are known to exhibit characteristic forms produced by previous morphologies and similarly are recognised as part of a continuum of adjustment over time. Based upon this knowledge, various authors (Various in Simon, 1995; Rosgen, 1994; NRA, 1990; Downs, 1992 in Downs, 1995; Harvey and Watson, 1986 in ASCE, 1998) have worked towards classifying channel change as a sequence of channel forms with time, or adjustment stages.

The American Society of Civil Engineers (ASCE) Task Committee on Hydraulics and Bank Mechanics recognise the relative inability of current expertise in simulating width adjustment, compared with the more successful methods used in channel depth change by aggradation and degradation (ASCE, 1998). Many existing numerical models of river channel morphology are limited in applicability because they neglect time-dependent changes in channel width. If a new evaluation system is to be truly sustainable it needs successfully to integrate the concepts of long termism, futurity and dynamism (or change) over time, which this statement acknowledges.

Further, the ASCE proposes a 'channel stability diagram' (CSD), (figure 4.1), where channel evolution sequences can be viewed in terms of 2-dimensionless stability numbers. Referring to figure 4.1, Ng is a measure of bank stability and Nh a measure of fluvial stability. For a channel to be 'stable' both bed and bank stability are essential conditions. The ASCE further state that the desirable range for long-term channel stability is for Ng to be <1 and for Nh to be ~1 (Watson *et al*, 1988a,b in, ASCE, 1998).

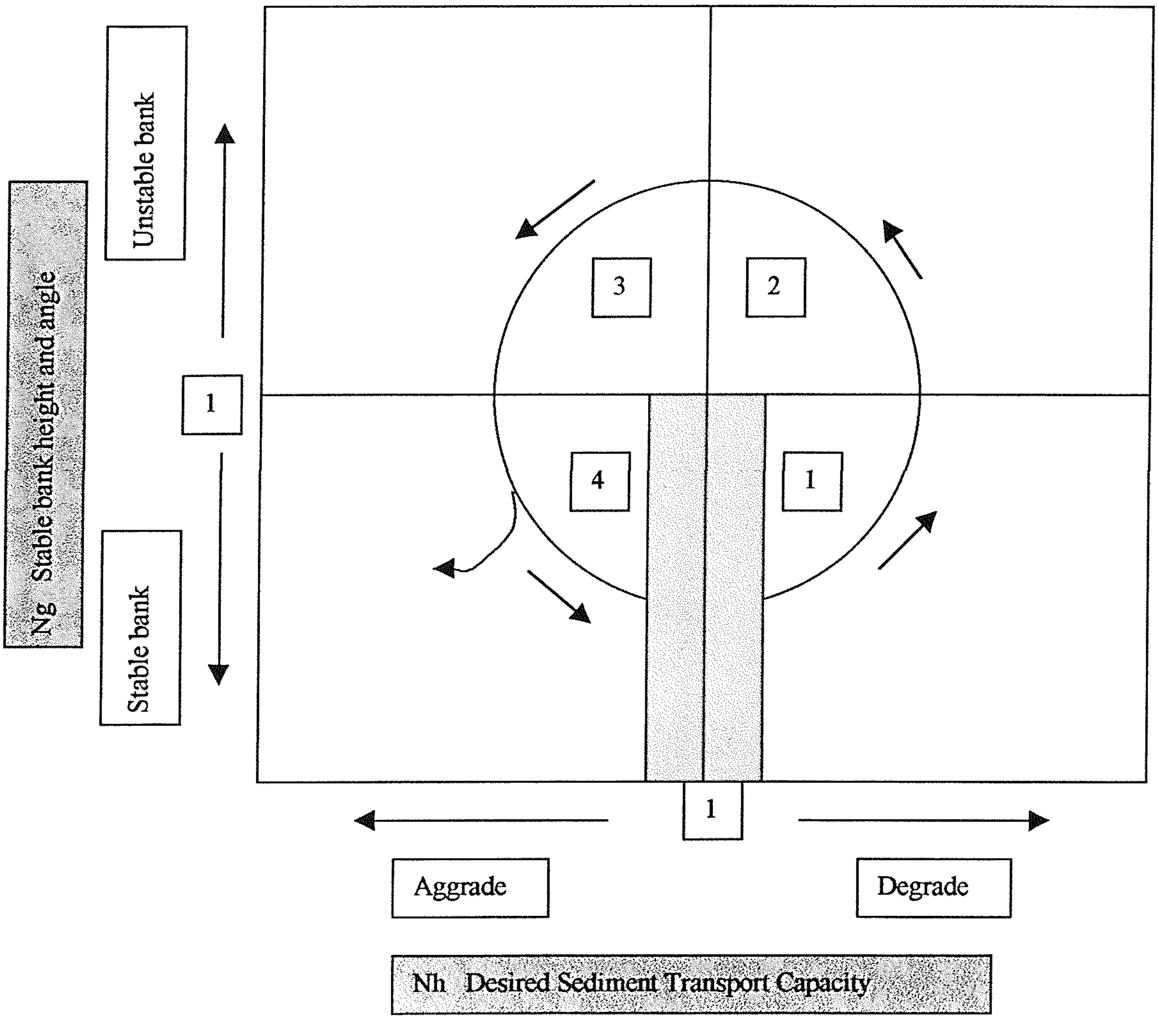


Figure 4.1: The Channel Stability Diagram (Watson *et al.*, 1988a, b in, ASCE, 1998).

Nh was preliminarily defined as the ratio between the desired sediment supply and the actual sediment transport capacity. Again however, Nh could be any reasonable ratio of parameters that could be used as surrogates for sediment transport. Nh for a degradational reach is >1 and <1 for aggradational reaches (Watson *et al.*, 1988a, b in, ASCE, 1998). The Watson model is pertinent to the design of a similar model as the basis of a sustainability evaluation system. Present data availability in the UK dictates that consistent data collection and collation is not always possible. Therefore, surrogate parameters, based upon data from RHS could determine a prototype rule-set for the evaluation of the general trends in channel metastability.

Each quadrant on the CSD is characterised by geotechnical and stability number pairs so that river reaches within each quadrant have common stability, flood control and project goal characteristics. Thus the pairs on the diagram are:

Quadrant	Pair
1	Ng<1, Nh>1
2	Ng>1, Nh>1
3	Ng>1, Nh<1
4	Ng<1, Nh<1

(ASCE, 1998).

As can be seen, as the channel evolves from a state of disequilibrium towards dynamic equilibrium, the channel progresses through the diagram's four quadrants in an anti-clockwise direction. ASCE suggest that rehabilitation should attempt to avoid as many quadrants as possible to reduce the amount of channel deepening and widening (ASCE, 1998). Similarly, with regard to sustainable management, it must be recognised that a sustainable river is not a river which will need unsustainable levels of maintenance to keep it in a more 'natural' state. It may be, for example, that past intervention in the catchment system indicates that the present river channel will not readily return to its pre-disturbed state. Therefore, to aim towards this goal would be a less sustainable option. The decision as to which at-point management option to take may then be based upon the overall stage of adjustment and long-termism on the river. It is not a sustainable option, in other words, to protect a small-scale erosional problem at one bank, if geomorphological theory suggests that a) this will stabilise naturally; or b) it is naturally unstable and that management will pass through too many of the CSD quadrants. This links directly to the criterion of 'minimum intervention', and also the concept of 'supported' and 'self-supporting' sustainability, both introduced in chapter 3.

The stage of channel evolution illustrated on the CSD provides physically based evidence of the dominant processes affecting a particular site or reach, and indicates the approaching or crossing of various ***geomorphological thresholds*** (Simon, 1989; Lohnes, 1991 in Simon, 1995). These thresholds need to be identified so that as soon as management shows a trend towards less sustainable practice, this might be observed, and management shifted or retained at more a sustainable level.

The generic states of adjustment that are required to ascertain levels of stability for an evaluation system, may be ascribed by:

1 informed observation of field indicators of stability and PDPs along with stream power/resistance relations;
2 the utilisation of data from a consistent database which provides information on substrate (resistance to change) and stream power.

Implicit in the stability diagram (Watson *et al.*, 1988a,b in ASCE, 1998) is the idea of the ***sediment budget***, implying that the riverbed goes 'up and down' and the river banks 'in and out'. If rules are identified which link sediment to power, then the value of a bottom-up approach, both conceptually and literally, begins to emerge.

The use of a 2-dimensionless model is particularly interesting in that it introduces the concept of ***boundaries and thresholds***. It forces decisions between quadrants, and stimulates management decisions depending upon ***direction of movement*** between quadrants. For these reasons the concepts behind the Watson-style model are to be used as a basis for gauging expert opinion on the thresholds which are crossed between management scenarios in the sustainable evaluation system.

4.3 Energy and propensity to change

The preceding discussion advocates the dominance of substrate in a working model of present river system sustainability. This parameter now needs to be combined with ***energy*** in the system to determine likely future channel adjustment or change over the longer-term. A number of researchers advocate the combination of substrate and energy as illustrative of a channel's propensity to change (Universities of Southampton and Newcastle, 1999; Lewin, 1983 in, Thorne, Hey and Newson (ed.), 1997; Nanson and Knighton, 1996; Knighton and Nanson, 1993; Nanson and Croke, 1992).

Indeed, the River Channel Typology report (RCT) states that, *"techniques used to relate driving variables to the dependent variables demonstrate that* ***specific power is the single most important variable available to explain reach geomorphology and substrate composition*** *[and that] changes in* *specific power (which could be effected by river engineering) have the potential to transform a reach to an adjacent [stability] class"* (Universities of Southampton and Newcastle, 1999). They continue that, *"however, the ability to predict dependent variables or class membership from driving variables is extremely limited and any transformation of a river from one class to another will be constrained by the dominant affect of channel substrate size on class"* (Universities of Southampton and Newcastle, 1999).

This support for the utility of both power and resistance as driving variables can only have practical application in an evaluation system if accompanied by clear definitions of thresholds or 'partings' around which rules of metastability and ultimately sustainability are formed. Research into such thresholds in Britain is limited (Universities of Southampton and Newcastle, 1999; Brookes, 1985, 1987, 1990 in Darby and Simon (ed.); Lewin, 1983 in Thorne, Hey and Newson, 1997). This should not be seen as a limitation, but simply illustrative of a field that has far more potential than currently recognised as evidenced by the research. With regard to an evaluation system, if the principles of these researchers are blended with robust data from the Wharfe channel then the importance of continuing this form of data acquisition will be emphasised.

Most pertinent to thresholds of power and resistance in England and Wales are the works of Brookes (1985, 1987, 1990 in Darby and Simon (eds.)) and also the River Channel Typology project (Universities of Southampton and Newcastle, 1999). Brookes (1985, 1987, 1990 in Darby and Simon (eds.)) states that unconfined lowland, meandering channels with low mean stream power (<35 W/m^2) do not have sufficient energy to modify their boundary. Empirical results suggest that stable meandering channels have mean stream powers less than 25 W/m2 and that unstable channels have mean stream powers greater than 35 W/m^2. Once mean stream power exceeds 35 W/m^2, lateral migration, bank erosion and/or degradation develop rapidly, especially in channels that have been disturbed by channelisation (see box 4.1) (Brookes, 1985, 1987, 1990 in Darby and Simon (ed.)).

Brookes' Stream Power thresholds

< 25 W/m^2:	stable meandering channels
< 35 W/m^2:	lowland meandering channels with insufficient energy for bank erosion
> 35 W/m^2:	unstable channels. Rapid development of lateral migration, bank erosion and/or degradation

Box 4.1 (Source: Brookes, 1985, 1987, 1990 in Darby and Simon (ed.)).

The River Channel Typology database has 362 sites with stream power values covering a range from 2 – 1815 W/m^2. This project, undertaken by the Universities of Southampton and Newcastle for the EA, recognised dominant stability classes for the database of British rivers, based upon these stream power values and substrate.

The RCT gives two fundamental partings for the driving variable of stream power for ***semi-natural*** British rivers (box 4.2). These are 7.5 W/m^2 for deposition and 35 W/m^2 for instability. RCT used discriminant function analysis to try and predict dependent stability class from the driving variable of specific power.

RCT Stream Power thresholds

7.5 W/m^2	deposition
35 W/m^2	instability

Box 4.2 (Source: Universities of Southampton and Newcastle, 1999).

In conflict with expectations, the RCT report concluded that a test for the predictive ability of stream power showed that although each group was statistically significant, there is a surprising trend throughout most substrate groupings in the RCT for the lowest values of stream power to be associated with those rivers exhibiting the highest incidence of instability indices (table 4.2). However, those channels that have unstable characteristics and low stream powers are dominated by fine sediment substrates. The lowest stream powers (below the 35 W/m^2 parting) are characterised by silt, sand and sandy gravel substrate that require relatively low energy for transport. Above the 100 and 1000 W/m^2 thresholds, the rivers are dominated by gravel/cobble and cobble substrates that require higher energies for sediment transport (Universities of Southampton and Newcastle, 1999). Perhaps even more importantly, it must be remembered that the majority of the power readings are still above the Brookes threshold of 7.5 W/m^2 (Brookes, 1985, 1987, 1990 in Darby and Simon (ed.)) and therefore some degree of instability in the bed and or banks will be exhibited. Similarly, perhaps one further profound factor, which would explain the trend, would be ***vegetation***. Even with a decreasing stream power (for instance, see the trends in row 'gravel/cobble') but a rising instability, if vegetation is less on and in the latter rivers then there will be less resistance to erosion.

There are three fundamental questions which must be asked before the thresholds of the RCT are accepted. First, is there *science* in river channel planform change, and thus the figures in table 4.2, additional to that expected; second, are the figures in the table *reliable*; and, third, is the problem in the rule-base design, of overlapping stream power *ranges* between not only stability classes but also substrate classes, overcome?

Local slope was not measured in the RCT, only estimated gradient from the 1:25,000 map. This could be a limitation, although as with the final evaluation system and its utilisation of RHS, localised slope data are often not accessible, if held on databases at all, which therefore has to lead to less satisfactory forms of data collection. Similarly, the sample number in the table is relatively small. Most of the classes average n2 – 5 which although providing a basis for the concept that the table illustrates, does little more than wet the appetite for more data.

	Stable				Bank unstable Bed stable				Bank stable Bed unstable				Unstable			
	n	Med.	range	O	n	Med.	range	o	n	Med.	range	o	n	Med.	range	o
Silt	2	47.5	13.8-81.1	47.6	2	40.8	16.6-65.1	34.3	6	37.8	8.0-105	40.9	-	NA	NA	NA
Sand	1	NA	NA	NA	4	198	6.3-290	123	1	NA	NA	NA	2	112	22.3-202	127
Gravel /sand	0	None	none	NA	3	103	66-139	36.7	2	73.2	36-111	52.9	5	63.3	21.3-114	37.3
Gravel	9	107	12-1766	570	12	142	21-1121	371	27	73.3	4-489.6	138	55	50.1	4.6-1443	218
Gravel /cobble	4	135.6	58.8-269.1	97.9	3	135	100-225	60.5	6	78.8	57.7-482	167	10	39	23-539	159
cobble	1	NA	NA	NA	2	95.5	53.7-97.9	24.9	13	142	7.2-427	117	30	79.3	9.2-2578	493

Table 4.2: Relationship between substrate, power and stability (Source: Universities of Southampton and Newcastle, 1998)

Unfortunately, the table supplies little quantifiable data for the evaluation system. Ranges around the median are so wide that they encompass far too many stability classes. For instance, for gravel substrate the rule-set would read:

If gravel and 107 W/m² then stable *(range 12 – 1766)*
If gravel and 142 W/m² then bank unstable, bed stable *(range 21 – 1121)*
If gravel and 73.3 W/m² then bank stable, bed unstable *(range 4 – 489.6)*
If gravel and 50.1 W/m² then unstable *(range 4.6 – 1443)*

Therefore, to refer to the median value for stream power only (the first value given in W/m^2) is not viable without a range. However, there are huge degrees of overlap in the ranges of the four stability classes. Therefore the dilemma of, for instance, fitting a river of 100 W/m^2 into one category is faced, even though according to the rule-set above, it fits into every category.

Lewin (1983, in Thorne, Hey and Newson, 1997) provides bankfull stream power and averaged rates of lateral channel shift for selected reaches of Welsh rivers. Thresholds are shown in table 4.3.

Ω Bankfull (W/m)	**Channel change (m2/m/yr)**
≥ 1000	≥ 1.0
750 – 999	0.75 - 0.99
500 – 749	0.50 - 0.74
250 – 499	0.25 - 0.49
< 250	< 0.25

Table 4.3: Averaged rates of lateral channel shift for selected reaches of Welsh rivers (Lewin, 1983, in Thorne, Hey and Newson, 1997).

Lewin's figures are not in the usual Watts/ m^2/sec,and no robust method exists for translating this data, but the relative relationship between power and propensity for change can still be gained from his figures.

The system is now challenged with inter-relating the parameters of a) substrate of bed and bank; and b) the relationship of ω mean stream power to the substrate of both bed and banks. Only then may a rule claim with confidence that for stream power x, bed and bank resistance combination y the channel is more or less stable. It is actually far more complex than this, which consequently offers a number of opportunities.

By taking power and resistance as a relationship it may be theorised that as, for instance, one moves from the upland to lowland environment, power declines at a negative exponential rate. It is hypothesised that the same trend occurs with resistance. As one moves down slope the bed and bank material generally exhibit a progressive change from more resistant rocks to less resistant alluvial silts and fines. Similarly, roughness also changes downstream. The importance of this relationship is in its ability to determine thresholds of change as the two parameters pass through the combination. Thus, if this is illustrated graphically (using malleability rather than resistance to achieve a more readily illustrative plot) fields of propensity to change can be identified (see figure 4.2). It is at point x that the sustainability evaluation system could be seen to predict change in the system.

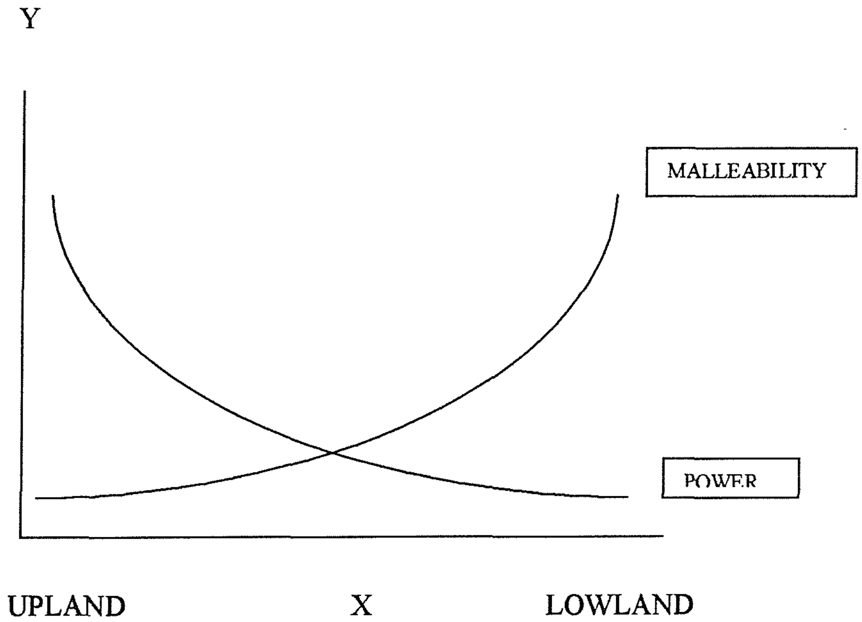


Figure 4.2: Propensity of channels to change – a conceptual representation

This concept could be developed further to suggest that if the reach to be assessed has a stream power of z, which for this argument is very high, and yet evidence of erosion is also high (y), then the site does not fit the relationship preferred. It is at this stage that the question has to be asked as to whether: a) gradient, stream power and malleability do show an inverse relationship; and, b) whether one can generalise to such extents about British rivers.

To test these assumptions, partings or thresholds between stream powers for British rivers need to be developed, and secondly, interrelated with resistance formulae. No research (to this author's knowledge) has explicitly linked stream power and resistance in such an explicit manner. Research on anabranching and anastomosing rivers (Nanson and Knighton, 1996; Knighton and Nanson, 1993) and the genetic classification of floodplains (Nanson and Croke, 1992) is the most relevant research. Unfortunately, despite the initial encouragement offered by these papers, a number of shortfalls means that they are not well suited for the quantification of the rule-sets. This is because: a) many of the papers deal with North American rivers which has implications for the transferability of scale; and b) many of the papers deal with rivers exhibiting particular characteristics (as illustrated in their titles).

The most pertinent in methodology of the three papers is Nanson and Croke's (1992) work. This research explicitly recognises that alluvial river channels can be differentiated on the basis of particular force-resistance relationships (Brotherton, 1979; Ferguson, 1981, 1987; Richards, 1982; Carson, 1984; Graf, 1984, in Nanson and Croke, 1992), and the stream's ability to do work (stream power), or more specifically, to entrain and transport sediment (shear stress) and the resistance of the channel boundary to erosion (Nanson and Croke, 1992). In addition they recognise that the amount and texture of the sedimentary is seen to be very important in determining channel and floodplain geomorphology (Schumm and Khan, 1972; Carson, 1984 in, Nanson and Croke, 1992) as both are closely related to stream power (Bagnold, 1966, in Nanson and Croke, 1992). Thus Nanson and Croke explicitly recognise stream power/resistance as an adequate indicator of change. They notably discount other variables, like riparian vegetation, human interference and inherited conditions on the basis of difficulty of assessment (Nanson and Croke, 1992). The sustainability evaluation system will include these parameters, although it is encouraging to note that the authors feel power and resistance are adequate.

In summary, Nanson and Croke recognise three classes of floodplain based upon this relationship:

High energy non-cohesive (>300 W/m^2);
Medium energy non-cohesive (10-300 W/m^2); and,
Low energy cohesive floodplains (<10 W/m^2).

The first perceived problem with Nanson and Croke's work is that the three categories of stream power are expressed only qualitatively as high, medium and low. This division along the river's continuum implies indirectly a corresponding decrease in the calibre of stream load. The calibre of the sediment load determines the sedimentary composition of the floodplain which in turn strongly influences the resistance of the stream banks to erosion (Hickin and Nanson, 1984 in Nanson and Croke, 1992). This statement supports once again the assumptions made earlier but lacks quantification. Nanson and Croke initially divided floodplains after Knighton (1984) into non-cohesive alluvium (gravel to fine sand) and cohesive alluvium (silt and clay). They then state that because of the 'almost direct relationship between sediment size and entrainment thresholds in the continuum of non-cohesive sediment, floodplains are divided into the two energy environments; high and medium. As silts and clay show an inverse relationship between erodability and sediment size, a third class of low energy cohesive is recognised' (Nanson and Croke, 1992).

The obvious dilemma with the application of this to the sustainability evaluation system is maximum grain size only reaching gravel. This aside, Nanson and Croke have achieved a list of partings of stream power for those grain sizes.

Other researchers mirror this methodology of using stream energy and sediment to define the first level of classification. Nanson and Knighton (1996), for instance, use these parameters, along with morphological characteristics as a first order to define the energy levels and then consider w/d ratio, migration, vegetative and sedimentary environmental characteristics to sub-categorise. The authors support this decision by stating that a simple bivariate relationship of stream power and sediment size cannot encapsulate the complexity of channel processes and that further differentiation requires morphological characteristics (channel and planform) that are often dependant on vegetation and so forth. The authors devise an interesting scheme for comparison of stream characteristics (figure 4.3), which encapsulates all information but would perhaps be more beneficial if plotted diametrically.

Bank resistance is relative to specific stream power or bank shear stress, and its influence on channel pattern can be greatly affected by the stabilising effect of bank vegetation (Smith, 1976; Hickin, 1984 in, Nanson and Knighton, 1996). Resistance to bank erosion thus controls channel migration rates (Hickin and Nanson, 1984 in, Nanson and Knighton, 1996).

Knighton and Nanson (1993) use an ordinal scaling of low, moderate, and high to define anastomosing river channel pattern. They do this in terms of three variables – flow strength, bank erodability and relative sediment supply (Knighton and Nanson, 1993). The authors argue that it is 'more appropriate to replace sharp thresholds by gradual transitions' (Knighton and Nanson, 1993). This decision could be contested at a number of levels, but that most pertinent to our own need is that asking the user of the RSI to decide between high or medium flow strength or erodibility is fraught with the limitations of subjectivity. This is solved by translating a figure of stream into a banding and feeding that back to the user.

Finally, Knighton and Nanson also take into account relative sediment supply rate. This is justified by stating that increasing w/d ratio is generally associated both with a larger (bed material) load and with the straight-meandering-braided transition (Knighton and Nanson, 1993). They include both bed and suspended load.

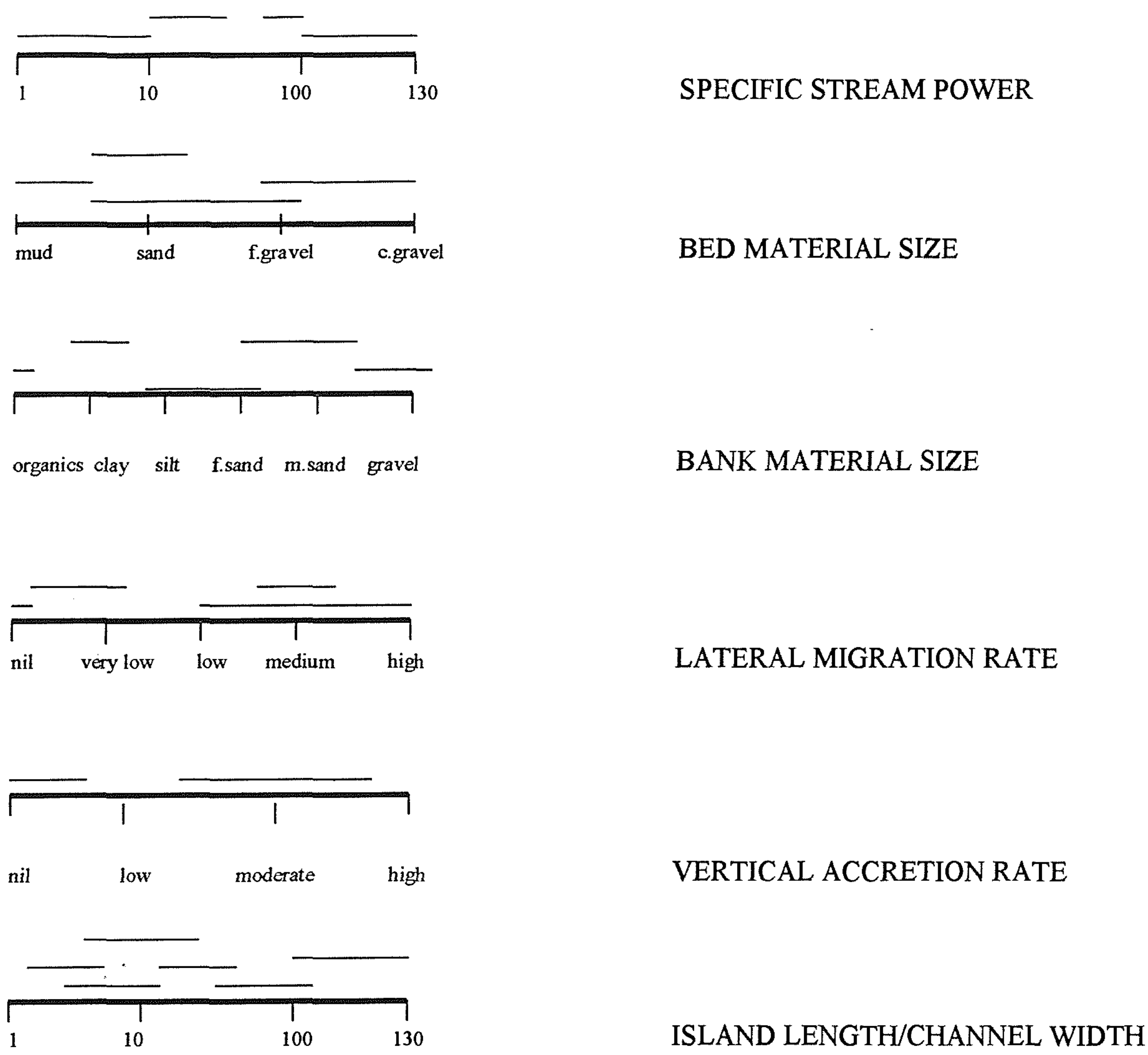


Figure 4.3: Diametric scaling of power and stream characteristics (After Nanson and Knighton, 1996)

4.4 Summary

What this chapter has evidenced is that if the sustainability evaluation system is to be transparent, robust, defensible and accountable, geomorphology needs to be at the core. Further, if this is to be the case, simple but robust rules need to be set, acknowledging thresholds to change and metastability, together with power/resistance relations. A system now needs to be developed which has the capacity to encapsulate these requirements within the wider context of the sustainability debate.

CHAPTER 5

Evaluating Sustainability and Sustainable Management

5.1 A new approach for the assessment of sustainable management in the context of existing methods

A central recommendation of the Rio Earth Summit was for individual countries to prepare national strategies and action plans to implement the agreements to which they were now committed regarding Sustainable Development. The complexity of the sustainable development agenda requires agreement on a multiplicity of both short and longer-term objectives and targets if progress is to be properly monitored and guided.

To date, 'targets' can broadly be seen as interchangeable with the development of 'indicators' for the measurement of success in Sustainable Development. The development of indicators is an ongoing process and especially well illustrated to date in the United Kingdom by the British Government Panel on Sustainable Development (BGPSD), the UK Round Table on Sustainable Development (UKRTSD), and the Department for the Environment, Transport and the Regions (DETR). Globally the UN (1996) provides one of the most comprehensive examples of practice (see chapter 1). As part of the implementation of the work programme on Indicators of Sustainable Development (ISDs) adopted by the UN Commission on SD (CDS) a working list of 134 indicators and methodology sheets have been developed. The documentation is widely accessible on the Internet (homeURL:http://www.un.org/dp Sustainable Development).

One major shortfall of indicators is the lack of qualitative or subjective measures. In river corridor management for example, it is argued that public perception of proposed policies and projects is particularly important to a scheme's success. After all, the restoration of a channel may incur several costs (both tangible and intangible) on the riparian land-owner or local resident, suggesting the need for including some form of assessment prior to project initiation.

As UKRTSD state, and closest to the crux of the problem:

> *"There are some environmental qualities which cannot be measured objectively, but which we nonetheless consider to be valuable and wish to preserve - such qualities include factors like natural beauty or tranquillity. Because such qualities are very hard, or even impossible, to quantify, they may be excluded from, or only partially covered in, quantified indicators"*
>
> (HMSO, 1996).

Similarly, it is often the case that indicators do not deal directly with the reconciliation of both environmental and economic change, often because it is difficult or impossible to measure both on a common basis, such as monetary valuation.

Indicators also obviously need a target or guideline against which to work and be compared against. This is an added problem in itself as this predetermined level could change with time (both seasonally or long-term) or perhaps change as other indicators change, requiring new targets to be set. Similarly, it is often problematic to set this predetermined level in the first instance.

The overwhelming problem with the use of indicators in measuring sustainable development and progress towards it is that there seems no clear difference between indicators of sustainable development and indicators of the environmental quality that might be yielded *by* sustainable development. Even over a decade after Brundtland, linkages between the parameters that they measure, which translate them from merely environmental quality to Sustainable Development, are still not truly recognised. It is suggested that these linkages could be more implicit than initially recognised, but more likely is that the complexity of the concept is still not wholly grasped and the use of indicators is not doing enough in capturing this complexity. Indeed, the use of indicators is believed to be holding back sustainability in some cases. It is often the case too much interest is given to the indicators themselves, rather than what they are indicative of. The holism that is meant to be so implicit to sustainability is lost, by simply fulfilling each measurable indicator. *Sustainability is, as the dictionary definition of holism states, greater than the sum of its parts*. There are intricate inter-relationships between the indicators that can not always be measured quantitatively. These need to be understood and policy shifted likewise.

5.2 Coping with the pragmatics of holism – The selection of appropriate rules and criteria

In the earlier stages of this research project the continuation of the use of indicators in assessing sustainability seemed to be the obvious action, albeit in the realms of the riverine environment. In reality however, when 'indicators' are spoken of in the realm of sustainable river corridor management, it is ***rules,*** or ***criteria*** within rules, that lead to the fulfilment of the key aims and objectives.

A high proportion of the work existing on ***criteria selection*** to date is in the realms of nature conservation, perhaps indicative of the high number of nature designations now existing. Landscape and nature conservation generally use criteria based upon rarity and vulnerability (NCC, 1990 in Loughborough University, 1991). In terms of the trade-offs that will be needed to reach realistic sustainable management of the river, 'high priority' sites could similarly be identified based upon their uniqueness or ***substitutability***. This could be defined as the ability of nature and/or ourselves to either recreate, or substitute for the loss of a site, over a given time-scale. The level of this criterion may then be determined by the ***representativeness*** of that site, its position in regard to given spatial scales of significance (for instance, European or local), and the need to protect that site based upon the potential detrimental effect of any kind of threat or degradation to the loss of that site.

Related to substitutability and irreplaceability, the significance of ***local character and importance*** must have just as an important part to play as larger spatial units. Often a site may be just as significant to the 'local' as another, or even the same site, may be to the nation. If the sustainability of a river can be maximised by trading off the natural environment for the economic, then ***mitigation*** may need to be considered. A large part of successful mitigation is the substitution of the loss with a similar resource for the utility of the 'losers'.

Substitutability can be seen as synonymous with ***irreplaceability***. Indeed, what the consideration of all the above factors lead to is the act of valuing the environment. To trade between assets there is a need to know the value of those assets. Indeed, the concept of 'irreplaceable' simply implies that the resource is too difficult or expensive to replace in human time-scales (Masters and Gee, 1995). The concept also implicitly recognises the natural recoverability or resilience of a habitat or community, and also the ability of man to recreate.

Again, analogies may be seen in the replaceability of the river system, leading to the following criteria:

- Site role and **function** relative to others
- Site reproduction
  - Key site/drivers/processes?
  - Site/drivers/processes long lived?
  - Trends of site/drivers/processes declining?
  - Can this be reversed?
- Physical sensitivity
  - Are any key site/drivers/processes site or habitat specific?
  - Are any particularly fragile?
  - Could human intervention stop damage?
- Island (biogeography)
  - Are key site/drivers/processes isolated by space or physical barriers?
  - Could recolonisation be achieved technically and financially?
- Technological factors
  - If destroyed, could conditions be reinstated/recreated?

(Adapted from Masters and Gee, 1995).

What these examples from nature conservation illustrate is the need to successfully identify river corridors which are vulnerable to passing a threshold that may be difficult to return across in the opposite direction. For instance, if the present day solution on a semi-natural upland reach is for strong intervention due to seasonal flooding, it may prove to be too costly to return that river to its semi-natural state in the longer term. Therefore factors of irreplaceability, substitutability, site reproduction and physical sensitivity need to be implicit in any evaluation system.

5.21 A preliminary set of rules for Sustainable River Management

To be able to design a list of rules that will give an output of the level of sustainability of any site when applied, further requires a firm knowledge of what a sustainable environment is believed to be. This must be gauged from the concepts and aims developed in chapter 3 and the statutory guidance as laid down by Government Ministers to the Agency (see chapter 2). Further, the rules must be able fully to utilise the existing tools introduced in chapter 3.

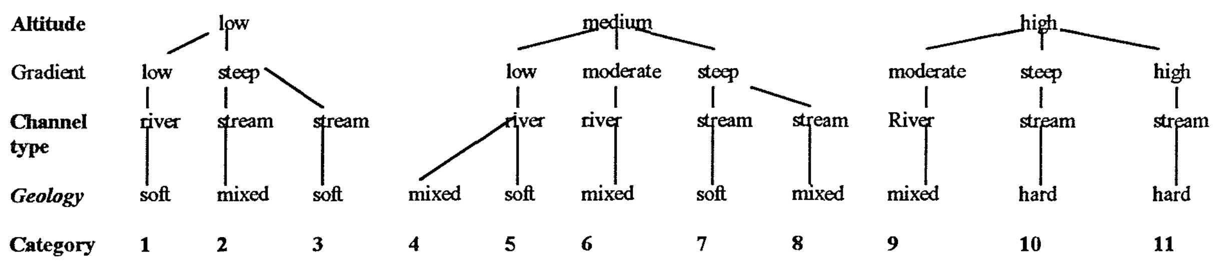
Based upon these considerations, and developing from the initial framework of Everard *et al.* (1995) a set of initial statements or 'issues' have been derived. They are presented below in a simple list format, and provide the first structured version of the rules and categorisations that need to be included in an evaluative system. As will be seen, these see a rapid development in complexity over the research period. This initial set however, provides a clear checklist for the succeeding discussions.

GENERIC

1. Which function would the user like to use as a focus for the enquiry?

   Water Resources
   Flood Defence
   Fisheries
   Recreation
   Conservation
   Navigation

2. Is the user using this system strategically or as a pre-requisite for an EIA or similar development proposal?
3. What category of river is the user assessing?



PHYSICAL

4 Does the river have a floodplain?

5 With what frequency does the river flood (defined as over bank top)?

6 What is the duration of seasonal flooding?

7 Has a Geomorphological Audit or similar survey been carried out?

8 What *Channel Adjustment Category* is the river?

9 Has a RHS been completed for any 500m section on the river?

10 Has a HQA been completed?

11 What is the HQA score?

12 Is Bio-technical engineering utilised on the channel and its banks?

13 Which of the following techniques are present?

Fencing off

Vertical earth bank protection

14 Bank-top alder planting

Fascines

Spilling

Logs and brush

Hurdles

Regrading

Willow

Rock

ECOLOGICAL

15 Would lateral bank erosion or flooding have a detrimental affect on a unique or locally-important species of flora or fauna?

16 Does this species have a wider conservation or protection importance?

17 Would lateral bank erosion or flooding have a detrimental affect on a unique or traditional practice where a cultural or heritage value might be lost?

18 Does this practice have a wider cultural and associated employment context?

19 Is it protected via routes such as Heritage or Tourism policies?

20 Is the river classified for water quality under the Agency's *General Quality Assessment Scheme (GQA) 1995*?

21 What grade?

22 Is the reach or its floodplain subject to any of the following conservation designations?

Wildlife	*Landscape Designations*	*Heritage*
SSSI	National Park	Sites & Monuments record
National Nature Reserve	Area of Outstanding Natural Beauty (AONB)	Scheduled Ancient Monuments
Local Nature Reserve	Hedgerows	Area of Archaeological Importance
Special Protection Area	Special Landscape Area	Listed Building
Special Area of Conservation		Conservation Area
Biosphere Reserve	***Nature Conservation Mapping Initiatives***	English Heritage/ Cadw Historic Designation
Ramsar site		World Heritage site
Wildlife site	Countryside Character	
Nature reserve	Natural Area	***Agri-environmental Designations***
Regionally important	Landmap	
Geological site		Environmentally Sensitive Area (ESA)
		The Habitat Scheme
		Countryside Stewardship
		Tir Cymen
		Wider Countryside Scheme

23 Are any of the following Buffer Zone initiatives in place?

Riparian Buffer strips

Vegetated Filter Strip

Stream-bank stabilisation: livestock exclusion zone

Wetland Buffers: ... riverine wetlands

floodplain wetlands

Ponds and lakes

ECONOMIC

24 What is the MAFF land class in the Buffer Zone (m)?

25 What is the *House Equivalent* of land in the Buffer Zone (m)?

26 Is/are there public right of way/s in Buffer Zone?

27 Are these of national importance? *(access for explanation)*

28 Does Buffer Zone contain national roads and/or railway?

29 Does Buffer Zone contain regional roads and/or railway?

30 Does Buffer Zone contain a route/s of access importance to the local community/business/industry/recreation?

31 What is the MAFF land class in the seasonal floodplain?

32 What is the *House Equivalent* of land in the seasonal floodplain?

33 Does seasonal floodplain contain national roads and/or railway?

34 Does seasonal floodplain contain regional roads and/or railway?

35 Does seasonal floodplain contain a route/s of access importance to the local community/business/industry/recreation?

36 What is the present estimation of expenditure/annum on flood alleviation?

37 What is present estimation (£/annum) on post-flood clean up?

38 Is river important for Game Fishing?

39 Is river used as a navigable waterway?

40 Is river and its riparian corridor utilised for public recreation?

41 Is the river referred to at all in the attraction of tourists/visitors?

42 Is there a Local Environment Group (LEG) in place?

43 Has a form of Consensus Building been carried out?

44 Is this continuing?

45 Are those involved of
- both sexes?
- all age groups?
- all levels of education?
- abled and disabled bodied?

46 Has a stakeholder group been established?

47 Do stakeholders include:
- government (national and local)
- Regulatory authorities and agencies
- Non-statutory bodies
- Industry
- Professional and industry bodies
- National environmental and conservation groups
- Local interest and community groups
- Individual members of public?

48 Do Stakeholders fulfil the following criteria?
- Must live/work within LEAP area
- Must command authority within their own organisation
- Are able to represent their constituency

Possess excellent local knowledge

Are skilled in assimilation and assessment of technical information

Can work to a tight timetable

Can attend all workshops

Include public, voluntary and private sector

49 Have partnership options been explored with other statutory bodies concerned with rural economy and society?

50 Is any part of the river a 'Rural Development Area' (as defined by the Rural Development Commission) or an 'Objective 5b Area' as defined by the Government for the purposes of EC Structural fund support?

51 Has public participation been used as a tool for gauging public attitude to their riverscape?

52 Which class of riverscape (NRA, 1993) is the river?

53 Are the river and its floodplain of high intrinsic community value?

54 Has a CBA or an appropriate valuation tool bee utilised for the measure of benefits and damage to the environment associated with the proposal?

55 Have market mechanisms been considered as a tool for discouraging new development in areas prone to flooding/

56 Is there an environmental foundation to local farming economy?

57 Are farming subsidies/grants already present in riparian area? (e.g. Countryside Stewardship, Set-aside, Environmentally Sensitive Areas (ESAs), the Habitat Scheme, Water Fringe areas, National Park authorities, landscape conservation grants). (Access for explanations)

58 Are there opportunities for diversification of farming interests (e.g. tourism)?

Split into the four sections of 'generic'; 'physical'; 'ecological'; and, 'economic', these issues not only reflect those of the conceptual model of sustainable management (see chapter 3) but also the guiding principles of sustainable development (see chapter 1). They also successfully encapsulate the majority of inter-Functional interests in the Agency. This breadth of information now needs translation into a simple set of criteria which may be used to readily assess the level of sustainability on any given upland rural river corridor.

5.3 Sustainable Management under uncertainty

> *'The man who insists upon seeing with perfect clearness before he decides, never decides'*
> (Amiel, F in, Baird, B, 1989).

What is initially apparent from the preliminary checklist presented above is the mixture of prompts that require sliding scales of response, figures or numbers, and yes/ no answers. This complexity begs the introduction of the clearer definition of thresholds and drivers so that either a constrained scoring system, and/or the boundaries between differing levels of sustainability, may be developed.

As has been illustrated (chapter 3), this thesis prescribes the development of a sliding scale or ***spectrum of sustainable management***. If research procrastinates whilst definite thresholds are prescribed, sustainable management will remain ambiguous. The 'scoring' of the environment has been criticised as naïve, but it is still recognised that distinct ***trends*** need to be recognised if the tool is to be taken seriously by public and practitioner alike.

Once thinking evolves towards that of sliding scales and thresholds, especially in relation to geomorphology and sustainability, there is an early recognition of ***uncertainty***.

Decision situations fall into three categories: certainty, risk, and uncertainty. Nature does not willingly comply with certainty, outcomes often remaining largely unknown from the processes, drivers or events which themselves are not always certain. Risk considers the case where more than one outcome is possible and the probability of each outcome is known if a particular alternative is chosen. All outcomes and their probability of occurrence are known. Numerous insurance decisions fall into this category. Again however, the majority of decision making in river management is not certain enough to allow risk management to always be a viable option. Uncertainty occurs where more than one outcome is possible for each alternative action and the probabilities of these outcomes are not known. Decisions are based to a great extent on subjectivity, incomplete information, and personal heuristics. The degree of uncertainty may range from partial to complete ignorance (Baird, B, 1989).

This degree of uncertainty is illustrated in the realms of fluvial geomorphology. There is sometimes an absence of rigorous methodology, robust data and a lack of understanding of the many interactions involved. This highlights the complexity of natural systems and the problems this creates for the understanding of them and for their effective management. However, one cannot wait until everything is known before decisions are taken. The continuing uncertainties and gaps in knowledge should be seen as spurs to the reduction of scientific uncertainty. The SCSD call for the strongest possible support for research into many areas of public concern, and caution against a failure to take fully into account the likely progress that scientific and technical advances may offer in the search for sustainable development. Past misjudgements should encourage a commitment to the careful monitoring of policy outcomes in circumstances where there will often be only limited data, and partial understanding of the processes at work. Resources devoted to the less glamorous activity of monitoring and evaluation is as essential as those allocated to the initial research (SCSD, 1995).

It must be argued that in the light of mechanisms such as the precautionary principle, uncertainty *per se* does not have to be seen as a limitation. In fact, it should be seen as a positive characteristic, and one that complements the often unpredictable natural changes that are implicit in all aspects of the environment. It should also be seen as an opportunity to elegantly shift the philosophy of sustainable management into the context of fuzzy logic.

5.31 The Fuzzy Logic of sustainability

Fuzzy logic is the key to successful sustainable management in that the acknowledgement of the inherent uncertainties of the natural environment, its interactions with human intervention, and the long-term effects of change, are central to the chosen level and type of management. The river, for example, is characteristically dynamic. It is often in a constant quasi-sustainable state, moving around perceived thresholds of sustainability. This movement is not of 'black or white' certainty. Instead, intervention has to be based upon 'grey' states of uncertainty. Kosko (1994) theorises that *"we can put black and white labels on things ... but the labels will pass from accurate to inaccurate as the things change"* (Kosko, 1994).

Over the last decade the theory of Fuzzy Logic has seen an accelerated growth in public, business and academic interest alike. Essentially, the fuzzy principle states that everything is a ***matter of degree***. It suggests that society really deals with three-valued or multivalued logic: statements that are true, false, or indeterminate. Fuzzy logic statements like 'grass is green' can have any 'truth value' or degree or fraction between 0 and 1, or any percentage between 0% true and 100% true (Kosko, 1994).

According to Kosko, fuzzy knowledge relates to ***fuzzy rules***, which is where the input to criteria is seen for assessing sustainability and sustainable management. The fuzzy rule relates fuzzy concepts in the form of a conditional statement: if X is A, then Y is B. The combinations of X and Y are infinite. ***Fuzzy entropy*** (meaning the uncertainty or disorder in a system) measures this degree (Kosko, 1994).

The work of Kosko may be tailored to erosion of the riverbank as an example. If one works on simple black-white logic then it can be said that the bank is either eroded or not eroded and that therefore there is bank stability or instability respectively. However, the situation is fuzzier than that. How eroded does the bank have to be before instability occurs? Or rephrased, how stable is a stable bank? …100%? …95%? Problems rapidly occur when the Fluvial Auditor is asked to decide between the bivalent decision of stable or unstable. Therefore, heuristics (if one has the riverine expertise) are used to infer the ***degree to which*** the bank is stable, or the degree to which the bank is unstable. Using the Kosko analogy, the stability set is 'A' and the instability set is 'not-A'. But the banks are not all or none of either, so that there is fuzzy entropy or vagueness in the bank stability system even if not on the fluvial audit sheet. The intermediate stages between stability and instability have simply been rounded up or down by the designer of the audit sheet.

The next stage in the development of a fuzzy set therefore is the sound science. A geomorphologist's view is needed on where the mid-point or threshold is, perhaps in percentage terms of erosion on the bank, between stability and instability. If one therefore assumes instability as number 1 (i.e. total instability or collapse) and stability 0 (i.e. no instability, totally stable), a mid-point of ½ can be assigned (figures 5.1 and 5.2). Introducing a mid-way point between stable and unstable introduces many more degrees of stability. The midpoint of the cube has fuzzy entropy 100% and is the threshold between stability and instability. All the other fuzzy unit scores in the lattice have fuzzy entropies less than 100% but more than 0% (Kosko, 1994).

Where: 11 = total instability

00 = no instability

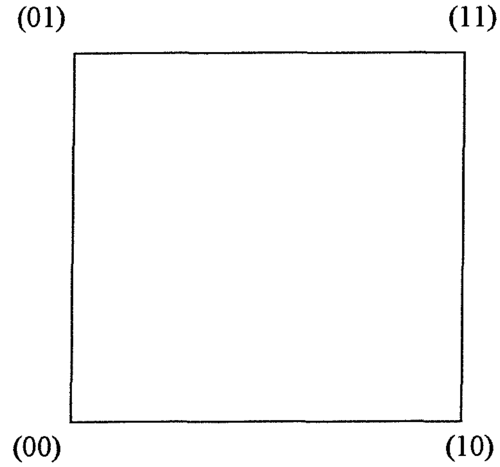


Figure 5.1: The fuzzy cube (Kosko, 1994).

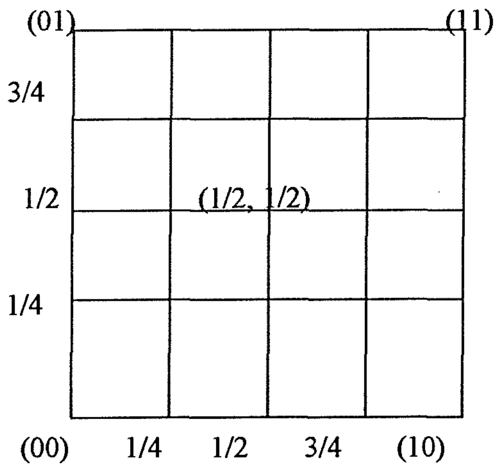


Figure 5.2: The mid-point (Kosko, 1994).

According to Kosko one can measure the fuzzy entropy with two strings (figure 5.3). The score x or fuzzy set A is defined as a point in the cube. If a dashed/striped string is tied from 'A' to the nearest corner this string keeps track of the proximity to the corner and distance from the midpoint. If 'A' moves away from the nearest corner, it moves closer to the farthest corner and vice versa. Therefore, a black string is tied from 'A' to the farthest corner. The percent measure of fuzzy entropy is the red divided by the blue. The bigger the number, the more the vagueness of 'A'.

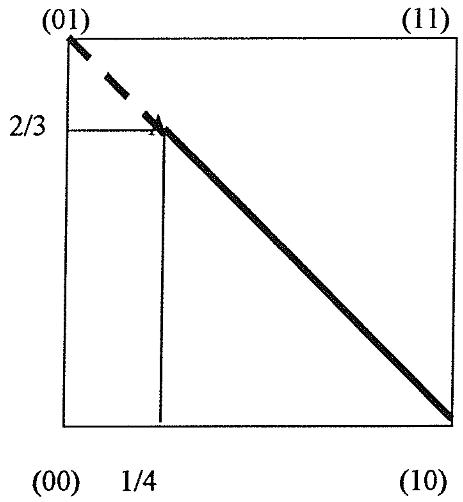


Figure 5.3: Fuzzy entropy (Kosko, 1994).

Sentences relate fuzzy sets and in this way reason that if the bank is unstable, a decision is made as to the management (or not) of that instability to bring about a sustainable state. The development of a fuzzy system is instigated. A fuzzy system is built in three steps:

- First, nouns or "*variables*" are chosen. Therefore X and Y translates as the input and the output respectively. This is seen in the riverbank as cause/ effect – for example in incision/ instability, or one step on, instability/ management.
- Second, the *fuzzy sets* are chosen. Fuzzy subsets of the initial X and Y are defined. This could be interpreted as degrees of incision and degrees of stability, or as in a further fuzzy set, degrees of instability, levels of management intervention in the system.
- Thirdly, *fuzzy rules* are chosen. This step associates X and Y sets. For instance: *if x is incision low/ medium, then y is bank stability high.*

Kosko represents the fuzzy system graphically. Fuzzy sets are drawn as triangles (figure 5.4) with the width of the base of the triangles representing the ability to control that set. For example, the wider sets lay in those states that may be hardest to control (for instance, it might prove unsustainable to try and control a level of stability that requires such a large level of intervention to shift it to the lower level of incision. This could be exemplified in the example of the 'incision medium' triangle (highlighted). If the degree of incision on the river-bank is defined as 60% then a large shift would be needed to shift it into the 'incision low/ medium' category (which hypothetically, is in this case, approximately 5-45%)).

The fuzzy rules are illustrated through the interaction of the two sets X and Y so that fuzzy 'patches' are drawn. If the entire fuzzy system is drawn as patches that overlap then these hang together and cover a line that runs from the lower left to the upper right (see figure 5.5). The less that is known about a problem, the sloppier the rules, and the bigger the patches.

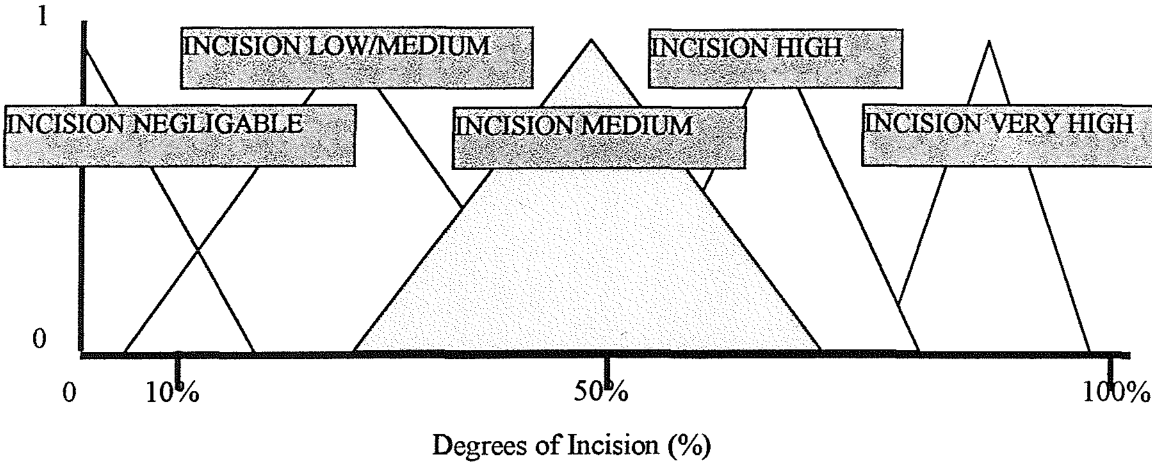


Figure 5.4: Rule triangles

Fuzzy systems are ideal for illustrating the holistic nature of sustainability and also the uncertainties in sustainable river management. The fuzzy system allows expression of heuristic knowledge in a non-math language. Geomorphological research can be referred to and expert consultation allows the conceptual drawing of thresholds.

Fuzzy logic offers much potential in its ability to aid the ***conceptual design*** of a rule-base which recognises the implicit uncertainty involved in managing natural systems. This research will not follow the graphical illustrations of Kosko (1994) but what it does do from this point onwards, is acknowledge that the bi-polar model of sustainability, the 'more or less' of sustainable decision making, is the only viable method of assessing truly sustainable river corridor management. There will often be a degree to which one rule does 'hit' upon other outcomes (or triangles) being likely, so that rule statements which predict the 'likely' change, or 'suggested' management must be seen as the most precise that the User of any system should hope to obtain.

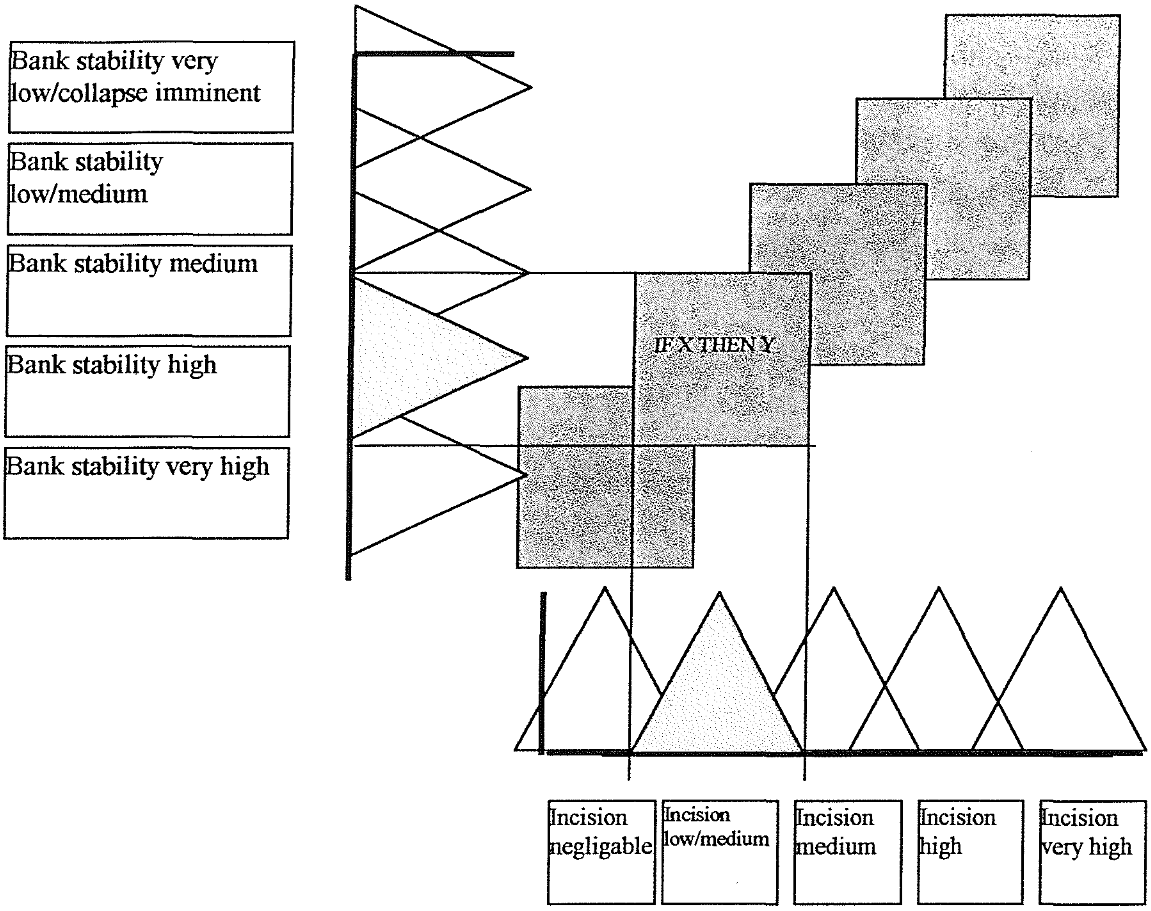


Figure 5.5: Rule patches

5.4 Introducing a rule-based Knowledge-Based System (KBS)

When one comes to putting the inter-relationships of science, philosophy, management and logic which are advocated through the preliminary rules on to paper, a kind of data overload is experienced. There is a severe danger of losing the clarity that the system needs to succeed.

One of the results of research in the area of artificial intelligence has been the development of techniques which allow the modelling of information at levels of abstraction that reflect the complexity of human thought and problem solving. These techniques are embodied in programming languages or tools which allow programs to be built that closely resemble human logic in their implementation, and thus the decision making that is required in sustainable management. These programs, which emulate human expertise in well-defined problem domains, are called ***Expert Systems (ES)*** or ***Knowledge-Based Systems (KBS)***. The complexities of 'data overload' are defined and constrained explicitly in the design of these systems.

Rule-based programming is one of the most commonly used techniques. Rules are used to represent 'rules of thumb' or ***heuristics***, used by the expert, which specify a set of actions to be performed for a given situation. Like the work of Kosko (1994), rules work on an ***if/then*** system. The *if* portion is a series of patterns which specify the facts (or data) which cause the rule to be applicable. The process of matching facts to patterns is called pattern matching. The inference-engine of the expert system automatically matches facts against patterns and determines which rules are applicable. The *then* portion of the rule is the set of actions to be executed when the rule is applicable. The inference engine selects a rule and then the actions of the selected rule are executed (which may affect the list of applicable rules by adding or removing facts). The process continues until no applicable rules remain (Riley, G, 1997).

Therefore, an expert system could take a number of interrelated expert rules (for instance, based upon those of the various players in the river management system), and determine the degree of sustainability, on a sliding scale, at either a management decision or strategic assessment level.

The decision to take up this framework as the design procedure for a sustainability evaluation system offers a number of advantages:

1. The method could be translated from a paper version to computer with comparative ease, and thus be of potential high value to the Agency;
2. The KBS irons out the innumerable intricacies and interrelationships of pragmatising the holistic (a large factor in the limitation of the concept thus far); and,
3. "...The Expert System is only as good as the expert" (Turban, 1988). System design offers the opportunity to gain highly respected opinions through reading, correspondence and structured interviews. This fulfils the need for the system to be clearly defined, transparent and accountable *and* to promote the concept further.

Everard (1995) suggested three steps in the design of an environmentally-based KBS on the sustainability of wetland use and conservation in the developed world (SWAMP). This is the only existing KBS on sustainability to the Author's knowledge and offers considerable potential for the design of a similar methodology for rivers and wetlands in the UK, if only based upon its conceptual structure. Modified from Everard (1995), the three steps to be passed in the quest for the present system could be seen as follows:

1. To identify sustainable states or uses to which the river and its riparian corridor might be put;
2. To identify the end-users and the needs of these users (including the information they have available, computer compatibility, time constraints and, existing knowledge/ expertise; and,
3. To recognise that appropriateness of sustainable state or use to area depends upon all of those characteristics included in the Agency statutory guidance towards Sustainable Development, together with the natural equilibrium of the system.

Thus, a parallel method of design for the system as that proposed in the five stages suggested in figure, chapter 3 is now posed. The two methods are actually very closely linked, but with an expert system having the advantage over desk based indices of being more easily applicable to complex situations, both spatially and temporally. Objectives, diagnostics and attributes still need to be defined, but can now be presented in a rule-based format rather than the paper index. Similarly, the concepts of thresholds and drivers and the subjective choice of objective measures are still valid, but in a system that is capable of 'remembering' linkages with other attributes. Advantage may also be taken of the ability to access such a system according to the knowledge already held by the user. So, a rule or question which is not wholly understood by the user could be explained in a separate gateway, and the user could even access the system from their own domain or Function in the EA, say Conservation, Recreation and Fisheries, or Flood Defence. Ultimately, the KBS presents a much more intelligent and cognitive form of the kind of goals and objectives discussed in chapter 3.

Developing the prototype subset of rules on screen format rather than paper, a far clearer picture of the rules is illustrated, which means that the non-specialist may converse with Computer Scientists with comparative ease when consulting on the ultimate ES that will be used.

The range of issues to be addressed and the respective *objectives* in sustainable river management have already been illustrated (chapter 3). Certain rules are easy to define, for instance if they are statutory designations (flood equivalents for example) or well known and accepted (for example bank stability indicators). Others however require more thought and ultimately iterations.

What is initially apparent from this preliminary list is the potential breadth of a prototype rule-base. To operationalise the initial rules a very simple subset is needed, to link a problem to a solution. In parallel to this, a simple software tool is required so that such rules can be operationalised with further research from these paper versions to the PC.

5.41 Identifying an Expert System shell most suited to the evaluation of Sustainable River Management

Choosing an appropriate expert system is no simple task. It is highly dependant upon the nature of the knowledge held by the knowledge engineer (this Author), the requirements of the system, the flexibility needed, the computer hardware available, funds and the methodology that has been chosen to follow. Ultimately the Author of this research project is a Geographer rather than a Programmer. For that reason, to begin from scratch and develop a system from the bare basics is not to be considered. Similarly, to develop a prototype for the Agency does not mean anything more than that – a prototype. Therefore, it need not be assumed that the software chosen for the prototype will necessarily be that chosen to continue with for subsequent implementation. For this reason the decision was made to utilise the extensive market that now exists in ***expert system shells***.

The market in Expert System Shells is a rapidly expanding and changing one, and thus not one well suited to publication in books, or even journals. In fact, the most appropriate, and by far the most extensive information source on shells is on the Internet. There exists a wealth of information (on every known shell existing at present in the 'free/cheap' market and the 'commercial' sector.

A suite of prerequisites needs to be met to choose the appropriate tool. These are:

1. MS-Windows compatibility (determined by facilities available);

2. Reasonable cost (preferably not >£500);
3. Comparatively easy to program (due to limited time and expertise of the Author);
4. 'Sellable' to the Agency (ease of use, accountable, defensible, transparent, user-friendly interface);
5. Well regarded in the field of AI;
6. Flexible to changes in the future (up-datable due to increased understanding of the rule-base, and policy changes in the EA);
7. Extensive 'help' facilities both for the system's developer and the ultimate user; and,
8. Ability to handle uncertainty.

Choosing the appropriate ES shell is only one half of the pathway that needs to be taken to develop the rule-base. The other is the parallel operationalisation of the rule-base 'list' by choosing a simple subset of if/then statements. Time and finances constraining, it has been necessary to develop a less complex software tool than the final shell, to develop these rules. The aspiration is for the Agency to develop the tool in its final shell format if the approach is deemed to be effective and justified in business terms.

MS-Windows Excel is the piece of software chosen for this stage in the research. It has three mechanisms entitled: ***VLOOKUP***; ***IF***; and, ***MACRO*** (appendix B) which make the expert system type series of if/then rules fully developable. MS-Windows Excel's ability to deal with simple rules and associations provides an excellent baseline for developing the evaluation system framework and identifying iterations that may be needed in rule-base assumptions before one accesses the final shell.

Continuing the argument throughout this research for a robust (scientific) basis to the rules, the simple subset is preliminarily based upon the geomorphological principles of propensity to change of the channel bed and banks. The reader is referred to the relevant chapter (4), for the scientific justification of this decision. A simple if/then rule-base of the interactions with the surrounding land-use is introduced along with management options. The printout of the *User Interface* of the Excel system is included in Appendix C, and the CD-Rom (thesis back cover, Appendix I). The reader is strongly recommended to access the interactive disk version for full appreciation of the consequences of changing initial conditions. For each drop down box of choices to which the user is steered, a list of rules is established on a separate page of the excel worksheet (these are shown in appendix C). The 'intelligent' rule-based knowledge of the system is contained on a further page. The need now exists to conceptualise the basic format for the software system.

5.42 SURCoMES - the Sustainable River Corridor Management Evaluation System

The decision has been made to name the evaluation system to be developed as part of this research as '**SURCoMES**' (Sustainable River Corridor Management Evaluation System) to explicitly and transparently recognise its field of applicability. Following the choice of the software system, there is an initial need to structure a conceptual model of the SURCoMES. This is required for a number of reasons:

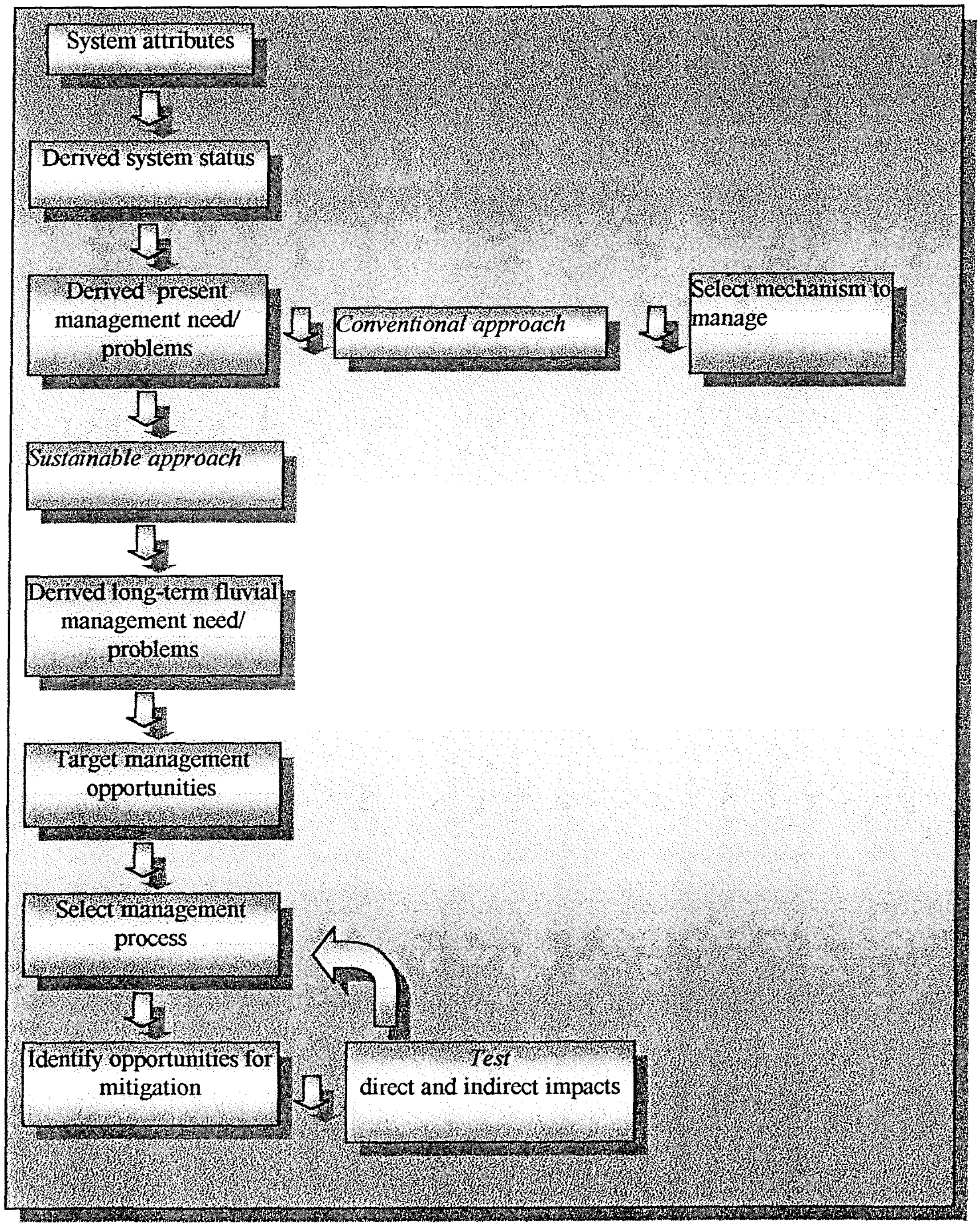
1) to define a simple conceptual map of the rule-base;
2) to define the divergence of a sustainable management system from traditional solutions;
3) to maximise the transparency of the process.

Box 5.1 illustrates in a flow diagram format, the rule-set paths of the SURCoMES. Each is considered in detail in table 5.1.

Data requirements for the system are as follows:

- River Channel Typology report (universities of Southampton and Newcastle, 1999);
- RHS version 3.1 CD-Rom (EA, 1999e);
- Stream power data;
- Data on riparian land-use;
- MAFF Land Use Bands;
- Designations;
- Mapping initiatives;
- Access routes/Public Rights of Way.

Table 5.1 highlights where more conventional approaches to environmental management interact with the model, for instance, channel quality management through restoration, or stability management through erosion control, or facility relocation. The new sustainable approach instead recognises that these measures are merely treating the symptoms and not the cause. Instead, looking towards the longer-term metastability of the system recognises that erosion control might actually be more costly in the long-term (perhaps both fiscally and socio-economically) if the system is naturally dynamic, either through flood or bed and bank process. The new sustainable management approach illustrates that rather than carrying out what at the time may be considered more sustainable solutions by the community (i.e. stopping the flood), one should be more open and transparent with that community and encourage them to face the true costs of the short term management solution.



Box 5.1: The SURCoMES model

Stage	***Process***	***Examples***
1) System attributes	Data accumulation on physical; biological and socio-economic environment	• Channel substrate • MAFF land use band • HQA
2) Derived system status	System *quality* and *meta-stability* derived from rule associations	• Channel feature combinations as indicators of stability • Number of land-use designations
3) Derived management need/problems	Derived from riparian conflicts highlighted through (2)	• Highly valued land adjacent to eroding earth cliffs ~ high management need
4) Derived long-term fluvial management need/problems	Derived from riparian conflicts with projected likely geomorphological meta-stability in *long-term*	• Highly valued land adjacent to eroding earth cliffs, expected to stabilise ~ moderate management need
5) Target management opportunities	Target based upon long-term management need and resources (funds/ land availability)	• Negotiations to let-erode • Soft bio-engineering • Restoration etc.
6) Select management process	Derived from consultations with Experts, and measured against *minimum intervention*	• If negotiations successful then let *managed* natural adjustment proceed
7) Identify opportunities for mitigation	Derived from consultations with Experts, and measured against *minimum intervention*	• Through public participation, compensation easements, property rights etc.
8) Test Net outcome	Derived through calculation of direct and indirect impacts, based upon (2), (6) and (7)	• If zero net adverse impact or minimum intervention then proceed

Table 5.1: Definitions of the SURCoMES model

The SURCoMES is a tool that offers a definable structure to the sustainable management process whilst being fully useable by a variety of audiences:

1) The river best practice project manager who wishes to identify the most sustainable option for management.
2) The local community member (whether individual member of public or community representative) who wishes to evaluate for his or herself the implications of management options on *their* river.

3) Education. SURCoMES provides an example of responsible environmental management to young people. It introduces the reality of 'being green' by illustrating how the environmental manager has to make trade-offs to achieve the optimal solution.

It is also foreseen that the SURCoMES will be combined with the present RHS version 3.1 CD-Rom (which is bound into the back of this thesis) so as to develop a fully usable and practical resource.

The conceptual format of the SURCoMES now requires translating into the software format. Excel requires a matrix style of rule association. For each if/then interaction iterated above, and to follow, a table of values and functions must be designed. It is highlighted that the ***values in these tables are less important than the trends that they hope to illustrate***. Further research and application will refine and improve the values over a time period exceeding that of this Ph.D. The following section explains the design and implementation of each rule-based association and the resulting management implications.

5.421 Present geomorphological status

Based upon the research presented in chapter 4, preliminary steps may be taken towards compiling a rule-base for quantifying present day physical stability of the river corridor. The existence of RHS is a key contributor to this process. Additionally, the RCT project, conducted by the Geodata Institute Environmental Consultancy has provided a large proportion of the baseline rules for the SURCoMES. The stability status' afforded by Watson *et al.* (1988a,b in ASCE, 1998) similarly provides a useful grounding for the rule-base.

The initial rules on resistance of the reach to erosion are based upon the criteria used to define the RCT channel stability class, so that those parameters and rules presented in box 5.3 are redefined to the SURCoMES compatible rules of box 5.4.

The initial planned procedure for the SURCoMES rule-base, to calculate both resistance to change *and* available power on the user interface, is fundamentally flawed. To provide a reliable measure of power would require at the very simplest, data on:

channel water width;
channel water depth;
length of reach;
mean velocity; and
gradient of channel bed.

Constraints on data availability mean that the latter two parameters are not provided in either the RHS (the ideal mechanism of provision) or any other consistent source with countrywide coverage. Gaining velocities (from the Agency or the Institute of Hydrology who cover approximately 500 more stations than the 900 recorded by the Agency) has been articulated as '*tricky*' and it has been suggested that '*inference is often the best way to work*' (Marsh, 1999). This begins to limit system use to only those rivers that have gauging stations, and highlights a key problem in sustainable management as being lack of data. The Flood Estimation Handbook at least provides a mechanism for assessing flood, and gives a consistent method of estimation (Marsh, 1999). The problem with flood data, especially in the UK, is the lack of information on flows just over bank-full. Floods of magnitude are less of a problem (Marsh, 1999).

The remedy would seem to be to ask the SURCoMES to calculate stream power, by inputting the parameters needed. However, this would require gradient of the channel bed (which unless they used a dumpy level), would more than likely involve the less accurate use of a 1:25,000 OS map. It would more inconveniently (for a system which is meant to be utilising existing databases and tools) require a velocity measurement. There is no known consistent (both temporally or spatially) mechanism for this in the UK.

Initially, it was foreseen that the work of Hey and Thorne (1984) and the RCT project would provide velocity data for sites which pair the Wharfe (site 199). Hey and Thorne do not have any sites which correlate with present RHS sites, so that the two sets of data could be paired in resistance and power. However, the RCT project does list 1500 semi-natural RHS sites, and the relevant stream power data. Therefore, for the purposes of the prototype SURCoMES, this data will be fully utilised.

Criteria used to define Channel Stability Class

Bank stable where:

(BE_sum+CL_sum+BC_sum+PE_sum>10)

Bank unstable where:

(GP_sum+EA_sum>10)

Substrate stable where:

(BE+BO+CL>=6 OR

(bed_matl=1)

Substrate unstable where:

(GP+SA+SI+CO>6) OR

(bed_matl=2)

Description of variables:

BE_sum	sum of bedrock bank substrate spot checks
CL_sum	sum of clay bank substrate spot checks
BC_sum	sum of boulder/cobble bank substrate spot checks
PE_sum	sum of peat bank substrate spot checks
GP_sum	sum of gravel/pebble bank substrate spot checks
EA_sum	sum of earth bank substrate spot checks
BE	sum of bedrock channel substrate spot checks
BO	sum of boulder channel substrate spot checks
CL	sum of clay channel substrate spot checks
GP	sum of gravel/pebble channel substrate spot checks
SA	sum of sand channel substrate spot checks
SI	sum of silt channel substrate spot checks
CO	sum of cobble channel substrate spot checks
bed_matl	compaction of bed material – 1 consolidated 2 unconsolidated

Box 5.2 (Universities of Southampton and Newcastle upon Tyne, 1999)

If bank substrate $\supseteq$ 50% Bedrock then stable (equivalent to <1 (Watson))
Clay
Boulder
Peat

If bank substrate $\supseteq$ 50% Gravel/pebble then unstable (equivalent to >1 (Watson))
Earth bank

If channel substrate$\supseteq$ 60% Bedrock then stable (equivalent to <1 (Watson))
Boulder
Clay

If channel substrate $\supseteq$ 60% Gravel/pebble then unstable(equivalent to >1 (Watson))
Sand
Silt
Cobble

Box 5.3: Rules of the RCT (Universities of Southampton and Newcastle upon Tyne, 1999)

It was preliminarily foreseen that sites which pair the Wharfe in certain defining characteristics, would provide a means of testing the assumptions made in the SURCoMES rule-set. The RHS version 3.1 Context Analysis (CA) function provides the most widely standardised and independent tool available to calculate such information to date. The CA provides an ideal mechanism for achieving this aim. The user of the CA is able to construct a list of RHS sites based upon the entry of a number of chosen parameters which define the site to be matched. This research is based upon "upland, rural" corridors. Therefore, the vital element to identification is essentially, *altitude*. If 'upland' is defined as 200m (+/- 10%) above sea level (EA, 1998g), then one can start searching for sites with a similar altitude only.

The input rule for the RHS PCA analysis is therefore:

> *"Sites +/- 100% proximity altitude 180-220m".*

This rule gives 256 sites, 30 being compatible with the utilisation of stream power data from the RCT (illustrated in table 5.2). The SURCoMES will therefore be developed based upon these 30 sites (including the Wharfe).

The Reader is referred to appendix C for the rule-tables described in this section.

The first rule associates the input data on the proportion of more resistant: less resistant left bank material (gained from the relevant RHS form) against the number of eroding cliffs recorded on that 500m reach. The 'score' decreases as eroding earth cliffs increase and the proportion of less resistant bank material increases. This decrease indicates a lower potential stability based upon the information that has been inputted into the system at present.

The score which is attributed to this rule-set and the following, is based fundamentally on the concept of fuzzy logic (see section 5.31 above). The score illustrates the *degree to which* the associated parameters are indicative of a more or less sustainable state. Within the first section of rules (rule-sets 1 to 11) they indicate the *degree* of geomorphological stability, which is then used to indicate the *degree* of sustainability. These sets of 'matters of degree' are progressively associated through the development of the system, resulting in a conglomerate *degree of sustainability* illustrated on the spectrum of sustainability. This degree aims to illustrate the present and future levels of sustainability on the relevant reach, and also its level on the spectrum of sustainability relative to other rivers of the same type. For this reasoning, the actual scores are less important than the trends which they display.

Following the calculation of this first rule for the right-bank also (rule set 2), the system now relates the two sets of tables, based upon a similar table of 'scoring' to develop a conglomerate score for the bank stability based upon resistance of substrate and earth cliff occurrence.

A question arises as scores begin to associate. As one combines substrate and features for both banks of the reach there are three choices:

1) combine scores additively;
2) combine scores multiplicatively; or
3) combine scores based upon a unique constructed rationale.

To combine scores ***additively*** will result in a very transparent index of scores. The user would see in the most accessible manner, how and why certain entered data give each resultant score. However, the number of rule-sets in the SURCoMES means that the agglomerating additive score becomes increasingly large as more data is entered and more rule-sets associated.

Combining scores ***multiplicatively*** eliminates much of this problem as many of the scores will be within a range +/- 5 around zero. Therefore, the resultant score may sometimes be negative. However, as the reader will see in the following pages, multiplying some scores would imply weighting particular relationships by an order of magnitude exceeding that of reality (e.g. influence of parameters on resistance to change in rule-set 12). For this reason, multiplicative scoring is constrained to only a small number of rules (see below for detail).

Finally, scoring parameters on a ***constructed rationale*** unique to the SURCoMES allows the controlled marriage of the above two alternatives. Therefore, both may be used, but where appropriate. As the reader will see, the additive system is used within most rule-tables, but the multiplicative system used more frequently when associating one rule-table with another. The choice of this methodology allows the transparency of option 1, with the flexibility of option 2. Appendix C provides the rule-tables for illustration.

In the case of rule-set 3, option 1 was adopted, and the scores combined in an additive scheme. Following on from rule set 3, and again based largely on the RCT, 'Bank Profile' is introduced into the rule base. Here, the extensiveness (as defined by RHS (33%)) of vertical/undercuts and/or vertical and toe on the RHS Sweep Up survey is inputted by the User. This information is combined with the previous rule set (3).

Rule set 4 again highlights an additive system. To have extensive vertical/ undercutting of the bank is obviously more unstable than if there were none. First, the preceding score (rule set 4) and extensive vertical undercuts are simply combined. This has to score negatively with regard to stability (this would be tackled differently if it were assessing habitat value). However, the reach must not be over-scored for *not* having vertical undercuts, therefore a low positive score is assigned if there are less than 33% vertical/undercuts.

Finally, with regard to indicators of the present bank stability of the reach, the present agglomerated score is combined with the extent of tree cover (which again is based upon the RCT schedule). This is prescriptive of the ability of the bank to retain more resistance through tree roots giving a greater degree of capacity to hold the substrate together.

Due to the uncertainties of the quantitative value of tree extent provided by RHS it is problematic to introduce more than a simple additive system of rules. In reality it is recognised that the significance of both banks having continuous tree cover is probably of an order of magnitude greater than adding one or two 'points'. However, until further research begins to unravel the significance to this degree of scale, it suffices at this level of research to recognise that a greater number of trees signify a greater potential to harness erosion. Further, the aim of the SURCoMES is to provide relative assessment (more or less sustainable) and in so doing, gains enough information from such a scale. Therefore, continuous trees on both banks score '+2' and those on only one bank, '+1'. If there is no continuous tree cover then no additional score is given.

The field indicators of bank stability are now to be combined with similar indicators of the stability of the channel bed. Similar to the procedure followed for bank stability, the initial rule sets establish the features and substrate of the bed. Thus, the extent of exposed bedrock/boulders in the spot checks of the RHS is placed against the extent of unvegetated mid-/point- and /or side-channel bars for rule set 6.

For the above reasoning, the scores for rule set 11 are defined as follows. An average (mean) is calculated between the calculated score for bed stability and the calculated score for bank stability. The field indicators that have been used to prescribe the stability of the reach have not attempted to define whether channel and/or bed are aggrading or degrading, as the Watson schedule would require, but simply how *stable* they are. Instability (i.e. lower values) may be identifying either extreme. It could be argued that the SURCoMES should perhaps include indicators of these two extremes, but by so doing a far greater degree of error is introduced. Similarly, the SURCoMES is a tool only to instigate further investigation by thorough fluvial auditing, dynamic assessment and various other means. Therefore, it is better not to prescribe incorrectly at this stage of the sustainability audit, but to simply identify *trends* in an informed manner.

5.422 Propensity to geomorphological change

From defining the above rules and interpreting their associations through a valuation system a measure of the ***present geomorphological status*** of the reach is now achieved. This is a valuable tool in identifying a baseline for geomorphological surveys of any kind. However, without the following parameter, little may be said on that reach's propensity to change, or how long-term that reach's status will be. Therefore, to introduce long-termism into the SURCoMES there is now a need to define the ***power*** available in that reach and the effect that that given power may have on the given resistance of that reach to change. The concept of propensity to change is fully discussed in chapter 4, to which the reader is referred.

Rudimentary associations now need to be built between the stability gained from field indicators above, and the stream powers of the reach. This will identify whether:

1. stream power has an affect on upland reach stability;
2. if there is a relationship, where might thresholds lay between stability and instability; and,
3. stream power/resistance relations provide predictive power at a generic level.

These associations were progressively developed based upon the testing and iterations of the inter-relationships between the parameters indicated in row 1 of table 5.3. Figure 5.6 was used to develop the correct trends. For instance, as bed and bank stability both increase from the previous site, as in site 4, then overall channel stability needs to increase by a consistent magnitude. Similarly if bed stability increases, but bank stability decreases then overall channel stability will increase by a lower order of magnitude (for example, site 10). The reader is referred to figure 5.6 for further illustration. As mentioned previously, rather than the figures or scores which are indicated in such a graph, it is the relative trends of different states of stability which are important for the resulting system.

RHS site	Alt.	Power	LBM	LBF	CS	RBM	RBF	Vrtcl/ Undct	Exp bdk	Unvg Bar	Veg bar	Mtr isl	Tree xt	Bed Mat	Bank stab	Bed stab	Chnl stab	RCT stab
7	215	142.84	3	1	1	3	1	2	1	1	2	2	3	2	3	5	4	0
32	200	118.59	3	2	1	1	2	2	1	1	2	2	3	2	2	5	3.5	5
63	220	310.64	2	2	2	3	2	2	2	2	2	2	3	2	-1	-4	-2.5	5
88	185	8.95	2	1	2	2	1	1	2	1	2	2	3	1	3	-1	1	0
102	210	427.66	3	1	2	3	1	1	2	1	2	2	2	2	6	-3	1.5	11
120	215	62.41	3	1	2	3	1	1	2	1	2	2	3	1	5	-1	2	15
123	180	60.49	2	1	3	2	1	1	2	1	2	2	2	1	4	4	4	10
140	200	219.48	2	1	2	2	1	1	2	1	2	2	2	1	4	-1	1.5	14
150	210	10.05	2	1	1	2	1	2	2	1	2	2	3	1	1	6	3.5	4
155	180	76.28	3	1	1	1	1	1	2	1	2	2	1	2	9	4	6.5	11
159	220	279.43	3	1	2	3	1	1	2	1	2	2	3	2	7	-3	2	11
169	215	177.35	2	1	3	3	1	2	2	1	2	2	3	1	2	4	3	13
199	200	1443.5	2	2	2	2	2	2	2	1	2	2	3	2	-3	-3	-3	2
215	180	74.09	3	1	3	3	1	1	2	1	2	2	2	1	6	4	5	3
381	210	81.71	2	1	2	2	1	1	2	1	2	2	3	1	3	-1	1	7
398	190	38.09	3	1	3	3	1	1	2	1	2	2	1	2	7	2	4.5	11
506	185	9.17	2	1	2	2	2	2	2	1	2	2	2	1	-1	-1	-1	2
561	180	21.71	2	1	2	2	2	2	2	1	2	2	3	2	-2	-3	-2.5	0
681	180	39.33	2	2	2	2	2	2	2	1	2	2	3	2	-1	-3	-2	2
723	200	38.59	2	1	2	2	2	2	2	1	2	2	3	1	-1	-1	-1	2
762	195	172.87	2	2	2	2	2	2	2	1	2	2	3	2	-3	-3	-3	2
797	200	59.86	2	1	2	2	1	1	2	1	2	2	3	1	3	-1	1	2
800	200	23.02	2	1	2	2	1	2	2	1	2	2	2	2	2	-3	-0.5	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
841	215	63.08	2	2	2	2	2	2	2	1	2	2	3	2	-3	-3	-3	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
977	200	64.34	1	1	1	1	1	1	2	1	2	2	1	2	10	4	7	11
1020	220	38.59	2	1	1	3	1	1	2	1	2	2	3	2	4	4	4	0
1293	200	20.75	1	1	2	1	1	2	2	1	2	2	3	2	6	-3	1.5	0
1479	220	20.75	1	1	2	1	1	2	2	1	1	2	3	2	6	-2	2	9

Please note:
[illegible]: <7.5 w/m2
Highlight: 7.5 – 35 w/m2
Highlight: >35 w/m2

Table 5.2: Parameters and stream power for Wharfe paired sites

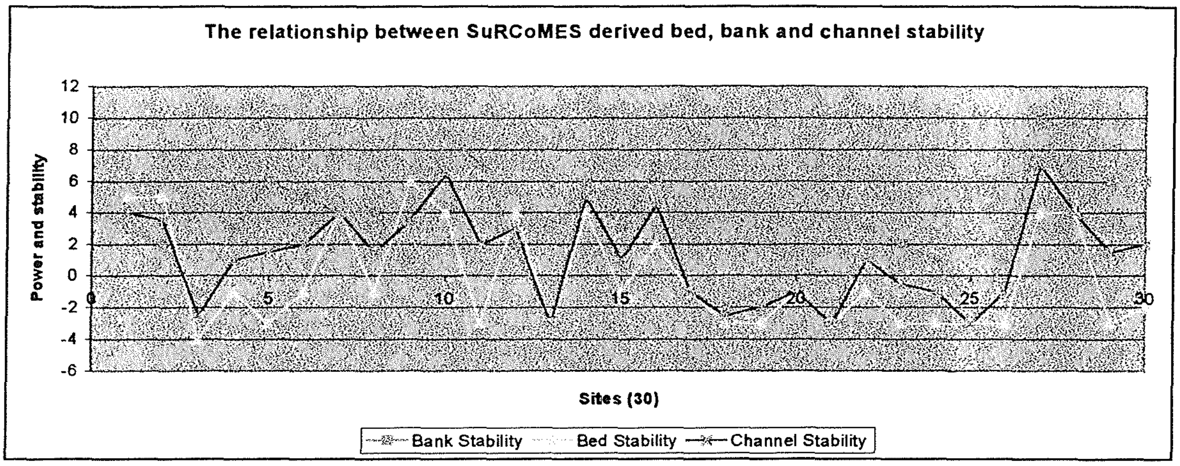


Figure 5.6

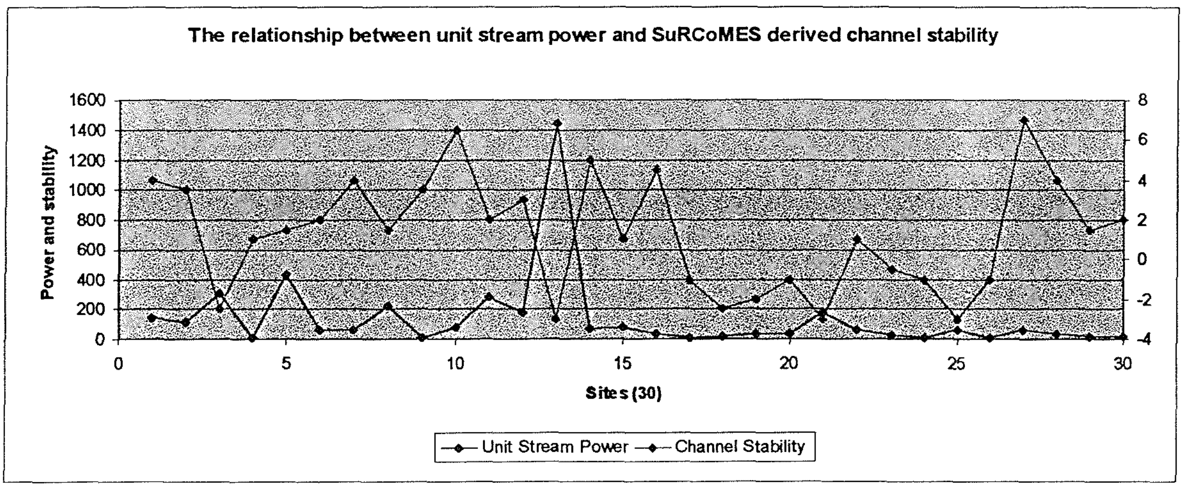


Figure 5.7

Table 5.2 also illustrates the stream power (gained from the River Channel Typology project, Universities of Southampton and Newcastle-Upon-Tyne, 1999). This information is then used to identify whether a strong relationship exists between the channel stability calculated by the SURCoMES and stream power. Upon reference to figure 5.7 it can be seen that the data set is too small to identify a quantifiable relationship between the two parameters. There appears to be an inverse relationship between increased stream power and decreased stability. However, it is not possible to calculate any meaningful sensitivity analysis, for example, the Pearson Product Moment Correlation coefficient, as neither parameter can be said to be dependant on the other.

Instead, there is a need to break the power range of approximately 1443 watts/m2 into sub-categories and identify any existing stability trends that fall within those ranges. Based upon earlier discussion (section), the sub-categories are those of Brookes (Brookes, 1985, 1987, 1990 in, Darby and Simon (ed.), 1999):

<7.5 watts/m2

7.5 – 35 watts/m2

>35 watts/m2.

Consistent with the remit of this PhD to provide 'guidelines' and not absolute figures at the scale of geomorphological process, values in the resistance/power table are to be standardised to a *ranking* of importance. Thus, values in table 5.2 range from –3 to 7. Rather than evaluate the partings and ranges of each combination, remaining generic is preferred, simply ranking for instance, 'power >35, dominant weak substrate, consolidated sediment, trees on one side only' (which equals 1.5) as one ranking higher from the next lowest value which is a group of stability scores ranging from –3 to –2 for 'power >35, dominant weak substrate, unconsolidated sediment, no trees'. Thus the increment does not reflect the true difference of ((value=1.5)–(values c. –2.5)) but an increment of –1. Thus, weighted values are attributed to each of the parameters outlined in table 5.4. This table illustrates graphically, the trends occurring with the Brookes divisions. Broadly speaking, it illustrates clearly that parameters have an effect upon stability in the following order of importance:

1) Whether bed material is consolidated;
2) Increasing continuous tree cover;
3) Increasing strength of bed and bank material.

These are weighted with respect to their ranking of significance (table 5.5).

Site Description	< 7.5w/m2	7.5-35 w/m2	> 35 w/m2
Dominant weak substrate; Unconsolidated; No trees;	-1	-2.5	-3 - -2
Dominant weak substrate; Consolidated; No trees;		1	-1 - 1
Dominant weak substrate; Consolidated; Continuous trees on one side only;		-1	1.5
Dominant weak substrate; Unconsolidated; Continuous trees on one side only;		-0.5	
Dominant strong substrate; Unconsolidated; Continuous trees on one side only;			1.5
Dominant strong substrate; Consolidated; No trees;		3.5	2 – 3
Dominant strong substrate; Unconsolidated; No trees;		1.5 - 2	2 - 4
Dominant strong substrate; Consolidated; Continuous trees on one side only;			4 – 5
Dominant strong substrate; Unconsolidated; Continuous trees on both sides;			4.5 - 7

Table 5.4: Relationship between parameters, stability and stream power

Parameter (in order of importance)	Weighting
Consolidated bed material	1
Continuous trees one side only	2
Bed and banks dominant strong material	3
Continuous trees both sides	4

Table 5.5: Weightings for each significant resistance/power relation

Based upon the above, to formulate the long-termism of the present geomorphological status, the resistance to change is now calculated. The parameters of resistance required are, bed and bank substrate, tree extent, and bed material. The valuations are conducted in a similar manner to rule sets 1 to 11, with scores being derived additively from the weighted values (see appendix C).

The reach is first assigned a value based upon the bank resistance, so that, as in earlier rule sets, bedrock is highlighted as having most resistance. Similarly, in rule set 11, bed and bank substrate combination of predominantly bedrock scores the highest value.

The resistance to change calculated thus far is now combined with power. As explained in chapter 4, the power divisions decided upon are based upon robust geomorphological research and are chosen for their generic value. Extensive research has been conducted, based upon the context analysis module in RHS version 3.1 and geomorphological knowledge, to assign the values illustrated in the following two IF function (see appendix) formulae.

=IF(Sheet2!D110=1,4,IF(Sheet2!D110=2,2,IF(Sheet2!D110=3,0,0)))

= If the extent of trees is continuous on both sides, then score 4, if only on one side then score 2, otherwise score 0.

=IF(Sheet2!D115=1,1,IF(Sheet2!D115=2,0,0))

= If the bed material is consolidated, then score 1, and if not then score 0.

To gain the overall ***propensity to change*** the results of these formulae and tables and are summed and then taken away from the present reach stability status.

5.423 Management Need

A measure of the likely long-term resistance of the reach is now known. The system now needs to derive ***management problems/ need*** based upon this data so that quality and stability management may be determined.

For this stage to evolve there is a need to:
1. derive the *socio-economic status* to parallel the geomorphological status;
2. input present quality of the river habitat (derived from HQA and *State of the Environment*);
3. combine (1) and (2) with the present and projected geomorphological status.

Prompts 13 to 21 of the SURCoMES user interface (appendix C) define the socio-economic status of the reach. The user is asked to input whether the reach has any land uses which the river manager will need to have regard to with particular respect to decisions implying an increase or even continuation of land-take or flood. Thus, the user is prompted so that the following rules (table 5.6) are constructed behind the screen:

If Land Use Band on Left Bank x then score y
If Land Use Band on Right Bank x then score y
IF agri-environment designation = YES then score 1, NO = 0
IF wildlife designation = YES then score 1, NO = 0
IF heritage designation = YES then score 1, NO = 0
IF landscape designation = YES then score 1, NO = 0
IF miscellaneous designation = YES then score 1, NO = 0
IF mapping initiative designation = YES then score 1, NO = 0
IF access routes = YES then score 1, NO = 0

Table 5.6: Socio- economic rules

It is foreseen that with further research these prompts would gain from the weighting of each parameter so that importance could be assigned to each parameter. These weightings could either be set nationally, or set on a project by project basis.

The sum of these rules gives the qualitative value of the land to either side of the river channel to a distance of 50m. This information is used as the arm of rule set 16 – the ***present management status*** of the reach - based upon present socio-economic status and present geomorphological status.

The formative elements of present management status have been categorised into orders of low; moderate; and high. This approach has been taken on the basis of the need to retain the breadth of conclusions, but with as much clarity as possible. To develop a three-order system of low to high there is a need to necessarily narrow down the 'noise' of a high number of figures.

The next stage involves the calculation of the geomorphological shift that will occur if the present geomorphological status and the projected future geomorphological status are not equal. Again, a simple ordination of low; medium; high is used for the definition of this shift.

Based upon information on this likely propensity to change of the reach and its present status, there is now a requirement to determine the ***future management need*** of the reach (rule set 17). The formative parameters within this rule set are present management need, and the projected shift or extent of geomorphological stability. This resulting combination provides the user with a clear indication, again on a sliding scale, of how sustainable management of the reach will be, or inversely, is it more sustainable to let this reach adjust naturally?

A particularly interesting facet of the Excel lookup system, as mentioned in section 5.41, is a) the IF function and, b) VLOOKUP. These two functions are the method by which the above rule sets are combined in both the tabular formats, but also page to page.

For instance, the following formulae are those inputted into the background workings of the system to define those values that appear to the user.

IF(C108<2.5,"low", IF(C108<6.5,"moderate","high"))

This formula dictates that ***if*** the data in cell C108 (which is the result of "present geomorphological stability status") reads at less than 2.5 in value, ***then*** the output in this cell will read "low". ***If*** the data in cell C108 reads at less than 6.5 but more than 2.5, ***then*** this cell will read "moderate". If both of these are not true, i.e. ***if*** these statements are ***false***, ***then*** this cell will read "high".

This rule formulation illustrates how the "IF" function of the Excel software follows the proposed format of the SURCoMES system perfectly. One is also able to extend this function to scores of the background information and data processing.

Similarly, the IF function has the ability to define more simple true/false statements. An example of this would be the background formulation to the user interface prompt on land-use designations.

IF(C191=1,"presence of agri-environment designations"," ")

Here, the user interface has already linked to a separate sheet with a separate function which scores for the fact that the user has identified the presence of agri-environment designations. Now, in this formula, a statement needs to be assigned to that score. So, if cell C191 scored 1, then it will be stated that there is a "presence of agri-environment designations". However, if this statement is false, then nothing is stated. In other words, there will only be a statement re-interpreted to the user if he or she recorded in the affirmative.

This style of formula was used for a number of rule sets to fully harness the capability of the system. For instance, it has been used so that information may be fed into the user interface as it is gathered, to complete management statements (see appendix C). These statements are presented in a user-friendly language and are intended to maximise the accountability and transparency of the SURCoMES system.

Additional to the IF function, the VLOOKUP function is used to extract the relevant values from each of the rule set tables. For instance:

VLOOKUP(B161,H250:T279,(K243+1),FALSE)

This formulae "looks up" cell B161, the value for 'propensity to change', and equates this to the table which covers cells H250:T279. The function then identifies which column to look down on the table as defined by the value in cell K243 ('present management status') to find the tabulated value. In this case, the function is acting on the table of rule set 17, figure 4.18 above.

One further piece of information relevant to this section of the SURCoMES, which is prompted by the user interface and directed back to the user in a more useable format, is the habitat quality assessment (HQA) score of the reach. This provides a useful indicator in its own right, but is also of direct use to later functioning of the system. From the habitat quality assessment score that the user inputs, the system guides information back to the same interface on the class of that reach and description of that reach relative to others 'of the same type'.

The 'same type' refers to the characterisation of semi-natural river habitats within the RHS system based upon habitat features using ordination techniques (Jeffers, JNR, 1998). From the determination of the altitude, slope, distance from source and height of source at any number of points along a given river (gained from the RHS database), it is possible to plot the corresponding component scores on the ordination of the first two components. The positions of the plotted points then help to characterise the RHS survey sites into the eight types of:

1) montane low energy
2) montane high energy
3) upland low energy
4) upland high energy
5) lowland low energy
6) lowland high energy
7) coastal low energy
8) coastal high energy

(Jeffers, JNR, 1998).

The Context Analysis function of RHS version 3.1 allows the User to access the resultant graphical representation of this method, so that any given semi-natural river may be located on the graph relative to others within a chosen percentage of proximity based upon the altitude, slope, distance from source and height of source. This provides SURCoMES with the ability to utilise this method as part of its habitat quality appraisal process. It also offers significant potential for future research into the utility of such a method for identifying relative levels of sustainability between rivers of the same type. The reader is invited to explore the operation of the CD-Rom version of SURCoMES before moving to consider its management implication.

The next step in the SURCoMES is to identify and target the ***management opportunities*** open to the reach, in the light of the derived management need. For example, will the reach be 'maintained and enhanced' or 'restored'. This section of the system utilises directly the decision paths derived from expert consultations. Description of the consultation process is provided in the remainder of this chapter.

5.43 Validating the Expert System – Involving the Experts

It is not sufficient or proper simply to assign thresholds and boundaries in sustainability and sustainable management based upon the knowledge of one author, particularly in a subject as diverse as sustainability. A selection of pilot rules may be offered, but it is impossible to progress from this stage without more constrained thresholds to change. There is a need to spread the accountability of the rule-base through participation. This is known as the Delphi Technique. Within the context of expert systems, this validation is also known as knowledge engineering. Knowledge Engineers are simply the human forums for collection and collation of data, thresholds, implicit knowledge, and rules, before these are then presented (usually in the software format) as the expert system.

In this research, it has been advocated from a very early stage, that a system for sustainable river corridor management in the U.K. Environment Agency should be firmly rooted within a robust science base. This may be achieved to a certain degree by a thorough literature search. However, much of management, whether environmental or infrastructural, is a form of 'art', and many of the rule systems that individuals work to, are implicit to themselves, rules-of-thumb or heuristics, based upon experience and background. This is why it is just as important to capture the human expertise as it is to capture the more widely referenced material.

It is also equally important for a system or tool that will be used by people with known expertise to be in agreement with the assumptions and outcomes of that system. If they are not, then the system will lack any form of respect within the circles that the system is intended for. It is for that reason that as well as adhering to the issues discussed in chapter 3 (e.g. utilising existing databases; using appropriate language) the final users need to be involved in the formulation stage of such a system.

In line with this recommendation, two consultation documents have been produced to parallel the information gained from the literature.

These documents have been exposed to a series of consultation stages that were felt necessary if the resulting tools were to be consistent with the best practice guidelines suggested in this research. Thus, consultees and the consultation periods were as indicated in appendix D. The number of 'experts' consulted in these participatory exercises was necessarily constrained. This decision was rationalised on the basis that the SURCoMES is a prototype which forms only one part of a wider research project. For full participation, further research is needed that will engage more players than practical in such a project. Complementing this recommendation is the capability within the prototype system for easy adjustment of the rules and thresholds as other expertise does become available.

5.431 Defining the rule-path to Sustainable Management (SURCoMES Part II) through a decision (tree) support model

Consultation .1

Further to those rules defined in section 5.42, a need exists for clearer definition of the rule-pathways that the expert applies to his or her management decisions after the definition of the current and proposed future scale of ***management need*** on the reach.

Complex intuitive decision making is increasingly being replaced by less complicated representation of the underlying subcategories ('decomposition'). This is used to assist the river manager in systematically determining appropriate goals; comparing the available alternatives or 'options'; estimating and utilising probabilities, costs, benefits, and risks (Baird, B, 1989). Under both the inherent risk and uncertainty of environmental management, the scientific rational approach of defining the decision path aims to make the most intelligent use of sparse information to assist the decision-maker in reaching an informed choice.

There are a variety of methods for capturing this information, with decision trees being the most easily illustrated and understood in the realm of the present challenge. These are graphical and thus far more accessible for ease of reference. Decision trees also add a further pragmatic dimension to the SURCoMES. They do not have the capability to build in fuzzy logic as with SURCoMES Part I, but they allow very practical recommendations to be made.

Baird summarises the defining elements of the decision tree,

> *'decision trees (also referred to sometimes as probability trees) are diagrams representing sequences of lines which depict probabilistic events branching to all possible sequences that can occur in any situation. At any source of branches (a node), the branches must be mutually exclusive and collectively exhaustive. Only one event may occur and all possible events are represented. Thus probabilities at every node sum to one. The probabilities on the first branch are simple or unconditional. Thereafter the probabilities are all conditional since some prior event must have occurred in order to reach that point in the tree'*
>
> (Baird, B, 1989).

The decision trees modified in this thesis do not represent the probability of situations occurring. Rather, they represent the heuristics that the river manager works with in ideal circumstances (i.e. with sufficient knowledge and experience). However, the structure remains the same. Thus, a simple decision tree for example might follow figure 5.8. Here the river manager is posed with the decision as to whether or not to manage the first unconditional statement or scenario (degrading or stable).

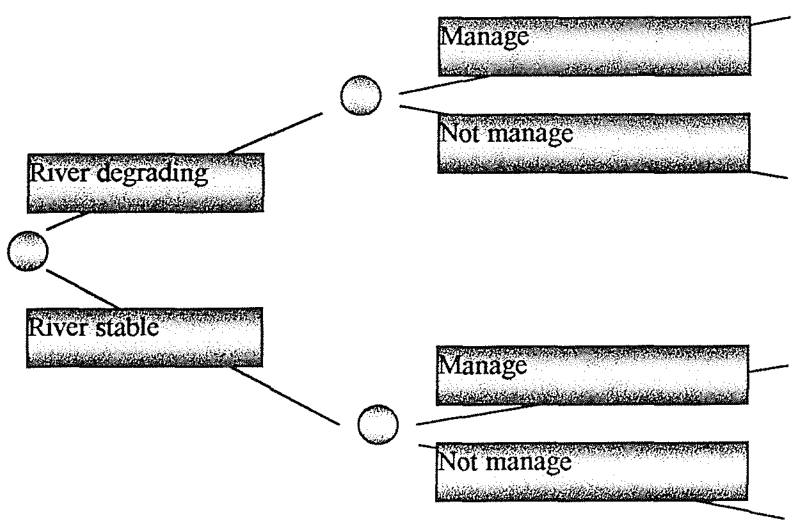


Figure 5.8: A simple conceptual decision tree

The SURCoMES consultation document engages the true complexity of this scenario so that ultimately there are five major branches and over ten times that many nodes and sub-branches (see appendix F).

The negative side of using this method over interviews as a preliminary stage is that a certain degree of bias is introduced from the outset by the initial decision to structure the trees prior to consultation and *then* ask for opinion. However, in the limited time and resources of a PhD research project, a degree of constraint is needed at the inception of the consultation. It is also emphasised at every opportunity, both verbally and on paper, that these suggestions are by no means the end-product, and that indeed, criticisms are welcomed. Following these consultations, a number of significant changes were made to the trees. An initial selection of ten trees was simplified to only five, and the content iterated and improved likewise.

A further important facet of using such a graphical method is in that the succeeding discussion of this thesis may then be visualised and indeed formulated within this decision support model.

Further, three ***simplified maps*** of the decision pathways are constructed (figures 5.9 – 5.11). It is planned that these would provide an overview for the user so that from the earliest stage of use, the outcomes and consequences of decisions are articulated clearly. This clarity could be heightened further by the power of the system to provide a generic auditing tool. Each significant branch of the decision making tree could be assigned a 'cost'. This cost will obviously change within a short period of time and around the country. The real cost could therefore be given in relative terms as a ranking. This would allow the user to base his or her decisions on transparent cost: benefit ratios between different branches.

The details of the decision tree branches have developed directly from the key discussions and recommendations of this thesis. Box 5.4 is a summary of the five decision trees developed.

Decision Tree	Issues
A	Defining the management problem
B	Hydraulic Modelling for constructing a new channel
C	Sustainable management options where minimal land constraints
D	Evaluating the cost: benefit of land protection: 'land-take'
E	Management schemes and incentives

Box 5.4: Titled decision trees

The content of the decision trees is a conglomerate of relevant research (Brookes, A *et al.*, in Brookes and Shields (ed.), 1996; Brookes and Sear, in Brookes and Shields (ed.), 1996; Brookes and Shields, in Brookes and Shields (ed.), 1996; Cooper, AB *et al.*, in Haycock *et al.* (eds.), 1997; Downs, 199; EA, 1997 (Witham); FWAG, 1997; Gardiner, and Perala-Gardiner, in Haycock, NE *et al.* (eds.), 1997; MAFF, 1993, 1996, 1996a; RKL-Arup, 1998; Sear, in Brookes and Shields (ed.), 1996; Tytherleigh, in Haycock *et al.* (eds.), 1997) and the result of consultation phases 1 and 2 (see appendices F and G). Further, those branches illustrative of specific expertise have been developed with the relevant expert (e.g. Branch B 'Hydraulic Modelling' was developed with Dr D Sear of the University of Southampton).

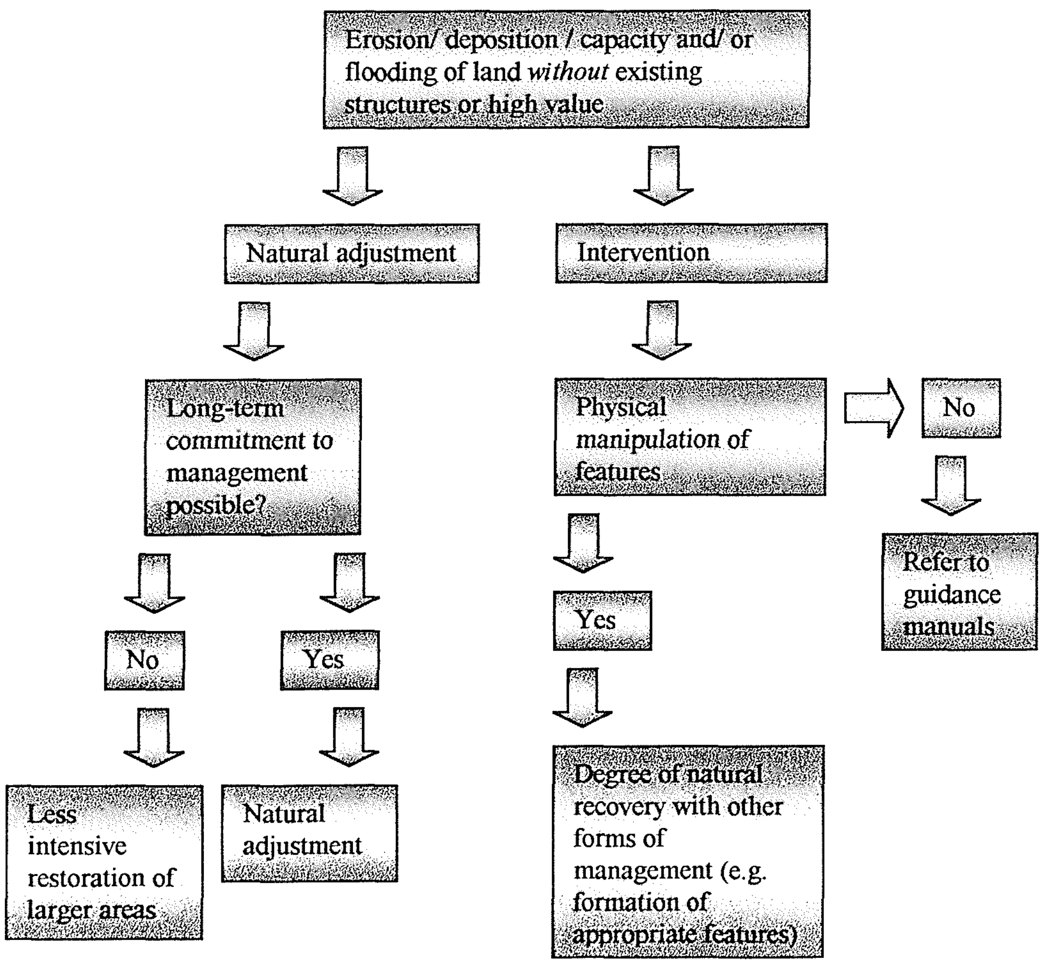
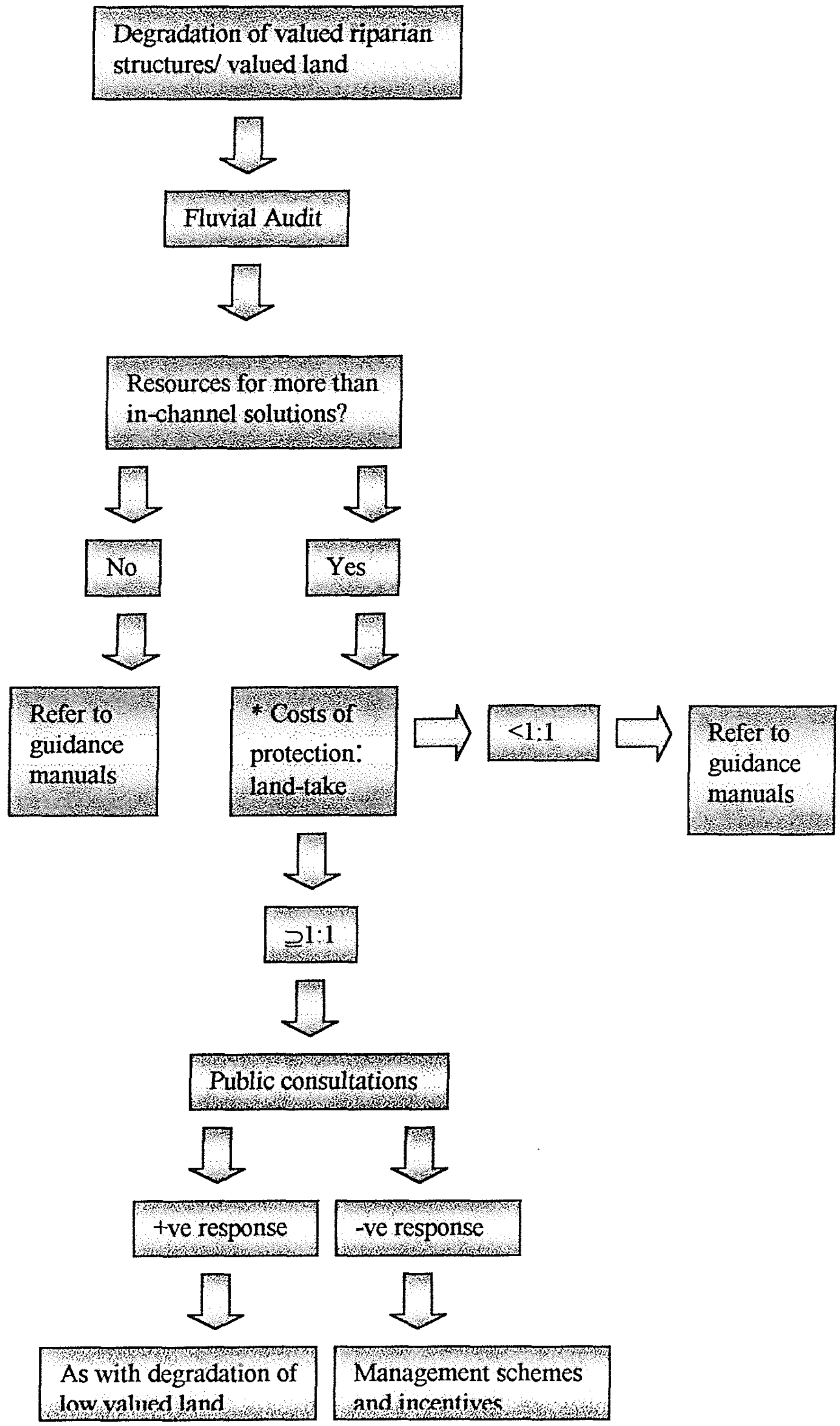
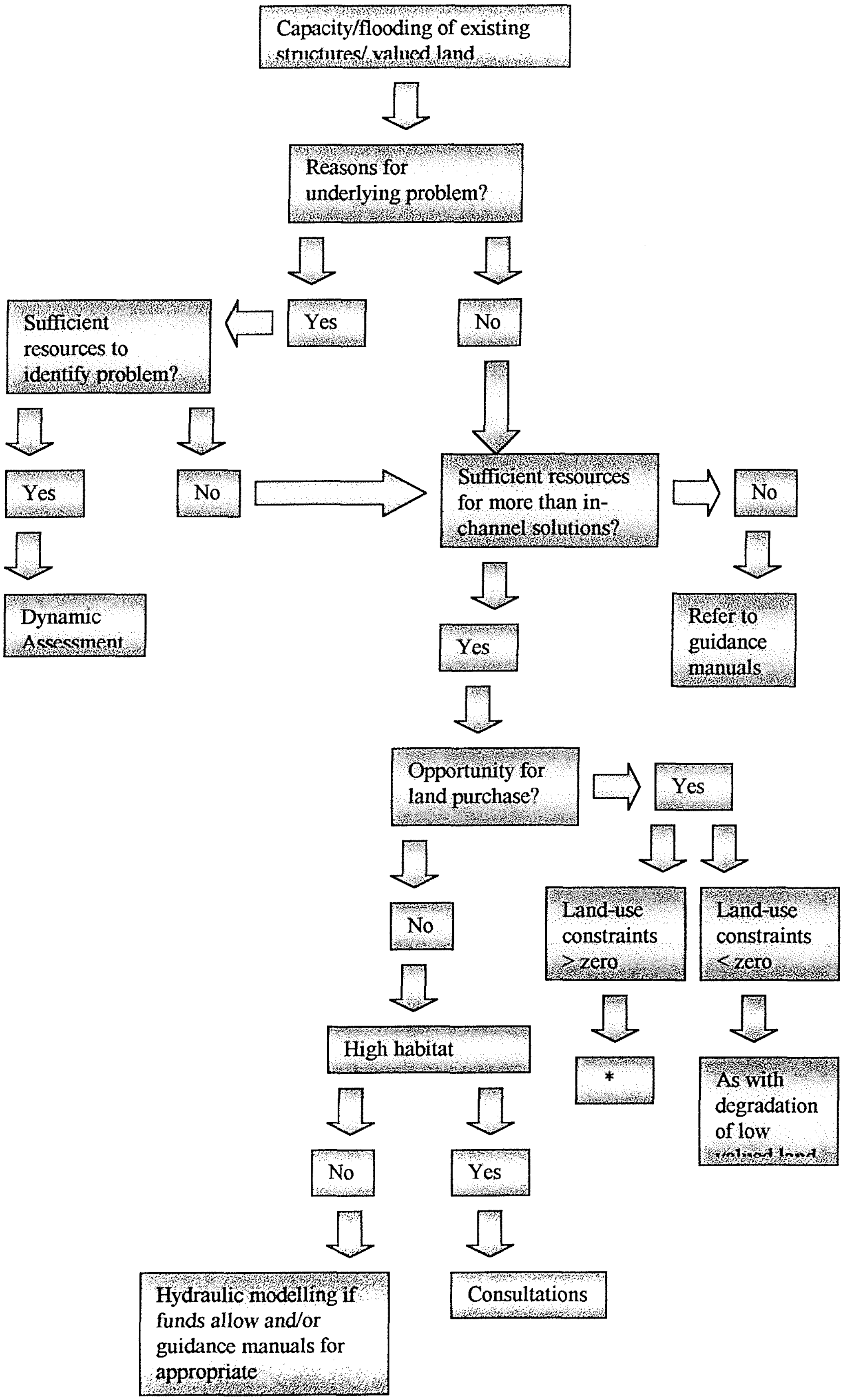


Figure 5.9: Simplified decision tree.1



Figures 5.10 and 5.11 (see over): Simplified decision trees.2 and .3


Capacity/flooding of existing structures/ valued land
Reasons for underlying problem?
Yes
No
Sufficient resources to identify problem?
Yes
No
Dynamic Assessment
Sufficient resources for more than in-channel solutions?
No
Refer to guidance manuals
Yes
Opportunity for land purchase?
Yes
Land-use constraints > zero
Land-use constraints < zero
*
As with degradation of low
No
High habitat
No
Yes
Hydraulic modelling if funds allow and/or guidance manuals for appropriate
Consultations

The content of the trees is self-explanatory. They are formulated on the basis of an 'ideal' best practice project, and illustrate the decision paths that *should* be taken to this end. Site-specific adjustments could be envisaged and incorporated.

5.5 Evaluating the sustainability of sustainable 'Best Practice Projects' – The Sustainability Appraisal Matrix - SAM

Consultation .2

SAM is an evaluation matrix based upon those often used in EIA (appendix G). Not unlike SURCoMES 2, this document was extensively tested and refined with fellow researchers at the University of Southampton prior to its release to the non-University environment. It has been formulated for three distinct reasons:

1. A forum for ranking consensus and expert opinion on perceived good management practice.
2. A method that illustrates how individuals with known and varied backgrounds (e.g. Flood Defence and Conservation; theorist versus practitioner) trade-off between various issues.
3. A method by which the issues implicit to the Agency infrastructure that may either constrain or provide potential in the drive to a more structured approach to sustainable river corridor management, may be illustrated.

In summary, the original checklist was composed of 69 parameters, all of which were modified, and in some cases considerably redefined from the initial rule statements of chapter 3, and key elements of the thesis. The user was initially asked to follow the instructions in box 5.5.

At the base of the matrix a number of blank rows were included. Consultees were instructed to add any additional parameters that they felt were missed in the present schedule.

Following several months of consultations and iterations with the experts, the SAM consultation document was modified to that presented in appendix G. This document, as its introduction suggests, is presented as a simple checklist to aid the decision making process in the planning and implementation of the Best Practice Project. Consultations defined the weightings which were considered appropriate for

Synchronous with the period leading up to the Earth Summit in Rio de Janeiro in 1992, the International Organisation for Standardisation (ISO) became directly involved in standardising the management of environment and development. By 1993 the ISO had created a new technical committee, TC207, to develop standards to optimise best practice in environmental management. The most pertinant international standards to sustainable development were ***ISO14000***: Improving environmental management and advancing sustainable development; and ***ISO14001***: Environmental Management Systems (EMS) – specification with guidance for use (Hillary, R, 1997). The ISO14000 series reiterates many of the objectives of these two.

Initial review: a detailed snapshot of the organisation's environmental impacts and performance
Policy: drawn up by the management team, with the only requirement being a "commitment to continual improvement".
Organisation and personnel: the standard requires clearly defined and stated responsibilities, authorities and resources. It covers policies on training and communication.
Register of regulations: requires up-to-date records of all legislation that currently pertains to environmental aspects of the organisation's activities.
Evaluation and register of effects: the organisation needs to establish procedures to identify and evaluate all its environmental effects, direct and indirect, and compile a register of those considered "significant".
Objectives and targets: these need to be identified and communicated throughout the organisation.
Management programme: to support the targets and allocate responsibilities and provide detail as to how targets should be achieved.
Management manual: should collate policy, objectives, targets and programme, and provide a key to the documentation providing the system.
Operational control: should ensure that the control, verification, measurement and testing required to support the programme are carried out adequately.
Records: these should be detailed enough to show how the management system is working, and to record progress towards the objectives and targets.
Audits: these are to confirm that the policy is being carried out and that the programme is being adhered to.
Reviews: a major review at periodic intervals to ensure that its management system conforms to the standard, and that may include changing the policy if objectives have been reached.

Box 5.6: Background to BS7750 (Source: Sheldon, in Hillary, R, 1997).

The UK has its own British Standard in the field of environmental management –BS7750. ***BS7750***: Environmental Management Systems, was introduced in 1992, pre-empting the ISO. This standard is the best tool currently available for all managers who want to be sure their organisation is achieving the best it can environmentally (Sheldon, C in, Hillary, R, 1997). BS7750 consists of those attributes illustrated in box 5.6.

BS7750 is applicable to all types of organisation, no matter what the size. It is also designed as a management ***tool*** not a regulatory device, enabling management teams to devise their own policy and provide the necessary support and information systems that are required (Sheldon, in Hillary, R, 1997).

While the standards in the ISO14000 series and BS7750 are voluntary, they are designed to enable the provision of assurance of performance through ***audits***.

Environmental Audit is defined by the International Chamber of Commerce as:

> *"A management tool comprising a systematic, documented, periodic and objective evaluation of how well environmental organisation, management and equipment are performing with the aim of helping to safeguard the environment by (i) facilitating management control of environmental practices; (ii) assessing compliance with company policies, which would include meeting regulatory requirements"* (ICC in, Hillary, R, 1997).

Auditing must be seen as a central determinant to *sustainable* management. As stated above, this does not necessarily indicate a regulatory perspective as the audit can be set internally by the company, or in this case the Agency. The Environmental Management System provides the framework within which the audit can function successfully. The EMS then gains credibility by formal assessment and accredited certification from the United Kingdom Accreditation Service (UKAS). Accreditation follows the stages illustrated in box 5.7.

The relevance of these mechanisms to sustainable management is in their utility for more successful institutional and infrastructural uptake of any new evaluation system. An auditable system, which acknowledges present international and national standards of accreditation, will gain from an initial defensibility and robustness that would otherwise need rectification at a later date. Similarly, if the new sustainable management system follows comparable phases to other systems it will have more widespread and understanding support.

Complementary to the audit approach is the integration of the new system with present practice in ***Strategic Environmental Assessment*** (SEA). SEA functions at the levels of policy, plan and programme (Glasson, J *et al.*, 1995). This structure parallels the building blocks of the sustainable management perspective with the SURCoMES guidelines having utility at the policy level, the SURCoMES evaluation matrix at the plan level and the programme level utilising the SURCoMES KBS (box 5.8).

Initial assessment:
- To verify that the system was based on significant effects and ensure that it is aimed at controlling an improving environmental performance and is auditable.
- To ensure that reliance can be placed on internal audits.
- To plan for the main assessment.
- To provide immediate feedback to the client which may assist in the remainder of the assessment process.

Desk study:
- To ensure compliance with all clauses of the standard and prepare checklists for the main assessment.

Main assessment:
- To verify that the system meets the requirements of BS7750 and/or ISO14001.
- To ensure that the system is capable of delivering and achieving performance improvement and regulatory compliance.
- To verify compliance with company policy and procedures.

Surveillance visits:
- To verify continued compliance and to ensure that the mechanism for continual improvement is working. These visits will occur every six months, with a renewal visit every three years.

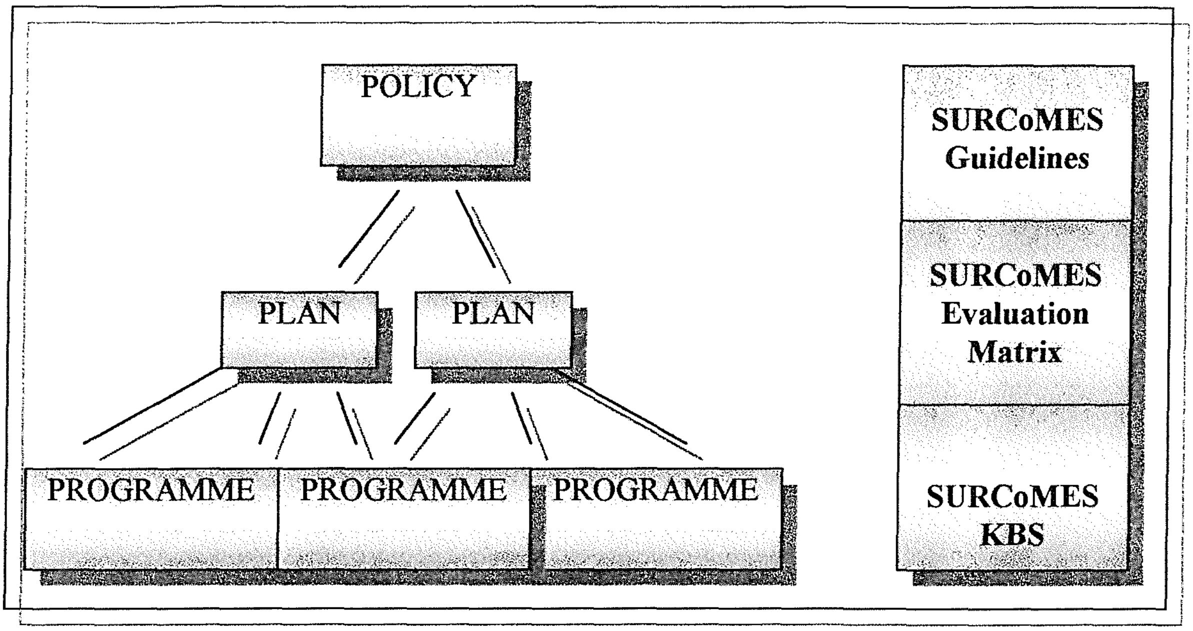
Box 5.7: Accreditation of the EMS (Source: ICC in, Hillary, R, 1997).

SEA is widely held as an important mechanism in the drive to sustainable development (Glasson, J *et al.*, 1995; Gardiner 1996 in Gardiner and Perala-Gardiner, 1997 in Haycock et al (eds.), 1997; Therivel, 1994 in, Gardiner JL and Perala-Gardiner C, 1997 in Haycock et al (eds.), 1997).

As Gardiner states, SEA offers a procedure to bring plans for sustainable management together ensuring that stakeholders are involved in a process which fully supports the holistic approach to planning (Gardiner, 1996 in, Gardiner JL and Perala-Gardiner C, 1997 in Haycock et al (eds.), 1997).

SEA is defined as,

> *"the formalised, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making"* (Therivel *et al.*, 1992 in, Glasson *et al.*, 1995).



Box 5.8: The relationship between Strategic Environmental Assessment and Sustainable Management (Modified from Glasson, J *et al.*, 1995).

The SEA process provides the opportunity to define the thresholds of more or less sustainable options appraisal so that boundaries might be drawn over which sustainability is compromised. Environmental Impact Assessment of the projects options within the constraints of the SEA would be complemented by the SURCoMES KBS.

5.7 Summary

This chapter has presented the development of an accountable, defensible and transparent set of tools for the more successful appraisal of sustainability and sustainable management in upland rural river corridors in England and Wales. The accountability can be seen in the consistency of the rule-sets within the SURCoMES and the weightings of the SAM, the defensibility in the use of knowledge engineering, and the transparency in the format of both systems so that the trade-offs between parameters are easily accessed and illustrated. Both systems have fully utilised the research within the preceding chapters (compatibility within the Agency structure; utilisation of existing tools; fuzzy logic; and the key goals and issues of the concept of sustainable management) whilst optimising the techniques which will be introduced in the final section of this research.

A further stage of testing is now required on the sites which have been identified in this research as upland rural locations with relevant data availability.

Chapter 6

Validating SURCoMES in the context of the Wharfe

6.1 Introduction

The two evaluative systems developed in chapter 5 – SURCoMES and SAM – need robust qualification if they are to be readily accepted by the Environment Agency as standard tools for the implementation and appraisal of more sustainable management.

Both tools have been extensively tested through consulting with the experts (consultations .1 and .2 discussed in chapter 5). The *SAM* will need to undergo further validation which will go beyond the period of this research project. As practitioners utilise the tool, iterations will need to be made parallel to changing institutional and infrastructural mechanisms. For this reason, further validation is not sought as part of this research project, but it remains important to assess the extent to which the SURCoMES model has *general* applicability across upland river corridors.

The rule-sets of the **SURCoMES** were initially built using the Wharfe site and the RCT. Chapter 5 included a first level of validation through the plotting of the rules and their associations. It also introduced the use of the Expert in validating the assumptions and heuristics involved in sustainable river management (consultation .1). A further level of verification now needs to be carried out on this tool, by:

1) Application of the stability criteria (resulting from consultations) *with* the socio-economic portion of the rule-sets to the 30 sites which pair the Wharfe in altitude. Relevant LEAPs will complement the RHS database to ascertain the representativeness and utility of these rules (SURCoMES Part I);
2) The use of the case study site (River Wharfe) to identify the accuracy of trends in the decision trees (SURCoMES Part II).

6.2 The application of SURCoMES Part I to Wharfe-paired sites

As introduced in chapter 5, 29 RHS sites pair the Wharfe based upon the following qualities:

1) altitude 180 – 220m;
2) semi-natural in character; and,
3) stream power data availability (RCT, Universities of Southampton and Newcastle, 1999).

The relevant Local Environment Agency Plan (LEAP) must now be used to gain detail on the socio-economic status of each reach (e.g. designations; Land Use Band; Access routes). Relevant LEAPs for each site are detailed in table 6.1. Table 6.2 provides an overall picture of the spatial scale of applicability of the SURCoMES prototype.

Each RHS site with sufficient and consistent information was tested on the SURCoMES system for its socio-economic status, together with a critique of this with regard to the breadth of information provided by the LEAP. A short summary of those most significant and representative of the SURCoMES' capabilities is now presented. These are dominated by sites within the Welsh Region due to data availability.

Local Environment Agency Plan	Environment Agency Region
Eryi, lleyn	Environment Agency Wales
Neath, port talbot and bridgend	
Severn uplands	
Teifi valley	
Usk	
Wye	
Derbyshire	Midlands Region
Staffordshire trent valley	
Teme	
Cheviot & east northumberland	North East Region
Derwent (yorks)	
Derwent and cumbrian coast	
Esk & coast	
Nidd and wharfe	
Tyne	
Eden and estuary	North West Region
Lune	
South cumbria	
West somerset streams	South West Region
Seaton/looe/fowey	

Table 6.1: Relevant LEAP documents and Region

Site	River	Leap/catchment	Grid Ref.
7	Cavey Burn	Cheviot & east northumberland	NT955255
32	Hareshaw Burn	Tyne	NY841855
63	West Allen	Tyne	NY782546
88	Lamb Beck	Eden and estuary	NY450337
102	Mosedale Beck	Derwent and cumbrian coast	NY355254
120	Lowther	Eden and estuary	NY547156
123	Belah	Eden and estuary	NY815121
140	Lune	Lune	NY654053
150	Stockdale Beck	Esk & coast	NZ646046
155	Lickle	South cumbria	SD247917
159	Chapel Beck	Lune	SD639955
169	Ouse Gill	Derwent (yorks)	SE641941
199	Wharfe	Nidd and wharfe	SD946756
215	Kettles Beck	Lune	SD750646
381	Noe	Derbyshire	SK142858
398	Gyrach	Eryi, lleyn	SH742758
506	Causeley Brook	Staffordshire trent valley	SJ925472
561	Cwmnantcol	Eryi, lleyn	SH641264
681	Garno	Severn uplands	SN974961
723	Clun	Teme	SO254821
762	Teme	Teme	SO251751
797	Glasffrwd	Teifi valley	SN754660
800	Dulas	Wye	SO053652
802	Cascob Brook	Wye	SO256653
841	Garth Dulas	Wye	SN940541
844	Gladestry Brook	Wye	SO257545
977	Nant Cynrig	Usk	SO052251
1020	Llia	Neath, port talbot and bridgend	SN934147
1293	T of Doniford Stream	West somerset streams	ST151355
1479	Warleggan	Seaton/looe/fowey	SX152747

Table 6.2: Location of RHS sites

7 Cavey Burn Cheviot & East Northumberland NT955255

The Cavey Burn is located in one of the most sparsely populated areas in England and Wales. It has three specifics points of socio-economic value – it is part of the National Park, it is part of the Cheviots Character Area, and has scheduled ancient monuments. The quality of the land is of the lowest banding. It has no notable importance for recreation, special wildlife sites, or access/ infrastructure.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix H, and summarised as:

High geomorphological stability;

Moderate socio-economic value;
High/very high habitat value; and therefore,
Very low present management need.

Future natural adjustment is likely to be moderately extreme, thus identifying that a moderate degree of intervention will be needed in the long-term.

In returning an output of *very low present management need*, the SURCoMES is acknowledging that in the context of high geomorphological stability on this semi-natural reach, and a moderate socio-economic value, a good balance exists in the fluvial system. The habitat value is high with this level of geomorphological stability, so there is no present need to manage. In the longer term, change is likely to be moderately extreme. This therefore indicates that long-term intervention in the system will need to be of a higher order than the present, to retain a sustainable balance of riparian interests.

102 Mosedale Beck Derwent and Cumbrian Coast NY355254

Mosedale Beck is included in this summary for its low socio-economic value compared with other sites. According to the LEAP, Mosedale Beck has no designations and the lowest level of land use.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Low geomorphological stability;
Low socio-economic value;
High habitat value; and therefore,
Very low present management need.

Future natural adjustment is likely to be moderately extreme, thus identifying that a moderate degree of intervention will be needed in the long-term.

The SURCoMES illustrates how with low geomorphological stability and socio-economic value, the river should be left to adjust naturally. There is therefore a minimal need for management. However, in the longer term, natural adjustment is likely to change by a 'moderately extreme' order. This may mean that the river might become more stable. Therefore, in the light of this, a moderate degree of management may be needed.

398 Gyrach Eryi, Lleyn SH742758

The river Gyrach is located in the North-western corner of Wales, west of Llanfaiffechan. According to the LEAP, this reach of the river is part of the Snowdonia National Park. There are no special sites (e.g. SSSI; AONB), and no infrastructure (e.g. road, settlements). Of note are the acid sensitive geology and soils, and the predominant land use of mixed dairy, beef and sheep. There is one footpath in the area.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Moderate geomorphological stability;
Low socio-economic value;
High habitat value; and therefore,
Very low present management need.

Future natural adjustment is likely to be less extreme, thus identifying that less intervention will be needed in the long-term.

This output recognises that where there is low socio-economic value at present, and moderate geomorphological stability, with good quality habitat, there is a *very low present management need.* This reflects the opportunity existing for natural adjustment to continue with the existing low socio-economic constraints.

The SURCoMES suggests that little intervention will be needed in the future, as the channel is unlikely to change dramatically. Environmentally and socio-economically this is a good example of an ideal sustainable management system.

681 Garno Severn Uplands SN974961

The Garno river is to the western side of Wales. The LEAP document identifies both an 'A' road and a railway running along the length of the reach. The land is agricultural and of Grade 4 status. The river is identified as important to trout fishing.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Low geomorphological stability;

Moderate socio-economic status;
Fair habitat quality; and therefore,
Moderate management need.

Future natural adjustment is likely to be moderately extreme, thus indicating that a moderate, and thus continued intervention will be needed in the system.

The output for the Garno recognises that although geomorphological stability is likely to continue being low, only *moderate intervention* will be required due to the moderate socio-economic status. In this type of situation, the SURCoMES Part 2 will then guide the user to consider how best to manage the reach with regard to specific features (e.g. the 'A' road and railway).

762 Teme Teme SO251751

This site provides the ideal case study for the SURCoMES to illustrate the effects on management of a highly unstable reach in the context of high land value.

The LEAP indicates that the Teme is a site with ESA status, designated as disadvantaged and a less favoured area agricultural designation, an AONB, designated SSSI, with a railway running along part of its left bank.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Low geomorphological stability;
High socio-economic status;
Poor habitat quality; and therefore,
High management need.

Future natural adjustment is likely to be moderately extreme, thus a moderate level of intervention will be required into the longer-term.

In the context of high geomorphological instability with high land value, the SURCoMES acknowledges that present management need must be high. Within the longer term, a moderate degree of change is likely in the natural system. This will not necessitate more than a moderate degree of change in the intervention that will be needed in the future.

797 Glasffrwd Teifi Valley SN754660

The LEAP indicates that Glasffrwd is a site with SSSI status, brown trout and scheduled ancient monuments adjacent to the reach. It has a land use band of E.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Low geomorphological stability;
Moderate socio-economic status;
Fair habitat quality; and therefore,
High management need.

Future natural adjustment is likely to be moderately extreme, thus a moderate level of intervention will be required into the longer-term.

Similar to the Garno, the Glasffrwd is of low geomorphological stability and moderate socio-economic status. However, because of additional SSSI status, and a scheduled ancient monument, this reach has a high management need. Further, future natural adjustment is likely to be moderately extreme. This adds a further dimension to the need for carefully planned, but flexible longer-term management solutions.

841 Garth Dulas Wye SN940541

The Wye LEAP notes that the Garth Dulas is significant for trout and salmon fishing. Related to the trout fisheries, the site is designated under the Brown Trout Strategy as having a fisheries category of 'wild'. There is also a SSSI adjacent to the reach. The reach has a land use banding of E.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Low geomorphological stability;
Moderate socio-economic status;
Fair habitat quality; and therefore,
Moderate management need.

Future natural adjustment is likely to be moderately extreme, thus identifying a moderate need to intervene in the longer-term.

The Garth Dulas, like the Garno, requires a moderate level of management, considering the socio-economic value against the very low physical stability. This need will continue in the longer-term due to the likelihood of continued low stability.

977 Nant Cynrig Usk SO052251

The Nant Cynrig is described in the LEAP as being of National Park status (Brecon) and designated as 'pristine' under the Brown Trout Strategy. It has no significant heritage sites, access or other infrastructure. It has a land use banding of E.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Moderate geomorphological stability;
Moderate socio-economic status;
Fair/high habitat quality; and therefore,
Very low management need.

Future natural adjustment is likely to be less extreme, thus indicating less need for longer-term intervention.

Nant Cynrig has a moderate level of geomorphological stability. The SURCoMES recognises this in parallel to a moderate socio-economic status and high habitat quality, and identifies a very low management need. A relatively good balance is likely to exist at the present. Further, future natural adjustment is likely to remain unchanged. The system therefore prescribes that it is unlikely that much intervention will be needed in the longer –term.

1020 Llia Neath, Port Talbot and Bridgend SN934147

The LEAP describes the Llia as significant for brown trout fisheries, and of water-associated SSSI status. It has a land use banding of E. It has no other significant designations, and no significant infrastructure.

Based upon this information, and that provided by the RHS, the SURCoMES returns the outputs of those presented in appendix, and summarised as:

Moderate geomorphological stability;
Moderate socio-economic status;

Fair habitat quality; and therefore,
Moderate management need.

Future natural adjustment is likely to be moderately extreme, thus indicating that moderate intervention will probably be needed into the longer-term.

The Llia is very similar to the Nant Cyrig in its moderate levels of both socio-economic and physical criteria. However, the Llia has been designated with SSSI status. This is recognised by the SURCoMES in its identification of a higher management need than the Nant Cyrig. The geomorphological stability is likely to remain similar to the present-day state. Therefore, the SURCoMES ascribes a likelihood of continued moderate intervention.

6.21 Summary of the testing of SURCoMES Part I

What these summaries hope to highlight is both the consistency and general applicability of the SURCoMES when sites display similarly valued assets (e.g. sites 7 and 32), and also its ability to highlight the effects of the relationship between the level of geomorphlogical stability and socio-economic status. For instance, the Teme provides good example of how the SURCoMES identifies the high priority for management within the context of a highly unstable river in an area of high socio-economic value. On the other hand, in the case of Mosedale Beck, the existence of high instability within the context of a low socio-economic value is acknowledged in the low present management need indicated by SURCoMES on this reach.

Of utmost importance, the testing of the SURCoMES in this manner allows the identification of a number of improvements that will be needed if the LEAPs are to be utilised fully and consistently for the SURCoMES. It is suggested that these limitations might have implications for other research of this nature. The recommendations are as follows:

1) Only map-based data is required for full functioning of the SURCoMES. However, this is only of use if fully compatible with the Ordinance Survey grid references. The majority of the LEAPs consulted did not have this facility;
2) Similar to point 1, all maps need to have either all major *and* minor tributaries marked, or, all listed in an appendix with relevant grid references;

3) The Environment Agency needs to be more consistent between LEAPs. The map-based data for instance, is variously found between the Consultation Report (e.g. Lune, 1998) and the Environmental Overview (Eden, Esk and Solway, 1999). This creates confusion in obtaining the correct document;
4) More consistency is required with regard to the breadth of information that each LEAP provides (e.g. Cheviot and East Northumberland do not provide the Land Use Bands of the catchment);
5) The LEAPs need to be made more accessible to the SURCoMES user. The experience of this set of tests has highlighted the ease with which the Welsh Region's LEAPs are to be accessed through their presentation on the internet. All data may be downloaded, and viewed at the Users pleasure. This was not the case with the other documents.

This section is provided as an introduction to how the SURCoMES might be tested and iterated beyond the period of this research. It is also highlighted that testing of such a kind helps to illustrate fundamental flaws in the utility of the Agency's present methodology for integrating catchment management (the LEAP document). It is suggested that these limitations will need to be addressed if the interdisciplinary goals of the Agency's Principal Aim are to be optimised.

6.3 SURCoMES Part II *in the context of the* Wharfe

For the purpose of the first SURCoMES case study it is most beneficial to study a small sub-section of the river Wharfe in more detail. With the aid of maps and the extensive literature on the Wharfe (appendix A) a picture of the sustainability of the current situation and similarly any management options open can be built based upon the SURCoMES rule-base. This may be utilised with the findings of the geomorphological audit and other site information derived from the literature, to progress through the decision trees of SURCoMES Part II. The viability of the resulting 'suggested management options' may then concluded.

In the 1997 geomorphological audit of the Upper Wharfe, 70 sections were identified based upon sensitivity to change, extending from Oughtershaw Beck and Green Field Beck at the upstream end, to Kettlewell Bridge (70) downstream (see map). Sections *15 to 33* of these 70 are described by Heritage and Newson as, 'unstable with significant re-deposition of bar features in the channel, [and] extensive sections of protected bank' (Heritage and Newson, 1997).

A Dynamic Assessment (RKL-Arup, 1999), further identifies sections 15 to 33 under the differently titled sub-reaches of ***D-I***. The dynamic assessment uses techniques within the Flood Studies Report () to estimate the ideal channel dimensions compared to existing, for the labelled reaches. These do not need to be considered in detail here, but suffice to say that in sub-reach G, actual channel widths vary between 19.5m – 40.5m. *Ideal* widths are calculated at 24m using stable sections and 20m using the 1.5-year flood (which is taken as a good equivalent to bankfull discharge). Similarly, in sub-reach I, actual channel widths vary between 16.5m and 40.5m. *Ideal* widths from stable sections indicate 23m and the 1.5 year flood estimation method, 20m (RKL-Arup, 1999). Local transport capacity variation emphasises this current sedimentary situation, with a reduction in competence across the flow regime being reflected in the development of bar features within the channel. Bank destabilisation and channel widening have occurred in places where the in-channel deposits have channelled flows against the banks, here the channel has become over-wide, indicating there is active instability (RKL-Arup, 1999).

The natural progression to the information in these two reports would traditionally be to look into remedial works on these reaches, and indeed the Dynamic Assessment does recommend such measures. The major difference between the more traditional approach and the Sustainable Management Plan however, is that based upon the rule-base, the question should be asked as to ***whether remedial measures should be implemented at all?*** Based upon the cost-benefit of long-term protection or a one-off incentive, for example, the option to 'let erode' may be the most economically, as well as environmentally sound decision.

In June 1999, Ecoscape Applied Ecologists Ltd conducted a RCS, SERCON assessment and reach summaries for the section of Wharfe from Yockenthwaite (upstream) down to the Skirfare confluence – a distance of approximately 15.5km. The report identifies three reaches within this larger stretch. Reach 1 is 9km long and comprised of 18 sections (section numbers 6 – 24 inclusive). More specifically, section numbers 10 – 13 (see appendix A) complement sections 15-33 of the geomorphological audit, and reaches D to I of the dynamic assessment (see table 6.3).

The use of the data provided by the RCS allows uptake of the SURCoMES. Further, the combined information provided by the RCS and SERCON, dynamic assessment, and geomorphological audit may be used to validate the conclusions of the SURCoMES Part II.

Obviously the RCS predated the RHS, and correspondingly presented information in a different format. However, it is possible to extract the information needed for the SURCoMES from the tabulated information that accompanies the RCS map. Information on the socio-economic status of the four reaches is gained again from the RCS, and also the relevant LEAP (Nidd and Wharfe, EA, 1997). Box 6.1 illustrates the qualities found. In summary, all four sections have very similar socio-economic status, with Land Use Band E (low-grade agricultural land). Importantly, they are all part of an Environmentally Sensitive Area, a major National Trust site, and in a National Park. The right-bank is also a SSSI, and the whole stretch of the river is also important for trout and grayling (Nidd and Wharfe, EA, 1997). The RCS also notes a 'well used footpath on the right-bank' [the Dales Way] and abundant hay meadows (Ecoscope Applied Ecologists, 1999).

Based upon this information, and utilising the LEAP and RCS, the SURCoMES is able to feed back a sustainability appraisal for each section (appendix C). Further, despite each section illustrating slightly different geomorphological characteristics (table 6.4), the overall effect of these differences is minimal. The output of Part I describes present management need for the whole 2km as 'moderate' and, within the context of likely future channel change, that it is 'less sustainable to manage' within the longer-term (box 6.2).

Sections 10-13: Socio-Economic criteria

Land Use Band left bank	E
Land Use Band right bank	E
Agri-environment	Yes
Wildlife/environmental	Yes
Heritage conservation	No
Landscape	Yes
Additional reasons	Yes
Mapping initiatives	Yes
Access routes	Yes

Box 6.1

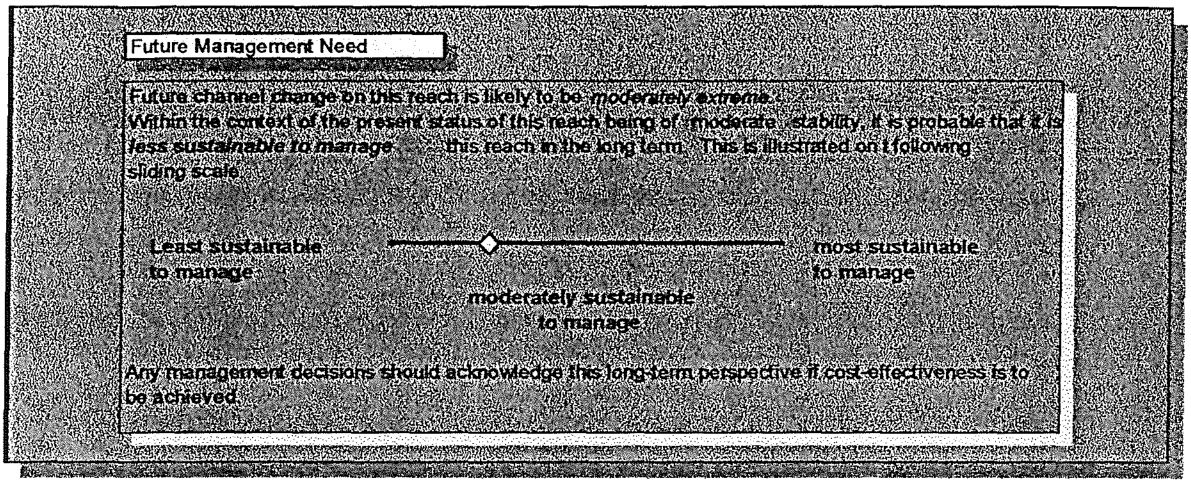
RCS reach	GM audit	Dynamic Assessment	Dynamic Assessment detail: Reach	Gross stability	Character
10	15 - 18	D1 – E3	D	Erosion	Exit to 90° meander bend displaying significant right bank erosion.
11	19 – 25	E4 – F6	E	Erosion	Unstable low sinuosity reach displaying in-channel sedimentary deposit downstream
			F	Deposition	Sharp 80° meander bend exhibiting some left bank erosion, channel deposits upstream of this
12	26 – 30	G1 – G5	G	Deposition	Complex series of gravel bars around and downstream of the right bank tributary
13	31 - 33	H0 – I10	H	Erosion and deposition	Tight double meander exhibiting significant bank erosion and downstream deposition
			I	Deposition	Major in-channel deposits within an over-wide channel

Table 6.3: (Source: RKL-Arup, 1999; Heritage and Newson, 1997; Ecoscape, 1999)

Physical attributes of sections 10 - 13

	Section 10	*Section 11*	*Section 12*	*Section 13*
LB substrate	>60% boulder/cobble	>60% boulder/cobble	>60% boulder/cobble	>60% boulder/cobble
LB features	eroding earth cliff 2-5	eroding earth cliff <2	Eroding earth cliff >5	Eroding earth cliff <2
Channel substrate	>60% gravel/pebble, sand, silt, cobble	>60% gravel/pebble, sand, silt, cobble	>60% gravel/pebble, sand, silt, cobble	>60% gravel/pebble, sand, silt, cobble
RB substrate	>60% boulder/cobble	>60% boulder/cobble	>60% boulder/cobble	>60% boulder/cobble
RB features	eroding earth cliff 2-5	eroding earth cliff 2-5	eroding earth cliff 2-5	Eroding earth cliff <2
Bank Profile	Vertical/undercut + toe present or none	Vertical/undercut + toe present or none	Vertical/undercut + toe extensive	Vertical/undercut + toe present or none
Tree extent	Not continuous	Not continuous	Not continuous	Not continuous
Exposed bedrock/boulders	5 or less	5 or less	5 or less	5 or less
Unveg mid/side bars	Extensive	Present or none	Present or none	Extensive
Veg mid/side bars	Present or none	Present or none	Present or none	Present or none
Mature Islands	Present or none	Present or none	Present or none	Present or none
Bed material	unconsolidated	unconsolidated	unconsolidated	Unconsolidated
Mean stream power	7.5 – 35 watts/metre2	7.5 – 35 watts/metre2	7.5 – 35 watts/metre2	7.5 – 35 watts/metre2

Table 6.4



Box 6.2: Future Management Need (SURCoMES extract)

The SURCoMES therefore identifies that the long-term sustainable option may not necessarily be to intensively manage the reach, despite the low *present* geomorphological stability and moderate *present* need for management.

This knowledge may now be set within the context of the information provided by the dynamic assessment (table 6.1), and the options available for management highlighted in SURCoMES Part II.

6.31 Case Study site 1: Section 10 (Ecoscope, 1999)/ Reach D (RKL-Arup, 1999)

Section 10 of the RCS displays,

"Exit to 90° meander bend displaying significant right-bank erosion"

(RKL-Arup, 1999).

Upon reference to the map (appendix A), it can be said that the exit to the 90° meander bend is not yet within the SSSI designated area. However, the Dales Way passes to its edge, and a field boundary meets the bank at right angles. It is also within sight of the Buckden Bridge. There is significant evidence of erosion with earth cliffs and exposed tree roots, together with gabions and recent tree planting (Ecoscope, 1999) which suggest efforts to remedy the problem.

This is the typical management situation with which the SURCoMES has been designed to deal. The fact that the National Trust owns the land eases the situation with regard to the minimum intervention approach, as the Trust pursue similar aspirations. The ESA status also provides opportunity through grant-aid and stewardship. These factors lead the decision tree to progress down the path illustrated in figure 6.1.

As may be seen, following a site visit, and the fact that the National Trust owns the land together with the Wharfe being the site of a Best Practice Project with Objective 5b funding, the user is referred to branch D. Branch D evaluates the cost: benefit of managed re-alignment against protection. In this situation, the land value is relatively low (low-grade agricultural land with no property). Therefore, negotiation with the National Trust yields a positive response. This leads the user to branch C, which considers management options where land constraints are minimal. It is decided that the problem may be allowed to resolve naturally. Long-term commitment is possible, due to the continuing community participation and funding, so that the 'Streamway Concept' or managed realignment is considered. Branch E then considers the financial implications of this style of management, by reference to management schemes and incentives. Cost of land loss per year on straight-line projections is thought to be lower than most. A voluntary management agreement is considered to be appropriate for the situation, but within the current political environment, only a 10-year agreement is considered. The user has three options suggested – the ESA scheme; the Habitat Scheme for Water Fringe Areas; and the Countryside Stewardship scheme. These options are considered 'acceptable' and appropriate for the present problem and thus, the sustainable management plan may then proceed.

The utility and practicality of this derived management solution must now be considered. High magnitude floods seem to have been responsible for the recently destabilised sections of the channel (Heritage and Newson, 1997). Similarly, the Buckden gravel trap is likely to have been a major factor contributing to bank instability and erosion. However, it is suggested that there will be progressive adjustments over the next decade or so to the river due to natural processes which will seek to restore the flooding hazard to its original frequency (RKL-Arup, 1998). Overbank flows used to be in excess of 20 times a year in the Buckden area, compared to the more recent figure of less than once every 6 months (Heritage and Newson, 1997). Bearing these facts in mind, the limitations of the suggested management solutions by SURCoMES must be acknowledged. Despite the suggested management solution being that of figure, this must still be considered in the context that it is 'less sustainable to manage' this reach in view of the long-term dynamism of the river. This information also supports the view that the SURCoMES only works as part of the whole. In other words, there is a need for it to be set within the context of the wider catchment, with the system drivers and processes that are identified through thorough fluvial audit or dynamic assessment and that are recommended at the outset of decision Branch A, being fully utilised.

6.32 Case Study site 2: Section 11 (Ecoscope, 1999)/ Reach E (RKL-Arup, 1999)

Reach 11 is covered by sections E and F of the Dynamic Assessment which state, "Unstable low sinuosity reach displaying in-channel sedimentary deposit downstream (E), [and] Sharp 80° meander bend exhibiting some left bank erosion, channel deposits upstream of this (F) (RKL-Arup, 1999).

This reach dictates a varying decision path to reach 10 based upon the stronger emphasis on reduction in channel capacity. Section 11 also draws out the ambiguities involved in the SURCoMES regarding distance from channel of riparian area. The chosen 50m for example, does not take into consideration the sewage works west of High Haw Garth Barn, or the track on the right-bank at the most downstream end of the reach. Therefore, sections E and F could see the development of either of the following paths (figures 6.2 and 6.3).

The first decision path dictates that the land surrounding the problem reach is *without* existing structures or high value (i.e. it only considers land within 50m of the channel). The problem does need intervention however, because of the adjacent sewage works. It is considered that system functioning, in the context of objective 5b funding, and the expertise that will be required, may be restored via manipulation of natural features. Habitat heterogeneity is a high priority considering the designations applicable to the site (reach 11 is a SSSI), therefore, intensive restoration of relatively small, but ecologically very valuable patches is suggested. Branch E is then accessed to evaluate the cost of land loss or productivity. The loss of land is determined as medium. Together with the provision of funds through the project funding, the suggested management solution is for land purchase of the buffer zone with management trials. If this proves unnegotiable, then the user is referred to the relevant literature.

The second path for reach 11 considers the scenario of taking the riparian zone to include the sewage works and track. Here, sufficient resources (both time and financial) mean that the problem should be researched at the catchment scale, including full dynamic assessment and fluvial audit.

6.33 Case Study site 3: Section 12 (Ecoscope, 1999)/ Reach G (RKL-Arup, 1999)

Section 12 of the RCS is complemented by reach G in the Dynamic Assessment, which is identified as a, "Complex series of gravel bars around and downstream of the right-bank tributary" (RKL-Arup, 1999). This reach is dominated by deposition, and therefore with reduced capacity. The track noted in section 11 again emerges at the downstream end of this section. There are also three field boundaries meeting the bank at right-angles, and both right and left-bank have post and wire fencing running parallel at a distance of less than 50 metres.

The decision path for section 12 should be exactly the same as for that of section 11 where low valued land is considered (see figure 6.2). The presence of a track, and field boundaries is accounted for in the fact that the need for intervention is acknowledged in branch C, and that intensive restoration of smaller patches allows the control over where these should be. Similarly, branch E recognises that buffer zones would also control where and how overbank flows would occur.

6.34 Case study site 4: Section 13 (Ecoscope, 1999)/ Reaches H and I (RKL-Arup, 1999)

Section 13 differs from 10 – 12 in that its downstream end is adjacent to a major road (B6160) (reach sections I4 to I10) and an archaeological site (remains of a cross), all to the left bank. This therefore raises the land value of the reach, which will a greater effect on decision branches D and E of the decision tree.

Reaches H and I are described in the Dynamic Assessment as,
"Tight double meander exhibiting significant bank erosion and downstream deposition (H) [and] major in-channel deposits within an over-wide channel" (I)

(RKL-Arup, 1999).

This section therefore exhibits a mixture of both erosion and, reduction in capacity, within the context of land which is perhaps less easily compensated for than the previous reaches. Two trees are followed for section 13 – one regarding bank degradation, and the other flood conductance.

The first (figure 6.4) acknowledges that the structures and functions of the land adjacent to the reach are highly valued. Therefore, a site visit is suggested, and within the setting of objective 5b funding, the user is directed to Branch D. The costs of protecting the land is identified as cheaper than land-take, and therefore, the user is referred to the relevant literature on how to protect the attributes in the most sustainable manner.

The second tree identifies the best management option where flooding is a concern. Here, again because of the funding available, a catchment wide context of assessment is suggested, in the same manner as for section 11 with high valued land, (figure 6.3).

DEFINE MANAGEMENT PROBLEM

DEGRADATION OF VALUED RIPARIAN STRUCTURES/ VALUED LAND

SITE VISIT TO ID CAUSE OF EROSION (FLUVIAL AUDIT)

SUFFICIENT RESOURCES (FUNDING/TIME) FOR WIDER CONSIDERATION THAN IN-CHANNEL SOLUTIONS?

YES

ENVIRONMENTAL/ SOCIO-ECONOMIC/ & FISCAL COSTS OF PROTECTION: LAND-TAKE

>1·1

NEGOTIATION WITH RIPARIAN LAND-OWNERS

POSITIVE RESPONSE

CAN WE ALLOW THE PROBLEM TO RESOLVE NATURALLY OR IS INTERVENTION REQUIRED?

LONG TERM COMMIT-MENT TO MANAGE-MENT POSSIBLE?

YES

'STREAMWAY CONCEPT' - REDUCE ANY CONSTRAINTS ON LATERAL MIGRATION FOR NATURAL ADJUSTMENT AND/OR FLOOD TO PROCEED

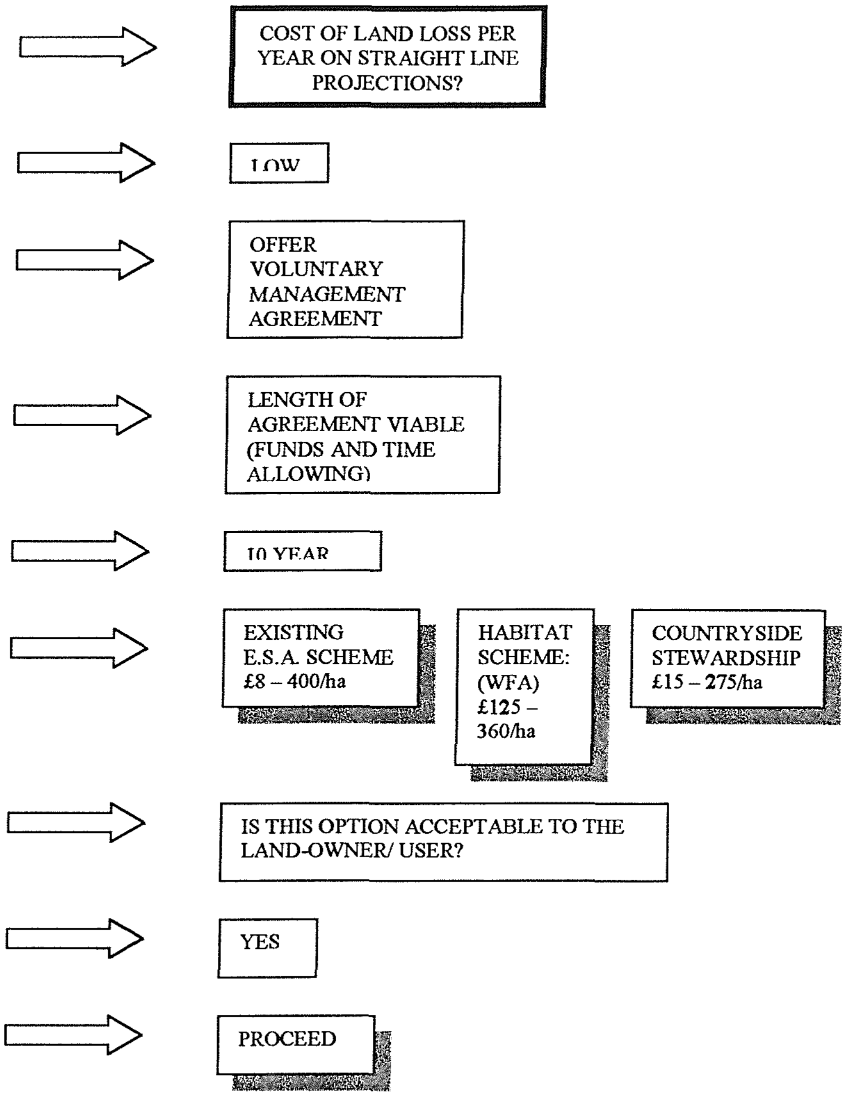
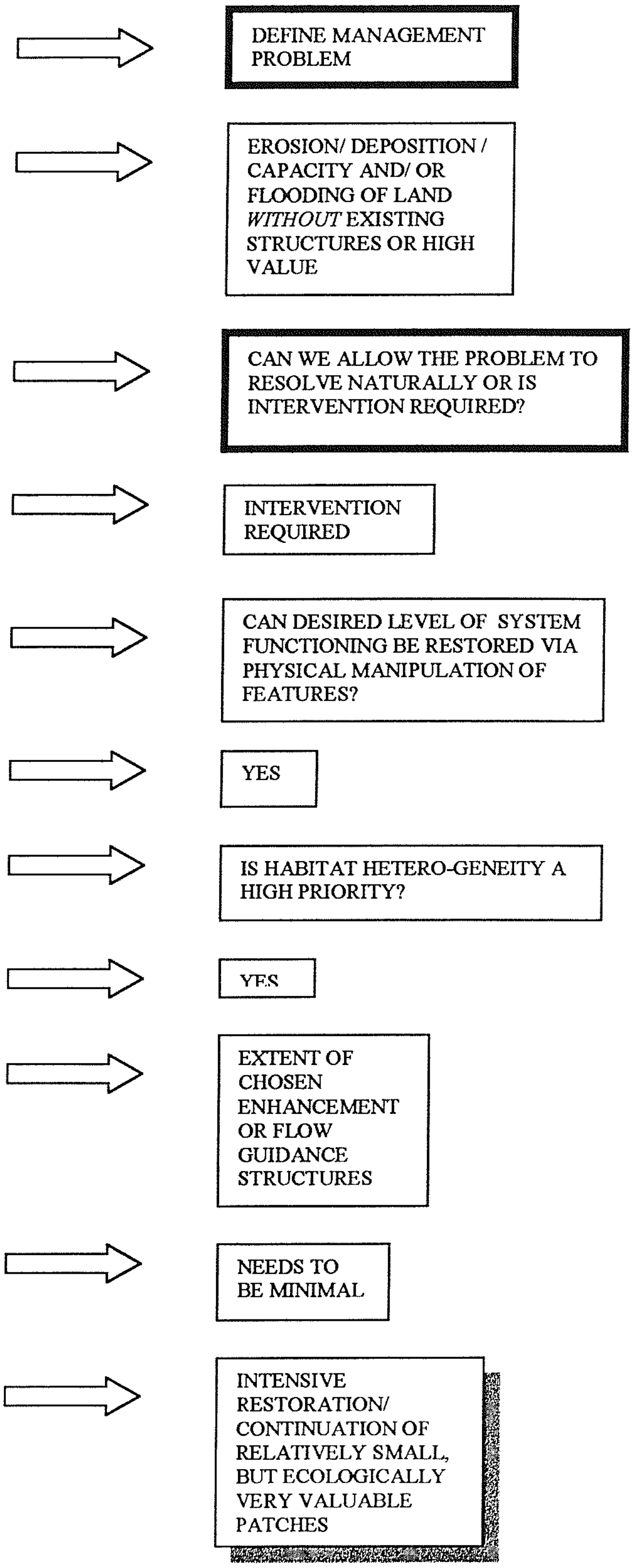


Figure 6.1: Section 10


DEFINE MANAGEMENT PROBLEM
EROSION/ DEPOSITION / CAPACITY AND/ OR FLOODING OF LAND *WITHOUT* EXISTING STRUCTURES OR HIGH VALUE
CAN WE ALLOW THE PROBLEM TO RESOLVE NATURALLY OR IS INTERVENTION REQUIRED?
INTERVENTION REQUIRED
CAN DESIRED LEVEL OF SYSTEM FUNCTIONING BE RESTORED VIA PHYSICAL MANIPULATION OF FEATURES?
YES
IS HABITAT HETERO-GENEITY A HIGH PRIORITY?
YES
EXTENT OF CHOSEN ENHANCEMENT OR FLOW GUIDANCE STRUCTURES
NEEDS TO BE MINIMAL
INTENSIVE RESTORATION/ CONTINUATION OF RELATIVELY SMALL, BUT ECOLOGICALLY VERY VALUABLE PATCHES

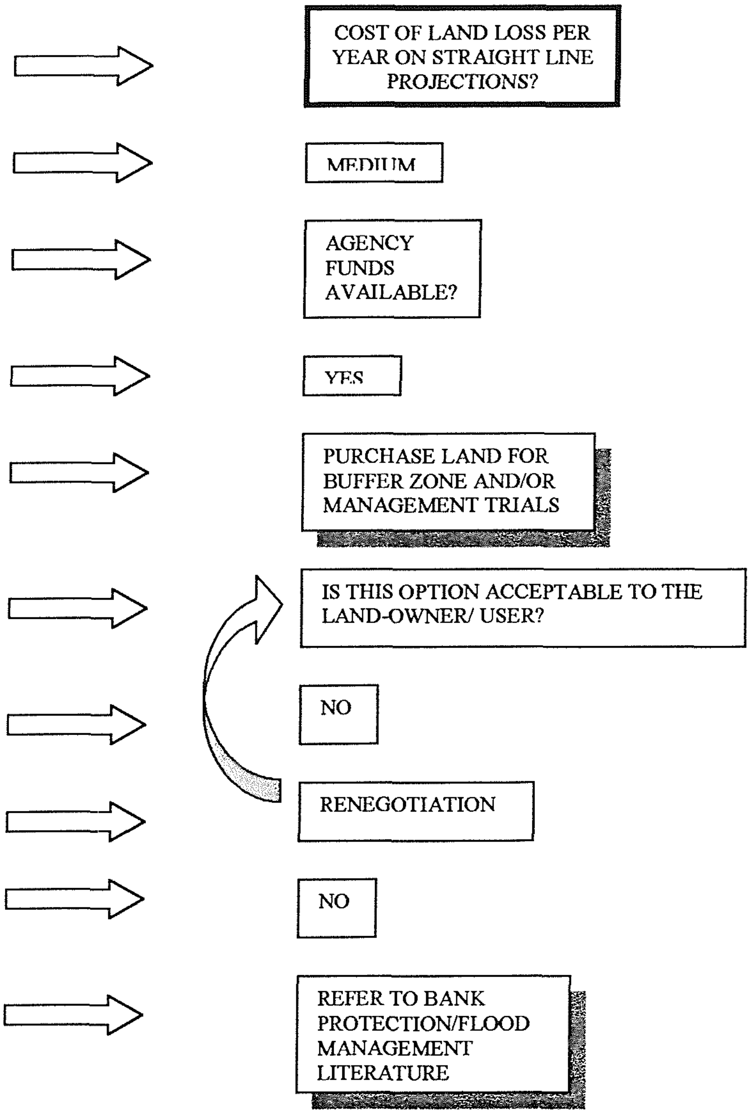


Figure 6.2: Section 11: Low valued land

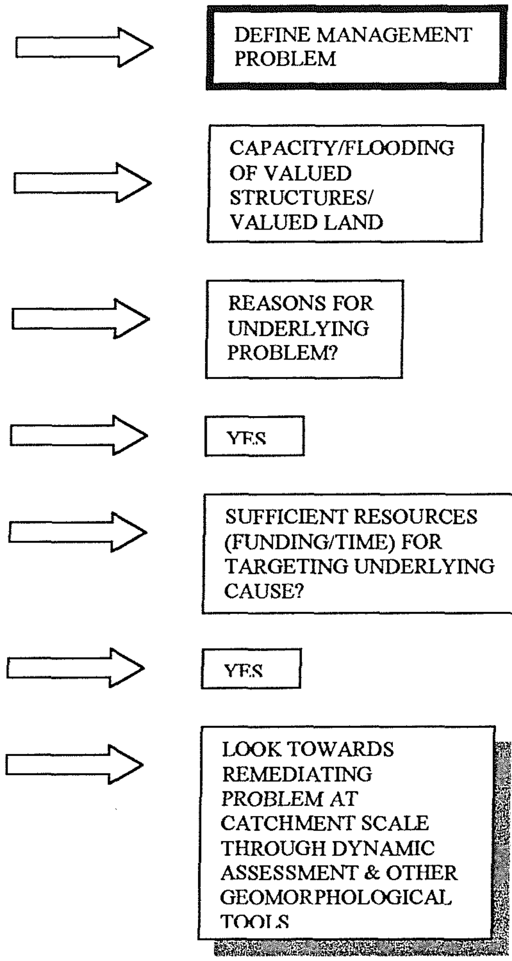


Figure 6.3: Section 11: High valued land

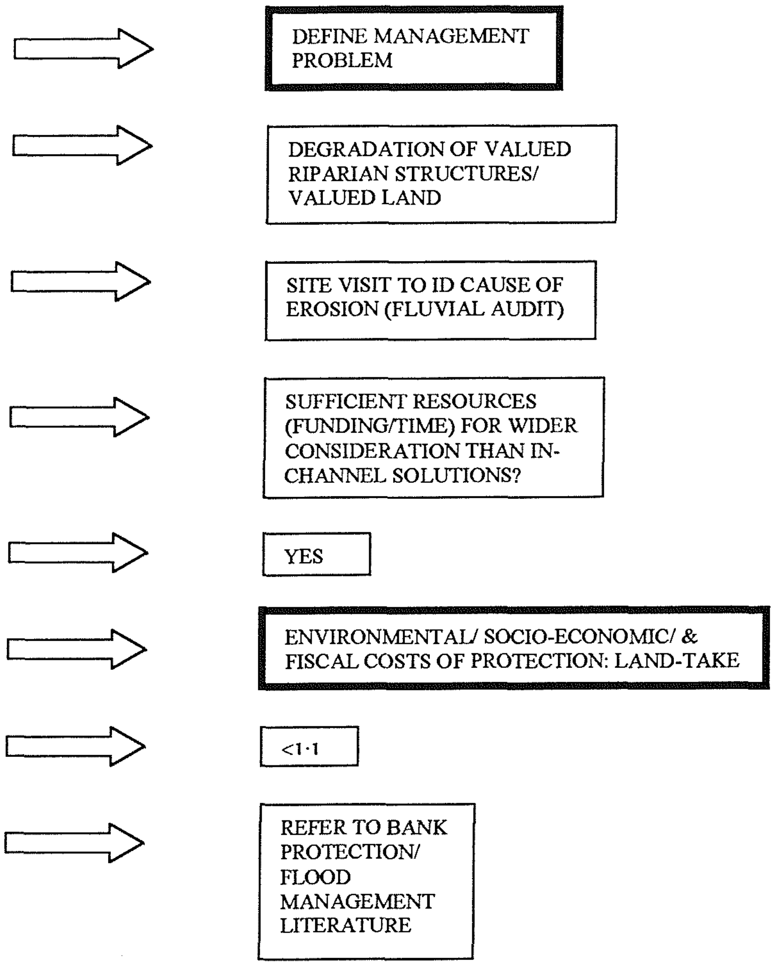


Figure 6.4: Section 13: Degradation of high valued land and structures

6.4 Summary

The testing of the SURCoMES in the context of the Wharfe has highlighted both the capabilities and limitations of the new evaluation system. The aspiration to devise a system which is as accountable, defensible and transparent as possible has been met, within the preliminary spatial confines of the upland rural river corridor. The system development has fully utilised the fundamental elements of good sustainable management, with the inclusion of participation as part of the initial rule-setting process, and the variety of key issues considered as important characteristics of the concept (see chapter 3).

A number of recommendations, including future work on the SURCoMES, are made in chapter 9. These may be summarised by the following statements:

1) The prototype SURCoMES structure has been developed with a high degree of flexibility so that future research may access the background rule-tables of the system and iterate and modify the assumptions as new information is made available. Password protection would constrain access to relevant expertise only;
2) It is foreseen that as experience grows, and with more resources, the first drop-down box of the system (river type as defined by the RHS), will be fully utilised for all river types;
3) It is foreseen that rivers that have been significantly modified will be capable of consideration in the SURCoMES with the inclusion of the RHS Habitat Modification Score;
4) Linking SURCoMES with the RHS CD-Rom (version 3.1) on one piece of software would eliminate the need for data entry in part I of the system. Instead, Macros could link the two;
5) Further research into the graphical display of the system would encourage the uptake of the system to a wider audience (e.g. schools, libraries).

The tools developed in section 2 of this research project have aspired to pragmatise the conceptual elements of sustainable management introduced in section 1. The following section now places these targets and tools for sustainable river management within the context of the techniques that will be needed by society if they are to be implemented successfully.

SECTION 3
IMPLEMENTATION OF SUSTAINABLE MANAGEMENT

Chapter 7

Economic techniques for optimising Sustainable Management

7.1 Introduction: Providing the right incentives for Sustainability

Societal behavioural change towards the concept of sustainable management that has developed over the last six chapters is unlikely to be successful in the long term if suitable incentives to change are not in place. These incentives are most suited to the catchment scale, and not just the river corridor. However, these incentives fully complement the discussions of the preceding chapters, and their potential must therefore be recognised.

Hardin (1968) suggests that people make choices to action mainly as a function of their immediate, personal consequences, because these are often more important to the individual than collective action to the environment. This, he terms, the 'Tragedy of the Commons' (Hardin, 1968 in, Gardner and Stern, 1996). If this is indeed the case, then these 'externalities' need to be internalised, or the costs on the environment made more internal to the individual if sustainability is to be taken seriously in practice and not just in theory.

To achieve this, there is a need for effective incentives which,

- ***internalise the externalities*** (e.g. the polluter bearing the consequences rather than the 'innocent party' who are polluted through no doing of their own)
- are ***large*** enough to be taken seriously
- attack the right barriers to sustainability in any particular situation
- are noticed through the marriage ***with information programming***
- are designed to discourage evasion, and are ***politically acceptable*** (Gardner and Stern, 1996).

This final point is particularly significant in the drive to sustainable river management - designing a policy with incentives that are noticeable but not politically objectionable is a significant challenge.

There are a number of ***market mechanisms*** and ***economic instruments*** that illustrate how effectively placed incentives can further the drive to sustainable management. these must be seen as supplementary to, or short-term substitutes for, fundamental attitudinal change. Ultimately we hope that society will come to view provision for the future and acceptance of change as implicitly worthwhile and reasonable in their own right (Clark, 2000). The mechanisms which hold the most potential for fulfilling these aims are:

1. adaptation of the 'polluter pays principle', pollution rights, and tax and permit systems;
2. compensation through grant aid and stewardship;
3. property rights approaches, including Co-management;
4. legal buffer zones, easements and covenants; and,
5. land use planning and insurance.

Each of these will now be considered in greater detail.

7.11 Adaptation of the 'polluter pays principle', pollution rights, and tax and permit systems

> *Economic instruments for environmental control seek to harness the pricing system to ensure that scarce environmental resources are protected and used efficiently*
> (Beckerman, 1990).

One of the most common economic arguments in the optimisation of the environment is the use of rights, taxes and permits to pollution (pollution being defined as *any* detrimental effects on the processes or drivers of the fluvial system).

Hardin suggests the use of incentives through the charging to the individual responsible of the long-term costs of the resource use by bringing these closer in time to the individual's behaviour (Hardin, 1968 in, Gardner and Stern, 1996). Essentially, "*the environment must be 'economised' so that it is used to the point where social costs are covered by the social benefits*" or where there is 'Optimum

Pollution'. In this way, *"the amount at which the social costs of reducing pollution by a further unit just equal the social benefits of doing so and where a further reduction in pollution would cost more than the value of the further ('marginal') benefits"* applies (Beckerman, 1990). This could be illustrated through the effects of degrading practices in the upper reaches on downstream processes. For instance, if the upstream riparian landowner were to fly-tip on his or her river bank to the extent that this alleviated erosion on that bank, then it may be the case that the downstream 'neighbour' on that river may experience increased energy entering their reach, with likely increased erosion. This act on the upstream reach may therefore have detrimental (and probably costly) effects on the downstream reach. This is a highly simplified example, but what it hopes to prove is that if the consequences of the upstream landowner is the responsibility of that landowner (i.e. they are made to pay for the downstream consequence) then they are less likely to partake in such a practice.

In terms of flood defence and sustainable river management this could be transcribed as the costs of land loss and the perceived unfavourability of using schemes like wetland restoration or managed re-alignment rather than the more traditional and tangible structural solutions. In this way, the term 'pollution' could be substituted for that of 'degradation'. More sustainable management must only be seen as viable where it provides the social and environmental benefits of higher quality riverscape/ aesthetics, higher biodiversity and the long-term goal of minimum intervention or lower cost maintenance of the river once stabilisation has occurred.

One market mechanism which illustrates this approach is the *Polluter Pays Principle.* Rather than sole reference to pollution however, an untapped potential link could exist in the realms of flood defence and what could perhaps be termed the ***Developer Pays Principle***. According to Beckerman, economic growth has been, and is likely to continue to be, the major means by which society will be induced to reduce degradation to socially optimal levels, *"as nations grow richer they become more willing to devote resources to improving the environment"* (Beckerman, 1990). A similar argument could be made for the preservation of the aesthetic and environmental value of the riverine landscape as well as the need to limit the current levels of expenditure used to maintain structural management solutions. By analogy with the positive prices for ordinary products, practices in conflict with the goals of sustainable river and floodplain management should carry a ***negative price***. This would correspond to both the negative benefit it confers on people and would also constitute the required disincentive to 'producers' to supply this undesirable product, or again, to those not using sustainable practices as recognised by the Agency. Ultimately, firms and producers (including individuals) could be seen as having the same sort of incentive to economise on the use of the environment as they have to economise on other inputs into their productive process.

Another related option within the realms of market pricing is the idea of ***'Pollution Rights'***. This is a method of using the price mechanism in a situation where uncertainty about the amount of damage done by the pollutant is combined with a fear that it could rise sharply if the optimum amount were exceeded (Beckerman, 1990). Under this approach, the Environment Agency would decide upon a 'desirable' level of development or degradation, and then issue on the market, 'rights' to this amount, allowing the equilibrium price to be settled on the market. Those that can reduce development or degradation cheaply will not want to buy as many rights as others and the price at which the rights settle will be the same as the optimum tax or subsidy (Beckerman, 1990).

With regard to farmers and individual householders on the rural floodplain, this concept would best be implemented through the mechanism of insurance. The mechanism could be implemented where the more degrading the practice/s, the higher the level of insurance premium that would need to be paid by the person/s responsible. This level of insurance premium would relate to the degree of detrimental effect that would be incurred by others. Therefore, the less degrading the practice, the lower the insurance premium. In this way, insurance is seen as an indirect tax in environmental management. The agreed level of insurance could also be passed on through land and property valuation. For instance, if the landowner did not eliminate or lessen the degrading practice (e.g. fly-tipping) then any new owner of that land would also have to pay that agreed level of insurance. By so doing, a further substantial disincentive arises. Those carrying out degrading practices would find that the resale of their property or land would incur this added cost to any buyer and therefore a disincentive to buy.

Economic analyses indicate that these ***tax and permit systems*** have the potential to achieve environmental standards at a lower cost than the more traditionally adopted command and control policies (Hodge, 1995). Beckerman identifies a number of advantages of using taxes and permits. Firstly, if all firms are subject to a uniform charge or unit of damage, those that can reduce development or degradation most cheaply will do so more than those that face relatively high or steeply rising costs. *"Therefore more of any given amount of [degradation] abatement will be made by firms that can do it most cheaply; they will use least resources and therefore least deprive society of these resources, minimising opportunity costs"* (Beckerman, 1990). This is known as ***Allocative Advantage***. Secondly, with such a system, *"individuals have an incentive to find the cheapest way to reduce their [degradation]. Firms will have a continuing incentive to experiment and to seek new and* *more economic methods of reducing [degradation], for the more they do so the more they save on pollution charges*" (Beckerman, 1990). There will be an ***Economising Incentive***. Thirdly, enforcement of direct controls is often a difficult and time-consuming process (Beckerman, 1990) which could be remedied by applying taxes or permits. This is all in agreement with the philosophy of the 'optimum' level of pollution introduced above (section 7.1).

The use of permits, taxes and rights to pollute are utilised in various countries (e.g. Scandinavia). As has been illustrated, they offer many complementary arguments to the sustainable management debate. However, they are still overwhelmingly regulatory, which in many ways is in contradiction to the fundamental need of sustainable management to change the underlying social metagoals of society. It simply addresses the symptoms rather than the cause. Approaches based upon compensation, co-management and easements however, illustrate some of the guiding principles of the tax and permit approach, but within forums which hold potential for even more holistic approaches to the sustainable management of the environment.

7.12 Compensation through grant-aid and stewardship

> *"I have a right to do what I want on my land, and if I am to be constrained by the community, I have a right to be compensated"*
>
> (Anonymous, in Cooper *et al.*, 1997).

In the UK, moves towards reduced agricultural production in rural areas provide a number of potential compensatory mechanisms to complement the sacrificial situation of land-take and flooding of the riparian area implied by sustainable management.

After a series of environmental initiatives in the 1980s, the 1992 CAP reforms introduced a package of agri-environmental measures which allowed EU funds raised for agricultural support to be spent, largely by farmers in pursuit of traditional farming operations, on schemes to enhance the countryside and provide greater public access. This provides a classic example of policy implementation to balance environment and development.

Within designated Environmentally Sensitive Areas, farmers can now be paid under the CAP for traditional low-input farming. Funds have also been provided to designate new habitat schemes, and for promoting public access onto set-aside land. Many of these initiatives (e.g. set-aside) are primarily driven by the need to reduce agricultural output, with the beneficial spin-off being the enhancement of the natural environment. The support for these initiatives however, whatever the initial driver, complements UK-funded schemes designed to sustain and enhance valued landscapes and habitats, as in the Countryside Stewardship Scheme in England and the whole farm management scheme (Tir Cymen) in Wales (Select Committee on Sustainable Development (SCSD), 1995). To give an indication of the scale of grant aid available with this regulation, box 7.1 provides the 1997 payment rates for the 'Water Fringe Option'.

Water Fringe Option Payment rates (£/ha)	
Withdrawal of permanent grass from production	240
Withdrawal of arable land from production	485
Extensive grassland management on permanent grass	125
Extensive grassland management on arable land	435
Raised water level supplement	40

Box 7.1

There are now more farmers involved in countryside management than ever before. Further, the U.K. Government remains committed to "conditionality" or "cross-compliance" (a policy whereby environmental conditions are attached to support payments to farmers) as a means of encouraging a more sustainable approach to rural land management. It has come into prominence not only because of environmental concern but also because of the need to achieve the maximum possible value from the large sums of public money invested in agriculture. The UK government has been one of the leading advocates of this approach in the EU.

Cooper presents an interesting table (box 7.2) illustrating farmers' perceptions of key constraints to land conservation. It seems from this evidence that although money has the greatest affect on uptake of such schemes, time, prevailing attitudes and a variety of other constraints have large and notable effects. If current schemes are to be followed into the time-scale of sustainable management, then this type of evidence deserves high levels of interest.

Constraint	frequency of response to multiple answers allowed %
Lack of money	95
Lack of time	26
Attitudes	21
Knowledge	10
Season/climate/weather	6
Other	21
Don't know	2
None	1

Box 7.2: Farmers perceptions of key constraints to land conservation (Cooper *et al.*, in Haycock *et al.* (eds.), 1997)

Grant aid is not limited to just AEP. Possible sources of grant aid for habitat *creation* in connection with riverbank protection include the set-aside scheme, Countryside Stewardship or Environmentally Sensitive Areas designation. However, with regard to compensation for land *loss* caused directly by the decision to let natural process continue unabated, modifications to existing grant-aid and stewardship mechanisms should be sought (box 7.3). Simply to suggest continued erosion or managed realignment of the riverbank is naïve if not suggested within a package of compensation for loss. But compensation is not a part of the present system. Thus, the Environmentally Sensitive Areas designation and Habitat Scheme could be spread over longer time periods than the present 10 years. Further, the Habitat Scheme could see the expansion into a 'Riparian Buffer' initiative. Similarly, the Countryside Stewardship could be expanded towards 'waterside land restoration' initiatives (see box 7.3 for detail of all these options).

One particular characteristic of the grant-aid approach however, is not so well suited to the sustainable management approach. The AEP scheme contracts finance farmers for only a few years at a stretch and little consideration is given to protecting any environmental gains once agreements expire. This is in direct contention with the long-termism prescribed by sustainable management.

As has been seen in the United Kingdom over the last fifty years or so, the use of grant subsidies needs to be approached with care. As Pennington states, "*conservationists claim success in obtaining more subsidies for their personal projects, farmers happily board the new gravy train of government grants, and bureaucratic budgets grow as the multitude of schemes requires more administrators for its operation. Farmers want to preserve their incomes and maintain inflated land values and, after initial opposition, have been quick to realise that a new coalition with the environmentalists may increase* *the rate of agricultural support. The SSSI payments, for example, direct benefits to those who are damaging, or threatening to damage, environmental sites – farmers and landowners who continue to practice good husbandry are given nothing* (Pennington, 1996). Similarly, the Countryside Commission Hedgerow Incentive Scheme comes under similar attack. In 1992/93, 607km of restoration work was completed, with a further 950km the following year. Perversely, at the same time as the CC was paying farmers to restore hedgerows, three times that number (3,000km) were removed due to farm intensification (DoE, 1993 in, Pennington, 1996). In other words farmers increase their incomes by restoring hedgerows, in the knowledge that several years hence they may claim more money to put them back. It is perfectly possible to receive conservation payments for one

OPTION 1: SLOUGHING EASEMENT
EA purchases land expected to be lost over next 30 years. Riparian owner retains right to use land for financial gain and receives initial purchase payment.

OPTION 2: MITIGATION
EA purchases land on riparian corridor and offers similar land to riparian landowner, to the same value in its place.

OPTION 3: ENVIRONMENTALLY SENSITIVE AREAS (ESA)
Incentive payments made by MAFF over a longer period than the existing 10 years to enter into management agreement to allow natural channel processes to continue uninhibited, except where damage or loss to 'valued' structures is foreseen.
Annual payments: £8-400/ha.

OPTION 4: THE HABITAT SCHEME: WATER FRINGE AREAS
Voluntary scheme, where farmers enter into 10 or 20 year management agreements to create buffer strips on the water's edge.
Annual payments (1996): £125-360/ha.

OPTION 5: THE HABITAT SCHEME: RIPARIAN BUFFER SCHEME
Based on 'Saltmarsh Creation' scheme. 20-year management agreements for the conversion of land into 'let erode' land where this is consistent with the provision of catchment level planning.
Annual planning: £195/ha permanent grassland; £525/ha arable land.

OPTION 6: COUNTRYSIDE STEWARDSHIP: WATERSIDE LAND RESTORATION
Administered by MAFF, encourages the restoration of a range of habitats and landscape features in return for annual area-based payments and limited capital payments. Aims to restore natural channel planform through 'let erode' programme. 10 year agreements.
Annual payments (1996): £15-275/ha.

Box 7.3: Options for grant-aid and stewardship field while continuing the process of intensification on another. Likewise it is quite legitimate to destroy habitat in order to expand production and then to claim money in future years to 'enhance' the environment by returning it to its original state (Pennington, 1996).

7.13 Property Rights Approaches and Co-management

A more favourable approach to enhanced sustainable management is the concept of property rights as a method of internalising both costs and benefits to the individual responsible for degrading practices on the river.

The property rights approach considers that in certain cases private decision making will fail to take significant considerations into account, resulting in market failure. If the result of certain activities benefits society as a whole, the people benefiting would often not be willing to pay their share since they benefit whether they pay or not. Similarly, market failure occurs when people not involved in the decision-making process incur costs. Upstream intervention affecting the downstream environment may not be considered by decision-makers. Therefore market decisions may be imperfect (Copeland in, Baden and Leal, 1990).
This approach rests upon the assumption that if the individual who is causing degradation has to pay the full cost of their actions and if the revenue they receive represents all of the value generated by those actions, they will undertake only actions that will lead to net gains for themselves and society. So, if increased flows cause problems downstream of, for instance, inappropriate bank reinforcement, then he/she must be responsible or legally liable for those detrimental effects on the downstream 'neighbour' and must consider them in determining their actions. This offers a potentially strong disincentive for unsustainable practice. The assignment of property rights determines ultimate responsibility for the costs (which encapsulates the 'Polluter Pays principle') and similarly, a legal system that recognises the property rights of all parties forces decision makers to consider these interests (Copeland in, Baden and Leal, 1990). Property rights encourage those that are responsible for degrading practices to consider the long-term effects of current behaviour (either positive or negative) as these will be borne by them. Thus, as property rights become better defined, resource stewardship becomes more attractive and equally, owners bear more of the costs of rapacious behaviour (De Alessi, 1998). *"Well-defined, enforced, and transferable property rights will create incentives for practical decisions, efficient actions, promotion of environmental quality, and sound resource stewardship"* (Baden and Leal, 1990).

This concept is well suited to the individual riparian landowner, particularly in the rural situation. If they own their land, or have certain rights to it, then they will not want to gain vast disbenefits from that land. The crucial determinant for the private ownership of a resource is that the *"welfare of the decision-makers is tied to the economic consequences of their decisions"* (L. De Alessi in, De Alessi, 1998). However, it must also be recognised that the river is a longitudinal system, affected by its upstream and downstream counterparts, and indeed its catchment as a whole. Similarly, a large proportion of farmland for instance, is already privately owned, so that one can not simply advocate a move to private property rights if they are already in existence. For this reason, there is a need to develop the principles behind private property rights further, towards a mechanism that ties disbenefits of degrading practices, or incentives for change, to others. This leads to the principles of ***co-management***, and the sharing of cost and benefit.

Co-management refers to the mechanism by which local communities manage resources under rules that they develop with the support of Government. This method, where they and the Government share power and responsibility is recognised as a promising new idea (McCay, 1993 in, Gardner and Stern, 1996).

Some authors argue that individually parcelled private property rights may offer the greatest rewards for conservation to their owners, but are also the most costly to define and enforce. Therefore, *common property*, conceived as a private arrangement, is seen as the optimal solution. It is often an effective way to internalise the benefits of conservation and reward the group with many of the benefits of parcelled ownership without so many of the costs (De Alessi, 1998).

There are a number of rules that need to be implemented for success. Ideally, the property rights need to be transferable to create an incentive for the resource to be moved to other uses or owners. So, if the river is more valuable to fisheries than to irrigation, the owner must have the right to choose the use of, and be able to charge users and capture a share of the benefits resulting from managing his/her property in a sustainable way (Copeland in, Baden and Leal, 1990). Similarly, the landowner should be able to claim as their own, any increased value of his resources that result from him or her managing the land sustainably.

De Alessi suggests that because common property regimes rely on group control, they are often most effective among homogeneous groups of people. *"Rules are easier to enforce in such a group. In some cases social ostracism or even mere disapproval is enough to warrant compliance with the* *rules*" (De Alessi, 1998). The level of control typically depends on the balance between the value of the resource and the costs of monitoring the group and excluding outsiders. This could be illustrated by riparian landowners along a river valley, particularly in the rural location.

The major problem with regard to river management, is the continuity of process and drivers between upstream and downstream ends of the river system, and defining a methodology which acknowledges this. In other words even if the most sustainable option financially for land owner 'A' is to accept managed retreat, this may not have the best repercussions for his or her upstream/downstream counterparts. A co-management system, or ***'Riparian Landowner Co-operative' (RiLaC)***, could be an agreement formalised in law with clearly defined boundaries within a given distance from the channel, that internalises the externality of being provided with a payment and perceiving the management process to be at an end. A sense of communal ownership would be propagated through the membership of homogenous, organised and one voiced groups which would achieve a facilitative political mechanism if managed correctly.

Such a system is exemplified by the New Zealand Resource Management Act (RMA) (1991). The RMA has as its purpose "*to promote the sustainable management of natural and physical resources" while avoiding, remedying or mitigating any adverse affects on the environment*" (Cooper *et al.*, 1997 in Haycock *et al.*, 1997). The RMA has brought together in one statute the management of land and water, thereby providing legislative support for considering off-site impacts of land use and the mechanisms for dealing with such impacts.

New Zealand property rights law is clear, with owners having the right to use, enjoy and take profits from the land, but they do not have the right to do with the land anything they wish. This means that restrictions on land use activities brought in as a rule in a regional plan under the RMA are legally enforceable.

Whilst the RMA provides such regulatory powers, "*there is now increasing acceptance in New Zealand that emphasis on a rules-based approach* [defined as a set of criteria that land-owners must adhere to] *does not meet sustainability goals, and that emphasis on encouraging voluntary adoption of environmentally-sound land management practices should be seen as more effective*" (O'Brian, 1994; MfE, 1996 in Haycock *et al.*, 1997). During the process of implementing the RMA it became apparent that farmers preferred a voluntary approach, supported by rules to bring the wayward farmers into line so as not to compromise the efforts of others (MfE, 1996). For instance, farming leaders were generally supportive of the RMA, but slightly critical of the *initial* approach of the scheme, which was seen to be over-regulatory, non-consultative and ignorant of farming operation (Simeonidis, 1994 in, Haycock *et al.*, 1997).

"There is now increasing recognition that this voluntary approach, when supported by education initiatives, making expert help available, and limited incentives (e.g. rates relief, provision of riparian plants), is the only approach to achieving large-scale implementation of riparian buffer zone management that is effective in the long-term" (Cooper *et al.*, 1997 in Haycock *et al.*, 1997). Therefore, in the context of England and Wales, the RiLaCs would have minimum intervention as a key objective but within a framework of practical guidelines on how this could be achieved financially and co-operatively. Based upon sound science through the use of the SURCoMES and SAM, any RiLaCs member could easily and accountably base his or her management decisions upon the likely cause/effect relationships on sediment and flow. The simple and transparent rule-base of the SURCoMES could aid the RiLaCs in prescribing likely problems of management. A major advantage of common property rights is in the risk sharing which it offers in the realms of flood defence, and greater consistency of bank protection measures rather than the common *ad hoc* approach. The RiLaCs would help facilitate this style of management.

According to Phillipson (1996), "*co-management, as a sharing of policy formation, implementation and monitoring responsibilities, may fundamentally alleviate some of the problems of sustainable [development] through initiating a more legitimate, informed and co-operative policy-making and management environment*" (Phillipson, 1996). Co-management signifies a redefinition of the relationship between state and user group with self-governance in a legal framework established by government. An example of the communalisation of Property rights is the fishing industry of Japan. Community based territorial use rights, reinforced by local modes of social regulation based on these principles of equity, have largely succeeded in preventing the tendency to over-exploitation in Japan's inshore fisheries (Kalland, 1996 in, Drummond and Symes, 1996).

For co-management to be sustained, Phillipson recommends that:

1. co-management arrangements should be formalised in law thus preventing circumvention;
2. there should be clearly defined rights and/ or boundaries of membership to propagate a sense of ownership and responsibility;
3. they should be homogenous, organised and one-voiced groups; and,
4. facilitative political mechanism is of prime importance (Phillipson, 1996).

An approximation to the concept of communalisation in the Agency might be achieved through regionalisation of policy integration within the policy process and the development of co-management systems. The Agency does have some of the building blocks in place, even if not explicitly recognised at present. The *Area Environment Groups* provide a typical example of an existing forum. Indeed, despite Ostrom stating that large-scale socio-economic changes have increasingly limited the possibilities for co-management she does suggest that larger community management systems built up of smaller ones – 'Nested Enterprises' - still have potential (Ostrom, 1990 in, Gardner and Stern, 1996). This could be seen as directly applicable to the Agency and a structure for a more community interactive management structure.

It is difficult to envisage how a successful co-management system might be implemented in England and Wales given the prevailing institutional and political culture. But as is highlighted in the example of the U.S. National flood insurance program (see section 7.5), elements of the co-management philosophy can be integrated with more traditional approaches in the river and floodplain area.

Unfortunately one major barrier to this transfer of property rights is the costs involved in transforming a situation from one in which individuals act independently to one in which they co-ordinate activities (Ostrom, 1990 in, De Alessi, 1998). In the context of England and Wales, it seems more feasible that rather than the stricter (i.e. Government controlled) common property rights advocated in the literature, a type of formal ***Consensual Co-management Agreement*** could be appropriated. This would set out a system of sharing costs and benefits of each of the individual landowner's actions along his or her stretch of river, amongst *all* owners.

As Ostrom states, the greatest weakness with property rights is the lack of resiliency in the face of pressure from outsiders. There are often informal agreements not recognised in courts and their owners often have no legal recourse (Ostrom, 1997 in, De Alessi, 1998). The co-management agreement would essentially need to be a consensual product, but one with a robust legislative framework as its basis. Without this it would not gain the credibility to overcome these obstacles.

7.14 Legal Buffer Zones, Easements and Covenants

As part of the co-management approach, ***Easements*** and ***Covenants*** are good examples of the form of agreement to which voluntary negotiations over land use might lead. Knetsch argues in favour of a system of easements to "*reduce uncertainty about investment in land development. Users of land generating recognised unsustainable practices would be required to purchase easements from neighbouring landowners. The neighbouring landowners would be compensated for the loss in the value of their land, and prospective purchasers of the neighbouring land wishing to use it for a purpose which required a cessation of the nuisance generating activity would have to buy back the easement*" (Knetsch, 1983 in, Corkindale, 1998). The covenant can be publicly registered as a restriction on the use of land. A party sensitive to a use to which a neighbour might put his or her land would purchase from the second party the latter's right to do what would otherwise be lawful. A party seeking a restrictive covenant would be likely to want it to 'run with the land', that is, to be binding on subsequent owners (Ellickson, 1973 in Corkindale, 1998).

Covenants negotiated between landowners will tend to optimise resource allocation among them, through promising restraint from specified negative behaviour. This pattern indicates that landowners feel that affirmative obligations are likely to be inefficient, perhaps because these agreements are expensive to enforce or because landowners fear a substantial drop in the value of their property from such encumbrances. In the U.S., property law has been hostile to the running of affirmative duties to succeeding owners. Where affirmative covenants are enforceable, they are often not enforced in practice. For example, the largest merchant homebuilder in the US, Levitt & Sons Inc., required homeowners to covenant to mow and weed their lawns weekly during the summer months. These covenants were not enforced by Levitt or its homebuyers (Ellickson, 1973).

In addition to promoting efficiency, covenants will not usually cause unfair wealth transfers among landowners. Parties will not agree to a contract that they perceive as unfair. Thus, assuming equal bargaining power and information, ***consensual covenants*** will not involve inequitable gains or losses to any party (Ellickson, 1973). This is of particular pertinence to the moves advocated towards sustainable management. Consensus achieves acceptance of sacrifice; acceptance of sacrifice achieves a sustainable environment.

However, Ellickson does state that covenants can cause problems when they impose external costs on third parties, reaching sub-optimal resource allocation and unfairness. The classic American example of this nature was the widespread use of covenants to prevent the sale of residential property to Blacks (Ellickson, 1973). It must be assumed however, that any covenant in sustainable environmental management would be reached through a thorough process of participation and consensus. For that reason, such politically incorrect and unfair practices would be minimised.

In the U.S., the application of ***Conservation Easements*** in particular has lead to co-operative public and private management of ecosystems. This is an important analogy to the ideal of minimum intervention in the riparian zone. A Conservation easement is a property deeded to a conservation organisation or governmental entity that prohibits, as part of the deed of trust, uses of that property that are incompatible with conservation or preservation objectives. Typically, an easement will,

> *"Prohibit subdivision of the property, construction of commercial buildings or operation of a commercial enterprise, the dumping of trash or waste materials and the conduct of activities which would result in a significant soil erosion, water pollution, loss of aesthetic value, or degradation of habitat for fish and wildlife or plant species. Conservation easements ordinarily do not provide public access to the property, nor do they prohibit construction of buildings, fences, or other improvements necessary to carry on activities compatible with conservation objectives"*
>
> (Ibid. in, Kwong in, Baden and Leal, 1990).

Kwong sees the conservation easement as an attractive approach to land conservation for several reasons, the most powerful of which being that the land remains in private ownership. The maintenance and upkeep of the land remain in the landowner's hands, which represents savings to the public sector (Kwong in, Baden and Leal, 1990). This is a big advantage if it is to be advocated as a viable mechanism to use in the drive to more sustainable river management. Sustainability as a concept has enough bridges to cross without additionally fighting financial unfeasibility. In the context of the river, most riverbanks are under private ownership already in England and Wales, so that this is directly transferable. Furthermore, the landowner often faces greater incentives to manage the land efficiently and in a manner consistent with conservation or sustainable management goals. Because conservation easement contracts are developed both by the landowner and the trustee, the landowner would formally commit the land to a form of sustainable management and agree to abide by the terms of the contract. The conservation easement in the U.S. is a legal document enforceable through the courts (Kwong in, Baden and Leal, 1990).

Very similar to the Conservation Easement, but with more explicit parallels to sustainable *river* management, is a second U.S. example, the U.S. Army Corps of Engineers' ***Sloughing Easement*** approach. The sloughing easement illustrates how the approach can be applied directly to the riparian system.

'Sloughing' gives the U.S. Government the right to allow riverbanks to slough (erode) whilst still compensating landowners for the loss of land. It is implemented on current erosion rates that are predicted to continue and the value of the easement is based on the highest and best use of that land. Value of future land eroded is discounted to the date of the easement. The easement allows for erosion at any time and acquires the right to allow the bank to erode or slough to the ultimate erosion line as determined by the Army Corps of Engineers (USACE, 1988).

As an example, in 1995 the Corps prepared a plan to remedy problem erosion on the Missouri River between Fort Peck Dam, Montana and Gavins Point Dam, South Dakota and Nebraska. Since the dam project inception there occurred significant lowering of the streambed downstream from the dams; a continuing net loss of high bank lands; a reduction in yearly rates of erosion; and, a widening of the channel in some locations. Although high-bank erosion rates were declining, the alluvial processes continued to be very dynamic between them (USACE, 1988).

The Corps straight line projection of erosion rates, assuming equilibrium in 50 years concluded a loss of 10,350acres of land beside the Missouri with 0.1% of total corridor (16,000000 acres), 1.2% of total valley land and 5.1% of high-bank lands. The corps stated "if this loss were evenly distributed along the river, it might be tolerated by landowners. However, the losses tend to be localised, so a single landowner can experience devastating losses" (USACE, 1988). The reader is reminded at this point, of the potential application here for the 'Consensual Co-management Agreement' proposed earlier.

On reference to the statistics in box 7.4, it can be seen that the economic effects of this erosion and the associated effects or losses, such as productivity capability, ranged from almost nothing for marginal lands to as much as $2,000/acre for very productive croplands.

Based upon these problems encountered on the Missouri, the Secretary of the Army was directed, under the U.S. Water Resources Development Act (1988) and Flood Control Act (1944) to,

> *"Undertake such measures, including maintenance and rehabilitation of existing structures, acquisition of real property and associated improvements (from willing sellers) and monetary compensation to affected landowners which the secretary determines are needed to alleviate bank erosion and related problems associated with reservoir releases along the Missouri River between Fort Peck, Montana and a point 58 miles downstream of Gavins Point. The cost of such measures may not exceed $3,000,000 per fiscal year. Notwithstanding any other provisions of law, the costs of these measures, including the costs of necessary real estate*

interests and structural features shall be apportioned among project purposes as a joint-use operation and maintenance expense. In view of structural measures, the secretary may acquire interests in affected areas, as the secretary deems appropriate from willing sellers." (USACE, 1988).

PROJECT AREA RIVER CORRIDOR COUNTIES: 16m acres
90% Agriculture
50% Grass
38% Cropped

LAND USE IN RIVER FRINGE (500ft border of lands along river edge)
25% Cropland
29% Grassland
32% Woodland
12% Sand dunes and marshes
2% Structures and utilities

Box 7.4: The economic effects of erosion and the associated effects or losses (USACE, 1988).

A sample Sloughing Easement Estate is provided in box 7.5. The sloughing approach is an interesting concept to consider in Britain. It offers an incentive (initial purchase payment and continued use of productive land) for the riparian landowner whilst financially the ACE have proved it cheaper than structural alternatives. Environmentally, it leaves the river to self-adjust, so that it supports the concepts of minimum intervention, metastability, flooding and erosion. It could also be seen as fully compatible with the RiLaCs philosophy.

As can be seen in the sample easement (box 7.5), future development is also constrained: "provided that no structures for human habitation shall be constructed or maintained on the land, and provided further that no other structures shall be constructed or maintained on the land nor shall any excavation be made or landfill placed on the land, or any change be effected which will alter the natural contour of said land" (USACE, 1988).

The perpetual right, power, privilege and ease permanently to overflow, flood, submerge, saturate, percolate and erode (the land described in Schedule A) (Tracts Nos ____, ____, and ____) together with all right, title and interest in and to timber, structures and improvements situated on the land except fencing, and also excepting all bodies of water and all related structures to keep water on or off the land, and roads and appurtenant structures, if any, including the appurtenant right of normal use and maintenance of all improvements so excepted; and further together with continuing right to clear and remove any trees, brush, debris, and natural obstruction which in the opinion of the representative of the United States in charge, may be detrimental to the project; provided that no structures for human habitation shall be constructed or maintained on the land, and provided further that no other structures shall be constructed or maintained on the land nor shall any excavation be made or landfill placed on the land, or any change be effected which will alter the natural contour of said land without first obtaining approval in writing from the representative of the United States in charge of the project; reserving however, the landowner (s), their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with or abridging the rights and easement hereby acquired; except that no use shall be made of said land contrary to Federal and State laws with respect to pollution; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines.

Box 7.5: Sample Sloughing Easement (USACE, 1988).

It is interesting to consider community opinion to the sloughing easement. The 1995 document includes the full list of Consultees and the adjoining correspondences. Consultation was carried out through the public meeting approach and was met with some hostility. Land acquisition had traditionally been unpopular with landowners so it was recognised that public input was necessary. To give some idea of the generally negative output from this consultation, common public comments included,

> *"ACE made the mess, they can clear it up;*
> *"Structural methods should be used;*
> *"Corps does not value land the same as owners;*
> *"Corps is short-sighted – land will be gone forever"* (USACE, 1988).

Many consider that the Corps' refusal to build structures is "contemptuous of the landowners and of the Congress of the U.S."(USACE, 1988), which they believed had given clear distinction and money to build stream-bank protection features. These comments are presented as an example of the often-misinformed beliefs of riparian owners or 'the public'. From a sustainability point of view the Army had considered all factors illustrated in table 7.1, which are admirable with regard to the key characteristics of sustainability, and yet were still met with these opinions. This exemplifies the need for good information programmes combined with comprehensive consensus building and awareness raising techniques. It is essential in a management case like the sloughing approach that the experts carry over their message to the non-experts in as clear and transparent way as possible. Indeed, the final conclusion of the corps summarises this lack of understanding of the financial and environmental sustainability of such an option,

"No combination of benefits – economic, environmental or social – outweigh the cost of $110m to construct bank stabilisation features. However, locally affected owners and state interests strongly support structural bank stabilisation. Acquisition by sloughing easements of affected areas at an established cost of approximately $10 million is a more fiscally responsible alternative than construction of stream-bank protection, however, a majority of the affected land owners continue to strongly support structural measures" (USACE, 1988).

Factors considered in the Sloughing Approach	
Social effects:	Community growth
	Potential land use
	Aesthetic and visual resources
	Community cohesion
	Wild and scenic rivers
	Cultural resources
	Population displacement
	Floodplain development
	Hazardous and toxic wastes
Economic effects:	Property values
	Tax revenues and local government finance (land acquisition would mitigate losses to willing sellers)
	Public facilities and services
	Employment and labour force
	Business and industry
	Agriculture productivity
	Commercial navigation
	Regional growth
	Displacement of farms
	Prime and unique farmlands

Natural resources:	Hydraulic nature of the historical river
	Hydraulic nature of the present river
	Stabilisation Vs channelisation
	Sedimentary transport
	Degradation
	Terrestrial/riparian habitat
	Aquatic habitat
	Ecosystems of concern wetland quality and quantity
	Waters of the U.S.
	Air and water quality
	Threatened and endangered *sp.*
	Man-made resources

Table 7.1 (USACE, 1988)

7.15 Land-use planning and Insurance

One last economic instrument, but albeit one with the most potential for optimising sustainable practices in parallel to a consensual RiLaCs initiative with easements, is the use of insurance. It is important to note that within the context of England and Wales, these foreign case-studies are more likely to illustrate the point through the mechanism of land-use planning. A case study is provided here to illustrate how the use of a particular insurance act in the U.S.A. has overcome many of the hurdles to sustainable management of the floodplains in America, together with utilising some of the social mechanisms discussed in chapter 8. This approach is suggested as particularly suitable in the flood risk management situation.

In December 1995 the "National Mitigation Strategy: Partnerships for Building Safer Communities" was prepared by the U.S. Federal Emergency Management Agency (FEMA) in support of the International Decade for Natural Disaster Reduction. The document foreword is reproduced in box 7.5 to provide a summary of the strategy principles together with the elements common with sustainable management.

The NMS uses as its basis the 1994 National Flood Insurance Reform Act which in turn developed from the 1968 Act of the same name. Prior to 1968 the Federal Government attempted to control flooding nationally through structural measures. As these became less feasible financially, the Government started to explore the possibility of decreasing disaster relief payments through flood insurance.

In spite of the cost, the Government continued to expend monies on Federal disaster assistance which prompted the question as to through which method monies should be made available most effectively after a flood - *disaster assistance* or *flood insurance payments*. The private insurance industry is largely unwilling to underwrite and bear the risk of flood because of its catastrophic nature. Moreover the risk of flood is subject to adverse selection, i.e. only the less desirable risks choose to insure thereby giving rise to underwriting losses (FEMA, 1997). In the 1970s it became apparent that after major floods, relatively few individuals who sustained flood damage had purchased flood insurance however, therefore, the 1973 Flood Disaster Protection Act proposed that regulated lending institutions could not make, increase, extend, or renew any loan secured by improved real estate or located in an hazard area in a participating community unless the secured property and any personal property securing the loan was covered for the life of the loan by insurance. FEMA concluded in the same period that voluntary participation as well as a mandatory program with weak sanctions, yields too few subscribers. In 1993 it was established that only 2m of the 11m structures in hazardous areas were insured. Reasons ranged from:

- homeowners believed they couldn't afford flood insurance in addition to mortgage payments on homeowners insurance
- lenders were often relaxed in enforcing the mandatory purchase provision without the sanction of penalty
- insurance policies purchased at the time of mortgages were often allowed to lapse.

Because this all led to disaster relief payments still being high congress decided to introduce more inducements which gave rise to the 1994 Reform Act (FEMA, 1997).

Consequently, and in parallel, congress set up a Federal flood insurance programme to complement this act. The ***National Flood Insurance Programme*** (NFIP) encourages property owners to purchase insurance for structures and contents from the Federal Government. It combines the concepts of insurance protection and hazard mitigation whilst providing an incentive for communities to adopt floodplains management ordinances to mitigate the effects of flooding upon new or existing construction (FEMA, 1997).

A community establishes its eligibility to participate in the NFIP in two ways:

1. By adopting and enforcing floodplain management measures to regulate new construction
2. By ensuring that substantial improvement to existing structures within its Special Flood Hazard Areas (SFHAs) are designed to eliminate or minimise future flood damage (FEMA, 1997).

"Throughout its history, the US has experienced natural disasters which have resulted in unacceptable loss of life, injury and property damage. During the past 6 years, the United States has been more seriously impacted by a series of large-scale hurricanes, earthquakes, and floods that have taken an extraordinary toll in human lives and suffering. Public and private resources, which are needed for the advancement of other national priorities and goals, have been diverted for recovery and reconstruction. Virtually every region of the country has been affected.

As more and more Americans have chosen to live along ocean or inland coastlines or in areas of seismic risk, often with little or no attention to the need for sound building practice or land use policy, the risk from natural hazards has grown exponentially. By the year 2010, the number of people residing in the most hurricane-prone counties (now $36 million) will have doubled, as will the number of those living in the most seismically active regions.

Floods have caused a greater loss of life and property, and have disrupted more families and communities, than all other natural hazards combined. In recent decades, over 800 percent of Presidentially declared disasters have been floods that have resulted in billions of dollars of losses. Although the natural phenomenon of flooding cannot be prevented, its impacts – like those of wind and seismic hazards – can be reduced through mitigation.

In response to the unacceptable loss of life and property from recent disasters, and the awesome prospect of even greater, catastrophic loss in the future, the National Mitigation Strategy has been developed to provide a conceptual framework to reduce these losses. Hazard mitigation involves recognising and adapting to natural forces and is defined as any sustained action taken to reduce or eliminate long-term risk to human life and property. The Strategy is intended to engender a fundamental change in the general public's perception about hazard risk and mitigation f that risk and to demonstrate that mitigation is often the most cost-effective, and environmentally sound, approach to reducing losses. The overall long-term goal of the Strategy is to substantially increase public awareness of natural hazard risk and -within 15 years –to significantly reduce the risk of loss of life, injuries, economic costs, and disruption of families and communities caused by natural hazards.

The foundation of the Strategy is to strengthen partnerships among all levels of government and the private sector to empower all Americans to fulfil their responsibility for ensuring safer communities. Effective implementation of hazard mitigation measures will contribute to the long-term economic and environmental well being of a community as well as protect the natural and cultural resources of our Nation.

All levels of government must be involved in the mitigation proceeds with both pre- and post-disaster mitigation efforts. "The National Mitigation Strategy – Partnerships for Building Safer Communities," sets forth major initiatives in areas of hazard identification and risk assessment; applied research and technology transfer; public awareness, training, and education; incentives and resources; and leadership-p and co-ordination. This strategy must be implemented in partnership with State and local governments and private sector constituents, including, and most especially, the general public."

James L. Witt
Director, Federal Emergency Management Agency

Box 7.6: Foreword, "National Mitigation Strategy: Partnerships for Building Safer Communities" (FEMA, 1995)

An SFHA is an area within a floodplain having a one-percent or greater chance of flood occurrence in any given year. SFHAs are delineated on maps issued by FEMA for individual communities. These flood zones are represented on the field maps by the darkly shaded areas with zone designations that include the letter A or V (FEMA, 1997).

Since 1983 the 'direct' policy program where insurance was only available from insurance agents who dealt with the Federal Insurance Administration has been supplemented by the 'write your own' (WYO) program where more than 90 insurance companies, based on an arrangement with the FIA, issue policies and adjust flood claims under their own names. The insurers receive an expense allowance and remit premium income in excess of claims to the Federal Government. The FIA pays losses in excess of premiums and sets the rates, coverage limitations and eligibility requirements (FEMA, 1997).

The Flood Insurance Manual (FEMA, 1997) outlines all of the general rules, eligibility, mock applications and Insurance ratings to the American people (FEMA, 1997). There are a number of analogies that we may draw at this early stage with the U.K. and flooding/erosion loss. Firstly, the U.K. too, could be argued to be spending too much on protecting those that choose to live in the flood risk zones. Individuals' costs are not borne by the individual, but by the taxpayer through higher council taxes for their area, and therefore, the house buyer continues to buy on this land, and the developer continues to build. Of utility for a parallel program in the U.K., the Agency holds a database in the U.K. of all areas at risk from the 1:50 year flood. This provides a vital database to such a program. In common with the measures advocated in this thesis, the FEMA program also utilises market mechanisms to internalise cost.

The cornerstone of the FEMA strategy is the internalising of the financial effects of flooding to the community affected. The ultimate goal is two-fold. By the year 2010:

1. to substantially increase public awareness of natural hazard risk so that the public demands safer communities in which to live and work; and,
2. to significantly reduce the risk of loss of life, injuries, economic costs, and destruction of natural and cultural resources that result from natural hazards.

Providing a disincentive for continued development of new property in flood prone areas of England and Wales requires greater influence from the existing commercial insurance structure. The risk of flood should be explicitly recognised in the home insurance policy (both 'contents' and 'buildings'). With regard to new housing development on the floodplain, potential homeowners could be made aware that they would be required to pay an extra premium on their house insurance specific to the risk that they must accept in choosing to live in such an area. If this disincentive to buy was large enough, then the developer would perhaps see a 'trickle-down' effect in the number of homes sold, or alternatively the need to lower prices to still attract potential homeowners. This could provide enough of a disincentive for the developer to consider building in alternative areas. The case study also provides example of how the adoption of floodplain management measures, either by the developer, or the homeowner could lower the costs of this insurance premium.

Insurance provides good example of how a disincentive for further development might be introduced. The work of Priest (2000) will fully engage this discussion in the next two years.

7.2 Identifying *sustainable* incentive programs

There is a profound issue at stake over the effectiveness of incentive policies in bringing about enduring changes in attitudes and knowledge about countryside management which will outlast the schemes themselves (Morris and Potter, 1995).

This chapter has identified a number of incentives advocated for truly sustainable management. Common characteristics of existing programs, and the respective levels of uptake and adoption of sustainable practices now need to be highlighted.

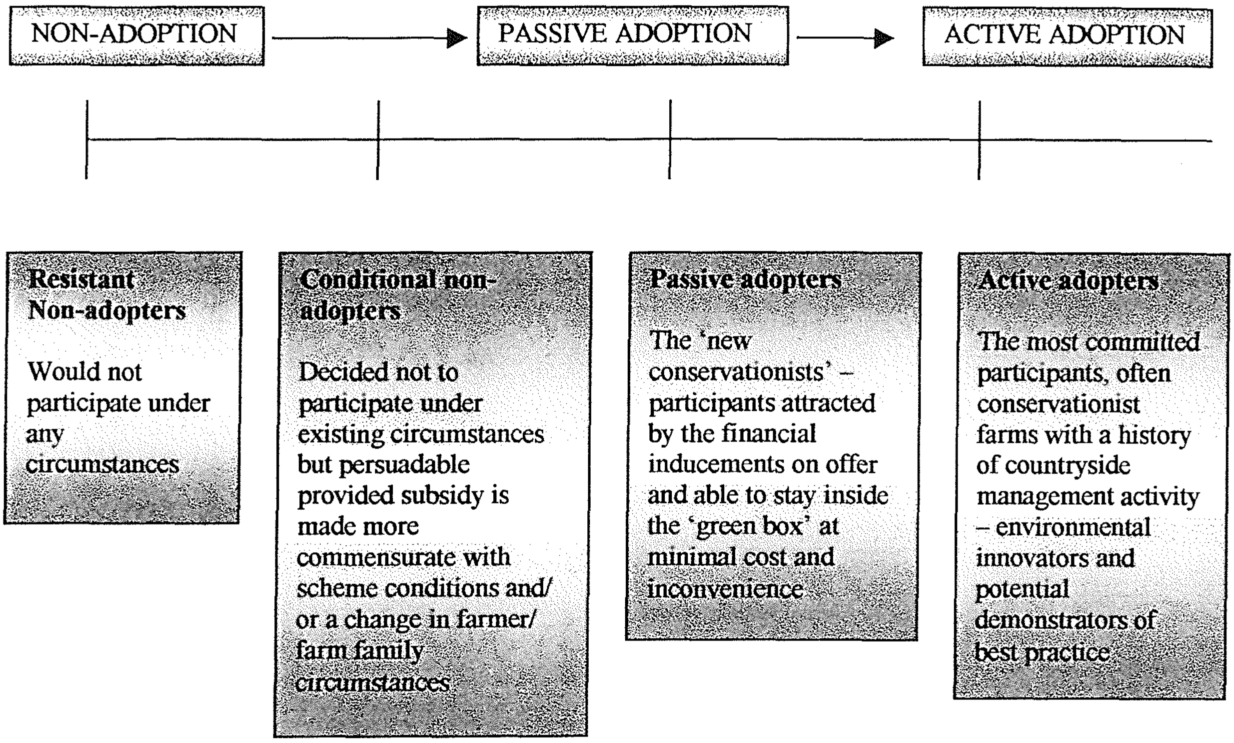
As Morris and Potter suggest, *"policy measures which encourage positive attitudes to [sustainable management] will in the long-term be more effective than those that do not. However, a central determinant is likely to be the attitudes and assumptions about [sustainable management] held by those entering schemes and their willingness to regard participation as a training and learning experience rather than a series of conditions which must be compiled with in order to secure a payment"* (Morris and Potter, 1995).

An interesting method of identifying adoption rates and the defining characteristics of those adopting sustainable practices is through Innovation-adoption theory (IAT). IAT tries to understand the individual choice processes and motives of farmers entering agri-environment schemes (Hodge, 1986 in, Morris and Potter, 1995). IAT found that in terms of agri-environment grants, schemes inevitably favour the more progressive farmers already attuned to environmental ideas. Recruiting those unsympathetic to conservation is much more difficult to achieve. More passive participants now make up the bulk of farmers presently enrolled in 'Environmentally Sensitive Areas' (ESA) schemes but that in being attracted principally by the financial incentive on offer, theirs is a more restricted engagement within the larger aims of the schemes (Morris and Potter, 1995)

Morris and Potter illustrated these conclusions in the following diagram (figure 7.1). As can be seen, for successful sustainable management, there is a need to capture the adopters in boxes 2, 3 and 4. The importance of incentives in the minds of the adopters, or potential adopters are also illustrated. These 'passive adopters' are the ones that need to be targeted in dual information/incentive programs for sustainability.

It is surprising to note the apparent shallowness of the passive participants' engagement with the countryside management goals of the ESA programme in Morris and Potter's work, and similarly the extent to which sustainability needs to be 'sold'. This must be seen as justification for partnership between robust science and philosophy and, participation and market utilisation.

Targeting the recruitment of more active adopters and encouraging them to take on a role as demonstrators of best practice, but also deploying advice, training and using all their considerable skills of persuasion to push more passive participants along the spectrum was highlighted by Morris and Potter as a potential avenue for research (Morris and Potter, 1995). This is similar to some of the LandCare initiatives to be introduced in chapter 8.



Characteristics	*Passive adopter*	*Active adopter*
Main motive for entry	Economic/ financial 'passive restructuring'	Environmental. Altruistic. 'Active restructuring for survival'
Conservation history	More likely to have carried out small scale creative conservation works, less likely to have reduced production intensity, to have sought conservation grants and advice	More likely to have carried out large scale conservation works, to have reduced production intensity, to have sought conservation grants and advice
Change in attitude towards self as a result of participation	Minimal change/little reorientation in thinking	Significant change reorientation in thinking
Perceived conservation value of scheme	Minimal. Motive for entry largely unrelated to environmental factors	Significant. Motive for entry based on recognition of positive environmental benefit of scheme
Impact of scheme on attitude to conservation	No change in attitude to conservation or land use	Rethinking of conservation and land use attitudes on ESA and non-ESA land

Figure 7.1: The participation spectrum (Morris, C and Potter, C, 1995)

7.3 Summary

This chapter has introduced the concept of internalising the externality of unsustainable practice to those involved, so that sustainable management becomes a goal of the riparian community as well as the Environment Agency. Various economic incentives to facilitate this guideline have been discussed, which have highlighted the opportunity for ***consensual co-management agreements*** between the Government and riparian community. These agreements would provide the skeletal structure and guidelines for ***Riparian Landowner Co-operatives (RiLaCs)*** which would be groups formalised under law that would co-ordinate at the community level, constraints on further degradation of riparian areas, whilst optimising benefits to the riparian owners. ***Easements*** would be key mechanisms within this framework, which would work to compensate the riparian user or owner for the sacrifice that strong sustainable river management often brings. New development would benefit from the increased utilisation of the ***commercial insurance*** structure, with premiums made payable for the acceptance of risk that development on the floodplain implies.

It is also suggested that with regard to economic mechanism and techniques for change,

1 Grant aid and stewardship needs greater emphasis on the long-termism of sustainable management, and natural fluvial process; and,
2 There should be less emphasis on command and control style regulation with pollution rights and taxes.

This chapter has also highlighted that incentives to change are not sufficient in themselves to shift current environmental management to more sustainable practices if the appropriate attitudes to change are not in place. Economic mechanisms are only a short-term substitute or supplements to, attitudinal shifts which are embedded in the cultural and social barriers to more sustainable practice. The following chapter discusses possible methods for the integration of these two techniques.

CHAPTER 8

Communicating Sustainable Management
Social sustainability and Public Participation

8.1 Introduction

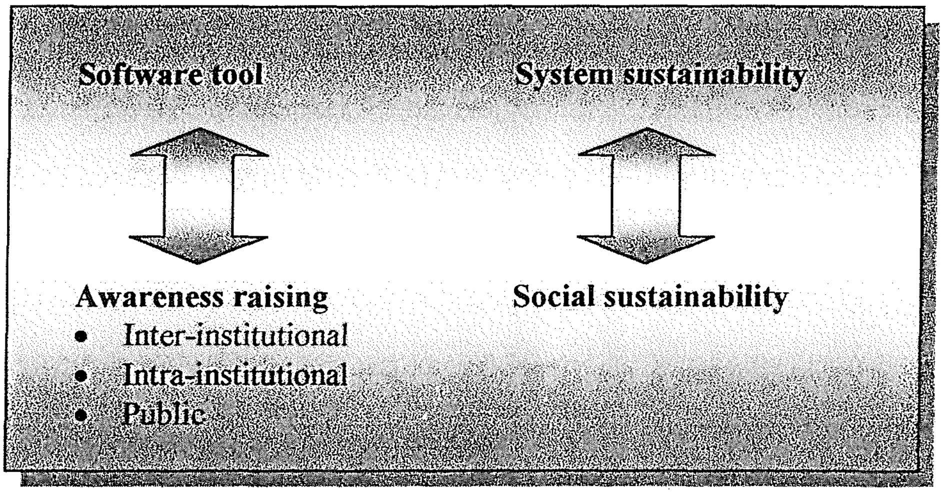
From the preceding discussion it is clear that there is a need to integrate economic incentives with successful awareness raising and information provision. The latter not only involves the education of those at ground level - the landowner or community. It involves those right up to policy level who need a fuller understanding of the need for integration of socio-economics and the physical processes of the river system parallel to the institutional and infrastructural framework within which policy must operate.

The sustainable river management model will only succeed if accompanied by this parallel campaign of awareness raising and promotion. There is a need for both ***system*** sustainability and ***social*** sustainability.

At present there is a lack of pro-action in the Agency's promotion of sustainability – both internally and externally. If sustainable management is to be pushed as a form of best practice then it should be promoted in the Agency and beyond as a way of thinking. What is not wanted is the perception of the concept as a separate entity, as something removed from everyday practice (box 8.1).

This chapter is sub-titled 'social sustainability *and* public participation' explicitly to recognise the distinction to be made between two very different dimensions of the research into the social science of sustainability. Not only do measures or rules on the social issues associated with the river need to be included in the SURCoMES, but the social context within which these must be set and the concept of sustainability ultimately sold, need to be acknowledged also.

If the SURCoMES is to be successful just as much as thought will need to be given to its presentation as to the underlying science. It needs to be transparent, consistent and defensible and similarly easily understood by various players. The transparency can be seen in the rule tables, together with the phased and consistent consultative evaluations throughout the SURCoMES development. Along with participation, both of these add to the defensibility of the system design with expert and public alike.



Box 8.1: Selling Sustainable Management

So far, there has been little analysis of the key cultural and social assumptions on which the model of sustainability rests (Macnaghten *et al.*, 1995). If the SURCoMES is to be a success there is a need not only to be aware of this but to integrate a deeper understanding of it into the methodology of implementation. An approach needs to be identified that has the capacity to be transferable to all river assessments, but is also sensitive to the individual and specific management situations and people at the local scale. There is a need to look to the forefront of social research to identify a technique that will be successful into the future, in all ways.

As Drummond and Symes state,

> *"in practice policy will need to replace the idea of sustainability limits with notions of equilibrium. At present, prescriptions about value shifts and institutional change remain highly generalised and of little utility for policy makers. Engagement with mainstream social theory and in particular with critical realism, can make a valuable contribution to the debate. Instead of focusing on simplistic notions of causality focused upon the event and its contingent conditions, we should now rather concentrate upon the underlying structures and mechanisms involved. It is the task of the social scientist to investigate and explain these underlying conditions more fully and, where possible, to identify more relevant points of entry for policy intervention"*

(Drummond and Symes, 1996).

There are a number of social mechanisms that the Agency might utilise in its pursuance of more sustainable management. The deeper theories of social and behavioural science have the potential to aid the transition to more sustainable management but with regard to policy,

> *"[Environmental Scientists] often draw conclusions based on their intuitive understanding, as if understanding human behaviour does not require the same careful methods of study needed to understand ecosystems - experimentation, mathematical modelling and the other systematic tools of science"*
>
> (Gardner and Stern, 1997)

Limitations of expertise must therefore be realised. This research project does not profess to fully expound on the intricacies of social science. However, this must not stop the consideration of such topics, but be seen instead as a forum by which further thought must be stimulated by those who *are* qualified.

8.2 Promotion of Sustainability within the Environment Agency

The consultations carried out as part of this research project have highlighted that there is at present, no formal education or information programme in place for Agency employees apart from informal and inconsistent (in time and place) road-shows, Sustainable Development (SD) documents and newsletters. Reliance instead is on the recognition of good results in SD projects promoting good practice. This is unfortunately resulting in the SD team receiving pleas from project proposers who need to 'make their project sustainable' epitomising the lack of integration of SD as a way of thinking rather than a separate element of practice. It is clearly easy to advocate further promotion of the concept. However, funding and institutional culture are major constraints to pragmatising the principal aim further throughout the Agency. Further, the assumption that 'promotion' means 'informing' is not always wholly correct (as discussed in section 8.3). Instead, a more participatory structure should be developed whereby individuals and the Agency contribute to the development of sustainable practices at their own level.

The SD team in Bristol are actively producing a SD series, presently totalling twelve (May, 2000). However, at no point in the extensive discussions held with the River Managers nation-wide, had there been any contact with these publications. The initial constraint has been overcome by producing the material in the first place, but not carried through to its fullest potential. Awareness of SD is often very low. Interviewees appreciate that superiors had probably come into contact with the SD series, but this is at the heart of the Sustainable Development debate within the Agency. The information needs to get through to the implementers on the ground, river managers, the community and contractors.

Similarly, of all discussions with those at ground level, only one had heard of 'some sort of road-show' but continued that it was not practicable to attend. The road-shows are championed as the practical measures that the SD team are taking to inform staff. This lack of success suggests then a need for complete review of who and where they are targeting.

The present situation in terms of promotion is therefore one of lack of information getting through to the people who need it. Agency staff are aware of the principal aim, but it seems that this is more within the context of drawing out the relevant phrases from the Agency Corporate Plan to secure project funding. In addition, where river managers are keen to manage sustainably the awareness of what this means in practice is vague. Firm guidelines are needed on:

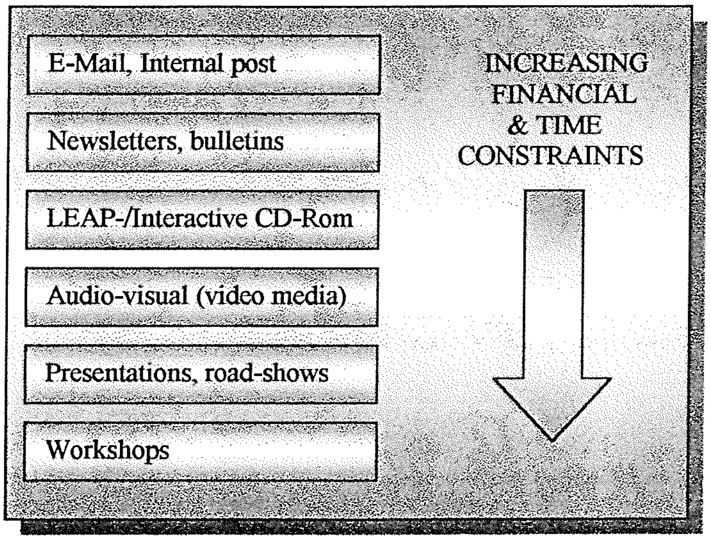
1. What a sustainable river achieves;
2. How this is achieved; and,
3. What it means in practice (e.g. funding, engineering).

There are certain steps that can be taken *now* in the ***awareness-raising*** component of sustainable management. First, there is a need to get sustainability established as a stage within basic Environment Agency procedures and working practices. As part of this move, there is a need to identify the most successful routes for information provision to Agency employees. Discussions have highlighted the inappropriateness of internal post – 'sustainability' leaflets and similar tools are generally not viewed as a priority. The E-mail system offers a more accessible route to some, although it may not be guaranteed that all employees check, or indeed even have access to, e-mail, and if so, whether they would choose to read, again, un-prioritised messages.

Bearing these observations in mind, it seems that the sustainable development message needs to be integrated into more regularly read materials. '*Environment Action*', the Agency newsletter could be an effective means as could bulletins that may be run, even if only office specific publications.

Additionally, more imaginative means should be trialed. Workshops, despite requiring funding and displacing man-hours from other tasks, should be regarded as particularly effective and targeted tools, especially if the SM message were integrated with other suitable training (e.g. the SURCoMES, RHS or Geomorphology training course). Similarly, if the current success of the SD road-shows were redressed, if planned and targeted well, these could be an effective means.

If the staff time or funding are not available for such labour intensive methods, then audio-visual tools, e.g. media or video, should be considered. Similarly, producing an interactive CD-Rom that integrates the SURCoMES with an educational/awareness raising element may be a low-cost but effective tool. The wider use of LEAP CD-Roms (e.g. Northumberland) could provide this means of integration (see box 8.2 for summary).



Box 8.2: Instruments for increased Institutional education and understanding of sustainable management

8.3 Promotion of Sustainability to 'the public' and Public Participation

The question might be asked as to why promotion of the concept of sustainable management should be considered in the public domain. Indeed, one might even suggest that this is a theoretical divergence from the matter in hand of pragmatising sustainable management for the Environment Agency.

However, this thesis advocates that 'a sustainable river is a river that is allowed to function more naturally, so that levels of erosion and channel migration might well increase and flooding will occur in a fashion more akin to its perceived natural state'. This will invariably involve these living in these risk-prone areas which is why, if these objectives are to be fulfilled, ***public participation*** is a major component. This is supported by the argument for the provision of well-placed incentives, introduced in the previous chapter.

Present practice within the Agency is commonly minimalist, consulting only with relevant Landowners. Involving the public or wider community may involve more resources short-term, but long-term benefits of monitoring and a more holistic approach will outweigh these costs. Renn *et al.* suggest a number of benefits:

- People who feel they have a say are more likely to be positive about proposals;
- Fresh ideas may emerge;
- You may get help in kind or other resources;
- People are far more likely to be part of a long-term solution if they have some ownership of the early ideas;
- Involvement on one project or programme builds understanding, trust and confidence that may be important on other occasions; and,
- There is a common language to discuss issues and develop ideas

(after Renn *et al.* (eds.), 1995).

Further, there are two fundamental schools of thought on the utility of public participation. The first is illustrated in the following quote:

> *'People generally are unfamiliar with the idea of 'sustainability' in its environmental sense. But once they understand it, they appear to identify positively with its values and priorities. Indeed, many sense a possible relationship between sustainability and a good 'quality of life'*
>
> (Macnaghten *et al.*, 1995).

The second has a more brutal, less idealistic basis, but is perhaps more realistic than the first. That is, that true sustainability requires trade-offs and therefore there is a need for the public to accept sacrifice. If the riparian zone is taken as a classic example, it might be that the sustainable option is to 'let flood'. Despite Macnaghten's quote, it is naïve to suggest that all people will 'identify positively' with this management option. It is for this reason, for the ***social sacrifice*** that sustainability implies, that there is a need to achieve consensus on the sustainability product. Essentially a command and control or adversarial style of approach is still being used but in a more consensual format, thus hopefully limiting public discontent. Ultimately there is a need for people to sign up to the science – some natural resources are being diminished in quality and quantity in various areas and it is this generation's place to act. It is the sincere hope however that through the initial manipulation of participation and also market mechanisms (see chapter 7) these trade-offs will eventually become acceptable to the public, and sustainability a more intrinsic part of millennium living.

> *Moves towards sustainability will affect everybody, so public involvement is seen as vital*
> (Macnaghten *et al.*, 1995)

As highlighted by the Agency's statutory objectives and their attempts at promoting partnership and communication (chapter 2), public participation is increasingly recognised as of central importance to sustainable development project success. The Agency believes that they should promote transparency and accountability with the public and thus provide a potential mechanism by which they can promote themselves in a good light. Indeed, the seventh statutory objective towards SD in the Agency reads,

> "develop a close and responsive relationship with the public, local authorities and other representatives of local communities, regulatory organisations and public bodies with environmental responsibilities" (EA, 1996I).

The Agency's response to the Government's citizen charter, 'Working with Business and Open Government Initiatives', has resulted in the EA 'Customer Charter' (EA, 1997b). This 18 page document presents the Agency's guiding principles, an introduction to what the Agency does and how the public "can get involved".

In addition to the publishing of the strategy and important policy documents for consultation, including the annual corporate plan, the Agency "*welcome comments from interested organisations and the public on these documents [and] also invite [the customer] to go to one of our Regional Committees or Area Environment Group meetings which provide the chance for you to make your comments heard*" (EA, 1997b).

Similarly, the SD team in Bristol have produced a 23 page publication entitled 'Consensus Building for SD' (EA, 1998k) in accordance with this objective. The team stresses the evolving need to 'achieve a consensus among all relevant parties, including the public [going] beyond traditional consultative frameworks to involve groups and individuals in a partnership approach'. Communication is defined as a two-way process of dialogue rather than the traditional one-way process of information provision, where communication techniques are required that 'provide a greater opportunity for public input and discussion' (EA, 1998k). This statement is reflected widely in management literature in general.

There is now a widely growing awareness that the 'old style' of consultation and public meetings should be seen as a thing of the past. There are a number of reasons for this, summarised by the following three:

1. *The audience will contain many different interests, with different levels of understanding and sympathy and it is therefore difficult to know how to pitch a presentation;*
2. *It is very difficult to keep to a fixed agenda – people may bring up any issue they choose and you just look authoritarian if you try and shut them up; and,*
3. *Few people get a chance to have a say* (Wilcox, 1995).

Further, Renn *et al.* (1995) suggest that traditional decision-making strategies are vulnerable in that they de-emphasise the consideration of affected interests in favour of objective analyses, and so suffer from a lack of popular acceptance. Secondly, because they rely almost exclusively on systematic observations and general theories, they slight the local anecdotal knowledge of the people most familiar with the problem and risk, producing outcomes that are incompetent, irrelevant, or simply unworkable (Renn *et al.* (eds.), 1995).

What these types of widespread negative experiences with public hearings have now incurred is the perception among the public that business and government do not take their concerns seriously, but are more interested in taking the path of least resistance to achieve their desired ends. The public believe that governmental officials regard them as unwanted intruders in the decision making process (Renn *et al.* (eds.), 1995).

Public consultation and participation is rapidly growing in popularity, perhaps more so in the USA. It is suggested in this research project as the complementary technique to co-management (see chapter 7). The Agency's document 'SD5: Sustainability examples from the USA and Canada' defines sustainability as "the balancing of economic, community and environmental issues and aspirations" thus recognising "community" in addition to the more widely banded marriage of just environment and economics. The Canadian National Round Table on the Environment and Economy (NRTEE) proposes the following guiding principle towards Sustainable Development,

> *"for consensus to operate, people must abandon command and control patterns of conduct. And only if they abandon them can there be the kind of interchange among equals that is so necessary in trying to weave Sustainable Development into the multitude of our activities"* (EA, 1997n)."

This is followed with the statement that essentially, Sustainable Development principles should be: purpose driven; inclusive not exclusive; involve voluntary participation; self design; flexibility; respect equal opportunity and diverse interests; accept accountability and time limits; and, have effective implementation (EA, 1997n).

> *"for environmental policies to be effective and legitimate, we need to involve the people who are or will be affected by the outcomes of these policies. There is no technocratic solution to this problem. Without public involvement, environmental policies are doomed to fail"*
> (Renn *et al.* (eds.), 1995)

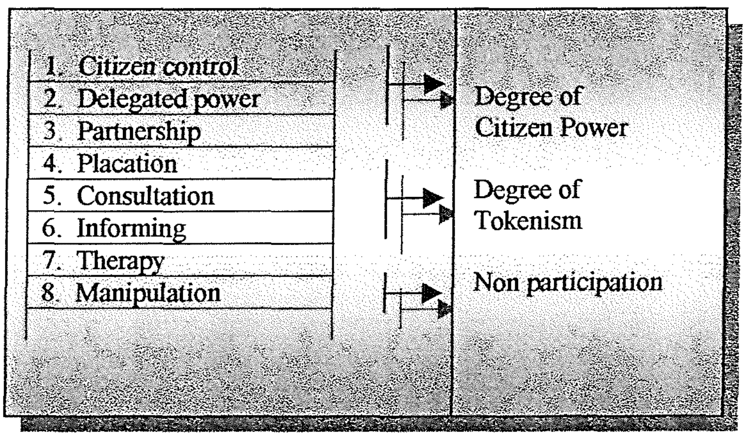
The Agency is starting to make use of a variety of psycho-sociological theories in its drive to heightened communication with the community. It states that *"techniques focused on information provision should underpin all community activities but that they will rarely be sufficient on themselves. A set of rules will be needed to resolve conflict and optimise the potential for consensus"*(EA, 1998k). Table 8.1 below, is presented to summarise Agency objectives in effective participation (EA, 1998k). Much of the content is covered by Treby (2000) to which the reader is referred.

Rule setting	Reaching a consensus on the procedures that participating stakeholders want to adopt
Evidence	Basing factual claims on the state of the art of scientific knowledge and other legitimate knowledge. Where there is scientific disagreement all relevant views should be represented
Reasoning	Interpreting factual evidence in accordance with the laws of logic and reasoning
Disclosure of values	Disclosing the values and preferences of each party, thus avoiding hidden agendas
Fairness	Attempting to find a fair solution wherever conflicting values occur

Table 8.1: Agency objectives in effective participation (EA, 1998)

The Sustainable Development team of the EA take the approach of the UK Environment Council stating participation as being their own aspiring goal. They see 'the critical quality of consensus building as agreement by consent with the end result of such agreements being commitment both to the agreement and to its purpose' (EA, 1998k).

The most widely referenced approaches to standardising public participation is that of Sherry Arnstein (1969) who put forward an eight-step **ladder of participation** to identify the level of public involvement in planning and decision making in the USA (box 8.3).



Box 8.3: The Ladder of Participation (Arnstein, 1969)

Eight rungs of participation were summarised by Arnstein as:

1 **Manipulation** and 2 **Therapy**. Both are non-participative. The aim is to cure or educate the participants. The proposed plan is best and the job of participation is to achieve public support by public relations.

3 **Informing**. A most important first step to legitimate participation. But too frequently the emphasis is on a one way flow of information. No channel for feedback.

4 **Consultation**. Again a legitimate step – attitude surveys, neighbourhood meetings and public enquiries. But Arnstein still feels this is just a window-dressing ritual.

5 **Placation**. For example, co-option of handpicked 'worthies' onto committees. It allows citizens to advise or plan ad infinitum but retains for power holders the right to judge the legitimacy or feasibility of the advice.

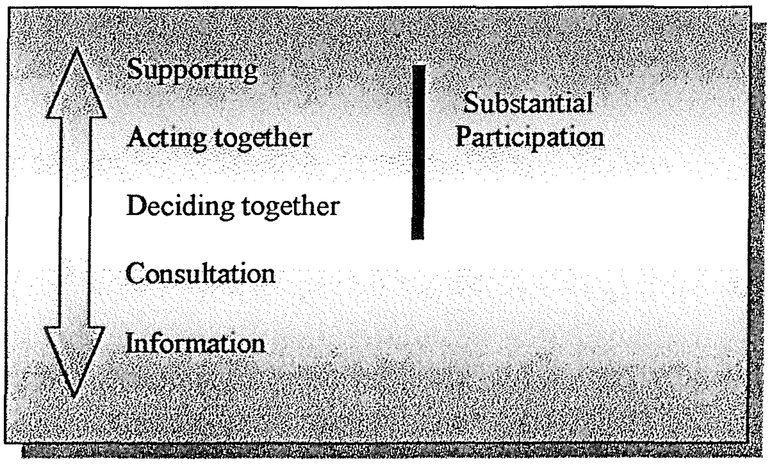
6 **Partnership**. Power is in fact redistributed through negotiation between citizens and power holders. Planning and decision-making responsibilities are shared e.g. through joint committees.

7 **Delegated power**. Citizens holding a clear majority of seats on committees with delegated powers to make decisions. Public now has the power to assure accountability of the programme to them.
8 **Citizen control**. Have-nots handle the entire job of planning, policy making and managing a programme e.g. neighbourhood corporation with no intermediaries between it and the source of funds (Arnstein (1969).

In a parallel manner to Arnstein, Wilcox suggests five levels or 'stances', which offer increasing degrees of control to the others involved (Wilcox, 1995):

- **Information**. The least you can do is tell people what is planned.
- **Consultation**. You offer a number of options and listen to the feedback you get.
- **Deciding together**. You encourage others to provide some additional ideas and options, and join in deciding the best way forward.
- **Acting together**. Not only do different interests decide together what is best, but they form a partnership to carry it out.
- **Supporting independent community initiatives**. You help others do what they want – perhaps within a framework of grants, advice and support provided by the resource holder.

Wilcox summarises these stances in a diagram reproduced in box 8.4.



Box 8.4: The five stances of participation (from Wilcox, 1995)

Wilcox continues in detail on his five stances of participation. These are summarised in table 8.2. What is seen as relevant here is the summary of the various mechanisms which could be applicable to the Agency's involvement in participation.

Despite the virtuous and beguiling nature of taking public participation to its highest level or 'rung', when the capital and temporal constraints on the Environment Agency are considered in conjunction with their existing statutory aims towards partnership, close and responsive relationships through consensus building and high quality information and advice, the Agency may be seen to rest in reality between 'deciding-' and 'acting- together' on Wilcox' table. However, this is not to be seen as a negative constraint. According to Treby (2000) to take the 'highest' level of participation is not always necessarily the best and most appropriate solution. Participation does not mean control of the decision (Treby, 2000). It is also suggested that, in regard to the Agency at least, there are a number of inter-stance processes and methods that are pertinent to sustainable river management in the Agency outside of these two. For instance, the presentation and promotion suggested as a typical process of the information stance, should really be seen as a preliminary stage in any sustainable river management project, as should communication and feedback, which is included under 'consultation'. Similarly, and as will be seen in the example of the National Mitigation Strategy of the U.S., the use of leaflets, media and video should be considered *alongside* surveys and meetings whether 'deciding together' or not. However, as Wilcox suggests, it is easy to be beguiled by the products and forget what is trying to be achieved. High cost presentations suggest you have made up your mind (Wilcox, 1995). This once again illustrates the need to judge each project on its own specific audience and partners before 'taking the plunge' with inappropriate tools. What works in one part of the country, or even county, may not work in another. It will depend upon the political situation and the local culture. For the building blocks to successful participation, the practitioner should follow the key principles in box 8.5. These provide a useful overview of how meetings should be managed.

Promotion to the public at large has not worked so far. The Agency professes that "we need to convey the message that Sustainable Development is not a huge complex but simply present the Agency duty and guidance and suggest how the Agency will tackle a project with this in mind". This short summary of public participation hopes to illustrate an important method for rectifying this situation.

There is also immense potential in the integration of the concept of sustainable management into ***education*** from an early age. This would complement and optimise the use of participatory methods. Indeed, the new Environment Agency CD-Rom 'Riverside Explorer', released in April 2000, aims to establish sustainability principles based upon RHS in English schools. This could be developed further with the increased involvement of school children in the practical elements of sustainable management on the riverbank.

Level/stance	Information	Consultation	Deciding together	Acting together	Supporting
Typical process	Presentation and promotion	Communication and feedback	Consensus building	Partnership building	Community development
Typical methods	Leaflets Media video	Surveys meetings	Workshops Planning for real strategic choice	Partnership bodies	Advice support funding
Initiator stance	'Here's what we are going to do'	'Here's our options – what do you think'	'We want to develop options and decide actions together'	'We want to carry out joint decisions together'	'We can help you achieve what you want within these guidelines'
Initiator benefits	Apparently least effort	Improve chances of getting it right	New ideas and commitment from others	Brings in additional resources	Develops capacity in the community and may reduce call on services
Issues for initiator	Will people accept consultation?	Are the options realistic? Are there others?	Do we have similar ways of deciding? Do we know and trust each other?	Where will the balance of control lie? Can we work together?	Will our aims be met as well as those of other interests?
Needed to start...	Clear vision Identified audience Common language	Realistic options Ability to deal with responses	Readiness to accept new ideas and follow them through	Willingness to learn new ways of working	Commitment to continue support

Table 8.2: Mechanisms for stances on participation (after Wilcox, 1995)

Key principles for public participation

- Identify and meet key interests informally.
- Run workshop sessions for different interest groups
- Bring people together after the workshop sessions in a report-back seminar. By then everyone should have some ideas in common.
- If you must do a one-off meeting, split people into small groups early on and run a report back in the second half.
- Make clear in all publicity that it is an ideas session with group discussion.
- Plan the layout of the room(s) so you avoid 'them and us' and can split easily into groups.
- In short, make a public meeting the last thing you do, and not the first.

Box 8.5

In 1999, the Department for Education and Employment published the 'Voluntary code of practice for supporting sustainable development through educational resources' (DFEE, 1999). The underlying objectives of this statement were proposed as two-fold:

1. To promote and disseminate good practice in the development and production of resources relating to education for sustainable development, and
2. To raise the status of the role of education in achieving the move towards sustainability (DFEE, 1999).

The existence of this document serves to illustrate that moves are presently being made to promulgate a greater understanding of the issues of sustainability to the public. It provides principals (ten in all) on 'good practice'. For instance, Principle 4 states: "*Values and Attitudes: Resources should help people to explore values and develop responsible attitudes in relation to their fellow citizens and the environment, from local to global level*" (DFEE, 1999).

Similarly, the 1996 review of the 1993 Toyne Report (Ali-Khan, 1996) provides even more tangible solutions to the problem of awareness-raising and education for sustainability (albeit in FHE institutions only). Despite pre-dating the Code of Practice by three years, this research asserts six 'key recommendations' to fulfil this objective. Those most pertinent to the present subject are summarised in box 8.6, below.

KEY RECOMMENDATION 1
Responsible global citizenship should be recognised as a desired core learning outcome. 'Enabling responsible citizenship' should be recognised as a core business of learning institutions and a legitimate purpose of lifetime learning.
KEY RECOMMENDATION 2
Funds should be made available to establish a national programme to support the further and higher education sector's response to the challenge of sustainable development. This programme should be modelled on the highly successful local agenda 21 programmes run by LAs.
KEY RECOMMENDATION 4
Within 3 years all RHE institutions should have developed the capacity to provide all students with the opportunity to develop defined levels of competence relating to responsible global citizenship.
KEY RECOMMENDATION 5
Those responsible for defining national standards relating to industrial and professional practice, and associated qualifications and standards, such as industry lead bodies and professional bodies, should ensure that appropriate reference is made to sustainable development issues.

Box 8.6: Key recommendations for awareness raising and education in sustainable development (Ali-Khan, 1996).

The review paper further provides evidence of the situation of sustainability in education. For example, in 1996, only 17 out of 180 survey respondents had set out in general terms what all their students needed to learn in order to be able to take account of sustainable development in their work and daily lives. Of these, less than 10 reported making progress (Ali-Khan, S, 1996). Similarly, review of Undergraduate and taught Postgraduate courses was suggested to include more flexibility for including sustainable development. Forum for the Future's Foundation Scholarship programme is championed as a scheme which successfully integrates work experience and education in sustainable development related sectors for first and second degree level.

The Toyne Report and the concordant review are making moves in the right direction, if the message of sustainability is to be seen as a cultural and social shift. However, by the time a young person reaches the level of first degree, or worst their second (as defined in the Toyne report), only a very specific audience is being targeted:

1. The audience will be of a level of intelligence required to enter a Further or Higher education institution, thus omitting those who are not in that environment
2. Only those who are in a suitable subject area will have the opportunity to be targeted i.e. the natural sciences of Geography, Environmental Science etc.

If the sustainability message is to reach the main populous through formal education then it is argued that this should be done from a far earlier age.

This research advocates convincingly that in principles of public participation and education are very important players in the success of sustainable management. The reality however is often a completely different story.

8.4 Fairness and competence versus apathy

One potential flaw of the preceding discussion is that participation is seen as a mechanism looked upon as equally attractive by participants as politicians and theorists. This is often not the case. Apart from the few who are already 'active' in the community or have a vested interest in a management proposal, the public's ***commitment*** to a project will need to be targeted parallel to the specific project detail. As Edmund Burke states, "It is a general error to imagine the loudest complainers for the public to be the most anxious for its welfare" (Burke in Wilcox, 1995).

Rational choice theory claims that individuals have a tendency to resist participating in collective decision making. This 'free rider hypothesis' poses a significant challenge for public participation. Design features need to be defined in the sustainable model for participation which will enhance the willingness of people to participate.

Renn *et al.* suggest that commitment is the other side of apathy: people are committed when they want to achieve something, apathetic when they don't. However, Renn *et al.* continue that commitment does not emerge from telling people you ought to care, inviting them to public meetings or bombarding them with glossy leaflets. People care about what they are interested in, and become committed when they feel they can achieve something. Hard selling does not achieve that. If people are apathetic about proposals, it may simply be that they don't share the same interests or concerns (Renn *et al.* (eds.), 1995). It seems then that people are most likely to be committed to carrying something through if they have a stake in the idea.

Indeed, non-rational choice theory responses to the free rider thesis are that people choose to participate not only on the basis of individual costs and benefits, but because they feel a social obligation to a desire to belong to a group. Other people participate for moral or altruistic reasons. They may be strongly committed to environmental preservation, for instance.

Increasingly, the antidote to these problems of commitment seems to be the handing over of a sense of project ***ownership*** to the people in question. In practice that means running brainstorming workshops, helping people think through the practicality of ideas and negotiating with others a result which is acceptable to as many people as possible. Apathy is directionally proportional to the ***stake*** people have in ideas and outcomes (Renn *et al.* (eds.), 1995). To try and reconcile some of these issues, Wilcox recommends a checklist of some of the early tasks prior to starting the formal processes of participation (box 8.7).

Two American methods for public participation which are worthy of attention in the British context are Citizens Advisory Committees and Planning Cells. ***Citizens Advisory Committees (CACs)*** were created in the 1980s, in the U.S., Canada, and Western Europe to represent affected interests in a variety of environmental decisions, including the development of legislation and regulatory standards, issuance of permits, land use decisions, and the planning of industrial and infrastructure projects. The CAC model primarily functions as a means of value reconciliation among the participants. ***Planning Cells*** are groups of about 25 people who are released from their everyday work obligations (for a week or at least three days) and are asked officially to prepare recommendations on problems of assessment, planning, or control. The objective is to provide these citizens with the opportunity to learn about the technical and political facets of the decision options and to enable them to discuss and evaluate these options and their likely consequences according to their own set of values and preferences.

Checklist of early tasks for successful participation

- Consider the potential obstacles to participation, for example: rigid views, authoritarian cultures, grudges and antagonisms, passive and hard-to-reach interest groups, NIMBYs, professionals and technicians with poor communication skills, groups defending perceived power and status, or lacking the confidence, skills, or knowledge to participate. How will these be managed?
- Meet the key agencies and lobbies. Get out and network formally and informally. Open new lines of communication. Meet one-to-one when possible to encourage candid responses.
- There are four main groups of participants: politicians; decision-makers and resource holders; activists; and ordinary people. How does one get beyond the (often self-appointed) activists? How will you pro-actively involve hard-to-reach groups? (Wilcox, 1995).

Box 8.7 (after Wilcox, 1995)

Of course, it must not be assumed that all people *want* to participate, and similarly that all people wish to participate to the most involved level on Arnstein's ladder. Some people will demand more involvement than others. Others will wish not to be involved. Participation may work best for all concerned, when each of the key interests – the stakeholders – is satisfied with the level of participation at which they are involved (Renn *et al.* (eds.), 1995). These different interests, or stakeholders, need to be identified and negotiated on a project by project basis, the level of participation appropriate to each individual being based upon geography and the political and socio-economic environment.

Further to deciding the appropriate level of participation, for those that *do* want to take part, participation must be conducted in the most ***fair*** and ***competent*** manner possible. Understanding of participation involves understanding power and the ability of the different interests to achieve what they want. It will also depend on people's confidence and skills. Many organisations are unwilling to allow people to participate because they fear loss of control: they believe there is only so much power to go around, and giving some to others means losing your own (Renn *et al.* (eds.), 1995).

Parallel to identifying the level and style of public participation, there is a need to identify factors external to the project, but beliefs that may be culturally embedded and thus play an important part in their level of commitment. People's inclination to attend to information about the environment is affected strongly by their sense of 'agency' – that is, by whether or not they feel a ***capacity to influence events*** associated with that information. This is related and influenced strongly by their degree of trust in the purveyors of the information (Macnaghten *et al.*, 1995). There are grounds for serious concern, for example, about the adequacy of government's (central and local) own representations and understandings of the concepts of 'sustainability' and 'sustainable development'. Such representations have frequently given the impression that there is an unambiguous 'objective' scientific underpinning to the terms, from which follow equally unambiguous social and political proscriptions which need now to be implemented. This approach neglects the significance of social, political and cultural processes involved in the emergence, definition and development of the concepts, and assumes an authority and effectiveness in 'policy' institutions which is now often increasingly questionable (Macnaghten *et al.*, 1995).

Environmental decision-making difficulties are not only aggravated within the lay people but also by differences between the social rationality of lay people and the bounded rationality of experts (Perrow, 1984; Evers and Nowotny 1987). Research shows that public perception of probabilities and risks differs considerably from professional analysis (Slovic, 1987 in, Renn *et al.* (eds.), 1995).

Parallel to this unambiguity there are also various ambiguities reaching the public with regard to scientific issues like global warming. It soon becomes the case that it is easier for the individual to 'switch off' altogether, or assert to make their own decisions based upon a confused level of mis-information.

Renn *et al.* suggest that trust in policy can be regained and in fact promoted, when:

- There is a high likelihood that the participants will meet again in a similar setting;
- Interaction takes place face-to-face in regular meetings over a reasonable period of time and people have a chance to get to know each other;
- Participants are able to secure independent expert advice;
- Participants are free to question the sincerity of the involved parties;
- Citizens are involved early on in the decision making process;
- All available information is made freely accessible to all involved;
- The process of selecting options based on preferences is logical and transparent;

- The decision making body seriously considers or endorses the outcome of the participation process; and
- Citizens are given some control of the format of the discourse (agenda, rules, moderation, and decision-making procedure)

(Renn *et al.*, (eds.), 1995).

In summary, people's inability or unwillingness to assimilate information may thus frequently be due to tacit political or cultural structures of empowerment or disempowerment, which may have no apparent connection with the environmental issue in hand. These must be addressed as equally and in some cases more important than the more standard methods of addressing commitment.

As with much of the sustainability debate, if the concept could be internalised to the individual then there is more chance of success. On the use of indicators, Macnaghten suggests that the majority of groups not only consider the idea of indicators an abstract and difficult concept, but more generally are suspicious of official statistics and information. Indeed, when asked about existing indicators, people tend to distinguish between those which could be easily correlated with their direct experience, and those which depended on 'expert' systems. The further removed indicators were from people's immediate realities, the less likely they were to find them credible (Macnaghten *et al.*, 1995). This argument complements the key characteristics that have been developed as implicit in the SURCoMES – transparency, accountability and defensibility. By having developed a system that tries to combat the problems of misinterpretation and suspicion highlighted by Macnaghten *et al.*, the SURCoMES may be met with slightly more success than the indicators approach.

This directs quite pointedly to the need for the SURCoMES to address issues right down to the local scale. People in most population groups express a strong identification with local 'place', and identify especially with their immediate communities, sub-communities and life-worlds (Macnaghten *et al.*, 1995). If this rule is followed, then commitment, fairness, competence and empowerment could be very powerful tools to effective decision making for policy and public alike. A tool that allows for varying levels of expertise could build a powerful mechanism for successful sustainable management.

Based upon this research it seems that what the Agency needs to do is shift the attitudes of those who have a direct affect on or are affected by projects implementing sustainable river management practices. These may range from the individual landowner or tenant who experiences land loss, right up to the local affected community as a whole.

Before participation at any level is advocated as the answer to all dilemma in sustainable management, there are a number of elementary issues which must be emphasised (common especially to information provision programs and the lower rungs of Arnstein's ladder). Some may assume for instance that education (public participation at its minimum) is sufficient to combat the barriers to sustainability. Rather than working towards partnership or control, the practitioner may see the lower rung as opportunity to remain politically correct but at a lower cost. In most cases power also remains to a high degree with the 'experts'. Research shows however, that education can help but that it is rarely sufficient in itself. Information programs aimed at attitudinal change (internal barriers) accomplish little when the external barriers to action are high (Gardner and Stern, 1996).

However, the most promising role for education *is* to help overcome the internal barriers to action, particularly those of ignorance and misinformation. Lack of information can be a serious internal barrier to action because it is not always obvious to an individual how to act effectively on his or her attitudes (Gardner and Stern, 1996). With regard to sustainable river management, information provision could definitely be applied in an effective manner to the actions of the landowner in terms of signing to loss of land or agreeing to restoration of a river and its riparian zone. There must be an assurance however, of an overall ***sustainable package*** of participation.

Here however, the next hurdle is encountered. If the information issuer does in fact manage to change the attitudes and beliefs of its audience, many barriers both "internal" to the individual and "external" in their social and economic environments keep these pro-environmental attitudes from being expressed in action. One rational choice theory explanation is that people can be encouraged to participate if they are offered a positive payment or incentive to participate or a negative incentive to not participate. This returns to the debate over the potential benefits of economic mechanisms in furthering the success of sustainable management.

The following case studies aim to highlight how public participation can be integrated into successful environmental management, whilst having regard to appropriate economic mechanisms.

8.5 Case Studies: Drawing on experiences from Home and Abroad

Much of the innovation in furthering the sustainability debate and its practice and promotion stem from the USA and Canada. It is interesting to note the very different prioritisation that the public is given in practices in the United States of America compared with the UK.

For instance, in 1993, President Clinton established the President's Council on Sustainable Development (PCSD), much like our own UK Round Table. Of six main task forces on the PCSD, 'public linkage, dialogue and education' and 'sustainable communities' were two. PCSD meetings were held throughout the USA in order to encourage ***public dialogue*** and to ***integrate local expertise*** from communities around the country. The opinion is expressed that 'if the president appears to be interested in sustainability then this gives a clear signal that sustainability is an important national issue (EA, 1997n).

Since 1990, 'Sustainable Seattle' has operated as a voluntary network and civic forum for the measurement of progress toward sustainability. The purpose of indicators to measure this progress is explicitly seen so as to *'inform the media and the community to act as a catalyst for people to make choices in their personal lifestyles so that Seattle can move towards sustainability'* (EA, 1997n).

It is interesting to note the importance placed on the part of the media in this context, and indeed as a general rule, the media are seen as of far more importance to the issue in the USA than in the UK. The following two case studies illustrate these approaches in more depth.

8.51 Optimising information and incentives – The 'National Mitigation Strategy' and 'Cover America' campaign (Components of the National Flood Insurance Program, USA)

One project which is of particular pertinence to the goal of sustainable floodplain and river management is the Federal Emergency Management Agency's (FEMA) National Mitigation Strategy (NMS). The NMS seems to have successfully crossed one of the most difficult hurdles towards the goal of sustainable management - addressing the present day unsustainable practices and looking towards *recognising and adapting to natural forces to eliminate the long-term risk to human life and property in the future*. The NMS is just one component of the National Flood Insurance Program set up by FEMA in 1993. This program has at its core, the realisation by the USA government that continued flooding and diversion of public and private resources by the Government to deal with the suffering encumbered is not sustainable, and indeed, becoming just too costly. The NMS has been developed to provide a conceptual framework to reduce these losses. Hazard mitigation involves recognising and adapting to natural forces and is defined as any sustained action taken to reduce or eliminate long term risk (FEMA, 1995).

In FEMA's words, "the foundation of the strategy involves strengthening partnerships and creating partnerships to empower all Americans" *(FEMA, 1995).*

By stating the overall long-term goal as one of "substantially increasing public awareness" a definite appreciation and more importantly an implementation of those concepts discussed in Gardner and Stern (1997) and others on human behaviour and the importance of social issues in environmental problems, is illustrated.

Even the NMS foreword instils a sense of virtuosity and morality in the reader. Rather than addressing the problem in terms of the 'public' the statement manages to internalise the principle aims and objectives through the use of more accessible language. "Families and communities" are affected by natural hazards and "effective implementation of hazard mitigation measures will contribute to the long-term economies and environmental well-being of a community as well as protect the natural and cultural resources of our Nation". Note the reference to "our Nation" - FEMA seems to be making every effort to introduce the NMS as a tool that <u>all</u> Americans need to take up if they want to protect their national capital. The strategy is inherently nationalistic and utilises a strong sense of American Patriotism to conjure up a certain level of moral obligations without purely instigating a set of policy controls.

One of the central characteristics of the NMS is the setting of concrete goals in the temporal sense. The "Major elements and Strategic Objectives" of the NMS set definite time spans for each of the goals of:

- hazard identification and risk assessment
- applied research and technology transfer
- public awareness, training and education
- incentives and resources, and
- leadership and co-ordination.

Further, FEMA stated:

> *"We must create a broad-based public awareness and understanding of natural hazard risks that leads to public support for actions to mitigate those risks. We must also create mitigation training programs that can be used in schools and communities to support public actions... " "Individual citizens must accept responsibility for becoming aware of the natural hazards (and) reducing their degree of vulnerability"* (FEMA, 1995).

Within the goal of public awareness, training and education it is particularly interesting to compare those objectives of FEMA with those of the idealists and advocates of Sustainable Development. In the words of FEMA, "achieving widespread public awareness of natural hazards in a community will enable citizens to make informed decisions on where to live, purchase property, or locate a business." The strategy also identifies the key prerequisite for any proactive scheme of this nature, "a need to determine the most effective method and message by which this information is to be transmitted to the intended audience" (FEMA, 1995). The following objectives are the methods by which FEMA hopes to address this goal and are offered here as a point of reference for a parallel strategy in the Agency (box 8.8).

- *"within 1 year develop a strategic all-hazards awareness, training, and education plan and an evaluation of the most effective methods and messages, involving hazard-resistant planning and design, natural hazard curriculum's, natural hazard safety programmes, and community risk reduction. Within 2 years, implement the priority items identified in the strategic plan. Within 5 years, and every 5 years thereafter, complete an assessment of the plan and modify it as necessary.*
- *within 2 years, complete an assessment of the most effective use of information technologies such as the interment and other media to disseminate information on natural hazards and mitigation.*
- *within 2 years develop a program targeted at state and local elected and appointed officials to encourage the development of legislation and administrative policies that support natural hazard mitigation.*
- *within 2 years develop a programme to encourage public-private partnerships for business' to educate their employees and customers about mitigation.*

"Ongoing public awareness, training and education activities include communicating the achievements, progress, and successes of the NMS; evaluating and updating tools (documents, plans, training courses and other mitigation guidance materials) to reflect state-of-the-art technology and engineering practices; and continuing to implement the strategic all-hazards awareness, training and education plan."

Box 8.8: Objectives of FEMA (FEMA, 1995).

It is valuable to note the emphasis placed on evaluation at all stages of the abstract, a tool which will need to be utilised to the full in any drive to successful Sustainable Development considering the uncertainties involved. Similarly, "awareness" does not encompass training and education, but all are rather introduced as separate entities. Indeed, the campaign which emerged from these goals, "Cover America", should be regarded highly as a *"well-planned and so far very successful programme utilising marketing, advertising and awareness raising, quite separate to the goals of training and education"* (FEMA, 1995).

In the Cover America campaign, FEMA first conducted ***market research*** to design an effective message, develop and implement a *media* plan to increase awareness quickly, and produce tie-in materials to help NFIP stakeholders. Focus groups were used and in-depth individual interviews with homeowners, renters and business owners who were and were not required to take out flood insurance under the Programme. The results of this participation lead to the first phase of the campaign - the *General Awareness Phase* of commercial advertisements on TV and in magazines. A *Response Oriented Phase* followed to motivate people actually to take action towards purchasing flood insurance, so advertisements included cut-out coupons for more information and a phone number to ring. They also used consumer mailings and various Public Relations efforts including media tours, articles for trades and consumers, booths and exhibits and a Speakers Kit for NFIP Stakeholders. From the *benchmark* to *first tracking survey* of perceptions and attitudes of more than 1500 people, general awareness has apparently increased by as much as 16 per cent, and within the first year, nearly 100,000 responses were received (FEMA, 1995).

Between 1994 and 1995, 'Mitigation Forums' were held with the public and private sector to identify, amongst other things, the most effective methods of projecting the NMS message. The most frequent responses were:

- Electronic and print media
- Displays and brochures
- Presentations by Federal, state and local agencies and professional organisations
- Formal training courses and school curriculums
- Public notification (e.g. newsletters, signs, mass mailings) and,
- Legislation.

Suggested points to highlight in the message were:

- Individual responsibility and self-reliance

- High costs of disasters
- Need for co-ordinated, multi-hazard approaches
- Need for ongoing mitigation efforts
- Identification of resources (FEMA, 1995).

Following these consultations, a web-page was set up (www.fema.gov/NFIP/nfiract.htm.) for online news and information, whilst focus groups informed FEMA that they wanted *facts* not shock pictures of mass flooding. There were two main phases of action in the campaign – General Awareness and Response Oriented. In the 'General Awareness Phase' a general awareness TV commercial reached 65% of all US households, 40 times through cable TV alone in the first 6 months. Simultaneously, a print-ad appeared in magazines with images from the TV campaign being used (FEMA, 1995).

In the 'Response Oriented Phase' beginning early 1996, two commercials to do more than just create awareness were introduced. One had a strong emotional appeal; the other a more logical comparison of flood insurance to other ways people choose to protect themselves. Slightly thereafter, a further print campaign was instigated along with a coupon to send in for more information. Yellow Pages directories have also been used with a new flood insurance section as have bulk mailing (approximately 200,000 consumers in 18 counties) of packages with a brochure and reply card.

Public relations efforts were estimated to have reached an audience of more than 12.5 million by winter 1996. A satellite media tour instigated the campaign, followed by articles in magazines and company brochures, NFIP booths and exhibits and a NFIP speakers kit (FEMA, 1996).

In 1996, FEMA estimated that awareness from the 'Cover America' campaign had increased by as much as 16%. *"More people recalled the TV advertisement than any other form of the campaign, although the 'it won't happen to me' attitude was still slow to dislodge"* (FEMA, 1996).

The 'Cover America' campaign offers a number of parallels for implementation of the SURCoMES and the sustainable management debate. It promotes risk acceptance and uses a mechanism (insurance) to supplement this acceptance. However, it is clear that funding for the campaign was high, which will unlikely be the case for the Agency. Similarly, the US campaign is on a far grander scale than the UK – floodplains are far larger and cost of loss far higher. This said, the procedure of general awareness - response oriented - public relations is an interesting and useful one as are the specific measures taken. It is unlikely that a long-term television campaign would be sustained financially in Britain as the benefits would not outweigh (flood damage) costs (because of the above reasons). However, a far shorter campaign, perhaps in the context of some mechanism like the BBC's 'Weather Programme' may be considered. In areas of higher risk, leaflet mailings could also be considered. The Yellow Pages would similarly be relatively inexpensive as would a short run of print ads or billboard posters, perhaps in local newspapers.

Suggested tools for awareness raising in the UK

- TV slot
- Yellow Pages – 'Flood Insurance'
- Satellite media tour
- Interactive Speakers Kit
- Catchment/location specific print-ads, posters and/ or leaflet drops

Box 8.9

Box 7.9 summarises the suggested methods of raising awareness. The interactive speaker's kit and location specific methods are the most realistic of the five, with lower cost: benefit ratios. In a nation such as Britain it is not feasible to blanket campaign the whole country with such methods, but instead to target those affected. The only exception to this would be a nation-wide billboard campaign with leaflets in the national press. It is interesting to note that at the time of writing a series of flood awareness advertisements ('Floodline') have been instigated by the Agency on billboards and the national press.

If 'sustainable' or 'best practice' projects are to be undertaken then the proposed RiLaCs programme offers the ideal mechanism by which the costs of awareness raising and education may be concentrated at the local scale.

8.52 Public involvement in land management – the Australian example of 'LandCare'

The innovation behind a RiLaCs type approach to sustainable river and floodplain management is the reconciliation that it provides for a number of the socio-economic constraints to sustainability.

The RiLaCs approach is foreseen as a community-based programme that internalises the costs and benefits of a person's actions, thus counteracting Hardin's 'Tragedy of the Commons' (Hardin, 1969). The approach also provides a forum at the local scale for effective planning and implementation of management strategies and practices. These benefit from a new marriage of knowledge between the public and/or private sector (technological and research-based expertise), and longer-term ground-level experience of those who interact with the environment (e.g. a Farmer).

Involving community-based management also offers potential for identifying new paths for funding opportunities, and longer-term, lower-cost solutions to problems that have in the past perhaps been prey to shorter-term engineering.

There is only one example, to the author's knowledge, of a similar approach to these aspirations. '***LandCare***' is a unique national programme in Australia which is a partnership of government, farmers, conservationists and community groups and which has quickly grown to involve about one quarter of the farming community in local voluntary conservation groups (Campbell, 1994). It is highlighted here as a more participative mechanism to parallel the 'promotional' stance of the NMS campaign.

LandCare was initiated in 1986 primarily to tackle soil degradation from over-farming in Australia. It was set up by the then Minister for Conservation, Forests and Lands, Joan Kirner, with support from the Victorian Farmers Federation. Since then, and encouraging with regard to the RiLaCs analogy, there has grown over 2000 LandCare groups, with an astonishing 70% of all rural landowners in some places (e.g. Victoria) being members (Campbell, 1994).

Particularly pertinent to the RiLaCs, LandCare is more than just an innovative, participatory land conservation programme on a large scale. It encompasses environmental education in schools and local communities, community-based land-use planning, community-based monitoring of the status of land and water resources, farmer-driven and farmer managed research and development, and community involvement in the allocation of public funds to land conservation. It shows what can be achieved when the people are actively involved in co-operatively thinking about the future of their land and communities (Campbell, 1994).

Learning by example and experiences is a far more valuable tool than turning purely to research, and based upon the limited experiences of these types of approaches it is useful to identify how LandCare has facilitated such a successful programme.

According to the LandCare approach, such a fundamental change in philosophies that would be needed for more sustainable living, does not and cannot come solely through the statesmanship of political leaders or through altruism among powerful groups whose power is vested in the *status quo*. Instead, they seem most likely to occur if 'ordinary people' are directly, actively involved in these issues at a human level, rather than remote from them. There is a need to do this on a scale larger than the individual or family, therefore bringing people together co-operatively and constructively at a community and regional level is the answer (Campbell, 1994).

The formation of a LandCare group broadly follows the flowchart in figure 8.1. The key characteristic and arguably major reason for success of LandCare is its ***flexibility***. Each group takes a different course and sometimes even folds before the full path is taken. Sometimes this is because objectives have been met, or groups were set up where there are not the people to support them. A group which comes to a natural end, once an issue has been 'solved' is not seen as a negative aspect.

Research suggests that additional to this flexibility, effective LandCare groups have a number of general characteristics which are shown in box 8.10.

Key characteristics of an effective LandCare group

- Closely defined goals
- Good leaders with vision and who involve members fully
- Clear achievable plan
- Tap local resources first
- Have interesting meetings with clear purpose
- Get practical things done locally
- Have credibility in their local community
- Have appropriate boundaries for physical and environmental planning and monitoring (Campbell, 1994).

Box 8.10 (Source: Campbell, 1994).

Obviously, some of the factors in box 8.10 imply a huge leap of faith on the part of the Environment Agency in England. It is not the norm to hand over such a high level of ownership to the 'non-specialist'. And yet, based upon this experiences evidenced, (that of 'Cover America' and the examples presented in the Agency's own publications, SD5 (EA, 1997n) and SD12 (EA, 1998k), perhaps such a leap in faith is needed, and indeed justified.

The Agency needs to look beyond the present situation to the long-term benefits of such schemes, not only within the context of river and floodplain management but within the broader context of government guidance and indeed European legislation on sustainable development. Social and cultural norms and meta-goals are very influential to this change, which is why we have seen that

direct involvement of the people is so important in facilitating these changes. As Campbell proffers, 'the sentiment that 'we're all in the same boat so we might as well paddle in the same direction' is an important pillar of LandCare group activity' (Campbell, 1994). The same should and could be said for the sustainability debate at a global level.

A proverb illustrates perfectly the objectives of any RiLaCs participation programme, and is presented similarly with relation to LandCare in box 8.11.

> *"Tell me and I'll forget;*
> *Show me and I may remember;*
> *Involve me and I'll understand."*
> (Anon, from Campbell, 1994).

Box 8.11: Proverb

In the case of LandCare, this adage has been pragmatised in the setting up of specific ***'land literacy programmes'*** such as Saltwatch; Drainwatch; Ribbons of Blue; Streamwatch; and Watertable Watch. Much worth lays in drawing parallels with these initiatives and the proposed RiLaCs programme.

Saltwatch is typical of the type of approach the RiLaCs should aspire to. Saltwatch began in Victoria in 1987 and by 1992 more than 900 schools and 50 LandCare groups were involved in gathering and analysing tens of thousands of water samples from various rivers and creeks. Each school or community analyses its data and sends it to a central agency for processing, receiving in return a computer-generated overlay map of district water quality. This is then placed on community walls so that the community 'owns' the problem. Groups are encouraged to look at trends over time within the catchment as well as planning management actions (e.g. fencing).

Farmer, local, government official identifies issue

Considers LandCare and calls a meeting with locals and interested groups

Meeting elects a steering group – investigates local problems, interest, resources and available assistance

2nd meeting – launches group, elects committee

Group decides on name, defines problems and what it know of the solutions

- Determines boundaries, goals and objectives
- ID sources of assistance
- Becomes incorporated (legal and insurance purposes)
- Maybe submits for government funding

Community become aware of group and develop relationships with local and state government and other sources of assistance

Group consolidation – activities (incl. Field days; tours; brochures; demo projects)

After approximately 1 year – group matures. Roles of participants become clear. Activities (incl. Property plans in the context of development and catchment plans, monitoring with schools and community, educational leaflets, video promotions etc)

Figure 8.1: The LandCare process

The other literacy programs take a similar approach. Drainwatch involved 2500 farmers and families in collecting water samples from drains flowing from 6000 irrigation farms. Streamwatch uses water quality data collected by schools to generate a water quality index which can then be compared between catchments. Teachers are trained to teach the children. Ribbons of Blue and Watertable Watch again use locals and schools to collect ground data for interpretation.

Not only do these land literacy programmes emphasise the potential of 'human' scale involvement, but some of the techniques being used by these communities also indicate a generally untapped and previously specialist dominated role being turned around. Increasingly, groups and individuals are using Geographic Information Systems for recording and storing information about natural resources and for property and catchment planning. GPS, Neutron Moisture Probes, Piezometers and Conductivity Meters and remote sensing have also been used by a wide variety of LandCare groups (Campbell, 1994).

Having this scale of monitoring offers far more than would be possible by Agency or Government representatives or workers, and, as Campbell argues, often with little penalty in terms of accuracy of the data (Campbell, 1994). Positive elements of public participation are engaged in the schemes and feelings of empowerment generally increased.

Various approaches that could be advocated for sustainable river and floodplain management have been championed in come form by the LandCare programme. ***LandCareNet*** is yet another example. This is a computer-based communications network for LandCare groups to exchange information (Lcnet@peg.pegasus.oz.au). It can be used on home computers and is fully interactive in that the participants can ask for information or initiate discussions. The network provides access to relevant conferences and information.

In the case of England, and the increasing accessibility of the Web and computer access in general (e.g. in libraries, workplaces, schools) this kind of facility could be seen as a major component of the sustainability group structure. There is huge potential worth for communication between RiLaCs working to the similar agenda of sustainable management but separated by distance or time constraints. Previous experience or useful resources could be shared; and, as would be the case with the UWBPP, fluvial audits for example could be made publicly available.

Once the RiLaCs have this kind of information and access to hand, further guidance could be provided for on-the-ground monitoring. One LandCare example of this is the 'Soil Structure Assessment Kit'. The designer of this kit used a fully participatory approach to its development . Farmers were asked to tell, in their own language, what they thought about soil structure. They then expanded upon this by going out to the land and showing practical evidence of their thoughts. This was then combined with the Developer's technical knowledge. The final kit however, is presented in a language that is bother understandable and relevant to the farmer and not technically jargonised (Campbell, 1994).

The success of the SSA Kit again offers valuable guidance to a similar ***'River Bank Assessment Kit'*** in the UK. Preliminary participation in the field with a pilot site (e.g. Wharfe) would highlight the more traditional methods and language of bank erosion and degradation by the local community. A workshop or some form of discussion forum could then be set up on how the community come to these assertions (i.e. the inherent rule-bases). This could then be combined with technical expertise to produce a kit that identifies at the first level, trouble or 'hot spots' along the river. On this basis full consultation and management options appraisal could follow.

Similarly, there would be considerable worth in a ***'River Habitat Monitoring Kit'*** which could support the integration of the Environment Agency's 'Riverside Explorer' CD-Rom mentioned earlier. This would give greater ownership to the community, perhaps through school conservation and biology studies, to build up and monitor progress in riparian habitat pre- and post-project. Trends in the monitoring would be seen by both the community and Agency which, unlike the situation now, may heighten people's awareness to the 'need to protect and where practical enhance', so maybe promoting some commitment to dealing with the implications of trends.

There are a number of additional LandCare initiatives that could be interpreted into British adaptations. These are:

1. Teaching LandCare to Teachers. 36 hours of this style of training is given in the LandCare scenario – could the same be put in place within LEAP areas?
2. The 'Community LandCare technicians training scheme' could be translated so that the nomination of suitable candidates by RiLaCs members could be endorsed by the EA, so that participants were recognised as competent in their field;
3. These endorsed technicians could advertise their resources as RiLaCs assistants on a commercial basis; and,

4. Tutorials of say, 30-days theoretical 'issues tuition' could be combined with 30-days work experience.

Politically speaking, and arguably the most poignant reason for the Agency and ultimately DETR to back these styles of management, is the remediation offered in difficult planning and management decisions with the public. If the 'people' are significantly involved in the issue, then public decision-making has the potential to overcome the often small minority of strongly voiced interest groups. With a deeper understanding of the complexity of issues, ordinary people could conceivably work alongside scientists and perhaps policy makers.

8.6 Summary

Chapter 8 has aims to highlight the need for setting all of the recommendations of the preceding chapters within the social context of sustainable management. Not only does the social context need to be taken into account in sustainable management, but social vehicles for change also need to be exploited.

A number of recommendations may be made based upon this statement:

1) Behavioural change to more successful progress towards sustainable management will be optimised through *both* the correct incentives *and* the use of appropriate social methods;
2) The SURCoMES and SAM will be optimised with appropriate social vehicles for attitudinal revision;
3) More information on sustainability and sustainable management is needed within the Agency. It is suggested that vehicles for this should be as interactive as possible within the constraints of resources (e.g. LEAP CD-Rom; Workshops; Roadshows);
4) Truly sustainable management may often involve social and economic sacrifice, particularly on behalf of the riparian land-owner. For this reason, higher levels of public involvement through public participation must be utilised;
5) Sustainability should be introduced to people from as early an age as possible, preferably through the education system;
6) A campaign similar to FEMA's 'Cover America' is suggested, where market research, through focus groups and other participative mechanisms highlights where the Agency is lacking in its promotion of more sustainable management. The procedure of general

awareness - response oriented - public relations phasing highlights a method for heightening awareness with greater publicity of sustainability through the use of various interactive methods;

7) The 'Land Literacy Programmes' used in the Australian LandCare Programme are highlighted as a useful method for involving the community in the management of their river. This would help in enhancing community understanding of why social sacrifice should sometimes be made. River habitat monitoring kits or bank erosion monitoring kits are similarly championed as a way of involving the community;
8) The RiLaCs (Riparian Land-owners Co-operatives) are proposed as the mechanism by which these recommendations could be activated and progressed.

Chapter 9

Review and guidelines on the targets, tools and techniques for Sustainable Upland River Corridor Management

This research has fully exploited the original challenge of:

1. Redefining sustainable development in clear and simple practical management targets;
2. Translating the concept into operational best practice; and,
3. Reviewing the institutional and infrastructural implications of these guidelines.

This chapter aims to summarise the recommendations for more successful sustainable river management that have developed over the preceding chapters. It is intended that this chapter may also be used, with little significant modification, as a 'stand-alone' document, particularly for the utility of interested parties in the Environment Agency.

9.1 Targets for Sustainable River Management

A new approach to the application of the concept of Sustainable Development in the context of river management has been proposed. Sustainable River Management has the key characteristics of:

1 ***Minimum intervention***. Levels of intervention at the minimum needed to sustain the system. Flooding, erosion, lateral migration and metastability should be maximised where appropriate;

2 *Geomorphology*. This is the underlying science of sustainable river management. Habitat is strongly dependant upon geomorphology. The understanding of upstream/downstream interactions, channel stability and instability, and flood and sediment conductance are all implicitly linked to the four key characteristics of sustainable management.

3 ***Supported and Self-supporting*** sustainability. Supported sustainable management occurs where a) the natural system has moved beyond the threshold where it might be expected to return to its natural state if left to natural adjustment; or b) where initial supporting of the system is needed before a threshold is reached where natural adjustment takes over. Self-supporting sustainable management occurs where the system requires little intervention. Once constraints to natural adjustment are removed, the system recovers rapidly.

4 ***The Spectrum of Sustainability***. Sustainable Management recognises that it can not be consistently stated that an environment is or is not sustainable. It is instead recognised as being of 'more or less' sustainability than a) other rivers of the same type (strategic); or b) different options on the same river (options appraisal).

This new approach is also centred on the ***strategic level*** of management, whilst providing practical guidelines at the level of ***implementation***.

The new approach of sustainable management is part of a larger theoretical structure based upon the level to which the concept of sustainability is considered. This structure involves a ***baseline*** of the environmental assets on a reach together with likely ***impacts*** on that environment. This is then set within the context of a spectrum of sustainable management, so that ***criteria*** might be used to assess the likely level of sustainability relative to the pre-impacted state.

Associated research illustrates this framework, and indeed completes a complementary model for the more successful assessment and appraisal of sustainability in environmental management. The concept of ***Natural Capital*** (focus of Newson, M, University of Newcastle-upon-Tyne) calculates the attributes and services that a resource exhibits at the outset of a project or proposal. The initial calculation provides a baseline on those assets that should be preserved. ***Zero adverse Impact*** (focus of Arnell, N, University of Southampton) exists at the strategic planning level. It is concerned more with balancing out the *effects* of a project or proposal on the environment so that there is a net negative impact on that environment. ***Minimum Intervention*** (focus of Clark, MJ, University of Southampton) aims to provide a day-to-day guideline for practical sustainable environmental management. At its core it aspires to maintain natural capital and minimise net negative impact. It is concerned with the *components* of management, and the *mechanisms* towards this aim. This new approach is also centred on the ***strategic level*** of management, whilst providing practical guidelines at the level of ***implementation***.

Essentially, sustainable river management should be seen to include the ***riverine environment,*** by which all natural resources and the processes acting upon them are considered, the ***market*** environment, which is taken to include more than only fiscal mechanisms, and ***community***, which includes public choice, participation and perception. Other models place 'community' and 'economics' in separate sectors, but it is argued that each is mutually exclusive with the other.

In summary, the new approach recognises and acknowledges:

- The Best Practice Project spatial and temporal scales of implementation;
- The strategic level of management, whilst providing guidelines for practical implementation;
- The utility of complementing other current research;
- The concept of minimum intervention, self-supporting versus supported sustainability, and the importance of geomorphology;
- That a new evaluative system will need to utilise the key goals and themes of sustainable management;
- That sustainable management must be appraised on a bipolar spectrum model; and,
- That a new evaluative system will need to utilise existing databases and tools, particularly RHS.

9.2 Tools for Sustainable River Management

Sustainable river management is optimised from the policy, plan, and through to project level by sustainability appraisal and audit.

A set of universally specifiable and preferably quantifiable criteria, which fully acknowledge the formative elements of sustainable development, but in a manner that surpasses all other attempts at measuring sustainability, have been developed. Holism implies the sum being more than the parts. Some facets may be additive in the riverine system, and some trade-offs may be needed. *This can not be fully represented within the traditional indicators approach to sustainable development.*

SAM (the Sustainability Appraisal Matrix) does evaluate the holism of the best practice project. This procedure provides an awareness-raising tool in the optimisation of the key characteristics of sustainable management, within the legal and political constraints of society.

SURCoMES (Sustainable Upland River Corridor Management Evaluation System) complements SAM, by providing an interactive tool for assessing a) the present and expected future levels of sustainability on semi-natural rivers, and b) the most sustainable management options in the context of (a).

SURCoMES is a tool that offers a definable structure to the sustainable management process whilst being fully usable by a variety of audiences:

1) The river best practice project manager who wishes to identify the most sustainable option for management;
2) The local community member (whether individual member of public or community representative) who wishes to evaluate for his or herself the implications of management options on *their* river; and,
3) Education. SURCoMES provides an example of responsible environmental management to young people. It introduces the reality of 'being green' by illustrating how the environmental manager has to make trade-offs to achieve the optimal solution.

SURCoMES is explicitly based upon the conceptual structure of sustainable river management, and the heuristics of the expertise involved. It has been derived as part of this research to highlight the opportunities which exist in sustainability appraisal and audit, and developed as a prototype by which trends to targets may be identified, and modifications made with further research.

The most important outcome of the SURCoMES is the illustration of how openly transparent, defensible and therefore accountable the concept of sustainable management can be. The detail of the rules themselves are not by any means seen as complete. The SURCoMES provides the mechanism by which future research can access the background rule tables of the system and iterate and modify the assumptions as new information is made available, and understanding of the various interactions which the system hopes to encapsulate is increased. It is foreseen that a system of this type would benefit from a form of password protection so that those with relevant authority (e.g. Flood Defence Manager, Project Managers) may make these iterations when appropriate. This reflects a core characteristic of sustainable management – flexibility to new information and ideas.

The tests performed in chapters 5 and 6 have illustrated how the SURCoMES might be improved into the future. It is foreseen that as experience grows, and with more resources, the first drop-down box of the system (river type as defined by the RHS), will be fully utilised for all river types. Similarly, this will correspondingly lead to the consideration of rivers with significant modification. An interesting task will be to provide an interactive link with the RHS Habitat Modification Score. It is also foreseen that the system will benefit from full interactive capability with the RHS database (version 3.1 at the time of writing). This linking of databases would eliminate the necessity for the majority of the drop-down boxes in the first page of the SURCoMES user interface. It is expected that inputting the RHS site number and river type would be sufficient for the majority of information required (Knaura, M, personal correspondence, 2000).

Opportunity also exists in the graphical display of the SURCoMES assumptions and conclusions. A system similar to the Environment Agency's 'Riverside Explorer' CD-Rom (Corbelli, D, personal correspondence, 2000) where the user is able to fully interact, and see the implications of, inputted preconditions on the river habitat, would be an exciting extension of the system.

It is also suggested that an extension of the SURCoMES which uses less scientific language, together with the graphical aids suggested above, would be a useful tool to be made available in local schools and libraries. This would complement the new 'Riverside Explorer' CD-Rom introduced by the Environment Agency in April 2000, which uses RHS to introduce school children to the river habitat. This is initially perceived to function in the rural community (in the UWBPP for instance, community meetings, Kettlewell School, and other routes to the local community could have benefited from such a system).

9.3 Techniques for Sustainable River Management

SAM and SURCoMES are tools which are to be set within the wider context of the Sustainable River Management Plan (SRMP). The SRMP is the technique by which the institutional and infrastructural mechanisms and implications of sustainable management must be recognised (figure 9.1).

Current EA guidance has been encapsulated within the SRM, SAM and SURCoMES.
The five bullet-pointed objectives of the Agency's floodplain policy complement the Sustainable Management perspective (box 9.1).

- development should not take place which has an unacceptable risk of flooding, leading to danger to life, damage to property and wasteful expenditure on remedial works;
- development should not create or exacerbate flooding elsewhere;
- development should not take place which prejudices possible works to reduce flood risk;
- development should not cause unacceptable detriment to the environment;
- natural floodplain areas are retained and where practicable restored in order to fulfil their natural functions.

Box 9.1: Environment Agency Objectives towards floodplain management

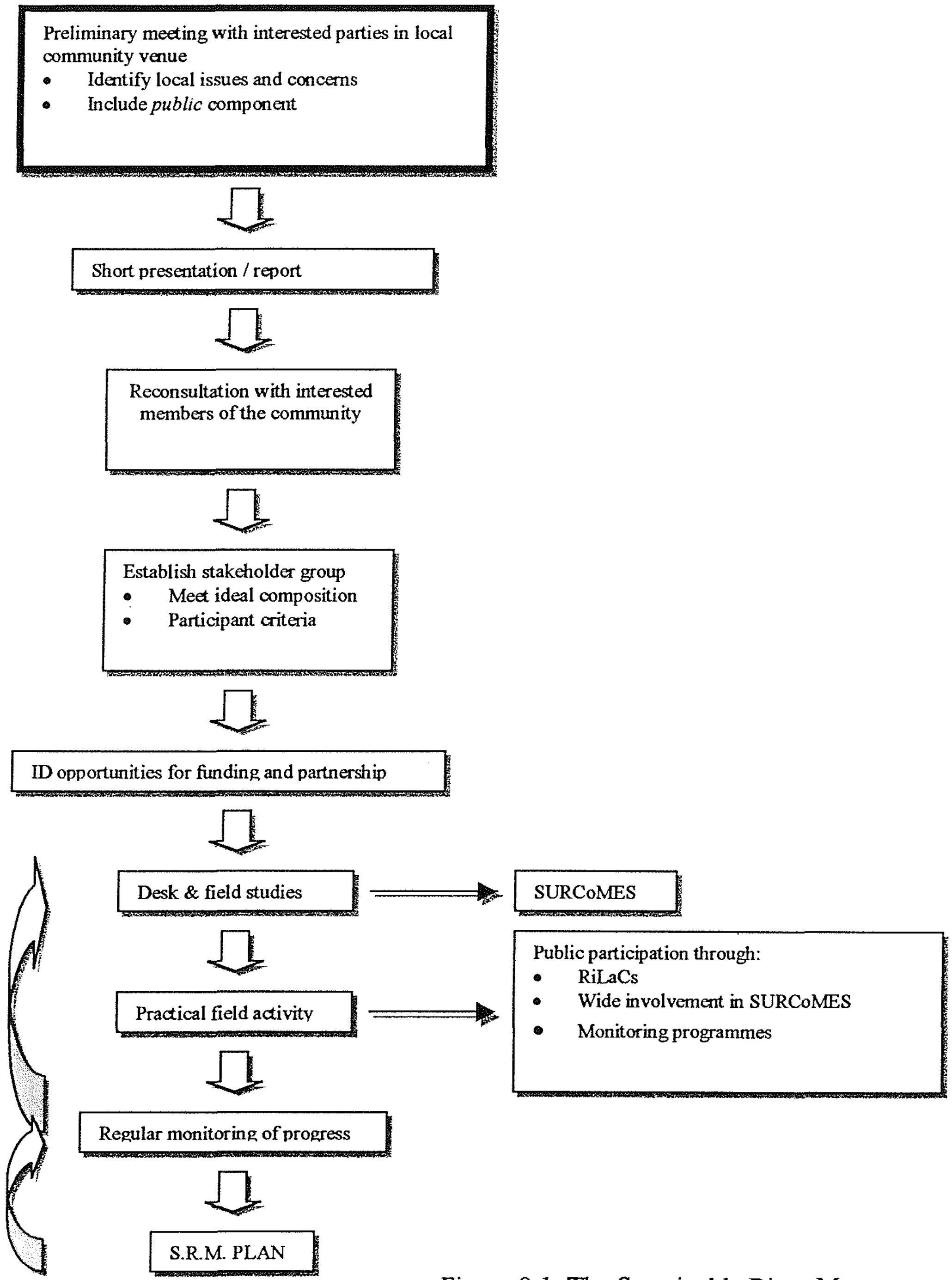


Figure 9.1: The Sustainable River Management Plan

Extensive consultations in this research have identified a number of further modifications which need to made in the Environment Agency if sustainable management is to be a success. Central are:

1. Increased coherence of information provision and sharing between the sustainable development team and those implementing the concept;
2. The definition of clearer guidelines (preferably measurable) to Agency staff who are required to implement the principle aim;
3. The redefinition of sustainable development, so that its core aim of 'best practice' is explicitly recognised;
4. The fuller uptake and utilisation of Area Environment Groups, Regional Development Groups and Community Leader Days to translate the message more effectively to those external to the Agency;
5. More enabling powers especially with regard to land-take and compensatory mechanisms;
6. Long-termism through softening the 'blow' of the financial year, extending financial pay-outs and stewardships and, more effective PPA;
7. Increased training in the relevant functions;
8. A more strategic approach with the respective resources; and
9. A stronger approach to sustainability.

Section 3 of this research identifies possible techniques for optimising the success of sustainable management in the present economic and social context of England and Wales. It is suggested that incentives for more successful uptake need to bring the consequences of detrimental activity on the river and its banks, closer in space and time to those concerned. Two key recommendations are the setting up of:

1 ***Riparian Landowner Co-operatives (RiLaCs)*** as a new approach to formalising legal constraints on further degradation of riparian areas, whilst optimising benefits to the riparian owners; and, set within this framework;

2 ***Easements*** to compensate the riparian user or owner for the sacrifice which strong sustainable river management often brings; and,

3 ***Site-specific flood insurance premiums*** as a disincentive for future development in flood-prone areas.

It is also suggested that with regard to economic mechanism and techniques for change,

1 Grant aid and stewardship needs greater emphasis on the long-termism of sustainable management, and natural fluvial process; and,

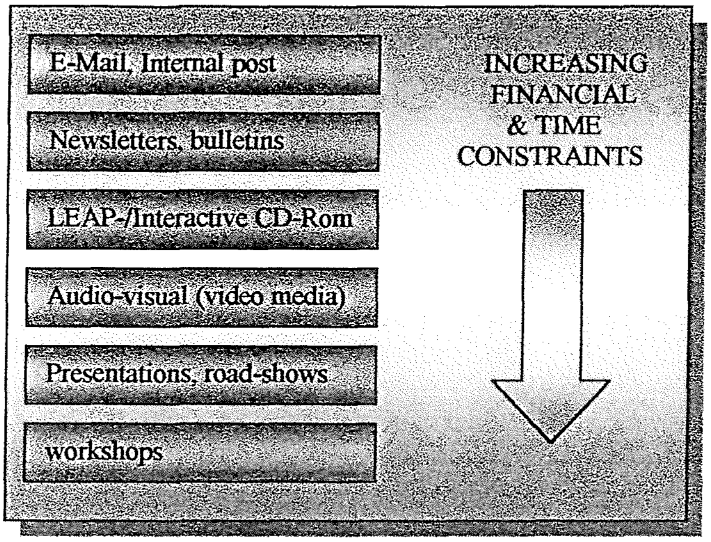
2 There should be less emphasis on command and control style regulation with pollution rights and taxes.

This set of recommendations serves only to supplement, or provide short-term surrogates for the wider change in attitude to more sustainable societal behaviour. Central are the following recommendations:

1) Behavioural change to more successful progress towards sustainable management will be optimised through *both* the correct incentives *and* the use of appropriate social methods;
2) The SURCoMES and SAM will be optimised with appropriate social vehicles for attitudinal revision;
3) More information on sustainability and sustainable management is needed within the Agency. It is suggested that vehicles for this should be as interactive as possible within the constraints of resources (e.g. LEAP CD-Rom; Workshops; Roadshows);
4) Truly sustainable management may often involve social and economic sacrifice, particularly on behalf of the riparian land-owner. For this reason, higher levels of public involvement through public participation must be utilised;
5) Sustainability should be introduced to people from as early an age as possible, preferably through the education system;
6) A campaign similar to FEMA's 'Cover America' is suggested, where market research, through focus groups and other participative mechanisms highlights where the Agency is lacking in its promotion of more sustainable management. The procedure of general awareness - response oriented - public relations phasing highlights a method for heightening awareness with greater publicity of sustainability through the use of various interactive methods;
7) The 'Land Literacy Programmes' used in the Australian LandCare Programme are highlighted as a useful method for involving the community in the management of their river. This would help in enhancing community understanding of why social sacrifice should sometimes be made. River habitat monitoring kits or bank erosion monitoring kits are similarly championed as a way of involving the community;
8) The RiLaCs (Riparian Land-owners Co-operatives) are proposed as the mechanism by which these recommendations could be activated and progressed.

These approaches are part of a more holistic package which suggests that awareness raising inter-institutionally, intra-institutionally, and extra-institutionally (public) will optimise well-placed economic incentives to change.

The Environment Agency needs to look towards manipulating present routes to publicity through tools which are currently available (box 9.1), whilst research in public participation and education needs to be considered along with experience from home and abroad, to optimise public accountability and acceptance of more sustainable management.



Box 9.1

Suggested tools for awareness raising in the UK

- TV slot
- Yellow Pages – 'Flood Insurance'
- Satellite media tour
- Interactive Speakers Kit
- Catchment/location specific print-ads, posters and/ or leaflet drops

Box 9.2

Public awareness raising is suggested through the routes of those in box 9.2. This is modified from the experience of FEMA (Federal Emergency Management Agency) of the United States, in the National Flood Insurance Programme. Similarly, the RiLaCs mechanism is further optimised through reference to LandCare, an Australian example of community-based management, which includes the local community in monitoring, land management and community-based environmental education programmes.

If the SRM, SAM and SURCoMES are to be fully integrated into the present infrastructure of environmental management, they need to be consistent with present tools for environmental appraisal. As illustrated in section 2, an auditable system, which acknowledges these tools will gain from an initial defensibility and robustness that would otherwise need rectification at a later date. Similarly, if the new sustainable management system follows comparable phases to other systems it will have more widespread and understanding support. The ***Strategic Environmental Assessment*** (SEA) structure parallels the building blocks of the sustainable management perspective with the SRM at the policy level, SAM at the plan level and the programme level utilising the SURCoMES.

Perspective

This research has aspired to redefine the global concept of Sustainable Development into workable best practice for river management in England and Wales. 'Sustainable Management' has achieved this goal, with the key characteristics of minimum intervention, flooding, metastability, and the greater utilisation of the science of geomorphology.

This exercise has illustrated how such a complex of ideas, aims and objectives may be clarified into transparent, accountable and defensible guidelines without losing the interrelationships and holism that is so characteristic of the concept.

It is envisaged that the methodologies developed in this research may be transferred to various other fields of management that need to incorporate sustainable development into everyday practice (e.g. Business Management, all spheres of Environmental Management).

The Sustainability Appraisal Matrix (SAM) which has been developed is a useful tool for complementing most project proposals that require Environmental Impact Assessment (EIA). The individual criteria and weightings are readily accessible to the user, so that depending on the type of project (e.g. Coastal Zone Management, river catchment management), detail may be easily replaced, added or modified.

The Sustainable Upland River Corridor Management Evaluation System (SURCoMES) is the first tool of its kind to not only appraise the present sustainability of a river, but balance the present management need against projected future changes in the system. Again, the SURCoMES has been developed so that those with the relevant authority may access the background rules to the system and adjust the detail as information and understanding improves. Various recommendations have identified how further research might harness opportunities to increase the widespread uptake and applicability of such a system.

Both the SAM and SURCoMES illustrate the first endeavours to evaluate progress towards more sustainable practices in environmental management. These systems have moved away from the commonly used 'indicators approach' to more explicitly recognise the importance of the connections *between* the indicators.

This research project combines the development of targets and tools with an appreciation of the techniques that will be needed by Institutions and the public to implement more sustainable management practices. The combination of financial incentives to counteract the social and economic sacrifice that sustainable management often implies, and increased public participation and awareness-raising, is identified as the key to optimising sustainability.

This research not only delivers a range of tools for the Environment Agency, but also an interesting and extremely developable field of research for further academic study. Much potential lays in the further research of techniques for implementing more sustainable management. Case studies from abroad would benefit from more research, and more specifically, the legal and political mechanisms to change identified (for instance, the lack of enabling powers of the Environment Agency, and the implementation of riparian co-operative groups).

The concept of Sustainable Management has great potential in achieving a more sustainable society. However, it will only be a success if reconciled with the correct tools and techniques for widespread societal change. This research hopes to lead the way in progress towards this goal.

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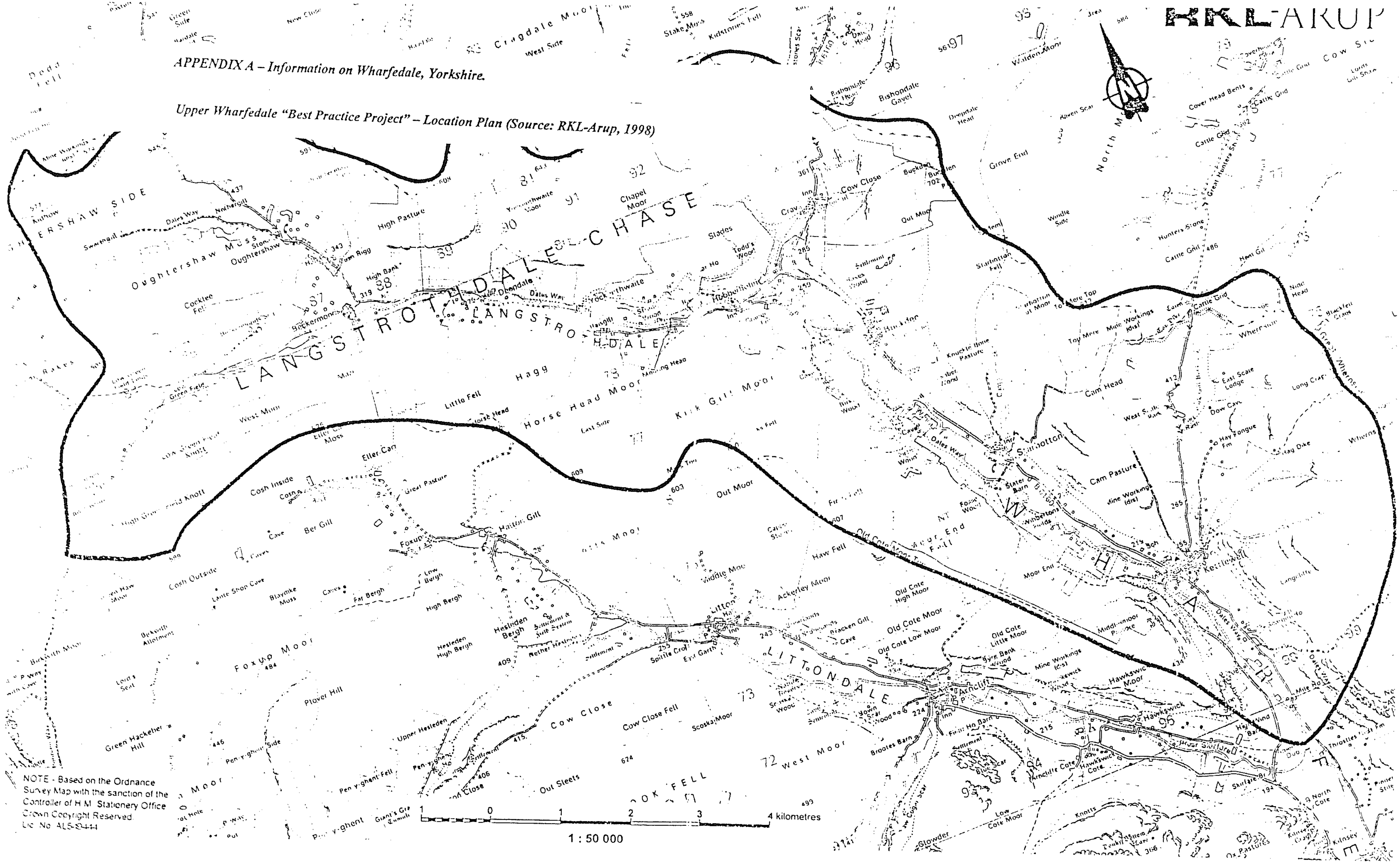
APPENDIX A – Information on Wharfedale, Yorkshire.

Upper Wharfedale "Best Practice Project" – Location Plan (Source: RKL-Arup, 1998)



65628

ENVIRONMENT AGENCY

NORTH EAST REGION

Environment Agency
UPPER WHARFEDALE "BEST PRACTICE" PROJECT - FEASIBILITY STUDY
LOCATION PLAN

Figure 1

Sample 'factfile' from the Upper Wharfedale Best Practice Project (EA, 1999-2000)

Upper Wharfedale Best Practice Project

factfile

Opportunities for Communities and the Environment

No 1 May 1999

This is the first in a series of factfiles to keep people informed about the project. Some of you will already be involved with the project or have heard about it during the early stages when a study was done to help plan the way ahead.

What is the project all about

It is all about teamwork, communities and organisations working together. It will show the advantages of managing land and water together in the uplands and the results will be used as an example to other areas in the country.

The project is designed to benefit the local economy, jobs and the environment. Local people will be involved in planning and practical work and will help keep a check on the health of their environment.

The Structure and Timetable

The project has been awarded a grant of more than £200,000 from the European Commission towards the £400,000 scheme.

The partnership, led by the Environment Agency, is managed by a Steering Group representing: The Environment Agency, The National Trust, English Nature, Yorkshire Dales National Park Authority, Farming and the Community, Yorkshire Water Services, Newcastle University, the Forestry Commission, Tilhill Economic Forestry and the Farming and Rural Conservation Agency.

The three-year scheme swung into action in 1998/99 but the main work is being done in the next two years.

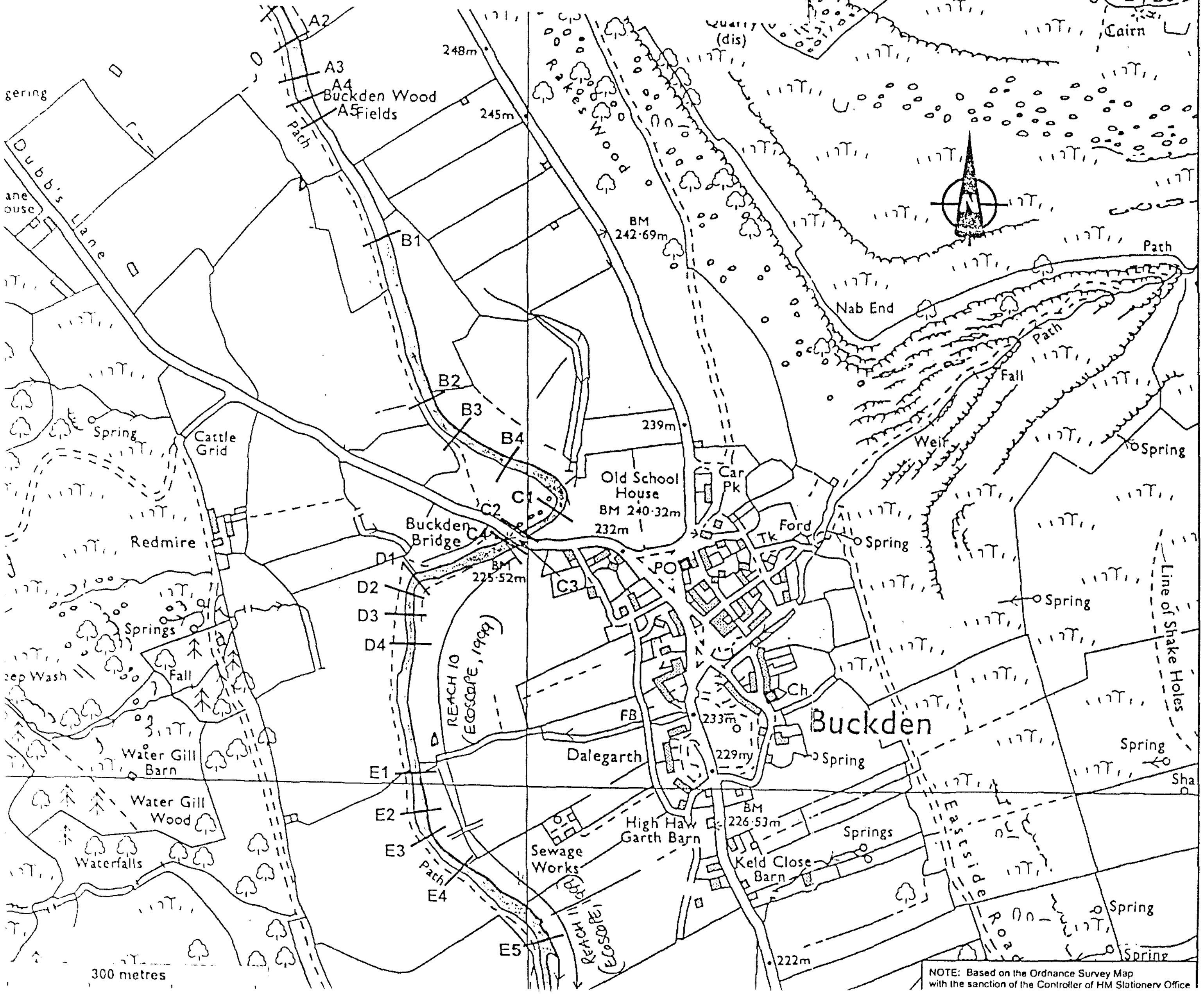
Aims

The major objectives of the project were developed from the findings of a study and are to:

- *Protect river banks to help prevent erosion and benefit wildlife.*
- *Manage woodland and encourage planting on the valley floor, beside hillside streams and other areas.*
- *Create wetland areas on the valley floor where appropriate and protect hay meadows.*
- *Improve footpaths susceptible to erosion.*
- *Seek positive changes in upland livestock farming practices to bring about environmental and social benefits.*
- *Protect spring water sources and other supplies to produce good quality water and protect the environment.*
- *Seek ways of improving sheep dipping practices to prevent river pollution.*
- *Carry out education projects with schools, colleges and the wider community.*
- *Put together a long-term plan and set targets to ensure the environment is protected for future generations.*
- *Block drainage channels, known as grips, to retain more water on the moor, which benefits the flora and fauna.*

ENVIRONMENT AGENCY

Location of unstable reaches of the Upper Wharfe from Dynamic Assessment conducted by RKL-Arup (1999) including locations of RCS carried out by Ecoscope Applied Ecologists Ltd. (1999)



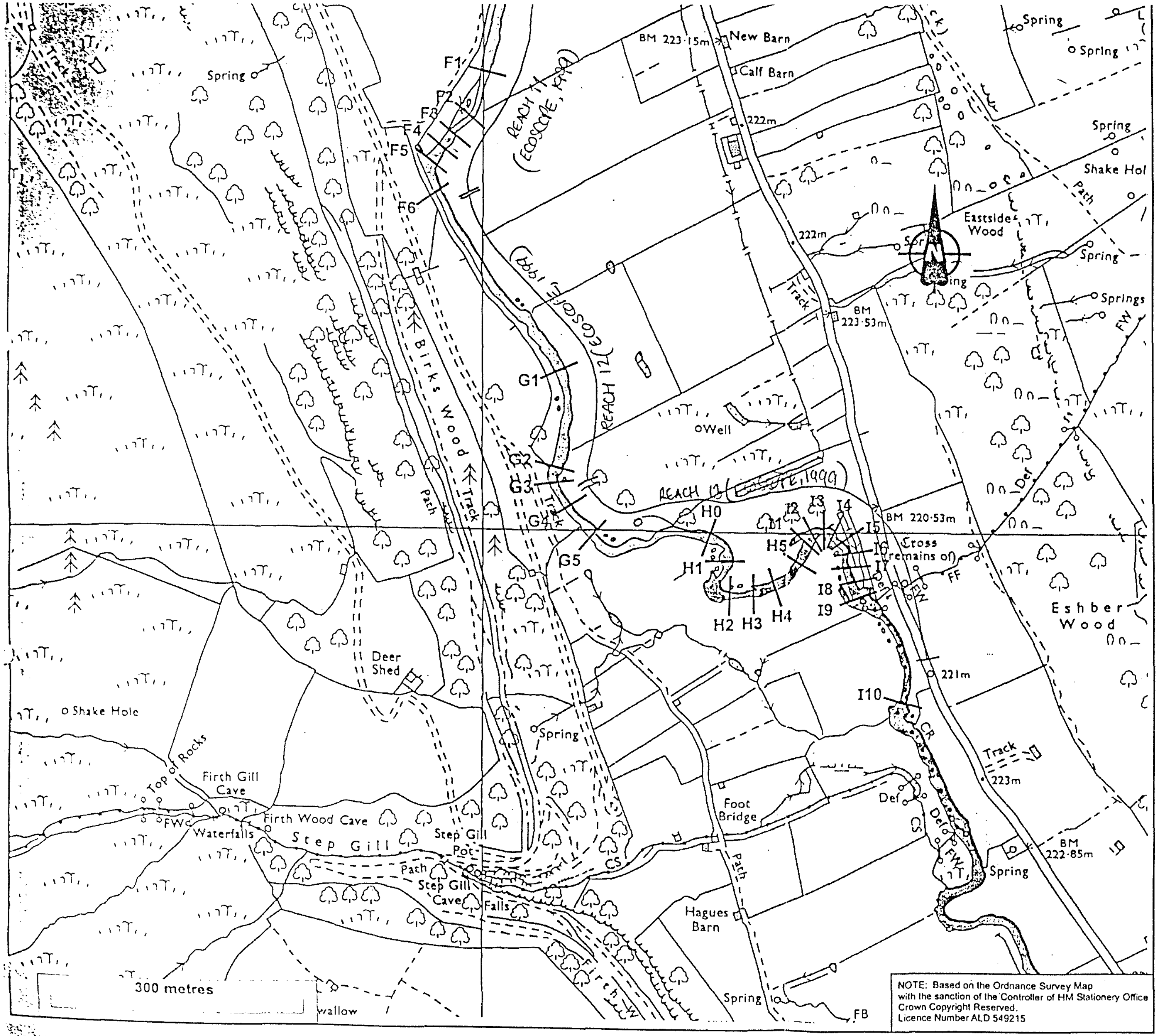
RKL-Arup

ENVIRONMENT AGENCY
NORTH EAST REGION

KEY

River Cross Section

Dynamic Assessment of Unstable Reaches of the Upper Wharfe
Reaches A to E showing locations of cross sections



RKL-Arup

ENVIRONMENT AGENCY

NORTH EAST REGION

KEY

—— River Cross Section

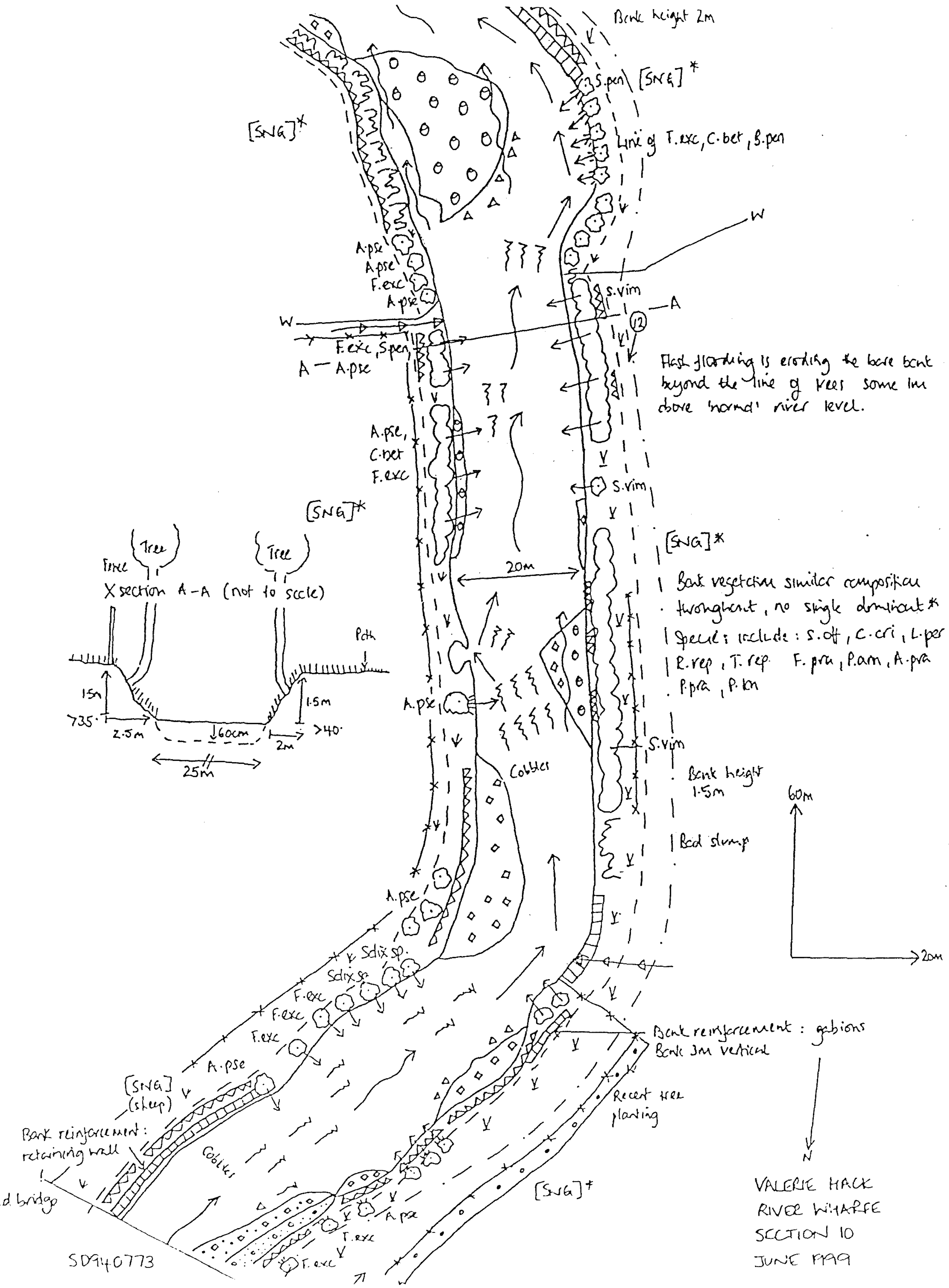
Dynamic Assessment of Unstable Reaches of the Upper Wharfe

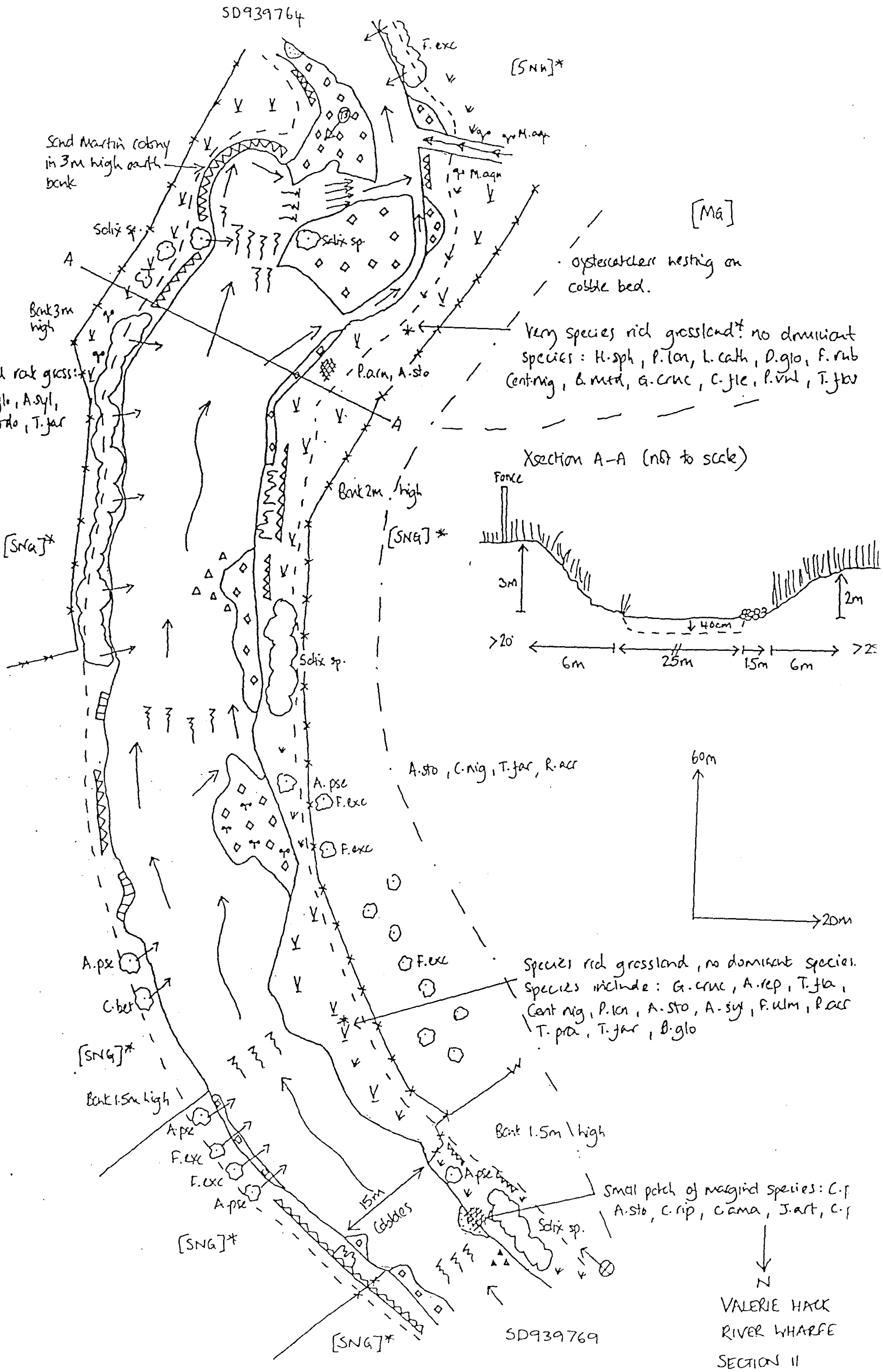
Reaches F to I showing locations of cross sections

Figure 3

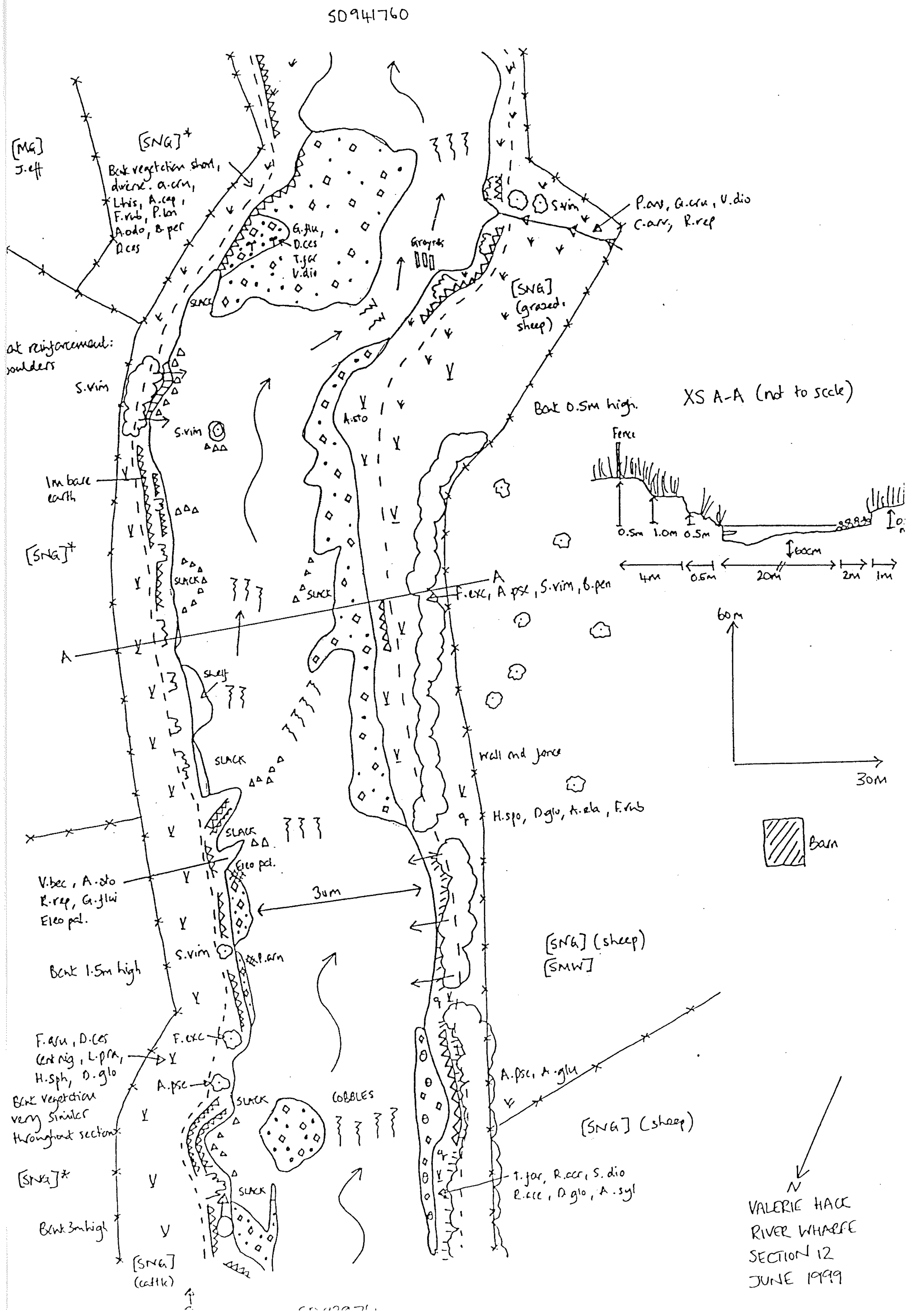
57004

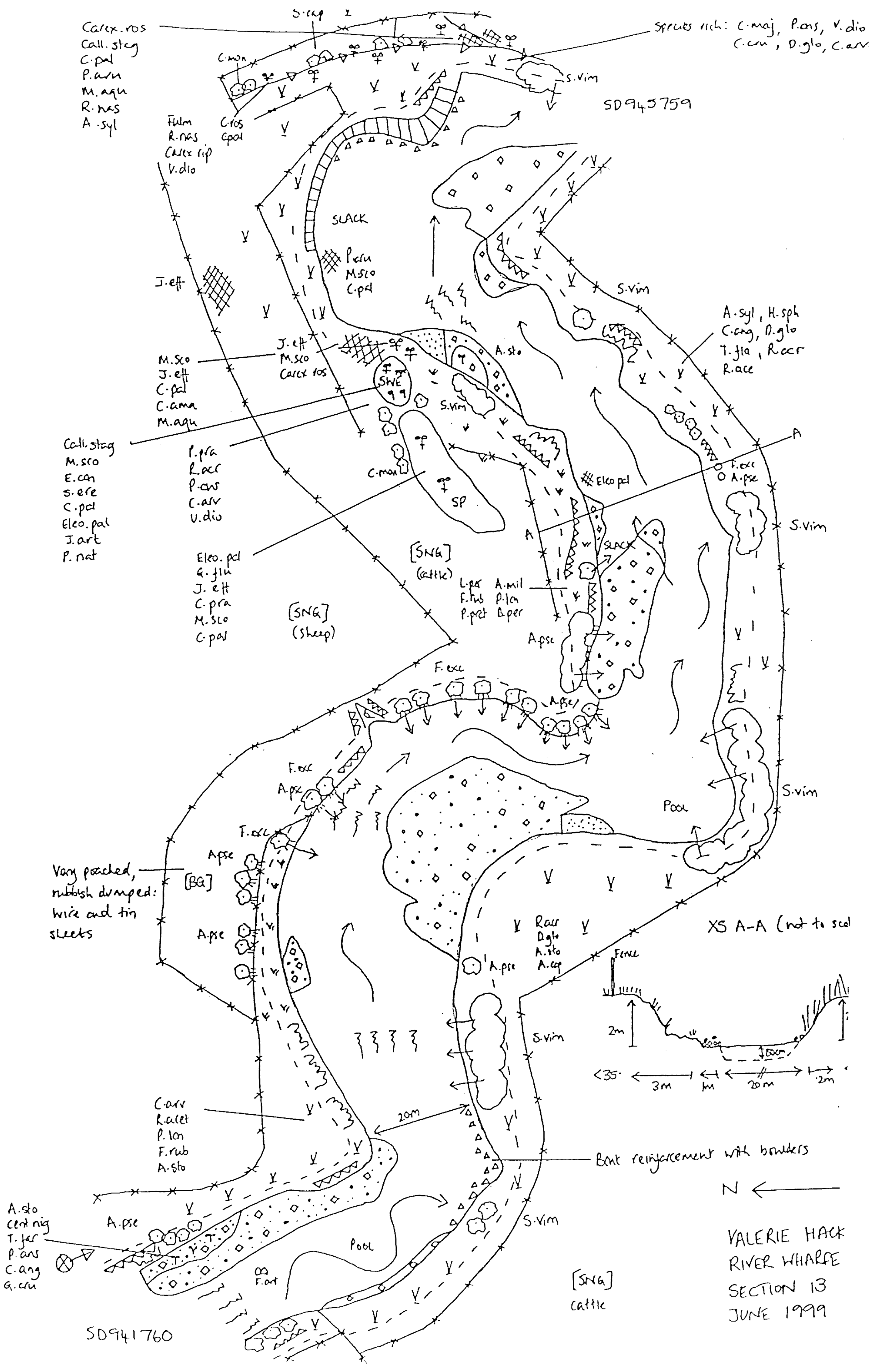
Reaches 10 – 13 of River Corridor Survey (Source: Ecoscope Applied Ecologists Ltd., 1999)





VALERIE HACK
RIVER WHARFE
SECTION 11
JUNE 1999


SD941760
[MG]
J.eff
[SNG]*
Bank vegetation short, diverse. a.crn, L.his, A.cap, F.rub, P.lan, A.odo, B.per, D.ces
G.flu, D.ces, T.far, V.dio
Groynes
SLACK
P.ans, G.cru, V.dio, C.arv, R.rep
S.vim
[SNG] (grazed: sheep)
at reinforcement: boulders
S.vim
A.sto
Bank 0.5m high.
XS A-A (not to scale)
Fence
0.5m 1.0m 0.5m
60cm
4m 0.5m 20m 2m 1m
1m bare earth
[SNG]*
SLACK
A
F.exc, A.psc, S.vim, B.pen
60m
30m
Shelf
SLACK
Wall and fence
H.spo, D.glo, A.ela, F.rub
Barn
SLACK
Eleo pal.
V.bec, A.sto, R.rep, G.flu, Eleo pal.
30m
[SNG] (sheep)
[SMW]
S.vim
P.arn
Bank 1.5m high
F.aru, D.ces, Cent nig, L.pra, H.sph, D.glo
F.exc
A.psc
A.psc, A.glu
Bank vegetation very similar throughout section.
SLACK
COBBLES
[SNG] (sheep)
[SNG]*
T.far, R.acr, S.dio, R.acr, D.glo, A.syl
SLACK
Bank 3m high
[SNG] (cattle)
N
VALERIE HACK
RIVER WHARFE
SECTION 12
JUNE 1999


Carex.ros
Call. stag
C. pal
P. arn
M. aqu
R. nas
A. syl
S. cap
Species rich: C. maj, P. ans, V. dio
C. cru, D. glo, C. arv
C. mon
S. vim
SD945759
Fulm
R. nas
Carex rip
V. dio
C. ros
C. pal
SLACK
P. arn
M. sco
C. pal
J. eff
S. vim
A. syl, H. sph
C. ang, D. glo
T. fla, R. acr
R. ace
M. sco
J. eff
C. pal
C. ama
M. aqu
J. eff
M. sco
Carex ros
SWE
A. sto
Call. stag
M. sco
E. can
S. ere
C. pal
Eleo. pal
J. art
P. nat
P. pra
R. acr
P. ans
C. arv
V. dio
C. mon
SP
Eleo pal
A
F. exc
A. pse
A
SLACK
S. vim
Eleo. pal
G. flu
J. eff
C. pra
M. sco
C. pal
[SNG]
(cattle)
L. per
F. rub
P. pat
A. mil
P. lan
B. per
[SNG]
(sheep)
A. pse
F. exc
A. pse
F. exc
A. pse
F. exc
Pool
S. vim
A. pse
Very poached,
rubbish dumped:
wire and tin
sheets
[BG]
A. pse
R. acr
D. glo
A. sto
A. cap
A. pse
XS A-A (not to scal
Fence
2m
<35°
3m
1m
20m
2m
S. vim
C. arv
R. acet
P. lan
F. rub
A. sto
20m
Bank reinforcement with boulders
N
A. sto
Cent. nig
T. fer
P. ans
C. ang
G. cru
A. pse
Pool
F. art
S. vim
[SNG]
cattle
VALERIE HACK
RIVER WHARFE
SECTION 13
JUNE 1999
SD941760

APPENDIX B – Logical Expressions, Excel (Source: MS-Windows, 1997)

VLOOKUP

Searches for a value in the leftmost column of a table, and then returns a value in the same row from a column you specify in the table. Use VLOOKUP instead of HLOOKUP when your comparison values are located in a column to the left of the data you want to find.

Syntax

VLOOKUP(lookup_value,table_array,col_index_num,range_lookup)

Lookup_value is the value to be found in the first column of the array. Lookup_value can be a value, a reference, or a text string.

Table_array is the table of information in which data is looked up. Use a reference to a range or a range name, such as Database or List.

- If range_lookup is TRUE, the values in the first column of table_array must be placed in ascending order: ..., -2, -1, 0, 1, 2, ..., A-Z, FALSE, TRUE; otherwise VLOOKUP may not give the correct value. If range_lookup is FALSE, table_array does not need to be sorted.
- You can put the values in ascending order by choosing the Sort command from the Data menu and selecting Ascending.
- The values in the first column of table_array can be text, numbers, or logical values.
- Uppercase and lowercase text are equivalent.

Col_index_num is the column number in table_array from which the matching value must be returned. A col_index_num of 1 returns the value in the first column in table_array; a col_index_num of 2 returns the value in the second column in table_array, and so on. If col_index_num is less than 1, VLOOKUP returns the #VALUE! error value; if col_index_num is greater than the number of columns in table_array, VLOOKUP returns the #REF! error value.

Range_lookup is a logical value that specifies whether you want VLOOKUP to find an exact match or an approximate match. If TRUE or omitted, an approximate match is returned. In other words, if an exact match is not found, the next largest value that is less than lookup_value is returned. If FALSE, VLOOKUP will find an exact match. If one is not found, the error value #N/A is returned.

Remarks

- If VLOOKUP can't find lookup_value, and range_lookup is TRUE, it uses the largest value that is less than or equal to lookup_value.
- If lookup_value is smaller than the smallest value in the first column of table_array, VLOOKUP returns the #N/A error value.
- If VLOOKUP can't find lookup_value, and range_lookup is FALSE, VLOOKUP returns the #N/A value.

Examples

On the preceding worksheet, where the range A4:C12 is named Range:

VLOOKUP(1,Range,1,TRUE) equals 0.946
VLOOKUP(1,Range,2) equals 2.17
VLOOKUP(1,Range,3,TRUE) equals 100
VLOOKUP(.746,Range,3,FALSE) equals 200
VLOOKUP(0.1,Range,2,TRUE) equals #N/A, because 0.1 is less than the smallest value in column A
VLOOKUP(2,Range,2,TRUE) equals 1.71

IF

See Also

Returns one value if a condition you specify evaluates to TRUE and another value if it evaluates to FALSE.

Use IF to conduct conditional tests on values and formulas.

Syntax 1

IF(logical_test,value_if_true,value_if_false)

Logical_test   is any value or expression that can be evaluated to TRUE or FALSE.

Value_if_true   is the value that is returned if logical_test is TRUE. If logical_test is TRUE and value_if_true is omitted, TRUE is returned. Value_if_true can be another formula.

Value_if_false   is the value that is returned if logical_test is FALSE. If logical_test is FALSE and value_if_false is omitted, FALSE is returned. Value_if_false can be another formula.

Remarks

- Up to seven IF functions can be nested as value_if_true and value_if_false arguments to construct more elaborate tests. See the following last example.
- When the value_if_true and value_if_false arguments are evaluated, IF returns the value returned by those statements.
- If any of the arguments to IF are arrays, every element of the array is evaluated when the IF statement is carried out. If some of the value_if_true and value_if_false arguments are action-taking functions, all of the actions are taken.

Examples

In the following example, if the value in cell A10 is 100, then logical_test is TRUE, and the total value for the range B5:B15 is calculated. Otherwise, logical_test is FALSE, and empty text ("") is returned that blanks the cell that contains the IF function.

`IF(A10=100,SUM(B5:B15),"")`

Suppose an expense worksheet contains in B2:B4 the following data for "Actual Expenses" for January, February, and March: 1500, 500, 500. C2:C4 contains the following data for "Predicted Expenses" for the same periods: 900, 900, 925.

You can write a formula to check whether you are over budget for a particular month, generating text for a message with the following formulas:

`IF(B2>C2,"Over Budget","OK")` equals "Over Budget"

`IF(B3>C3,"Over Budget","OK")` equals "OK"

Suppose you want to assign letter grades to numbers referenced by the name AverageScore. See the following table.

If AverageScore is	Then return
Greater than 89	A
From 80 to 89	B
From 70 to 79	C
From 60 to 69	D
Less than 60	F

You can use the following nested IF function:

```
IF(AverageScore>89,"A",IF(AverageScore>79,"B",
IF(AverageScore>69,"C",IF(AverageScore>59,"D","F"))))
```

In the preceding example, the second IF statement is also the value_if_false argument to the first IF statement. Similarly, the third IF statement is the value_if_false argument to the second

IF statement. For example, if the first logical_test (Average>89) is TRUE, "A" is returned. If the first logical_test is FALSE, the second IF statement is evaluated, and so on.

Macros: Automating tasks you perform frequently

If you perform a task repeatedly in Microsoft Excel, you can automate the task with a macro. A macro is a series of commands and functions that are stored in a Visual Basic module and can be run whenever you need to perform the task. You record a macro just as you record music with a tape recorder. You then run the macro to repeat, or "play back," the commands.

Before you record or write a macro, plan the steps and commands you want the macro to perform. If you make a mistake when you record the macro, corrections you make will also be recorded. Each time you record a macro, the macro is stored in a new module attached to a workbook.

With the Visual Basic Editor, you can edit macros, copy macros from one module to another, copy macros between different workbooks, rename the modules that store the macros, or rename the macros.

[redacted]

SURCoMES

Sustainable Upland River Corridor Management Evaluation System

This system is a prototype for the Sustainability Appraisal of upland, rural, river corridor Best Practice Projects on semi-natural sites in England and Wales. It has been joint funded by the Environment Agency of England and Wales and the University of Southampton.

Part I defines the current and estimated future geomorphological stability of the river corridor. This is combined with the socio-economic, legal, and political constraints in the riparian area to ascertain the present sustainability status, and the likely long-term sustainability of the corridor.

Part II is a decision support model. This defines the most sustainable management option based upon local, national, and international management need and opportunity.

This system raises awareness to the breadth of opportunities available in sustainable environmental management. Management outcomes are not constrained only to those illustrated.

Please note: Select 'Full Screen' on the 'View' menu before continuing.

SURCoMES. I

Please fill in the following sheet, using the drop-down boxes and prompts provided.

Data Requirements: RHS Database Version 3.1;
Relevant LEAP; and,
R&D Technical Report W87 (1999)

1. RHS site number

2. Which of the following 11 river types (RHS, 1996) best describes your river or reach?
9 high altitude, moderate gradient river with mixed geology

3. Which of the following most closely describes the left bank material?
>50% or 10 spot checks of gravel/pebble, earth bank

4. Which of the following most closely describes the left bank features?
Eroding Earth Cliff (EC) 2 - 5 of the SPOT checks

5. Which of the following most closely describes the channel substrate?
>60% or 6 spot checks of gravel/pebble, sand, silt, cobble

6. Which of the following most closely describes the right bank material?
>50% or 10 spot checks of gravel/pebble, earth bank

7. Which of the following most closely describes the right bank features?
Eroding Earth Cliff (EC) 2 - 5 of the SPOT checks

8. Which of the following most closely describe the bank profile? (Section L, RHS)
'Present' or 'none' vertical/undercut and/or vertical + toe on SWEEP

9. Which of the following most closely describe the extent of trees? (Section J, RHS)
Neither bank with Continuous Tree cover

10. Please indicate the extent of the following channel features on your river or reach (Section K, RHS)
1. Exposed bedrock/boulders
5 or less SPOT checks
2. Unvegetated mid- /point- and/or side-channel bars
'Extensive' (>33% or 3 spot checks)
3. Vegetated mid- /point- and/or side-channel bars
'Present' or 'none'
4. Mature islands
5 or less SPOT checks

11. Which of the following most closely describes the bed material? (Section L, RHS)
Unconsolidated

12. Which of the following categories does the calculated mean stream power fall within? (refer to R&D W87, 1999)
>35 watts/m2

13. Which of the following describes the MAFF Land Use Band of land within 50m of the left bank?
Medium productivity agricultural land/isolated dwellings

14. Which of the following describes the MAFF Land Use Band of land within 50m of the right bank?
Medium productivity agricultural land/isolated dwellings

15. Does land 50m to either side of banktop display any of the following Agri-Environment designations?
Countryside Stewardship — Yes

16. Does land 50m to either side of banktop display any of the following Wildlife/Environmental designations?
SSSI — Yes

17. Does land 50m to either side of banktop display any of the following Heritage conservation designations?
Conservation Area — Yes

18. Does land 50m to either side of banktop display any of the following Landscape designations?
National Park — Yes

19. Does land 50m to either side of banktop display any of the following additional reasons for considering conservation?
Important for recreation/ amenity interests — Yes

20. Is any of the riparian area under consideration part of one or more of the following mapping initiatives?
Landmap — Yes

21. Does land 50m to either side of banktop display any of the following access routes?
National road/railway — No

22. Which of the following HQA scores most closely describes the Habitat Quality of the reach?

>=40 to <45

Based upon this information, this site is:

HQA Class: 4

Description: Poor

Colour Code: Blue

On the basis of the information you have provided, this river system exhibits the following relative measures of stability. These are the component parts of the system sustainability.

They must not be seen as anything more than an aid for the user to understand the interaction of the individual elements leading to "more" or "less" sustainable states relative to:

a) rivers or reaches within the same proximity on RHS 3.1 Context Analysis (see RHS, 1996); or
b) the effects that various management options may have on present status.

Bank stability status — LESS … MORE STABLE

Bed stability status — LESS … MORE STABLE

Present Geomorphological stability — LESS … MORE STABLE

Propensity to change — LESS … MORE LIKELY TO CHANGE

Socio-economic status — LESS … MORE VALUABLE

Left Bank

Right Bank

Habitat Quality relative to other rivers of the same 'type'

V. POOR … HIGH

Present Management Need

Present geomorphogicalcal status of this reach is *low*. Balanced against this, present socio-economic status is *high* with a MAFF Land Use Band of *D* on the left bank, and a MAFF Land Use Band of *D* on the right bank. The socio-economic status of this reach is effected by the presence of:

agri-environment designations;
heritage conservation designations;
wildlife designations;
landscape designations;
miscellaneous designations;
mapping initiative designations;

The Habitat Quality of this reach is *Poor*

Based upon this balance between the present physical stability and the present land value of this reach, the present management need is suggested to be: *high*

This value may reflect the need to either a) manage a site due to its high natural environment value, or b) manage a site due to its high socio-economic value.

Future Management Need

Future channel change on this reach is likely to be *moderately extreme*. Within the context of the present stability of this reach being high it is probable that *a moderate degree of intervention* will be needed into the longer-term (>10 years). This illustrated on the following sliding scale.

Less intervention to intervene … **more intervention**

moderate degree of intervention

Any management decisions should acknowledge this long-term perspective if cost-effectiveness is to be achieved.

INPUT DATA, SURCOMES USER INTERFACE

River Class
1 low altitude, low gradient river with soft geology
2 low altitude, steep gradient stream with mixed geology
3 low altitude, steep gradient stream with soft geology
4 low altitude, steep gradient stream with mixed geology
5 medium altitude, low gradient river with soft geology
6 medium altitude, moderate gradient river with mixed geology
7 medium altitude, steep gradient stream with soft geology
8 medium altitude, steep gradient stream with mixed geology
9 high altitude, moderate gradient river with mixed geology
10 high altitude, steep gradient stream with hard geology
11 high altitude, high gradient stream with hard geology

Bank features
Eroding Earth Cliff (EC) <2 of the SPOT checks
Eroding Earth Cliff (EC) 2 - 5 of the SPOT checks
Eroding Earth Cliff (EC) >5 of the SPOT checks

Stream Power category
<7.5 watts/m^2
7.5-35 watts/m^2
>35 watts/m^2

Extent features1
>5 of the SPOT checks
5 or less SPOT checks

Extent features2
'Extensive' (>33% or 3 spot checks)
'Present' or 'none'

Extent features3
'Extensive' (>33% or 3 spot checks)
'Present' or 'none'

Extent features4
>5 of the SPOT checks
5 or less SPOT checks

Bank substrate
>50% or 10 spot checks of bedrock, clay, boulder/cobble, peat
>50% or 10 spot checks of gravel/pebble, earth bank

Channel substrate
>60% or 6 spot checks of bedrock, boulder, clay
>60% or 6 spot checks of gravel/pebble, sand, silt, cobble

Bank profiles
> 33% ('Extensive') vertical/undercut and/or vertical + toe on SWEEP
'Present' or 'none' vertical/undercut and/or vertical + toe on SWEE

Extent of trees
Continuous Trees on left and right bank
Continuous Trees on one bank only
Neither bank with Continuous Tree cover
Data missing

Bed Material
Consolidated
Unconsolidated
Data missing or 'unknown'

Riparian Land Use
Extensive grass/few properties/low productivity agricultural lan
Medium productivity agricultural land/isolated dwellings
Low density urban/high productivity agricultural land
Medium density urban
High density urban

Agri-Environmental Designations
Environmentally Sensitive Area (ESA)
The Habitat Scheme
Countryside Stewardship
Tir Cymen
Wider Countryside Scheme

Miscellaneous Reasons for protection or conservation
important for recreation/ amenity interests
unique or locally important species of flora and/or fauna
wider conservation or protection importance
unique or traditional practices where cultural or heritage value
practices with wider cultural and/or associated employment co
protected via routes such as heritage and tourism policies

Wildlife conservation designation/s:
SSSI
National Nature Reserve
Local Nature Reserve
Special Protection Area
Special Area of Conservation
Biosphere Reserve
Ramsar site
Wildlife site
Nature reserve
Regionally important Geological site

Heritage conservation designation/s:
Sites & Monuments record
Scheduled Ancient Monuments
Area of Archaeological Importance
Listed Building
Conservation Area
English Heritage/ Cadw Historic Designation
World Heritage site

Landscape Designation/s:
National Park
Area of Outstanding Natural
Beauty (AONB)
Hedgerows
Special Landscape Area

Nature Conservation Mapping Initiative/s:
Countryside Character
Natural Area
Landmap

Access
Public right of way
Public right of way of national importance
National road/railway
Regional road/railway
Contains routes of access important to local community/busine

Yes

HQA
<39
>=39 to <40
>=40 to <45
>=45 to <46
>=46 to <50
>=50 to <51
>=51 to <56
>=56 to <57
>=57

Opportunities for mitigation
None.
Very little. At considerable distance from site (regional/national)
Negotiable. Regional with some local opportunities
Reasonable. Local opportunities promising
High. Local opportunities rife

Management problem
Riparian loss/erosion
Reduced channel conductance/flood
Both

Management Intervention
0
1
2
3
4
5

No.

Links
Left bank material link
Left bank feature link
Right bank material link
Right bank feature link
Bank profile link
Left bank combination link
Right bank combination link
Left and right bank link
Bank combination and bank profile link
Extent trees
Channel features 1
Channel features 2
Channel features 3
Channel features 4
Bed material
(1) x (2) features (X)
(3) x (4) features (Y)
X x Y
Channel substrate link
Channel substrate x (X x Y)
Stream power link
MAFF Land Use Band LB
MAFF Land Use Band RB
MAFF R & L combination
Agri-Environment Designations
" " " (yes/no)
Wildlife/Environmental Designations
" " " (yes/no)
Heritage conservation designations
" " " (yes/no)
Landscape designations
" " " (yes/no)
Miscellaneous reasons for protection or conservation
" " " (yes/no)
Mapping Initiatives
" " (yes/no)
Access Routes
" " (yes/no)
HQA link

SYSTEM DATA

Left bank material x left bank features (L)	-1
Right bank material x right bank features (R)	-1
(L) x (R) = bank materials x features (LR)	2
(LR) x (bank profile P) = LRP	1
LRP x extent tree cover = BANK STABILITY STATUS	-1
Channel features 1 x channel features 2 (X)	-1
Channel features 3 x channel features 4 (Y)	1

LEFT BANK		eroding EC <2 (+)	EC 2 - 5	EC >5 (-)
>10 bedrock etc (+)	1	3	2	1
> 10 gravel etc (-)	2	1	-1	-2

RIGHT BANK		eroding EC <2 (+)	EC 2 - 5	EC >5 (-)
>10 bedrock etc (+)	1	3	2	1
> 10 gravel etc (-)	2	1	-1	-2

LB x RB	-2	-1	0	1	2	3
-2	-4	-3	-1	-1	1	2
-1	-3	-2	-1	1	2	3
0	1	1	1	1	1	4
1	-2	-1	-1	2	3	5
2	-1	1	1	3	4	6
3	1	2	3	4	5	7

(LB x RB) x bank profile	E (+)	P or N
-4	-5	-3
-3	-4	-2
-2	-3	-1
-1	-2	1
0	1	1
1	-1	2
2	1	3
3	2	4
4	3	5
5	4	6
6	6	7
7	6	8

	Both cont.(++)	One cont (+)	No cont	No data
	1	2	3	4
-5	-3	-4	-5	-5
-4	-2	-3	-4	-4
-3	-1	-2	-3	-3
-2	1	-1	-2	-2
-1	2	1	-1	-1
0	1	1	0	0
1	3	2	1	1
2	4	3	2	2
3	5	4	3	3
4	6	5	4	4
5	7	6	5	5
6	8	7	6	6
7	9	8	7	7
8	10	9	8	8

		>3 (+)	3 or less
>5 (+)	1	1	2
5 or less	2	-1	1

		>5 (+)	5 or less
>3 (+)	1	3	2
3 or less	2	2	1

(X) x (Y) = Z	2

(Z) x channel substrate = zcs	-3

zcs x bed material = BED STABILITY STATUS	-4

PHYSICAL STABILITY STATUS((bank+bed)/2)	-2.5

POWER

Substrate combinations (bank only):	0

Note: 1=total bedrock
2 =total gravel
3 = mixed

Substrate combinations (bed and bank):	0

ΣSubstrate combinations (bed and bank):	0
ΣTree extent:	0
Bed Material:	0
Propensity to change weighting= (Sum of substrate, tree xtent and bed material)	0

Propensity to change = physical stability status - weighting	-2.5

	-1	0	1	2	3
-1	-2	1	1	2	3
0	1	1	1	1	1
1	1	1	2	3	4
2	2	1	3	4	5

	>6 bedrock etc (+)	>6 gravel etc (-)
-2	1	-6
-1	2	-5
0	1	1
1	3	-4
2	4	-3
3	5	-2
4	6	-1
5	7	1

	Consolidated +	Unconsolidated -	Missing/ unknown
	1	2	3
-6	-5	-7	-6
-5	-4	-6	-5
-4	-3	-5	-4
-3	-2	-4	-3
-2	-1	-3	-2
-1	1	-2	-1
0	1	1	1
1	2	-1	1
2	3	1	2
3	4	2	3
4	5	3	4
5	6	4	5
6	7	5	6
7	8	6	7

WATSON ET AL		Bank <1 (+)	Bank >1 (-)
Channel >1 (-)	1	1	-2
Channel =1 (+)	2	2	-1
Channel <1 (-)	3	1	-2

most sustainable

LEFT BANK		RIGHT BANK >10 bedrock etc	> 10 gravel etc	Neither
		1	2	3
>10 bedrock etc	1	3	3	3
> 10 gravel etc	2	3	0	0
Neither	3	3	0	0

L & R		BED >6 bedrock etc	> 6 gravel etc	Neither
		1	2	3
	0	3	0	0
	1	0	0	0
	2	0	0	0
	3	3	3	3

TreesX		
both sides	1	4
one side	2	2
neither	3	0
data missing	4	0

Bed Material		
consolidated	1	1
unconsolidated	2	0
data missing	3	0

SOCIO-ECONOMIC

If Land Use Band on Left Bank x then score y	2
If Land Use Band on Right Bank x then score y	2
IF agri-environment designation = YES then score 1, NO = 0	1
IF wildlife designation = YES then score 1, NO = 0	1
IF heritage designation = YES then score 1, NO = 0	1
IF landscape designation = YES then score 1, NO = 0	1
IF miscellaneous designation = YES then score 1, NO = 0	1
IF mapping initiative designation = YES then score 1, NO = 0	1
IF access routes = YES then score 1, NO = 0	0
Socio-economic status (LB)	1
Socio-economic status (RB)	1
Socio-economic status	0

HQA

If HQA x then HQA Class y	4
If HQA x then description y	Poor
If HQA x then colour code y	Blue

MANAGEMENT STATUS

NB: 1=less management needed

Management Need statement	
IF(C108)<0,"low",IF(C108)<6,"moderate","high"))	low
IF(C176<6,"low",IF(C173<9,"moderate","high"))	high
IF(C149=1,"A",IF(C149=2,"B",IF(C149=3,"C",IF(C149=4,"D","E"))))	D
IF(C153=1,"A",IF(C153=2,"B",IF(C153=3,"C",IF(C153=4,"D","E"))))	D
IF(C156=1,"presence of agri-environment designations","")	agri-environment designations
IF(C158=1,"presence of wildlife designations","")	wildlife designations
IF(D160=1,"presence of heritage conservation designations","")	heritage conservation designations
IF(C162=1,"presence of landscape designations","")	landscape designations
IF(C164=1,"presence of miscellaneous designations","")	miscellaneous designations
IF(C166=1,"presence of mapping initiative designations","")	mapping initiative designations
IF(C168=1,"presence of access routes/ public rights of way","")	

Present Management Need   High

Present physical stability   Socio-economic status

low   moderate   high

low

moderate

high

NB 1 = least management needed

Extent of future physical change   moderately extreme.

Propensity to change   Present physical status

low   moderate   high

less stable

moderately stable

more stable

NB 1 = less severe projected physical change

Future Management Need   2   a moderate degree of intervention

Present Management Need

least   most

Extent of projected physical change   1

moderate   2

SYSTEM DATA

Left bank material x left bank features (L)	-1
Right bank material x right bank features (R)	-1
(L) x (R) = bank materials x features (LR)	2
(LR) x (bank profile P) = LRP	-1
LRP x extent tree cover = BANK STABILITY STATUS	-1
Channel features 1 x channel features 2 (X)	-1
Channel features 3 x channel features 4 (Y)	1

LEFT BANK		eroding EC <2 (+)	EC 2 - 5	EC >5 (-)
>10 bedrock etc (+)	1	3	2	1
< 10 gravel etc (-)	2	1	-1	-2

RIGHT BANK		eroding EC <2 (+)	EC 2 - 5	EC >5 (-)
>10 bedrock etc (+)	1	3	2	1
< 10 gravel etc (-)	2	1	-1	-2

LB x RB	-2	-1	0	1	2	3
-2	-4	-3	-1	-1	1	2
-1	-3	-2	-1	1	2	3
0	-1	-1	1	1	1	4
1	-2	-1	1	2	3	5
2	-1	1	1	3	4	6
3	1	2	1	4	6	7

(LB x RB) x bank profile	E (+)	P or N
-4	-5	-3
-3	-4	-2
-2	-3	-1
-1	-2	1
0	1	1
1	-1	2
2	1	3
3	2	4
4	3	5
5	4	6
6	5	7
7	6	8

	Both cont (++)	One cont (+)	No cont	No data
	1	2	3	4
-5	-3	-4	-6	-6
-4	-2	-3	-4	-4
-3	1	-2	-3	-3
-2	1	-1	-2	-2
-1	2	1	-1	-1
0	1	1	0	0
1	3	2	1	1
2	4	3	2	2
3	6	4	3	3
4	5	5	4	4
5	7	6	5	5
6	8	7	6	6
7	9	8	7	7
8	10	9	8	8

		>5 (+)	5 or less
>5 (+)	1	1	2
5 or less	2	-1	-1

		>5 (+)	5 or less
>3 (+)	1	3	2
3 or less	2	2	1

(X) x (Y) = Z	2

(Z) x channel substrate = zcs	-3

zcs x bed material = BED STABILITY STATUS	-4

PHYSICAL STABILITY STATUS((bank+bed)/2)	-2.5

most sustainable

POWER

Substrate combinations (bank only):	0

Note: 1=total bedrock
2 =total gravel
3 = mixed

Substrate combinations (bed and bank):	0

2Substrate combinations (bed and bank):	0
2Tree extent:	0
Bed Material:	0
Propensity to change weightings (Sum of substrate, tree xtent and bed material)	0

Propensity to change = physical stability status - weighting	-2.5

	-1	0	1	2	3
-1	2	1	1	2	3
0	1	1	1	1	1
1	1	1	2	3	4
2	2	1	3	4	5

	>8 bedrock etc (+)	>8 gravel etc (-)
-2	1	-6
-1	2	-5
0	1	1
1	3	-4
2	4	-3
3	5	-2
4	6	-1
5	7	1

	Consolidated +	Unconsolidated -	Missing/ unknown
	1	2	3
-6	-5	7	-6
-5	-4	6	-5
-4	-3	5	-4
-3	-2	-4	-3
-2	-1	-3	-2
-1	1	-2	-1
0	1	1	1
1	2	-1	1
2	3	1	2
3	4	2	3
4	5	3	4
5	6	4	5
6	7	5	6
7	8	6	7

WATSON ET AL		Bank <1 (+)	Bank >1 (-)
Channel >1 (-)	1	1	-2
Channel <1 (+)	2	2	-1
Channel <1 (-)	3	1	-2

LEFT BANK		RIGHT BANK >10 bedrock etc	> 10 gravel etc	Neither
		1	2	3
>10 bedrock etc	1	3	3	3
> 10 gravel etc	2	3	0	0
Neither	3	3	0	0

L & R	BED >8 bedrock etc	> 8 gravel etc	Neither
	1	2	3
0	3	0	0
1	0	0	0
2	0	0	0
3	3	3	3

TreesX		
both sides	1	4
one side	2	2
neither	3	0
data missing	4	0

Bed Material		
consolidated	1	1
unconsolidated	2	0
data missing	3	0

SOCIO-ECONOMIC

If Land Use Band on Left Bank x then score y	2
If Land Use Band on Right Bank x then score y	2
IF agri-environment designation = YES then score 1, NO = 0	0
IF wildlife designation = YES then score 1, NO = 0	1
IF heritage designation = YES then score 1, NO = 0	1
IF landscape designation = YES then score 1, NO = 0	1
IF miscellaneous designation = YES then score 1, NO = 0	1
IF mapping initiative designation = YES then score 1, NO = 0	1
IF access routes = YES then score 1, NO = 0	0
Socio-economic status (LB)	8
Socio-economic status (RB)	8
Socio-economic status	8

HQA

If HQA x then HQA Class y	4
If HQA x then description y	Poor
If HQA x then colour code y	Blue

MANAGEMENT STATUS

NB: 1=less management needed

Management Need statement

IF(C108<0,"low",IF(C108<6,"moderate","high"))	low
IF(C176<6,"low",IF(C173<9,"moderate","high"))	high
IF(C149=1,"A",IF(C149=2,"B",IF(C149=3,"C",IF(C149=4,"D","E"))))	D
IF(C153=1,"A",IF(C153=2,"B",IF(C153=3,"C",IF(C153=4,"D","E"))))	D
IF(C156=1,"presence of agri-environment designations","")	agri-environment designations
IF(C158=1,"presence of wildlife designations","")	wildlife designations
IF(C160=1,"presence of heritage conservation designations","")	heritage conservation designations
IF(C162=1,"presence of landscape designations","")	landscape designations
IF(C164=1,"presence of miscellaneous designations","")	miscellaneous designations
IF(C166=1,"presence of mapping initiative designations","")	mapping initiative designations
IF(C168=1,"presence of access routes/ public rights of way","")	

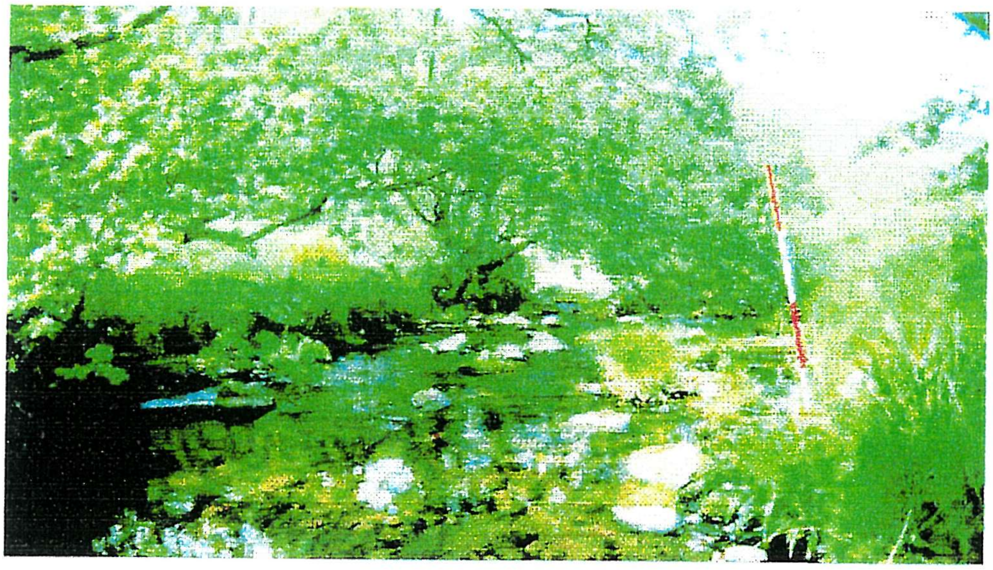
APPENDIX D – List of Consultees for SAM and SURCoMES

Consultee/s	*Position held*	*Consultation Stage*
Professor MJ Clark	Project Supervisor, University of Southampton, Dept of Geography	Stage 1
Ms S German	PhD Researcher, University of Southampton, Dept of Geography	
Ms E Treby	PhD Researcher, University of Southampton, Dept of Geography	
Professor MJ Clark	Project Supervisor, University of Southampton, Dept of Geography	Stage 2
Dr S E Darby	Lecturer, Fluvial Geomorphology, University of Southampton, Dept of Geography	
Ms S German	PhD Researcher, University of Southampton, Dept of Geography	
Mr C Hill	Manager, Geodata Institute Environmental Consultancy	
Dr D A Sear	Lecturer, Fluvial Geomorphology, University of Southampton, Dept of Geography	
Ms E Treby	PhD Researcher, University of Southampton, Dept of Geography	
Professor MJ Clark	Project Supervisor, University of Southampton, Dept of Geography	Stage 3
Dr S E Darby	Lecturer, Fluvial Geomorphology, University of Southampton, Dept of Geography	

Mr C Hill	Manager, Geodata Institute Environmental Consultancy	
Dr D A Sear	Lecturer, Fluvial Geomorphology, University of Southampton, Dept of Geography	
Dr L Chalk	Collaborative Projects Officer, Environment Agency, NE Region	
Mr C Kirkbride	Yorkshire Dales National Parks Authority	
Mr B Jones	Environment Agency, Bangor Area, N Wales	
Mr M Knaura	RHS Team, EA, NW Region	
Mr D Corbelli	RHS Team, EA, NW Region	
Ms H Parsons	RHS Team, EA, NW Region	
Conservation and Recreation Officer	EA, NW Region	
Ecology Officer	EA, NW Region	

APPENDIX E – Plates for Wharfe-paired RHS sites (Source: EA, 1999e)

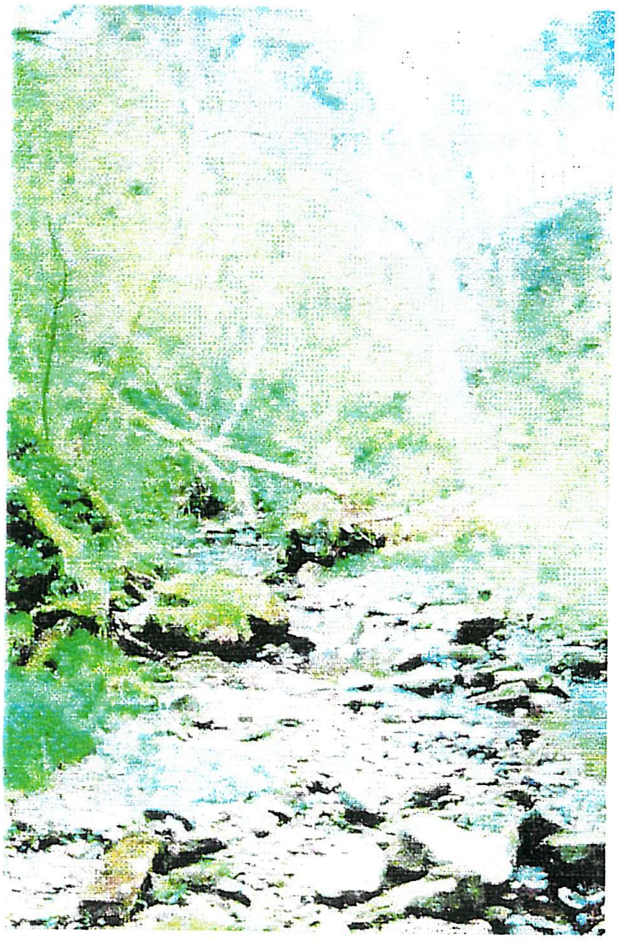
1. Site 7 (a)



2. Site 7 (b)

3. Site 32 (a)

4. Site 32 (b)

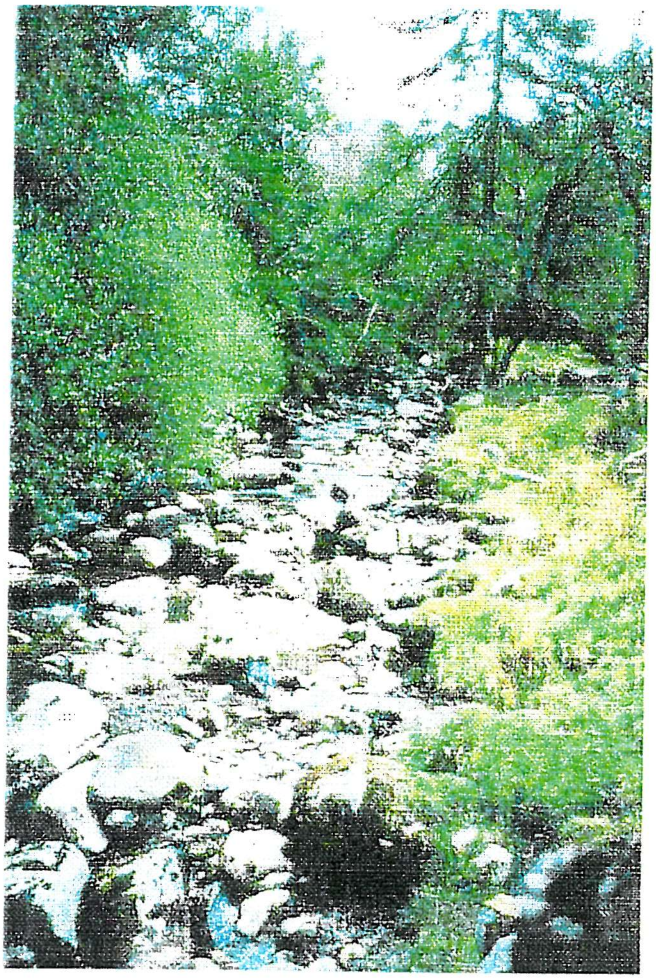


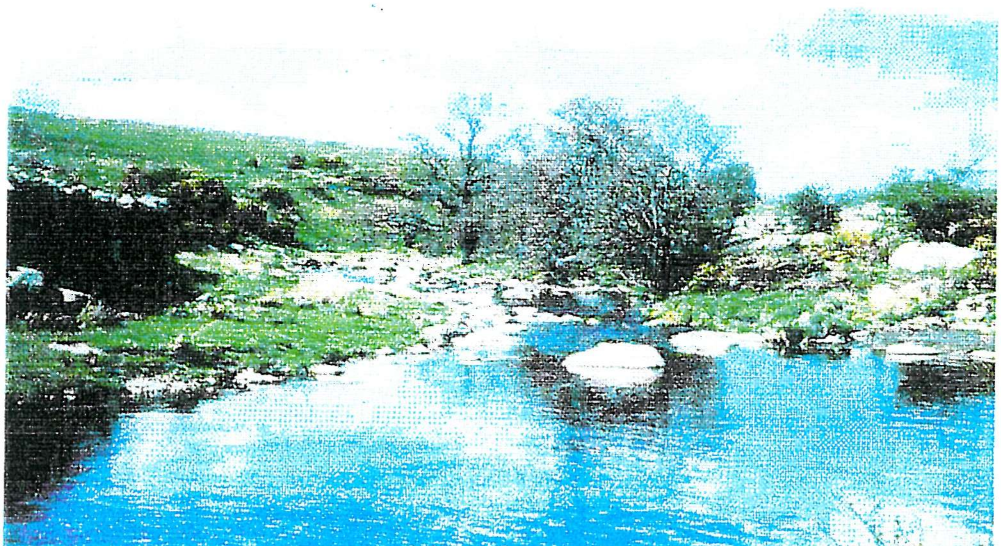
5. Site 32 (c)

6. Site 63 (a)

7. Site 63 (b)

8. Site 88

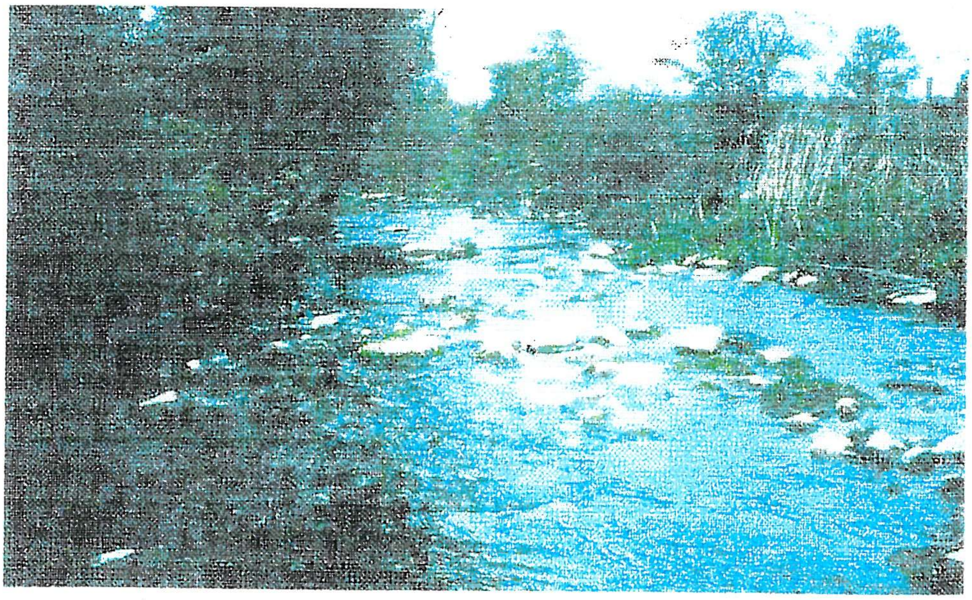




9. Site 102 (above) and 10. Site 120 (a)

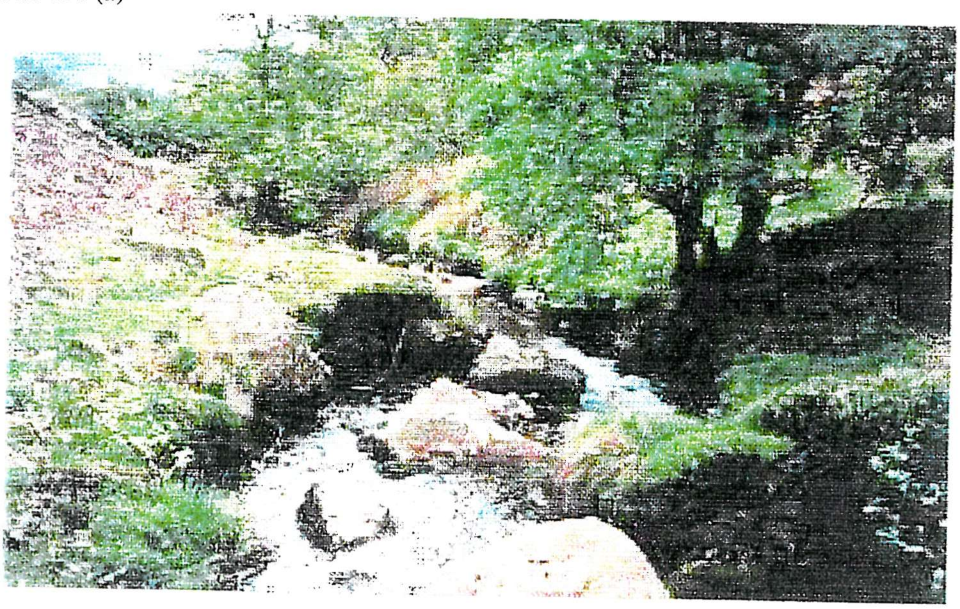
11. Site 120 (b)

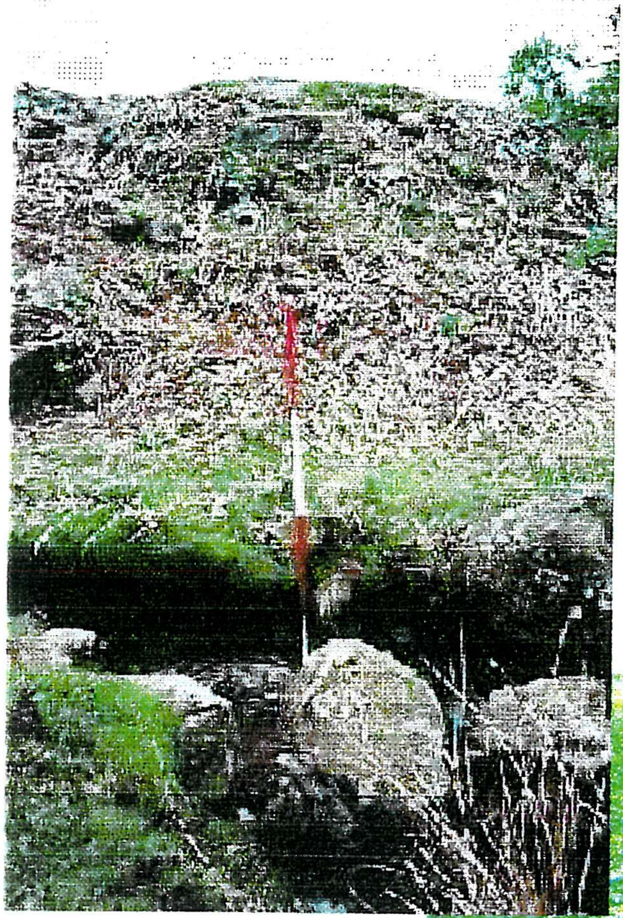
12. Site 123

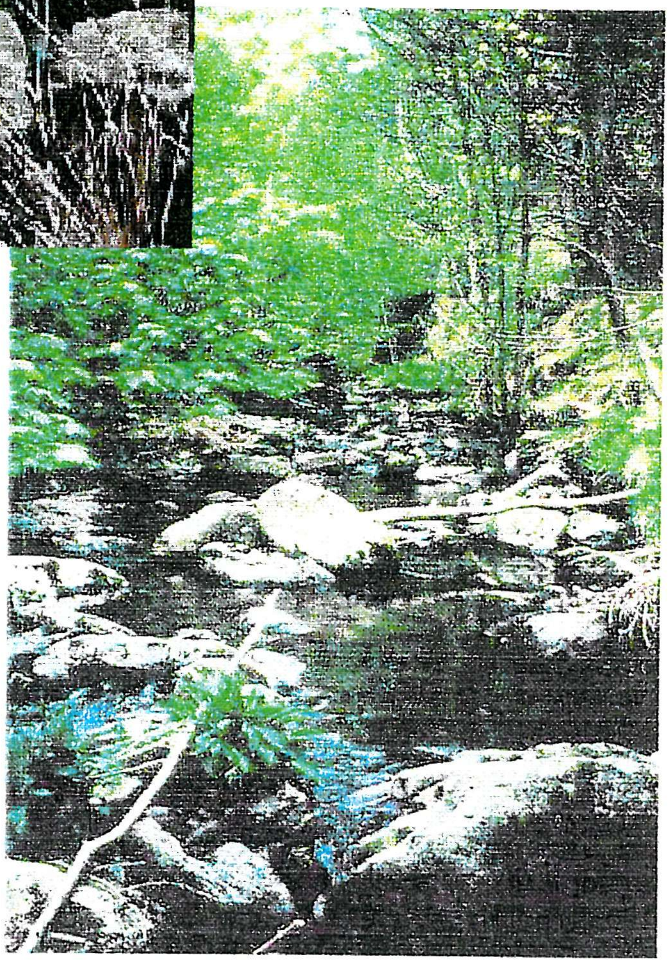


13. Site 140

14. Site 150 (a)



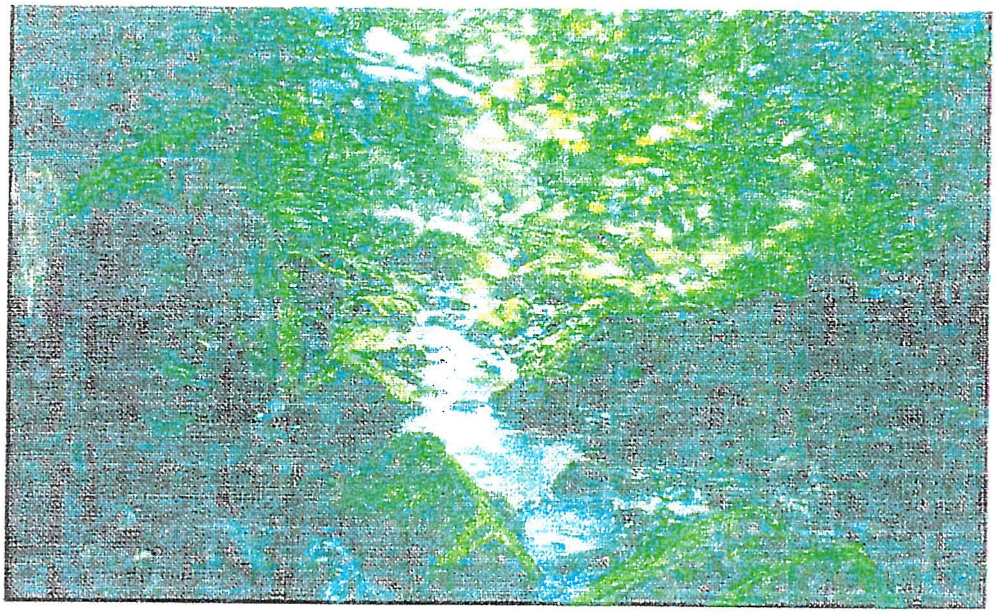




15. Site 150 (b) (above) and 16. Site 155

17. Site 159 (above) and 18. Site 169

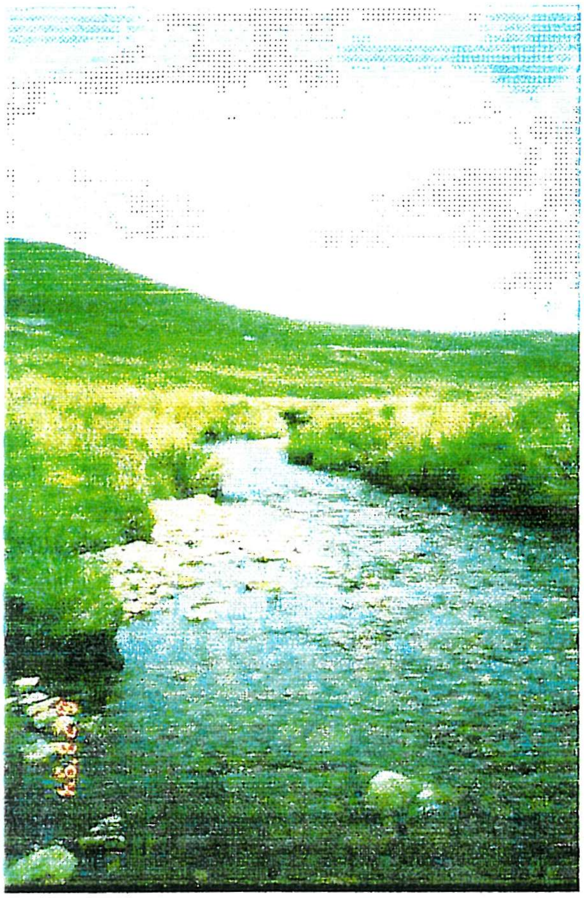
19. Site 215

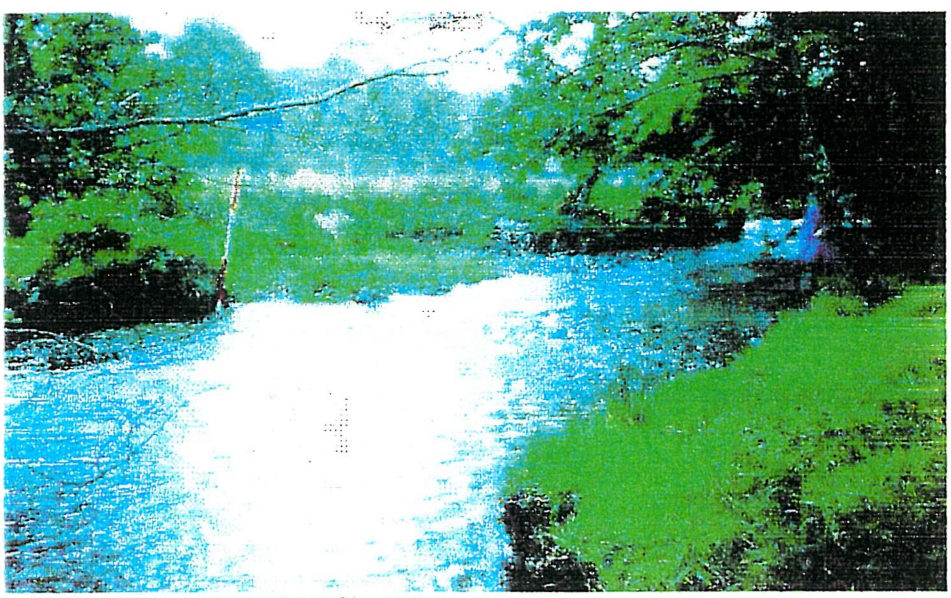


20. Site 506 (a)

21. Site 506 (b)

22. Site 506 (c)

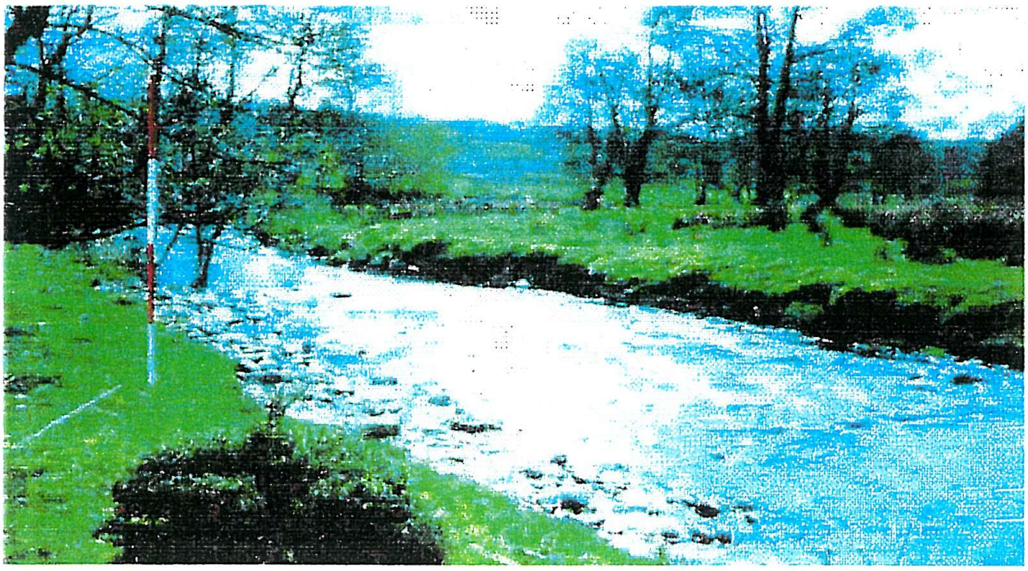


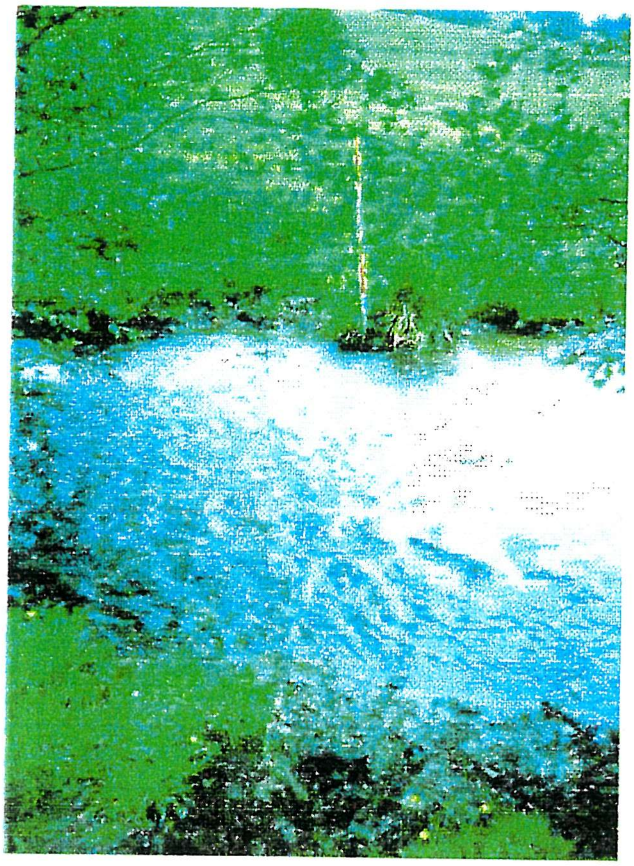


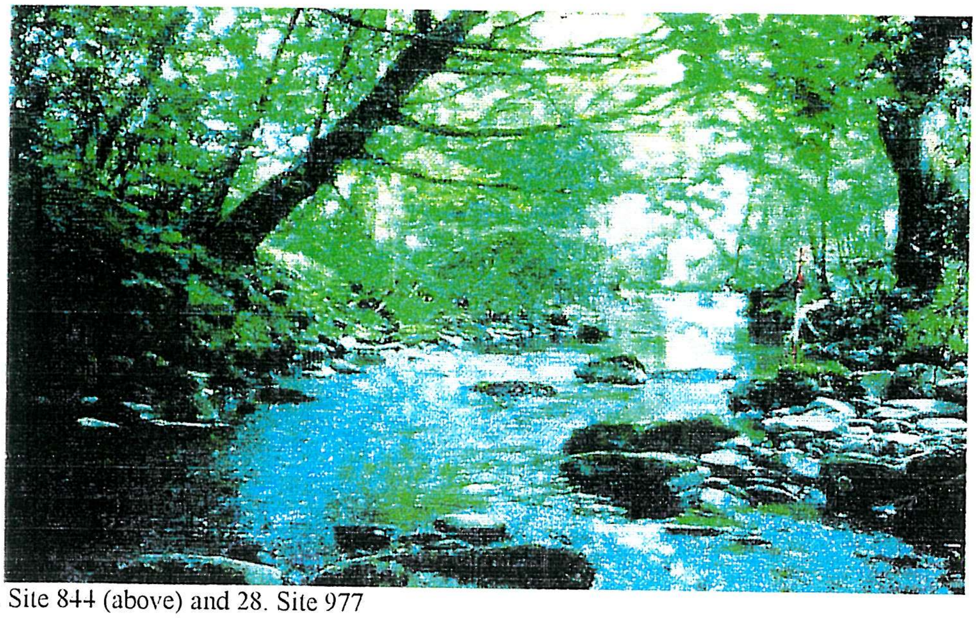
23. Site 797 (above) and 24. Site 800

25. Site 802

26. Site 841





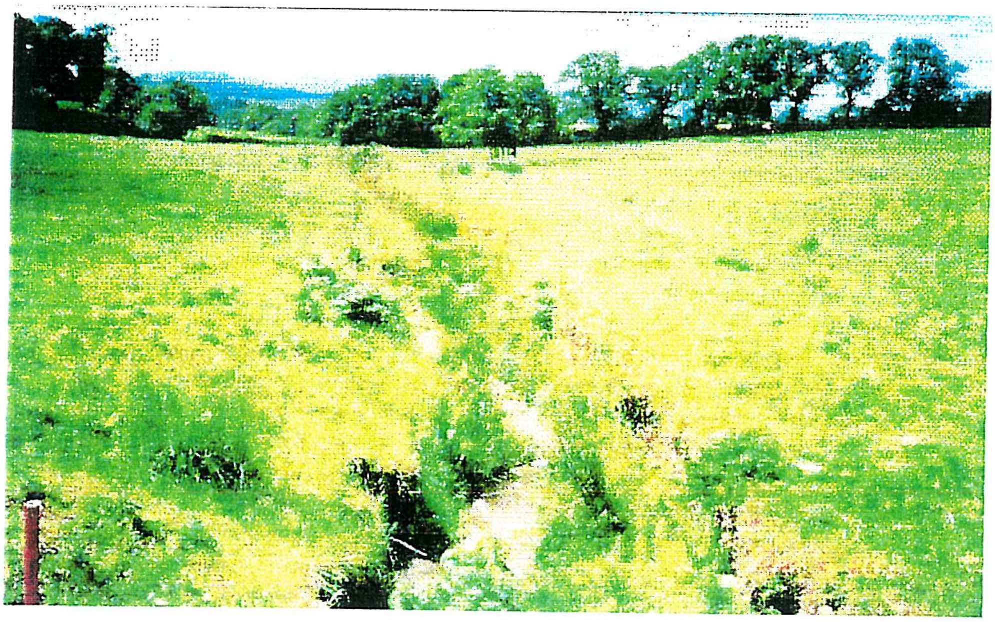


27. Site 844 (above) and 28. Site 977

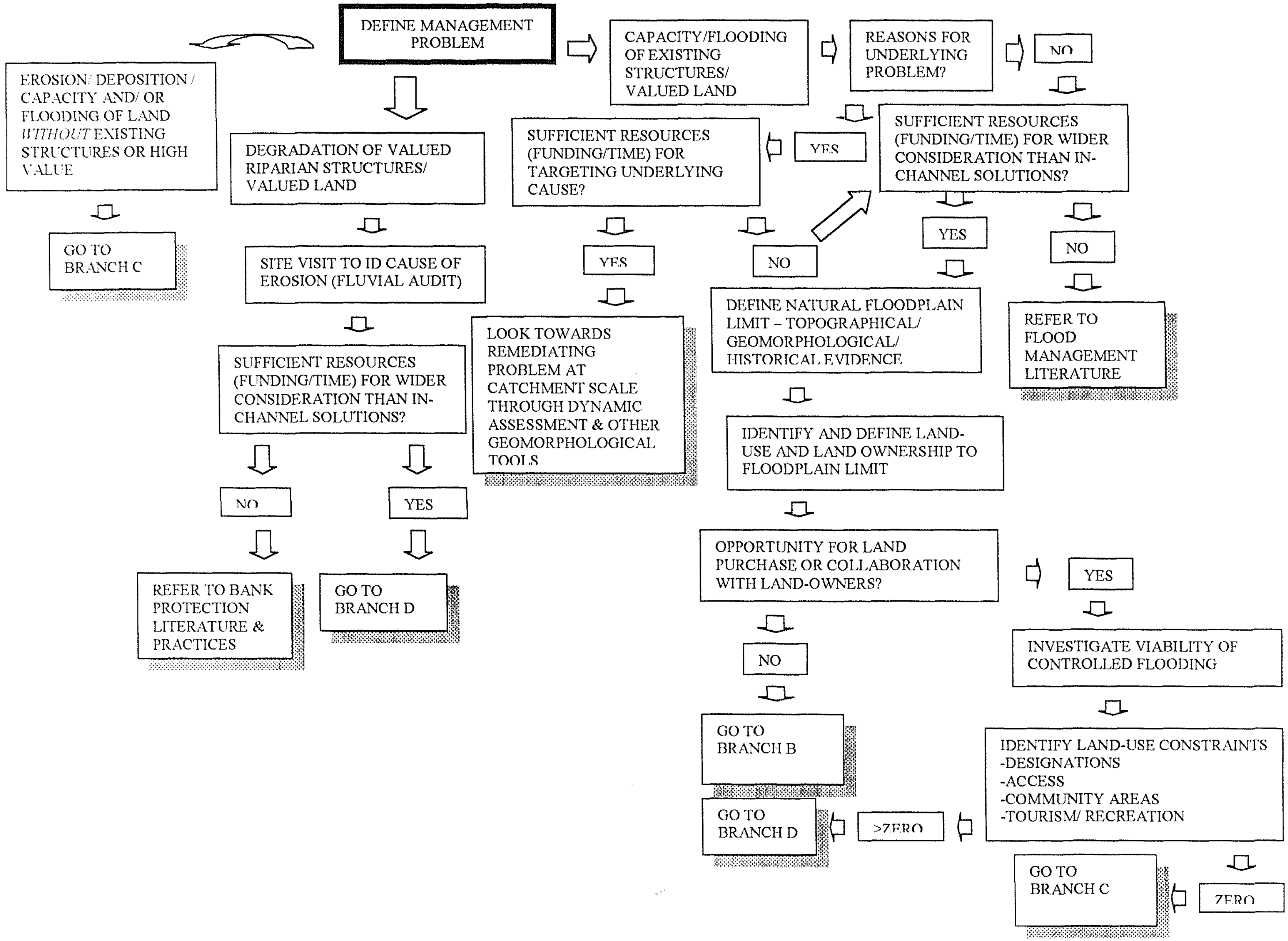
29. Site 1020

30. Site 1293 (a)

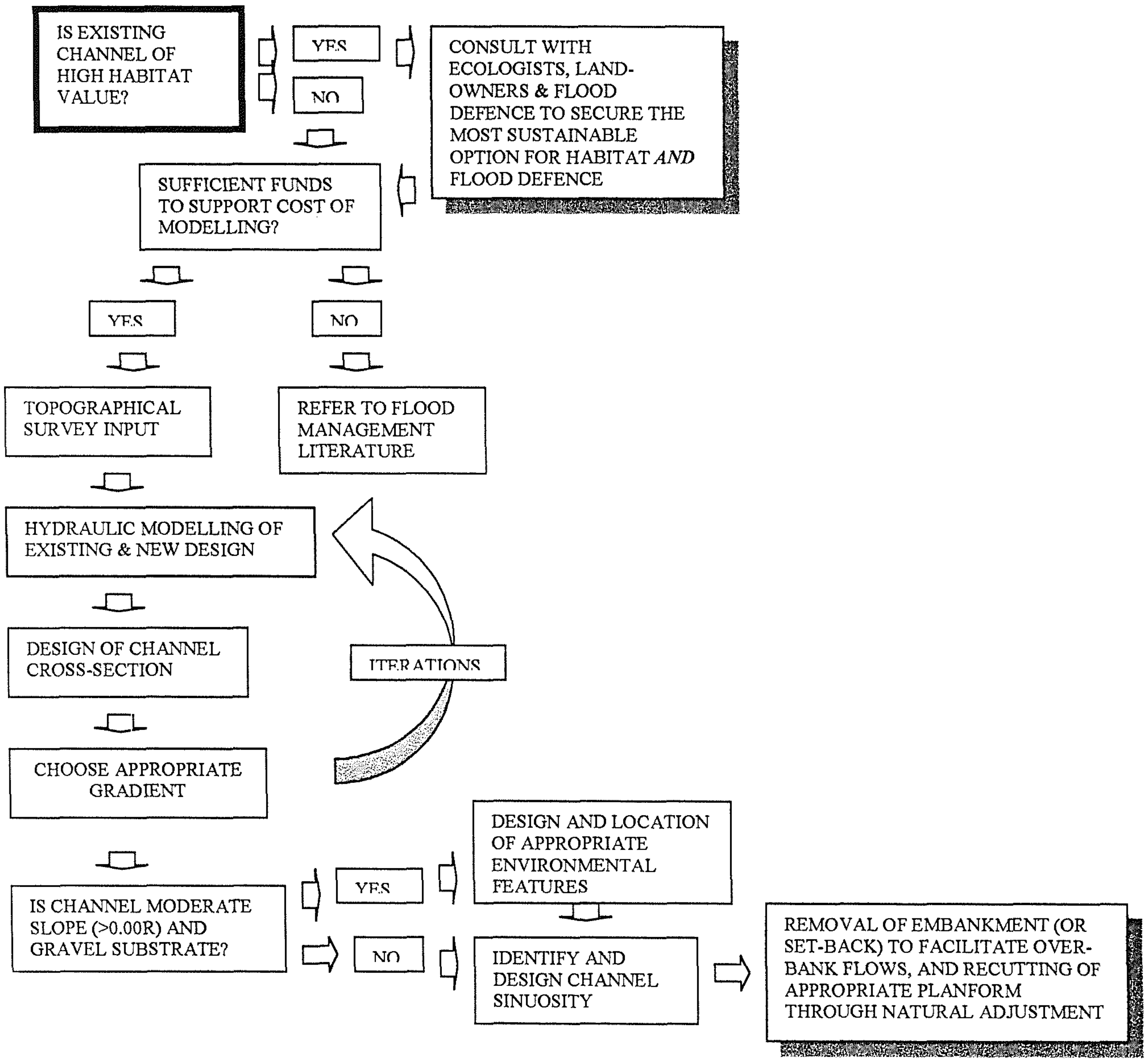
31. Site 1293 (b)



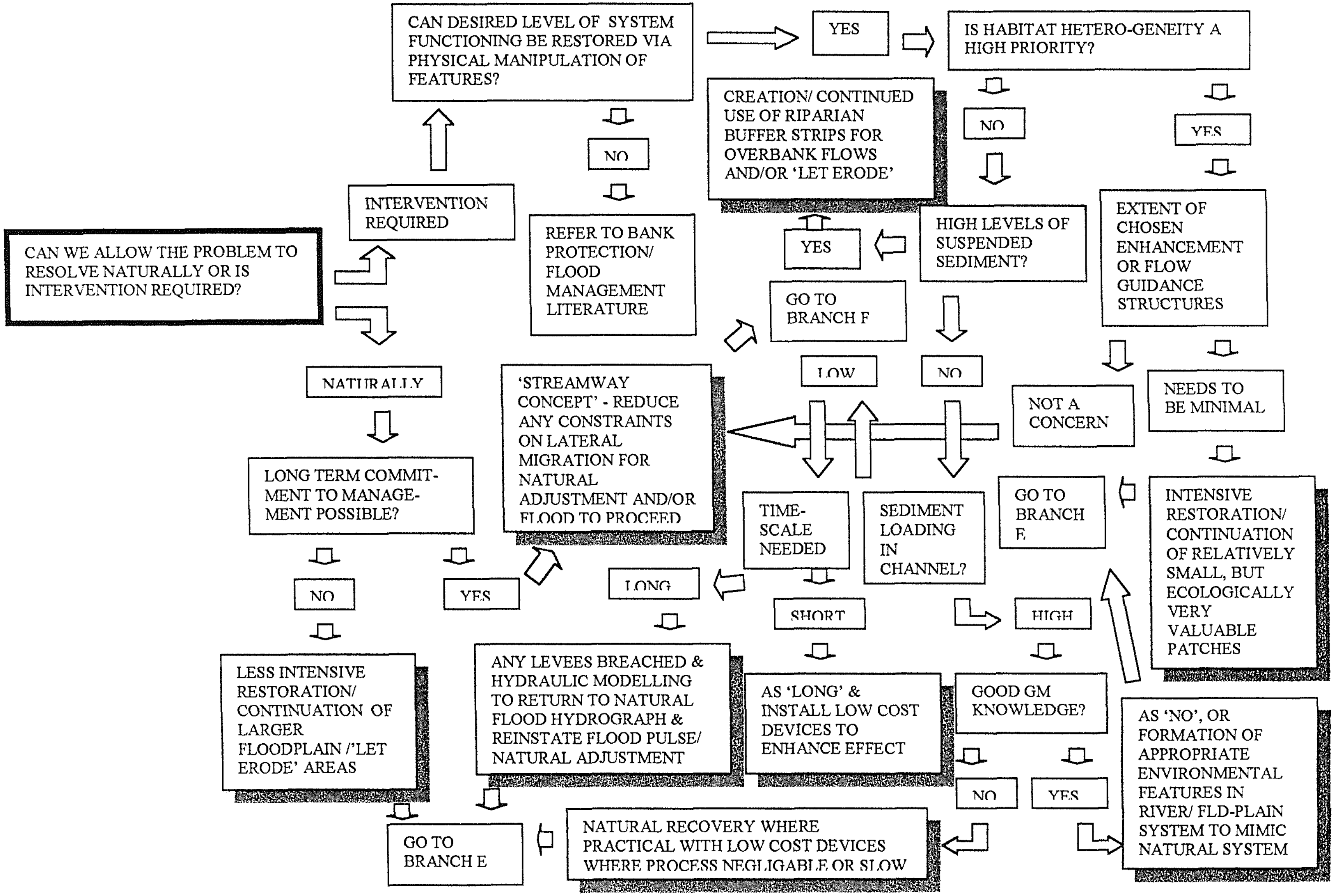
APPENDIX F – Decision trees for SURCoMES (Consultation.1) **BRANCH A:** ***Defining the Management Problem***



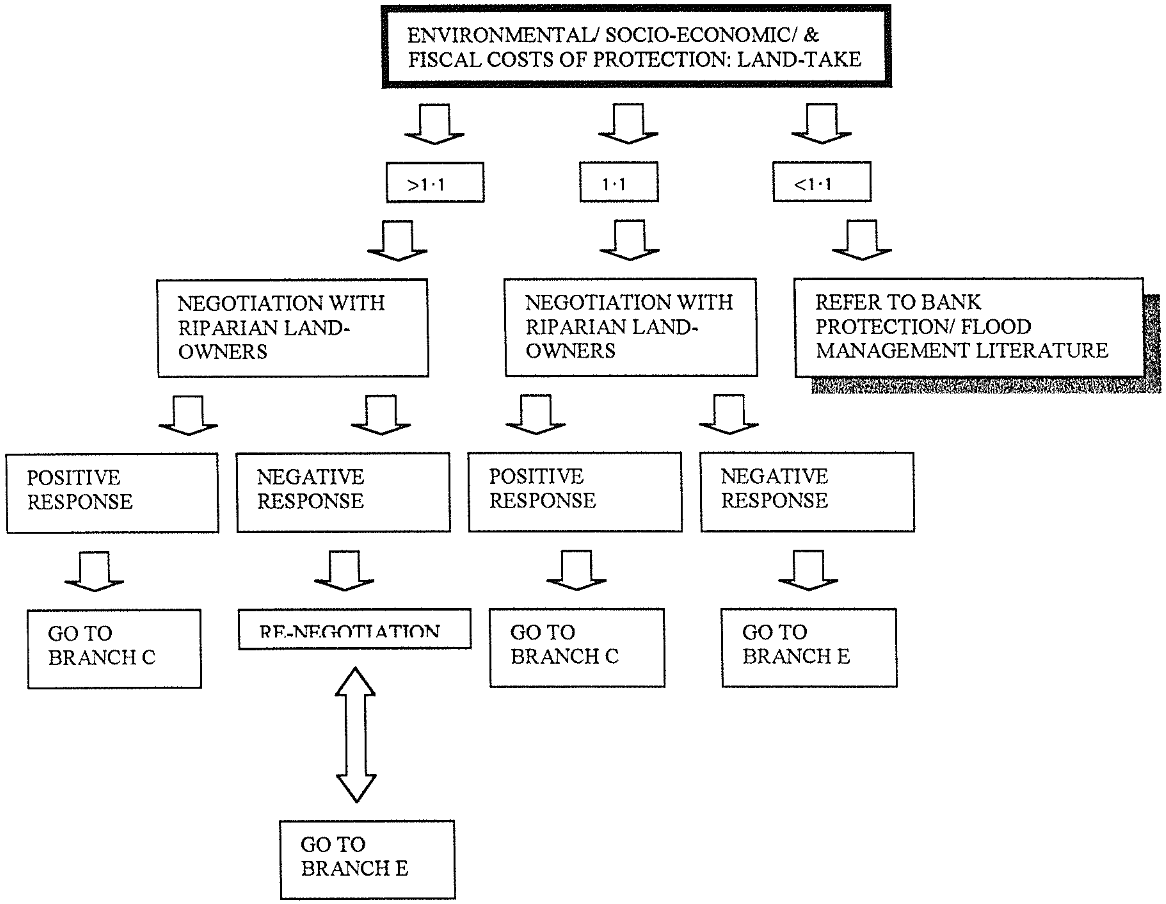
BRANCH B: ***Hydraulic Modelling for constructing a new channel***



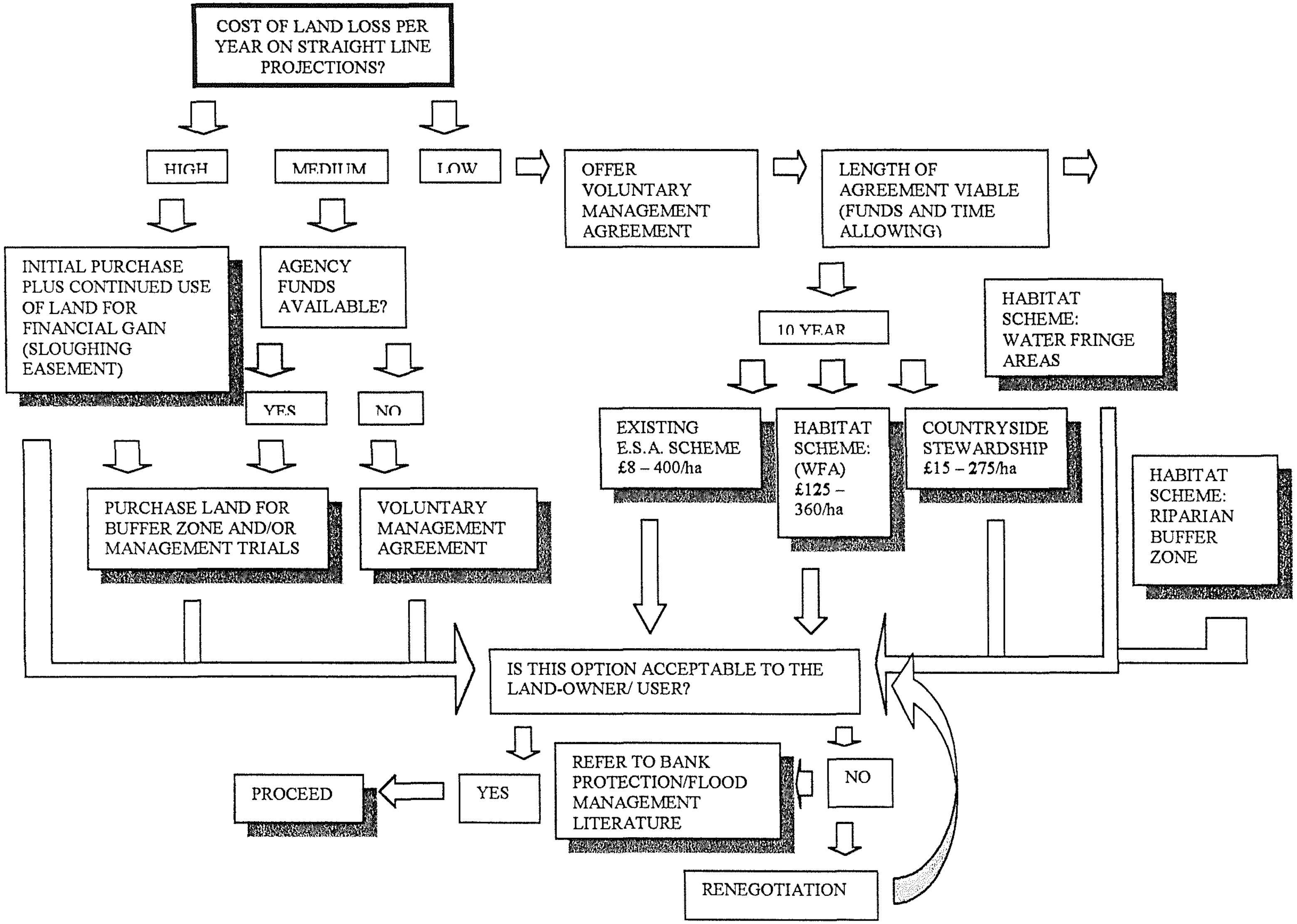
BRANCH C: ***Sustainable management options where minimal land-constraints***



BRANCH D: ***Evaluating the Cost: Benefit of Land Protection: Land-take***



BRANCH E: *Management Schemes and Incentives*



BRANCH F: ***Guidelines for Project Level Sustainable River Corridor Management***

PRELIMINARY MEETING WITH INTERESTED PARTIES IN LOCAL COMMUNITY VENUE

- IDENTIFY LOCAL ISSUES AND CONCERNS
- INCLUDE 'PUBLIC' COMPONENT

⇩

SHORT PRESENTATION / REPORT

⇩

RECONSULTATION

⇩

ESTABLISH STAKEHOLDER GROUP

⇩

ID OPPORTUNITIES FOR FUNDING AND PARTNERSHIP

⇩

DESK & FIELD STUDIES

⇩

PRACTICAL FIELD ACTIVITY

⇩

REGULAR MONITORING

⇩

S.R.M. PLAN

Sustainability Appraisal Matrix (SAM)

For the evaluation of Best Practice Projects in Upland Rural River Corridors of England and Wales

---

The following is a procedure to evaluate the successful implementation of Sustainable Development in Best Practice Projects in upland, rural river corridors in England and Wales.

This document is the outcome of a wider Research Project funded by the Environment Agency (through the National Centre for Risk Assessment and Options Appraisal) into developing better practice guidelines for implementing the Agency's principle aim towards sustainable development in river management.

Sustainable river corridor management implies longer-term, more holistic and imaginative solutions to management problems than has occurred in the past. This means a greater emphasis on **balancing** enhancement of the natural **environment** with the continuing need for maintenance of **economic** activity.

In practice, River Managers and other relevant parties need guidelines on how this can be achieved, and if the decisions taken are indeed the most sustainable options. The following checklist is designed to help provide a first level of support for these types of decisions.

The checklist is composed of 35 criteria which are considered important components for consideration in any best practice 'sustainable' river management project. Extensive consultations have taken place with Agency staff and Academics to ascertain the weightings or importance that should be attributed to these criteria for the most sustainable outcomes. It must be recognised that these weightings will undergo geographical and project specificity. Those included here are a generic guideline.

How to use the checklist

1. Tick those criteria which have been acknowledged at the planning stage of the project.
2. Sum all tick-boxes for each subject (e.g. 'Natural Environment'). Each subject sums to 100, therefore tick-boxes summed will be a percentage of the total.
3. Compare the total consideration (%) that is being given to each subject. Is there an imbalance in the totals?
4. Consider why certain criteria have ***not*** been acknowledged, and identify whether it would be feasible and appropriate to bring these into the project – refer to the importance that these criteria have been attributed with for inclusion in best practice project management.
5. Revisit the list throughout the project cycle to a) identify fulfilment of criteria; and, b) monitor progression towards criteria not originally acknowledged.

PARAMETERS CONSIDERED IN SUSTAINABLE BEST PRACTICE

1 Natural Environment (catchment scale geomorphology & biodiversity)	*Importance weighting*	*Sum of criteria acknowledged* =
Consideration of the opportunity for minimal intervention in the natural environment, prior to the following actions	10	
Consideration of upstream/downstream interactions and effects/impacts (e.g. increased power to downstream) over time-scales commensurate with processes	7	
Consideration of variety of geomorphological factors: • Management of channel stability and instability (e.g. patterns of erosion/deposition and the sustainability of treating individual points of occurrence) • Maintaining flood and sediment conductance (e.g. channel narrowing/engineering causing less capacity to transmit flood-waters) • Manipulation of riverine features, processes and drivers (e.g. replacing lost riffles and pools in appropriate places; imitating natural flow deflectors and reinstating sediments) (Seek guidance from Geomorphologists) • Intervening in the channel mass and energy budget (e.g. increasing channel roughness to slow flow velocity and therefore potential energy for erosion; inserting flow deflectors rather than constructing walls on bank-side)	27	
Good geomorphology as a key foundation of good habitat (e.g. if we reinstate natural features like pool and riffle sequences, then habitat will naturally improve for fish spawning)	21	
Aesthetics/ landscape (e.g. Riverscape Assessment, NRA, 1993)	10	
Consideration of Biodiversity Action Plans and related initiatives	25	

2 ***Economic Environment***	*Importance weighting*	*Sum of criteria acknowledged*
Co-ordinated management of the riverine system encouraged where possible (e.g. consultation with river-bank owners along lengths of channel beyond the individual land-owner's territory)	14	
'Precautionary principle' adopted where uncertainty or potentially serious risks exist	10	
Market mechanisms considered as a tool for discouraging new development in areas prone to flooding/land loss?	9	
Long term perspective taken where possible	14	
Cost implications internalised to the people responsible wherever possible (e.g. polluter pays principle)	8	
C.B.A. or another appropriate valuation tool utilised for the measure of benefits and damage to the environment associated with the proposal	10	
Identify opportunity in funding/ compensation • Identify if project area qualifies for EC Structural funding (e.g. Objective 5b) • Identify if site is a 'Rural Development Area' (as defined by the Rural Development Commission) • Identify farming subsidies/grants already present in riparian area (e.g. Countryside Stewardship, Set-aside, Environmentally Sensitive Areas (E.S.A. s), the Habitat Scheme, Water Fringe areas, National Park authorities, landscape conservation grants) • Identify opportunities for diversification of farming interests (e.g. tourism/ environment)	35	

3 Social Environment		*Importance weighting*	*Sum of criteria acknowledged* =
Level of consultation:			
Number of levels of public participation followed (planning and implementation stages of project)	1) Information provision (e.g. leaflets, brochures)	6	
	2) Consultation (e.g. surveys, meetings)	14	
	3) Public and Practitioner Deciding together (e.g. workshops, planning for real strategic choice)	14	
	4) Public and Practitioner Acting together (e.g. partnership bodies)	5	
	5) Supporting (e.g. advice, support funding)	5	
Variety of awareness raising and education methods used to promote the sustainability message from Agency to public		7	
Variety of awareness raising and education methods used to promote sustainability message within the Agency		4	
Stages of consultation:			
Consensus building at Project Identification stage including, general public; community leaders; local interest groups, N.G.O. s, Government		6	
Participation at Project Preparation stage, including local committee; affected people e.g. riparian (river-bank) landowners; local Government, N.G.O. s; money lenders; working group		7	
Participation at Project Implementation stage, including river-bank landowners; schools and local societies; working group; students; local co-ordination committee; N.G.O. s		7	
Consultee/ Stakeholder Group composition:			
Regulatory and Government Agency (national and local)		5	
N.G.O. s		5	
Industry and Commerce		5	
Local interest organisations/ community groups/ Individual members of public, preferably through Local Environment Group (LEG)		6	
Public's representatives (e.g. Parish Council)		4	

4 The Project cycle	*Importance weighting*	*Sum of criteria acknowledged* =
Project identification		
• Identifying local issues and concerns • Consulting on possible solutions and sustainable management • Identifying possible working group/s (i.e. partnership/s)	17	
Project preparation (baseline data)		
Physical: • Defining natural floodplain limit • Completing a Fluvial audit/ DCBS/ Hydraulic modelling/ Dynamic Assessment • Standards met (e.g. flood defence Standard of Service)	16	
Biological: • Completing River Habitat Survey/ River Corridor Survey • Where land constraints limited, restoration considered	16	
Land Use: • Identification of present land use practices/soil conservation and future opportunities • Identification of MAFF land use bands • Identification of land acquisition opportunities • Identification of funding opportunities • Identification of time-scale opportunities	15	
Recreation/Community: • Identification of access routes • Identification of tourism and recreation areas which may effect certain management decisions • Identification of designations which may effect certain management decisions • Identification of areas valued by the community	12	
Project implementation		
• Definition of tasks and responsibilities • Consensus built up through a number of consultations • Getting locals involved in monitoring etc. (e.g. schools) • Getting local riparian (river-bank) land-owners involved, especially in decision making and monitoring • Cost: benefit of bank protection to managed land-take calculated if relevant to project • Where bank protection required, softer bio-engineering techniques considered	13	

Project evaluation/ monitoring and public accountability		
Consultation on what <u>all</u> stakeholders think of outcomes, problems... (i.e. full participation) • Consideration of remedial measures that could be introduced if problems occur • Considering the possibility of using this project as a reference point for others, once there are lessons to be learnt from • Perception studies of environmental change -degradation & improvement	11	

398 Gyrach Eryi, lleyn SH742758

On the basis of the information you have provided, this river system exhibits the following relative measures of stability. These are the component parts of the system **sustainability**.

They must not be seen as anything more than an aid for the user to understand the interaction of the individual elements leading to "more" or "less" sustainable states relative to:

a) rivers or reaches within the same proximity on RHS 3.1 Context Analysis (see RHS, 1998); or,
b) the effects that various management options may have on present status.

Bank stability status — LESS … MORE STABLE

Bed stability status — LESS … MORE STABLE

Present Geomorphological stability — LESS … MORE STABLE

Propensity to change — LESS … MORE LIKELY TO CHANGE

Socio-economic status — LESS … MORE VALUABLE

Left Bank

Right Bank

Habitat Quality relative to other rivers of the same 'type'

V. POOR … V. HIGH

Present Management Need

Present geomorphogicalcal status of this reach is *moderate*. Balanced against this, present socio-economic status is *low* with a MAFF Land Use Band of *E* on the left bank, and a MAFF Land Use Band of *E* on the right bank. The socio-economic status of this reach is effected by the presence of: *landscape designations;*

The Habitat Quality of this reach is *High*

Based upon this balance between the present physical stability and the present land value of this reach, the present management need is suggested to be: ***very low***

This value may reflect the need to either a) manage a site due to its high natural environment value, or b) manage a site due to its high socio-economic value.

Future Management Need

Future channel change on this reach is likely to be *less extreme*. Within the context of the present stability of this reach being very low it is probable that ***eventually, less intervention*** will be needed into the longer-term (>10 years). This illustrated on the following sliding scale.

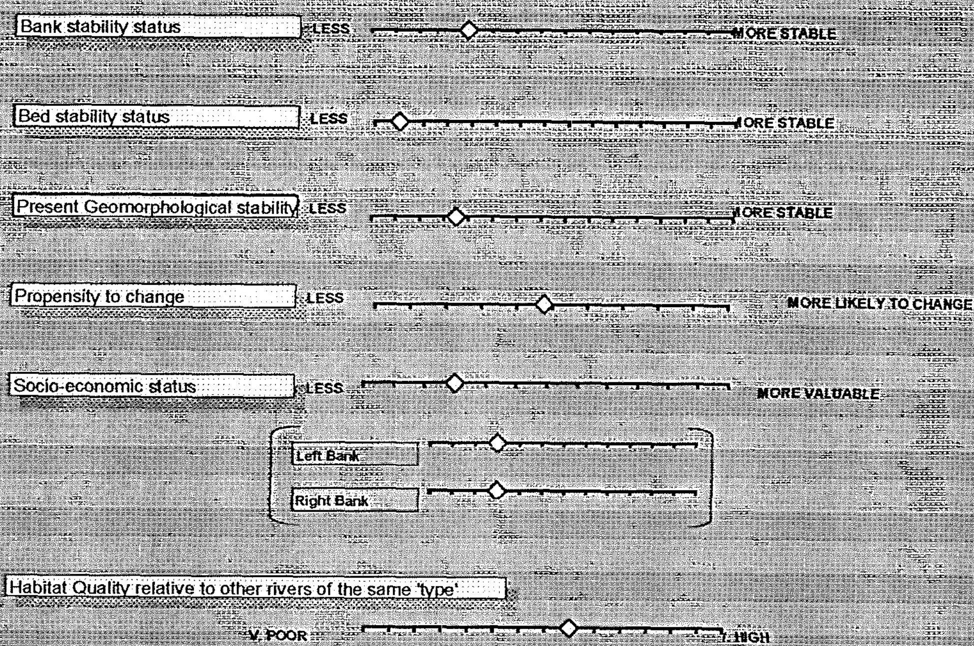
Less intervention … **more intervention**
to intervene
moderate degree of

681 Garno Severn uplands SN974961

On the basis of the information you have provided, this river system exhibits the following relative measures of stability. These are the component parts of the system sustainability.

They must not be seen as anything more than an aid for the user to understand the interaction of the individual elements leading to "more" or "less" sustainable states relative to:

a) rivers or reaches within the same proximity on RHS 3.1 Context Analysis (see RHS, 1998); or,
b) the effects that various management options may have on present status.



Present Management Need

Present geomorphogicalcal status of this reach is *low*. Balanced against this, present socio-economic status is *moderate* with a MAFF Land Use Band of *E* on the left bank, and a MAFF Land Use Band of *E* on the right bank. The socio-economic status of this reach is effected by the presence of:

miscellaneous designations

access routes/ public rights of way

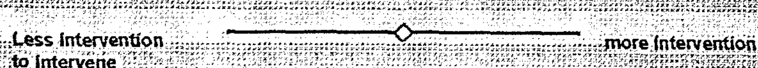
The Habitat Quality of this reach is *Fair*

Based upon this balance between the present physical stability and the present land value of this reach, the present management need is suggested to be: *moderate*

This value may reflect the need to either a) manage a site due to its high natural environment value, or b) manage a site due to its high socio-economic value.

Future Management Need

Future channel change on this reach is likely to be *moderately extreme*. Within the context of the *present stability of this reach being moderate* it is probable that ***a moderate degree of intervention*** will be needed into the longer-term (>10 years). This is illustrated on the following sliding scale.



moderate degree of

797 Glasffrwd Teifi valley SN754660

On the basis of the information you have provided, this river system exhibits the following *relative measures of stability. These are the component parts of the system sustainability.*

They must not be seen as anything more than an aid for the user to understand the interaction of the individual elements leading to "more" or "less" sustainable states relative to:

a) rivers or reaches within the same proximity on RHS 3.1 Context Analysis (see RHS, 1998), or,
b) the effects that various management options may have on present status.

Bank stability status — LESS … MORE STABLE

Bed stability status — LESS … MORE STABLE

Present Geomorphological stability — LESS … MORE STABLE

Propensity to change — LESS … MORE LIKELY TO CHANGE

Socio-economic status — LESS … MORE VALUABLE

Left Bank

Right Bank

Habitat Quality relative to other rivers of the same 'type'

V. POOR … V. HIGH

Present Management Need

Present geomorphogicalcal status of this reach is *low*. Balanced against this, present socio-economic status is *moderate* with a MAFF Land Use Band of *E* on the left bank, and a MAFF Land Use Band of *E* on the right bank. The socio-economic status of this reach is effected by the presence of:

heritage conservation designations;
wildlife designations;

miscellaneous designations;

The Habitat Quality of this reach is *Fair*

Based upon this balance between the present physical stability and the present land value of this reach, the present management need is suggested to be: ***high***

This value may reflect the need to either a) manage a site due to its high natural environment value, or b) manage a site due to its high socio-economic value.

Future Management Need

Future channel change on this reach is likely to be moderately extreme. Within the context of the present stability of this reach being high it is probable that ***a moderate degree of intervention*** will be needed into the longer-term (>10 years). This is illustrated on the following sliding scale.

Less Intervention to Intervene … **more Intervention**

moderate degree of

On the basis of the information you have provided, this river system exhibits the following *relative measures of stability. These are the component parts of the system sustainability.*

They must not be seen as anything more than an aid for the user to understand the interaction of the individual elements leading to "more" or "less" sustainable states relative to:

a) *rivers or reaches within the same proximity on RHS 3.1 Context Analysis (see RHS, 1998); or,*
b) the effects that various management options may have on present status.

Bank stability status LESS — MORE STABLE

Bed stability status LESS — MORE STABLE

Present Geomorphological stability LESS — MORE STABLE

Propensity to change LESS — MORE LIKELY TO CHANGE

Socio-economic status LESS — MORE VALUABLE

Left Bank

Right Bank

Habitat Quality relative to other rivers of the same 'type'

V. POOR — V. HIGH

Present Management Need

Present geomorphogicalcal status of this reach is *moderate* Balanced against this, present socio-economic status is *moderate* with a MAFF Land Use Band of *E* on the left bank, and a MAFF Land Use Band of *E* on the right bank. The socio-economic status of this reach is effected by the presence of:

landscape designations;
miscellaneous designations;

The Habitat Quality of this reach is *Fair/High*

Based upon this balance between the present physical stability and the present land value of this reach, *the present management need is suggested to be: very low*

This value may reflect the need to either a) manage a site due to its high natural environment value, or b) manage a site due to its high socio-economic value.

Future Management Need

Future channel change on this reach is likely to be less extreme. Within the context of the present stability of this reach being very low it is probable that **eventually, less intervention** will be needed into the longer-term (>10 years). This is illustrated on the following sliding scale.

Less intervention to intervene — **more intervention**

moderate degree of

1020 Llia Neath, Port talbot and bridgend SN934147

On the basis of the information you have provided, this river system exhibits the following relative measures of stability. These are the component parts of the system sustainability.

They must not be seen as anything more than an aid for the user to understand the interaction of the individual elements leading to "more" or "less" sustainable states relative to:

a) rivers or reaches within the same proximity on RHS 3.1 Context Analysis (see RHS, 1998); or,
b) the effects that various management options may have on present status.

Bank stability status LESS MORE STABLE

Bed stability status LESS MORE STABLE

Present Geomorphological stability LESS MORE STABLE

Propensity to change LESS MORE LIKELY TO CHANGE

Socio-economic status LESS MORE VALUABLE

Left Bank

Right Bank

Habitat Quality relative to other rivers of the same 'type'

V. POOR HIGH

Present Management Need

Present geomorphogicalcal status of this reach is *moderate*. Balanced against this, present socio-economic status is *moderate* with a MAFF Land Use Band of *E* on the left bank, and a MAFF Land Use Band of *E* on the right bank. The socio-economic status of this reach is effected by the presence of:

wildlife designations;

miscellaneous designations;

The Habitat Quality of this reach is *Fair*

Based upon this balance between the present physical stability and the present land value of this reach, the present management need is suggested to be: ***moderate***

This value may reflect the need to either a) manage a site due to its high natural environment value, or b) manage a site due to its high socio-economic value.

Future Management Need

Future channel change on this reach is likely to be *moderately extreme*. Within the context of the present stability of this reach being moderate it is probable that ***a moderate degree of intervention*** will be needed into the longer-term (>10 years). This is illustrated on the following sliding scale.

Less intervention to intervene **more intervention**

moderate degree of