W_{ot}	channel width at the overtopping level (m or ft)
A_{ot}	channel cross-sectional area at the overtopping level (m^2 or ft^2)
P	wetted perimeter ($P \sim W$ for large channels (m or ft)
R	hydraulic radius ($R \sim D$ for large channels) (m or ft)
S	channel slope
S_v	valley axis slope
RW	mean waterline width, riffles (m or ft)
RD	mean flow depth, riffles (m or ft)
RD_m	maximum flow depth, riffles (m or ft)
Z	meander arc length (m or ft)
p	channel sinuosity
F_L	Lacey's silt factor
F_b	channel bed factor defined as V^2/D ($F_b = 0.58\ D_{50}^{0.50}$)
F_s	channel side factor defined as V^3/W
x	kinematic viscosity of fluid ($cm^2\ s^{-1}$)
g	acceleration due to gravity
V_o	Kennedy's non-silting velocity ($m\ s^{-1}$ or $ft\ s^{-1}$)
V	flow velocity ($m\ s^{-1}$ or $ft\ s^{-1}$)
D_{50}	particle size of bed material, intermediate axis, such that 50% are finer
D_{65}	particle size of bed material, intermediate asix, such that 65% are finer
D_{84}	particle size of bed material, intermediate axis, such that 84% are finer
D_{90}	particle size of bed material, intermediate axis, such that 90% are finer
D_{50t}	particle size of bed material defined by the length of the minor axis such that 50% respectively of the particles by number are smaller
Veg I	grassy banks with no trees or shrubs
Veg II	1–5% tree/shrub cover
Veg III	5–50% tree/shrub cover
Veg IV	> 50% shrub cover or incised into floodplain
R^2	coefficient of determination
n	number of gauging station sites employed in the development of the channel geometry equations
ASPRAT	Aspect ratio (*DMAX*/*R*) [where *DMAX* is maximum depth (m) and *R* is the hydraulic radius measured at the bankfull level]
SLOPE	bankfull channel slope
DMEAN	mean diameter of bed sediment (mm)

16 River Channel Classification for Channel Management Purposes

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INTRODUCTION

The desire of geomorphologists to classify river channels can be explained as a means of reducing an extremely complex environmental feature into a series of discrete units which facilitate further study or help organise management operations. Classifications provide a weak form of explanation because all schemes involve a set of criteria which relate to an *a priori* expectation of the way in which researchers believe their river channels to be distinguished. As the criteria for any one classification scheme are unlikely to be generally applicable for numerous uses, designs for classification tend to be specific to the intended *purpose* of that scheme, and this is one of a series of fundamental attributes of classification outlined by Grigg (1967), and summarised by Mosley (1987). Within fluvial geomorphology, the majority of river classifications have concerned natural river channel patterns, sub-dividing according to distinct morphological characteristics. These characteristics may indicate discrete physical processes for the particular channel category, thus facilitating an explanation of the resulting morphology. Since the middle of the 20th century, classification schemes, starting with Horton's (1945) ordering of river networks, and Leopold and Wolman's (1957) division of streams into 'straight', 'meandering' and 'braided' on the basis of their sinuosity, have become progressively more complex, utilising increasing numbers of criteria, involving multiple levels of study and resulting in greater numbers of class divisions. For instance, a recent scheme by Alabyan (1992) incorporates a hierarchy of structural, planform, and limiting conditions within which each of several channel types can exist. Recent reviews of geomorphologically-based natural river classifications include those by Church (1992), who discusses classification according to channel size, and Mosley (1987) who stresses the overlap between geomorphological and ecological classifications. Mosley (1987) also notes the interest in schemes of river *characterisation* rather than *classification*, stemming from the interest in the river continuum concept (Vannote *et al.*, 1980) and the transitional nature of morphological change in river channels (e.g. Ferguson, 1987). River classifications involve a sequential subdivision according to designated criteria whereas characterisations concurrently use multiple criteria which allow the formation of statistically distinct groupings. Growth in the number of hierarchical river classification schemes, especially those with an ecological basis or purpose, are reviewed in Naiman *et al.* (1992).

Changing River Channels. Edited by Angela Gurnell and Geoffrey Petts.

Now that the legislation associated with river channel management in many countries has become more environmentally aligned, the desirability of retaining or recreating natural river features has permitted fluvial geomorphology to become integrated more fully into river channel management. With this integration has been an increase in geomorphological river classifications which are designed for, or have application to, river channel management. This may be because, as Rosgen (1994, p. 195) suggests,

> Rivers are complex natural systems. A necessary and critical task towards the understanding of these complex systems is to continue the river systems research. In the interim, water resource managers must often make decisions and timely predictions without the luxury of a complete and thorough data base. Therefore, a goal for researchers and managers is to properly integrate what has been learned about rivers into a management decision process that can effectively utilize such knowledge.

Clearly, river classifications are appropriate tools in this context, as they can be designed according to the level of available knowledge or data, allowing managers to act upon summaries of this information, and then be readily re-iterated as understanding improves.

RIVER CHANNEL MANAGEMENT CLASSIFICATIONS

The distinguishing feature of river channel classifications applied to management purposes is an emphasis on the processes which have created and act to maintain the channel, rather than on the river morphology. Thus, in opposition to Cowardin's (1982) assertion that classifications simply label objects without producing any information, it is the express purpose of applied schemes to inform river management decisions, for instance, to guide engineering designs or to assess the river's conservation value. Management applications not only explain the pre-eminence of process inference in the classification, but help to delimit a restricted range of temporal and spatial scales over which schemes normally operate. Classification schemes of natural river morphology have to reconcile interconnectivity of catchment-scale structural controls, reach-level channel pattern differences and micro-scale variations in channel bedforms, each of which varies over different time periods (see Frissell *et al.*, 1986; Naiman *et al.*, 1992) and it is these challenges which have led to interest in hierarchical classification schemes. Conversely, applied geomorphological classifications have tended to adopt both a meso-scale spatial outlook (i.e. a 'reach' level in the approximate range of 10^1–10^3 metres) with a meso-scale temporal concern (changes over the 10^0–10^2 year period) as a consequence of the link with practical management concerns and with civil engineering. Some channel management classifications have therefore developed as a particular level of a hierarchical classification scheme (see below). These spatial and temporal restrictions should not, however, be regarded as making channel management classification simple. Frissell *et al.* (1986) note that, of the five spatial hierarchies in their classification scheme, 'reach' systems can be the least physically discrete and, as reaches can display an inter-dependency of process and form, an understanding of both features is necessary for a successful classification. Furthermore, the potential influence of catchment characteristics (including human influences) and position in the river network means that reaches may appear to exhibit an homogeneity over two orders of magnitude between 10^1 and 10^3 metres in length (cf. example by Downs below). Therefore, it can be difficult for a surveyor to retain scale-independency when delimiting appreciable differences between reaches. However, because applied classification schemes tend to focus upon 'disturbed' (previously altered) rivers rather than on natural ones, the problem of delimiting boundaries between reaches is, in some cases, simplified from natural river classifications in which the geomorphologically progressive change in river channel characteristics inhibits recognition of homogeneous river reaches. This is because piecemeal channelisation works along with land use pressures which result in construction at or near to the channel edge help to segment the channel network.

Although they are designed for relatively restricted spatial and temporal interpretation, river channel management classification schemes show a wide variety of forms. This chapter illustrates a number of these differences. For instance, a major distinction may be drawn between schemes which proceed on the basis of existing features (morphological), in which information about current processes is inferred at a later stage, and methods which explicitly distinguish active processes from facets of the existing morphology and thus classify on the basis of river channel adjustment. Also, some schemes are designed to provide information about the river channel conservation value (whereby differences are noted between the morphology of the existing river channel and the morphology of the channel which would exist naturally without human disturbances), whereas others more directly serve the requirements for a channel management authority. In the section focusing on classification of adjustment processes, a further division is suggested between procedures for classifying prevailing changes which, in the absence of changes in controlling factors, may be expected to continue in the short-term (perhaps 10^1 years depending on the dynamism of the system), from those which focus on the sequence of change. Classifications of sequential alterations often use location-for-time methods in which empirical evidence of spatial segregations in adjustment processes are used to infer a relative temporal sequence of adjustment; lack of knowledge concerning time periods of geomorphological adjustment precludes a more exact sequencing. Finally, attention is turned to the way in which a management-style classification can be used to increase geomorphological understanding of river channel adjustments. This is achieved by transforming the classification into a characterisation scheme which indicates the sensitivity of the river channels to adjustment. Understanding the sensitivity of river channels potentially provides an extremely appropriate tool by which to design environmentally sympathetic river channel management options.

CLASSIFICATION OF EXISTING FEATURES

Channel management classification methods based on the existing channel morphology are a natural progression from geomorphological attempts to typify natural rivers. Two examples are given below: the first obtains management information directly from a classification based on natural features, and the second collates an inventory of natural features which are used to score the environmental value of the channel and thus indicate, for example, its susceptibility to degradation by channel management procedures.

As a consequence of natural stream channels being governed by catchment characteristics which vary over a wide variety of spatial and temporal scales (see Frissell *et al.*, 1986), natural channel classifications are increasingly utilising a hierarchical approach. The scheme developed by Rosgen (1985, 1994) identifies four inventory levels ranging from a broad morphological classification (level I) to monitoring (IV). In between these are 'morphological description' (II) and 'stream state or condition' (III). The level of morphological description exists to subdivide stream channels into homogeneous reaches based upon reference to values derived from five delineative criteria. The criteria consist of an entrenchment ratio to describe the relationship between the river and its valley, the width: depth ratio to summarise channel shape, the degree of meandering through measurement of sinuosity, in-channel particle size analysis as an indication of sediment transport processes, and water surface slope as a summary of 'sediment, hydraulic and biological function' (Rosgen, 1994). Figure 16.1 provides the bounding value ranges for each criteria, derived from empirical investigations on 418 rivers, and the resulting designation of 41 stream types. Channel management applications are based upon the assumption that rivers within each type class react similarly to particular human disturbances. Therefore, case studies can be used to determine the potential response behaviour of numerous other, similar, rivers. Rosgen uses this logic to develop guidelines for installing fish habitat improvement structures which are physically suited to their river environment. In conjunction with temporal series of aerial photographs, the classification can also provide the basis for specifying channel evolution sequences occurring in response to changes in their controlling variables. Management interpretations of sensitivity to disturbance, recovery potential, sediment supply, bank erosion potential, the influence of vegetation on bank stability and river restoration techniques can be also defined according to stream type.

Rosgen's scheme provides a management tool that could be adapted for use in many areas of the world. However, the scheme has been in development since 1973 and makes heavy demands on empirical data. In many cases of channel management application, information is required rapidly, often from one site visit. In response to such a requirement, the Thames Region of the UK's National Rivers Authority have developed a system for classifying river channel susceptibility to disturbance (NRA, 1990). The site visit utilises a reconnaissance evaluation scheme to help score the environmental condition of a stream in comparison with an ideal 'natural' channel; land use pressures within the Thames catchment mean that very few streams are likely to comply with this ideal. Table 16.1 summarises the resulting six-fold classification which ranges from almost natural channels which are highly susceptible to disturbance to culverted reaches with no geomorphological value. Channel reaches delimited by this scheme are entered into a Geographical Information System to provide background information for judging development proposals requiring NRA consent and to help the NRA plan its own channel management operations. In relation to this latter use, the classification can aid the design of channel enhancement or restoration schemes, as well as being useful for scheduling maintenance operations. Decisions will be based around the classified conservation value. For instance, the rarity of highly susceptible channels implies a high con-

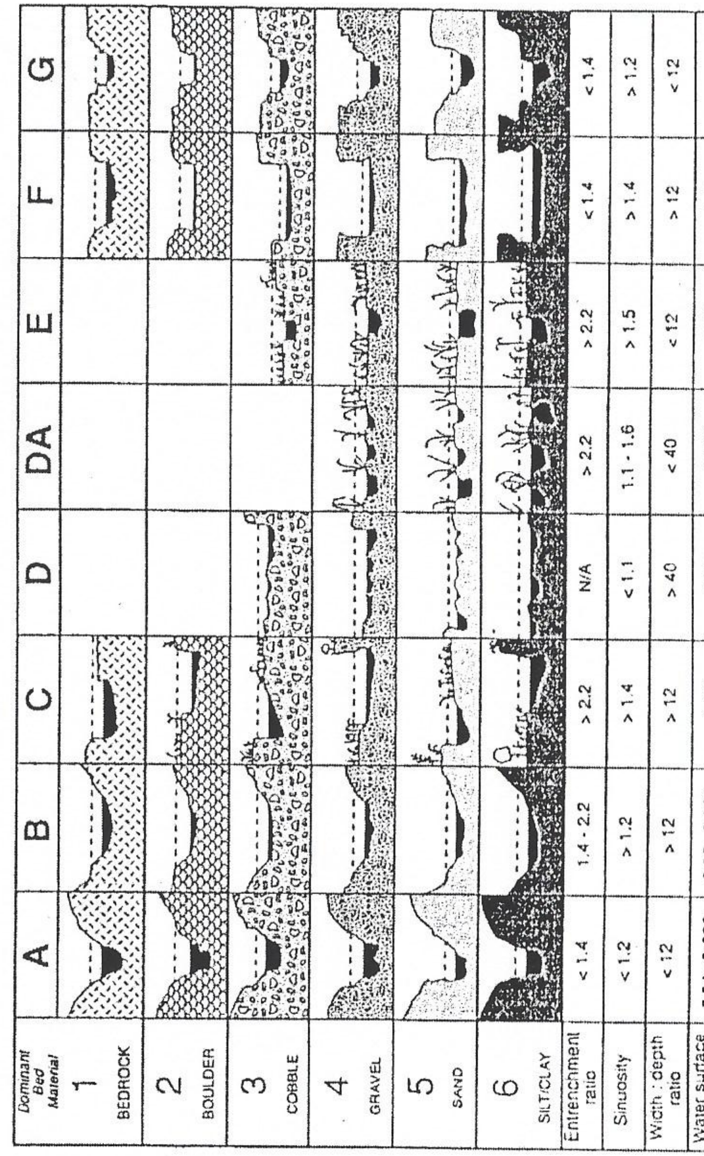

Figure 16.1 Forty-one stream types at the scale of morphological description distinguished by Rosgen (1994). Redrawn from Rosgen (1994) by permission of Elsevier Science Publishers

Table 16.1 Summary of NRA (1990) scheme for classifying river channel susceptility to disturbance

Susceptibility to degradation	Score	Description
High	8–10	Conform most closely to a natural, unaltered, state and will often exhibit signs of free meandering and possess well-developed bedforms (point bars and pool–riffle sequences)
Moderate	5–7	Show signs of previous alteration but still retain many natural features or may be recovering towards conditions indicative of the high category
Low	2–4	Substantially modified by previous engineering works and are likely to possess an artificial cross-section (e.g. trapezoidal) and will probably be deficient in channel bedforms and bankside vegetation
Channelised	1	Awarded to reaches whose banks and/or bed have been subject to hard protection (e.g. concrete walls, sheet steel piling)
Culverted	0	Totally enclosed by hard protection
Navigable	–	Classified separately due to their high levels of flow regulation and bankside protection, and their probable strategic need for maintenance dredging

servation value and engineering works should be strongly opposed. Engineering works should also be resisted in moderately susceptible channels because, depending on stream power and sediment budget, they are likely to have the highest recovery potential (ability to return to a natural form). Where recovery is evident, then in-channel maintenance operations should also be resisted unless unavoidable (i.e. genuine need for flood defence operations). Conversely, reaches of low susceptibility have the highest enhancement potential, and engineering works should be encouraged to incorporate restoration measures.

CLASSIFICATION OF ADJUSTMENT PROCESSES

As river managers increasingly recognise that rivers are not simply '*water*courses', but involve the interrelated movement of water and *sediment* within a dynamic river channel, there has developed an aspiration to comprehend river channel dynamics prior to undertaking river management operations or land use developments close to the channel edge. In response to this demand, and to simplify the specific nature of individual river channel adjustment processes, a number of methods have been produced which classify adjustments. Unlike geomorphological classifications of river channel patterns based on (hierarchies of) morphological features, classifications of river channel adjustment are explicitly value laden; adjustment processes are inferred directly from morphological features. Essentially, therefore, the resulting classifications represent a simple summary of an evaluation procedure.

Prevailing adjustments

In the absence of repeat river channel cross-section and planform surveys, absolute measures of river channel adjustment over the 'recent' period (arguably 10^0–10^2 years) are very difficult to ascertain, especially if changes in the channel depth are required, which negates the use of map comparisons. As a consequence, assessments of river channel adjustment required for management purposes have often used programmes of field observations. Some of these programmes have proceeded to classify the observed adjustments as prevailing changes which, unless their controlling parameters are altered, should be expected to continue into the near future. Examples of such schemes include those developed for relocated channels in the United States by Brice (1981), for channelised rivers in Denmark by Brookes (1987) and for catchment-wide surveys of rivers within the Thames basin, UK, by Downs (1992). Each method separates channels at the 'reach' level (of Frissell *et al.*, 1986) and classifies river channel activity according to cross-sectional adjustments. The resultant classifications by Brice and Brookes are illustrated in Figure 16.2 and details of the scheme by Downs is given below (and see Figure 16.4). Not surprisingly, many similar modes of adjustment are recognised, including processes of lateral migration (erosion of outer bank, deposition on inner; cross-sectional dimensions preserved) which is given as B by Brice, W4 and D2 by Brookes, and as M by Downs, and processes whereby a sinuous low flow channel is reforming within an overwide straightened reach (C in Brice, W5 in Brookes, R in Downs). The condition of morphological inactivity (short-term absolute stability) may be contrasted to the named categories of Brice and Brookes, and is given explicitly by Downs.

Classification of river channel adjustments in the Thames basin, UK, reconciled field survey evidence amassed from morphological indicators of change with a logical set of river channel adjustment categories. After development and testing of a reconnaissance evaluation procedure for a pilot catchment, four river networks were assessed for indicators of river channel changes (Downs, 1992). Grouping the individual indicators of change suggested over 20 types of prevailing adjustment. The total number of categories was reduced by developing a matrix centring on four basic forms of change in the river channel cross-section. These basic categories described channels which were *Stable* (no observable indicators of recent river channel change), cross-sections where indicators of erosion demonstrated that the cross-section was *Enlarging*, cross-sections which appeared to be contracting in area (*Depositional*) and cross-sections which were undergoing planform shift whilst approximately maintaining their dimensions (*Laterally Migrating*). A non-directional two-dimensional matrix of these four basic conditions results in 10 classes of river channel adjustment (Figure 16.3). In this classification, the three basic active categories are subdivided by their rate of change, and the three types of compound activity are recognised as indicative of complex channel adjustments following human disturbance of the river channel. Some of the adjustment categories represent channels which are in dynamic equilibrium, whereas others may represent non-equilibrium conditions. Figure 16.4 illustrates each class with a summary description.

The purpose of classifying modes of river channel change is to guide planners and engineers involved in the management of the river or its surrounding corridor. For instance, in the case of the Danish survey (Brookes, 1987), recommendations were

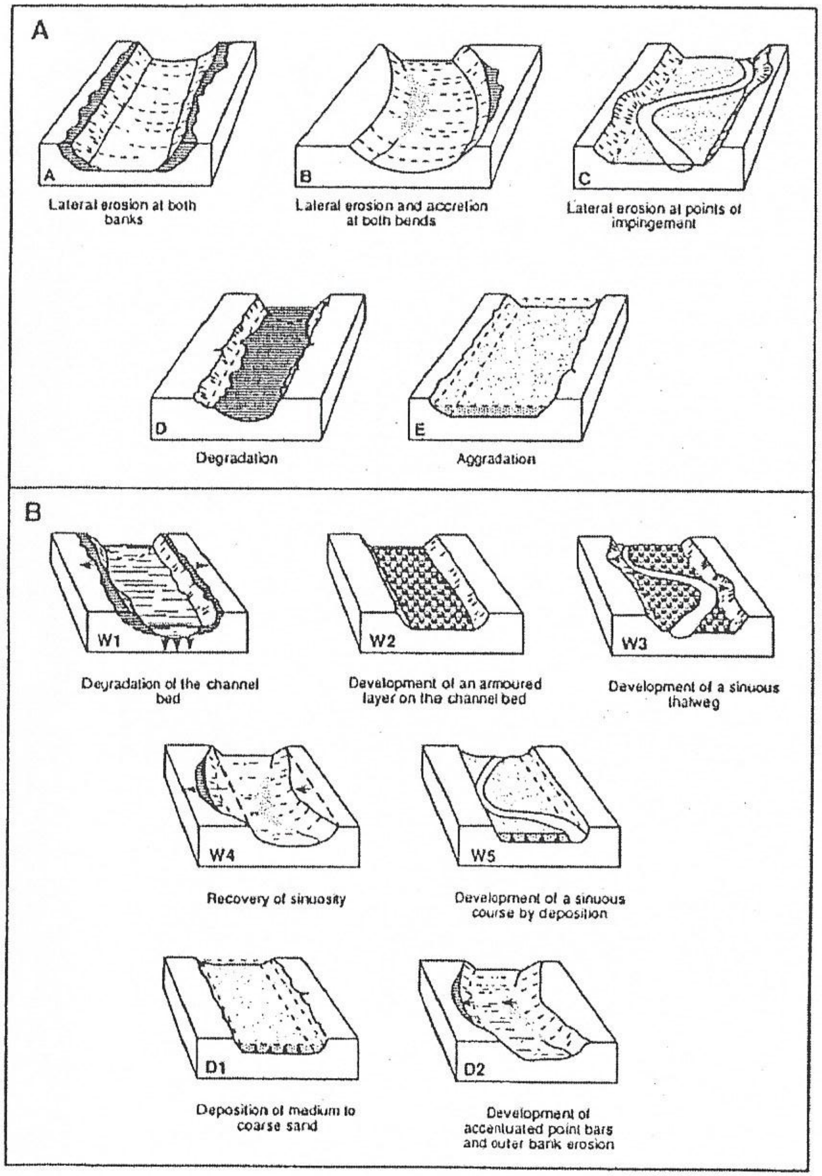

Figure 16.2 Comparison of river channel adjustment classifications of (A) Brice (1981) and (B) Brookes (1987). Redrawn from Brice (1981), and from Brookes (1987) with permission of J. Wiley & Sons

Stable	S			
Deposition	d	D		
Lateral Migration	m	R	M	
Enlargement	e	C	U	E
	Stable	Deposition	Lateral Migration	Enlargement

Channel Adjustment Categories:

S -	Stable	m -	less severe lateral migration
D -	Deposition	e -	less severe enlargement
M -	Lateral Migration	R -	'Recovering' reach
E -	Enlargement	U -	'Undercutting' reach
d -	less severe deposition	C -	'Compound' reach

Figure 16.3 Classification of river channel adjustments based on reconnaissance surveys undertaken in the basins within the Thames catchment, UK. From Downs, 1992

made for the introduction of environmentally sympathetic channel management techniques, as required by Danish law, according to channel change type. The assessment of Brice (1981) was designed to indicate the degree of instability induced by relocating stream channels for the purposes of highway construction. Thus, the classification scheme becomes the basis of a stability assessment which combines four spatial frequencies of bank erosion (*rare*; *local*; *local and severe*; *general*) and four extents of dimensional change (> *5%*; *5–20%*; *local changes* > *20%*; *general changes* > *20%*). From the potential of 16 stability classes, 13 are recognised in the 103 study sites. The largest class group is the 'stable' channels (*rare* bank erosion and < *5%* dimensional change; 31 cases, 30.1%), followed by two classes indicating local changes (20 sites with *local* erosion and *5–20%* dimensional change; 15 cases *local* erosion with < 5% dimensional change). In comparison, Downs (1992) found that the proportion of 'stable' Thames channels is 37% when defined by type S and the culverted reaches, or 77% if slow rate of change categories (d, m, e) are also incorporated. However, this overall figure masks the fact that the percentage of 'active' channels (those not of type S or culverted) varied between catchments from nearly 83% (92.4 km) of the Roding to only 16.6% (6.4 km) of the Lambourn. The Ravensbourne, in which 12% of the river network is culverted, has 28.5% (8.3 km) of active channels while the Sor has 73% (47.8 km). Clearly, the inter-basin differences in adjustment revealed by the classification scheme highlights the fact that Thames channels should not be viewed simply as presenting one single channel management challenge and that geomorphological appraisal is a necessary pre-requisite for environmentally-aligned management approaches. Additional information processing from this scheme is outlined later in this chapter.

A related technique for assessing the prevailing stability of river channels has been developed by Simon *et al.* (1989) and is summarised in Simon and Downs (1995).

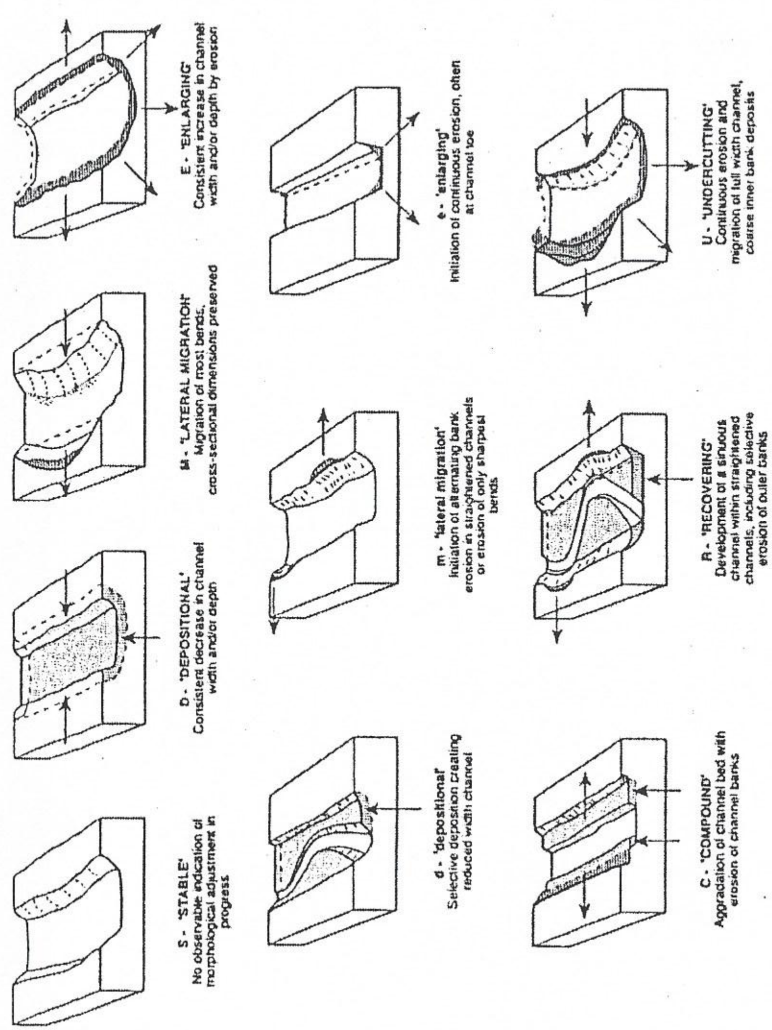

Figure 16.4 Diagrammatic representation and description of river channel adjustment classification from Downs (1992)

Table 16.2 Summary of scheme for assessing the potential instability of river channels (Reproduced from Simon and Downs (1995), with permission of Elsevier Science Publishers

1.	Bed material					
	bedrock	boulder/cobble	gravel	sand	unknown alluvium	silt/clay
	0	1	2	3	3.5	4
2.	Bed protection					
	yes.	no	(with)	1 bank protected	2 banks protected	
	0	1		2	3	
3.	Stage of channel evolution (see Figure 16.5B)					
	I	II	III	IV	V	VI
	0	1	2	4	3	1.5
4.	Percent of channel constriction					
	0–5	6–25	26–50	51–75	76–100	
	0	1	2	3	4	
5.	Number of piers in channel					
	0	1–2	<2			
	0	1	2			
6–8.	Percent of blockage: horizontal (6), vertical (7), total (8)					
	0–5	6–25	26–50	51–75	76–100	(divide values by three)
	0	1	2	3	4	
9.	Bank erosion for each bank					
	none	fluvial	mass-wasting			
	0	1	2			
10.	meander impact point from bridge (in feet)					
	0–25	26–50	51–100	> 100		
	3	2	1	0		
11.	Pier skew for each pier (sum for all piers)					
	yes	no				
	1	0				
12.	Mass wasting at pier (calculated for each pier)					
	yes	no				
	3	0				
13.	High-flow angle of approach (in degrees)					
	0–10	11–25	26–40	41–60	61–90	
	0	1	2	2.5	3	
14.	Percent woody vegetative cover					
	0–15	16–30	31–60	61–99	100	
	3	2.5	2	1	0	

This scheme, which is now being utilised in 11 States of the USA to assess the magnitude and distribution of bridge scour problems, scores potential instability as the total of marks obtained from individual questions in a reconnaissance evaluation survey. Table 16.2 shows how questions score the degree of instability implied by either an observed morphological feature of the channel or its vegetation, or from structural features of the bridge. Higher overall scores indicate a more unstable channel and field experience suggests that the threshold classification for channel instability which may threaten the crossing structure occurs where scores exceed 20. When tested on 1100 West Tennessee sites, 13% scored more than this critical value, with a mean of 12.3 (Simon and Downs, 1995). Sites which are identified as critically unstable are then assessed for their socio-economic and strategic value prior to making recommendations for engineering mitigation works.

Sequences of adjustment

If channel management strategies are to be designed which manage the dynamics of river channels then, alongside the procedures outlined above for assessing *existing* changes, it is desirable to have knowledge of the temporal *sequence* of changes which is probable at individual sites. With this knowledge, it becomes possible to manage probable future adjustments of the channel. One example, using a classification scheme alongside aerial photographs to induce stereotypical sequences of changes, has already been mentioned (Rosgen, 1994). However, in the absence of detailed archival evidence, and because full sequences of changes are likely to exceed a geomorphologist's working life, many schemes utilise knowledge of river channel processes in conjunction with location-for-time substitution to translate spatially segregated modes of change into projected temporal sequences. Study is usually facilitated by distinct human actions which modify the river channel or aspects of its water and sediment discharges.

The model of bed-level changes following channel straightening forwarded by Parker and Andres (1976), where degradation and then aggradation follow the passage of a knickpoint from the base of the affected reach, is an early example of this type of study, and classification of post-channelisation changes is still the most fully developed. Two similar models of adjustment now exist; the first is a five-stage evolution model developed for the passage of a knickpoint through Oaklimiter Creek, Mississippi (Schumm *et al.*, 1984; Harvey and Watson, 1986), and the second is a six-stage model based on channel bank changes following channelisation for rivers in West Tennessee (Simon, 1989, 1995). Figure 16.5 illustrates the two classification schemes. Both schemes begin with a pre-modified category which, in the Simon classification, is followed by the channel immediately following re-sectioning. Degradation of the channel bed follows due to stream power increases in the steepened reach (caused either by knickpoint progression or the reduction in channel length). Eventually, deepening of the channel leads to oversteepening of the banks and, when critical bank heights are exceeded, bank failure occurs primarily through mass-wasting processes, and a channel widening stage ensues. An aggradational phase follows in which a new low-flow channel may begin to form in the sediment deposits. Instability of upper channel banks may continue during this period. The final stage indicated by both schemes is the restabilisation of the channel banks and the development of a channel within the deposited alluvium which is of a similar capacity to the pre-modification channel. However, the new channel may possess a higher width:depth ratio than the original (Schumm *et al.*, 1984), and may be multi-staged in cross-sectional form.

In a straightened channel, fitting an observed change into the appropriate stage in either of these schemes would help to guide a proactive channel management strategy. However, both the schemes rely on the homogeneity of the underlying alluvial sediments and the uniformity of the channelisation procedure to produce a response sequence which is suitable for classification. Classification of river channel changes resulting from, for instance, urbanisation are much more difficult to classify due to

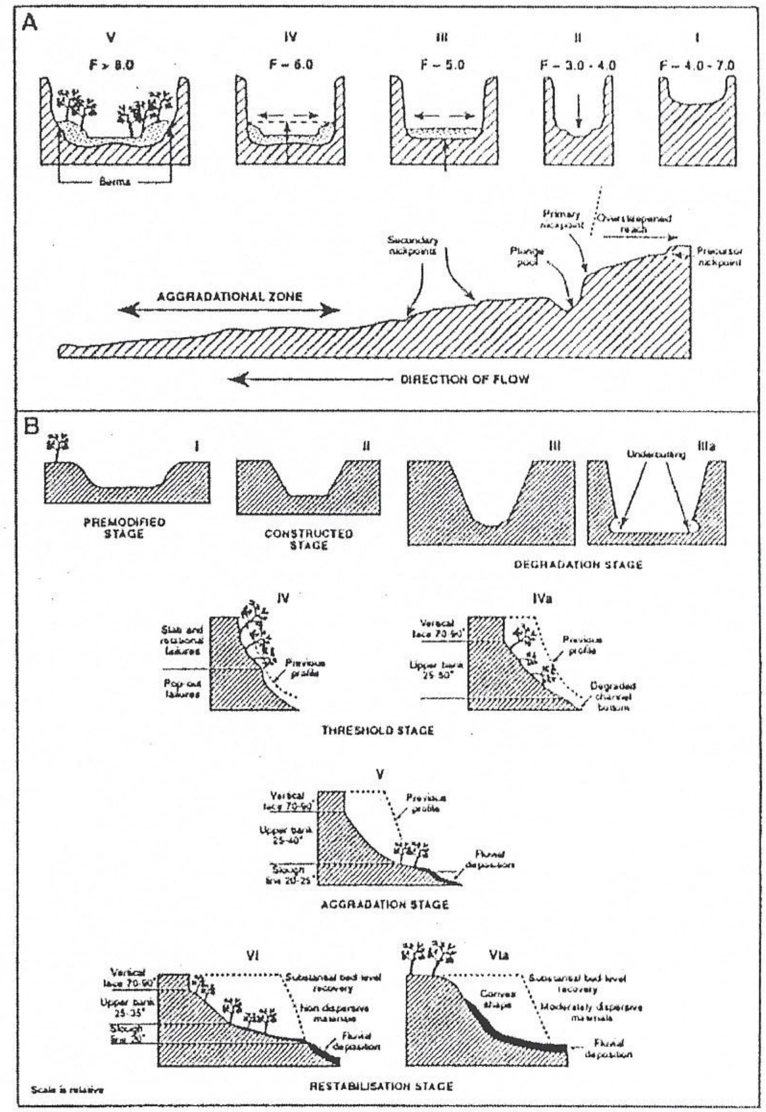

Figure 16.5 Comparison of classification schemes by (A) Harvey and Watson (1986) and (B) Simon (1989) for sequences of river channel adjustment following channelisation. Redrawn from Schumm *et al.* (1984), by permission of American Water Resources Association, and from Simon (1989) by permission of J. Wiley & Sons. F = form ratio (width:depth)

the number of interacting factors. For instance changes may depend on the degree of urbanisation (Leopold, 1968) and its position within the drainage basin (Ebisemiju, 1989), the type of drainage system installed (Roberts, 1989), local variations in the underlying rock type and channel gradient (Neller, 1988), whether or not the urban hydrograph exceeds the critical threshold of stream power required for bed erosion, whereby channel incision rather than general cross-sectional enlargement may occur (Booth, 1990), and whether concurrent channelisation works take place (Neller, 1989; Gregory *et al.*, 1992). Indeed, for the Monks' Brook in Hampshire, Gregory *et al.* (1992) found that location-specific factors did not allow a spatially segregated model of river channel adjustment to be recognised from the urban expansion of Chandler's Ford. Instead six styles of river channel change were agreed (Figure 16.6) which included active and inactive channels, cross-sectional contraction or enlargement, and different styles of erosion.

FROM CLASSIFICATION TO CHARACTERISATION: RIVER CHANNEL SENSITIVITY TO ADJUSTMENT

Classification schemes which predict spatial or temporal sequences of channel adjustment are not yet used routinely in river channel management. They require further validation by empirical study and should, ideally, indicate the time periods involved. Furthermore, contrast between the examples classifying post-channelisation adjustments in homogeneous alluvial sediments with those following urbanisation demonstrates that prediction of change needs to assess confounding environmental factors as well as general models of adjustment. This notion demands an understanding of the impact of individual parameters and a method which assesses their cumulative effect on the river channel. Gregory (1987) suggests that some knowledge exists about causes of river channel change, how this change is manifested in the channel, and how much change may be expected, but the specific nature and extent of changes brought about by individual influences will vary significantly according to their design, site and situation (the 'singularity' of Schumm, 1991). This variability is illustrated by the range of channel capacity changes in response to dam construction, urbanisation, land use and other changes documented by Brookes and Gregory (1988, pp. 152–153).

Recognising specific causes of river channel change implies knowledge of the *sensitivity* of river channel change to each individual parameter. However, although geomorphologists have shown increasing interest in the concept of sensitivity (recent advances in Thomas and Allison, 1993), difficulties in obtaining suitable data has prevented geomorphological sensitivity approaching the level of sophistication common in neighbouring disciplines (Downs and Gregory, 1993). Data deficiencies include those of defining the complete set of controlling environmental mechanisms which are responsible for river channel adjustment (input data), and the paucity of long-term monitoring of adjustments with which to validate models (response data). To reduce these problems, Downs (1992) based an empirical assessment of the sensitivity of Thames river channel adjustments on a classification scheme derived from Figure 16.4 to provide the response data. For purposes of statistical validity, the number of types of adjustment was reduced from the 10 in Figure 16.4 into the four

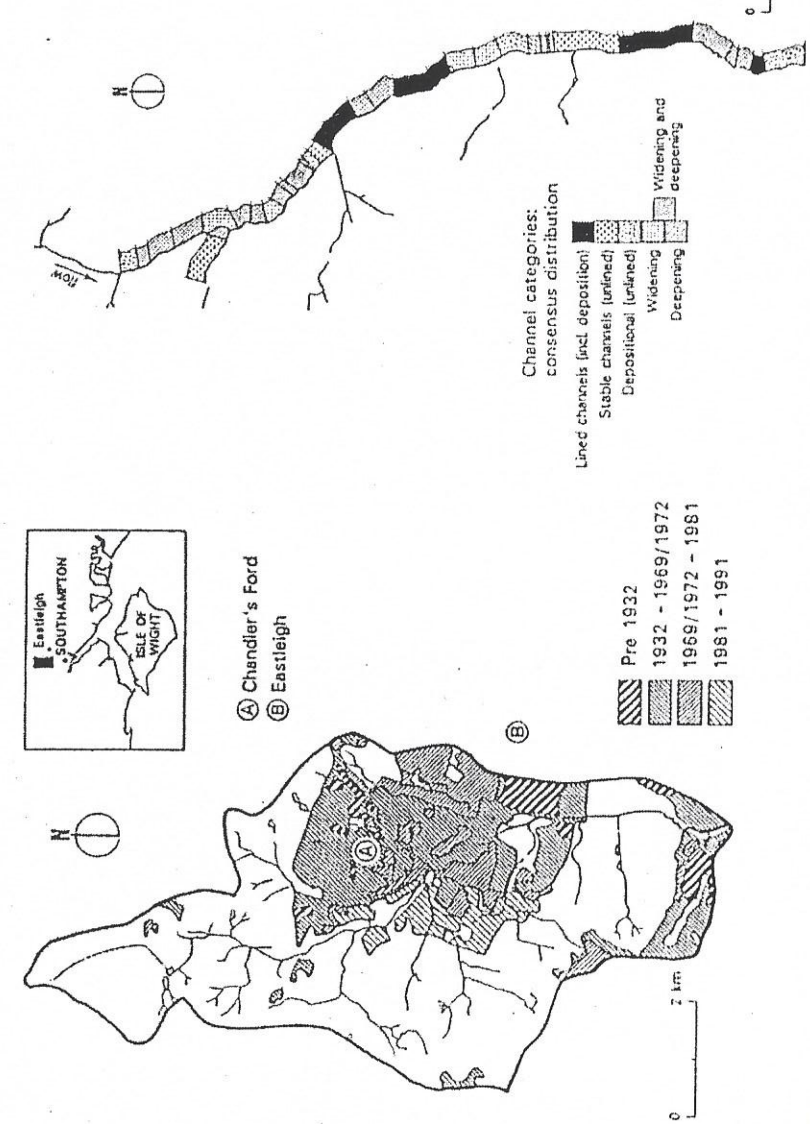

Figure 16.6 Consensus distribution of river channel adjustments in the Monks' Brook, Hampshire, UK. The Monks' Brook has been affected by the extensive urban area growth of Chandler's Ford and channelisation measures. Modified from Downs and Gregory (1993) with permission of J. Wiley & Sons

basic types in which *Enlargement* included channel adjustment classes E, e and U, *Lateral Migration* comprised M, m and R and *Deposition* consisted of channel adjustment types D, d and C. Input data was compiled from maps and field survey. Information was processed via multivariate logistic regressions equations (details in Downs, 1994a, 1994b and 1995) so that the parameter estimate accompanying statistically significant variables facilitated the calculation of a percentage probability of obtaining a particular adjustment style for single or combined environmental parameters within the class groups *channel gradient*, *rock type*, *land use* and *channel management* (Downs, 1994b). In utilising attainable data, this procedure converts the meaning of sensitivity from '...the ratio of the response of a device to the stimulus causing it.' (*Oxford English Dictionary*, 1989, vol. 14, p. 986) to 'the likelihood of obtaining a particular response (style of river channel adjustment) relative to the existence of an input parameter (catchment characteristic)'.

The best-fit equations produced by this procedure are multivariate linear characterisations of the classified adjustment (Downs, 1994b). Channels in the Thames basin are found to be sensitive to variables within all four categories of environmental parameter. By broadening the study to consider how river channel adjustment may be associated with drainage basin characteristics upstream and downstream of the adjustment, as well as alongside it, Downs (1995) demonstrates that channel adjustment is primarily conditioned by regional natural characteristics (*gradient* and *rock type*) while the specific nature of an adjustment category is likely to result from human actions (*land uses* and *channel management*).

CONCLUSION

Examples in this chapter have illustrated how river channel classifications are providing information for the management of dynamic river channels. Developing from geomorphological classifications of natural river channels, a focus on meso-scale spatial and temporal concerns has led to a range of management-related (applied and applicable) classifications whose strength lie in segregating river channel (adjustment) types as the basis for spatially differentiated, but systematic and integrated, management operations. Uses for the schemes include providing inventories of conditions for prioritising river conservation efforts, supplying information about adjustment processes so that management designs may account for the prevailing river channel dynamics, and contributing stereotypical sequences of change so that channel management measures may pre-empt future changes.

Classifications schemes are not ideal, they contain aspects of subjectivity, of generalised judgement and of qualitative interpretation when, for proactive river channel management purposes, a comprehensive physical model of river channel sensitivity to adjustment would provide management certainty. Unfortunately, the gap between conceptual understanding of river channel behaviour and modelling ability (Anderson and Sambles, 1988) ensures river channels will continue to be managed without perfect understanding. At a time when public opinion, enshrined now in legislation, is putting a high value on environmentally sympathetic river management, leading to a demand for geomorphological information, classification schemes provide an attainable target, the 'intermediate technology' with which to communicate geomorphological information of use to river managers. Additionally, the value of a classification may be enhanced further when the scheme is used in extended analysis, as illustrated in the characterisation of adjustment sensitivity. In this mode, classification provides a basis for increasing basic geomorphological understanding of the spatial variability of river channel adjustment. Indeed, linking cause with effect within the context of the drainage basin has broader environmental management implications, particularly within the context of schemes of integrated river basin management which may become more prominent in the 21st century.

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