

**PRESENTATION TO 30th MEETING OF THE
FLOOD DEFENCE MANAGERS GROUP
WALLINGFORD**

FLUVIAL GEOMORPHOLOGY

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Purpose of Paper

The purpose of this paper is to briefly outline the relevance of fluvial geomorphology and the substantial benefits which could accrue from applying it nationally across the NRA. It compliments information given in a previous paper dated 27 October 1993 (Ref. 1) which was presented to a national FRCN meeting on 9 March 1994.

Definition of Geomorphology

Geomorphology has relevance to the appraisal and solution of both riverine and coastal management problems. In particular fluvial geomorphology is concerned with the processes of water and sediment movement in river channels and with the channel forms produced by these processes. It is a vital part of river management for several reasons, including:-

- i) providing an understanding of the factors which contribute to the stability of natural river channels;
- ii) anticipating the environmental impacts of particular management decisions;
- iii) developing stable designs for Flood Defence capital, maintenance, fisheries and conservation projects;
- iv) designing sustainable river restoration projects.

The application of geomorphology enables a river management problem to be placed in the broader spatial and temporal context and allows interpretation of both cause and effect (Ref. 2). It therefore compliments the traditional engineering approach to the management of rivers (Figure 1).

Geomorphology in the NRA

Geomorphology has a major contribution to make to Flood Defence Capital and Operations works. However to date the input of fluvial geomorphology to the design or maintenance of river projects within the NRA nationally has been on an ad-hoc basis. One exception is within Thames Region where the two geomorphology staff have made a consistent input to the majority of external and internal project designs, procedures and policies over the past eight years. Increasingly this has been in the role of client, as follows:-

- a) undertaking appropriate training and development of guidance notes for use particularly by NRA staff so that geomorphological principles can be applied to several hundred projects per year;
- b) directly becoming involved in major or complex projects;
- c) developing briefs for geomorphology work which is contracted out, and monitoring and approving work on behalf of the client Flood Defence staff;
- d) managing a geomorphology term consultancy;
- e) developing appropriate standards and audit of schemes.

Advice has been provided where possible within the limit of resources to other Regions and to Head Office. This has included assistance in the development of national methodologies (eg River Habitat Survey) and training of staff. Thames staff currently teach geomorphology on a national basis at Water Training International (Tadley and Burn Hall) and other venues.

However the inconsistency in approach nationally is surprising as a geomorphological input to the majority of projects involving channel works can lead to solutions which work with natural processes rather than against them and are therefore likely to be sustainable over time. Principally through national R&D Projects completed to date in the Flood Defence and Recreation/Navigation Commissions it has been demonstrated that geomorphology represents a value-for-money approach for the NRA (Figure 2).

Examples of Geomorphological Approach now available to the NRA

1. Use of Fluvial Audit for the assessment of sediment-related problems. This is the key output of the Flood Defence R&D Report on Sediment and Gravel problems undertaken by the University of Newcastle (Figure 3). Adopting this approach can mean that a wider range of options/alternatives are considered and that the final management solution is sustainable and more cost-effective.
2. Determining the correct sediment sizes to be reinstated in different river environments is important (Figure 4 is an example for an urban river in South London). It is estimated that there may be in excess of 50 different geomorphological river types in England and Wales and it is probable that without a geomorphological input to design considerable monies are wasted because incorrect grain-sizes are reinstated. Figure 5 shows the success/failure of projects for different values of stream power. In general low energy streams (low slope and discharge) experience sedimentation thus obscuring reinstated features (eg Thames/Anglian Regions). By contrast high energy streams (eg Welsh Region) with high slopes and discharges may actually erode reinstated features (Ref. 3).
3. Undertaking strategic geomorphological surveys for entire catchments to record the susceptibility of rivers to future management practices. Through such surveys in Thames Region it has been found that on average only 5% of channel length per catchment could be described as 'natural' ie containing undisturbed geomorphological features. For the River Thames as a whole useful management information can be gained on lengths of channel eroding (Figure 6). At a more detailed reach level eroding banks (red dashed), unvegetated cliffs (brown square)

and unvegetated beaches (brown triangle) can be depicted (Figure 7); (Ref. 4).

4. Designing mitigation in flood alleviation schemes based on geomorphological principles. Figure 8 shows the example of the Wraysbury River to the west of London. The works, which were finished early in 1992, incorporate a number of measures to mitigate the effect of widening the existing channel. A low-flow notch was excavated to a depth of about 200mm below the design bed level. Low flows are confined to this notch, which approximates the anticipated low-flow width for a natural channel at that location and by a series of carefully sited blockstone groynes which train the flow (Figure 8). Water depth of the order of 300mm is retained at low-flow, with velocities of about 0.3m/s. A natural pool-riffle sequence has also been created. The groynes are also intended to allow for deposition of silt loads carried in the flow, deposited in the wider, shallower areas of the bed.

Benefits of Adopting a Geomorphological Approach

Sediment-related river maintenance costs the NRA nationally at least £10 million per year. The R&D Project on sediment and gravel problems in rivers undertaken by Newcastle University concluded that much of this cost could be recovered following adoption of a rational, long-term management strategy based on the combination of geomorphology and river engineering. The cost-benefit of some geomorphological solutions compared with the maintenance costs are shown in Figure 9.

Consequences of a "do nothing" approach

- the NRA nationally will be deprived of procedures for minimising environmental impacts and designs which are probably more cost-effective;
- many thousands of projects per year will be built without the benefit of a geomorphological appraisal or guidance notes. Many projects will require continual maintenance whilst others will fail through instability;
- piecemeal training of Flood Defence and Conservation/Fisheries staff will continue;
- there may be a failure to develop national specifications/standards for the inclusion of geomorphology in river management.

Conclusion

Geomorphology can be applied to all projects, plans and proposals for the river environment and compliments the traditional engineering approach to rivers. This can lead to a more strategic approach for consideration of alternative solutions.

Geomorphology has been shown to be vital to efficient and effective river management. It should be developed and applied nationally through continual training, appropriate guidance and specification/standards. Cost-effective and sustainable design in Flood Defence could save considerable sums of money in the long run, outweighing the relatively low cost of an initial geomorphological appraisal.

Geomorphology has also been proved through a number of national initiatives, with potentially very significant implications for the NRA. This work will continue to be extended in 1994/95 and 1995/96 as part of the River Habitat Survey Initiative and through an R&D project in the General Commission which will evaluate more fully the costs and benefits of adopting a geomorphological approach as well as producing further guidance.

References

1. NRA (27 October 1993) 'Proposal for a National Centre of Expertise in Thames Region: Fluvial Geomorphology'. Paper for discussion.
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3. Brookes, A (1992) Recovery and restoration of some engineered British River Channels., pp. 337-352 in Boon, P.J. et al (ed) River Conservation and Management, John Wiley & Sons, Chichester.
4. NRA (1993) Thames 1:10.000 Map Atlas of Bank Protection and Erosion. Prepared by University of Nottingham for NRA Thames Region.

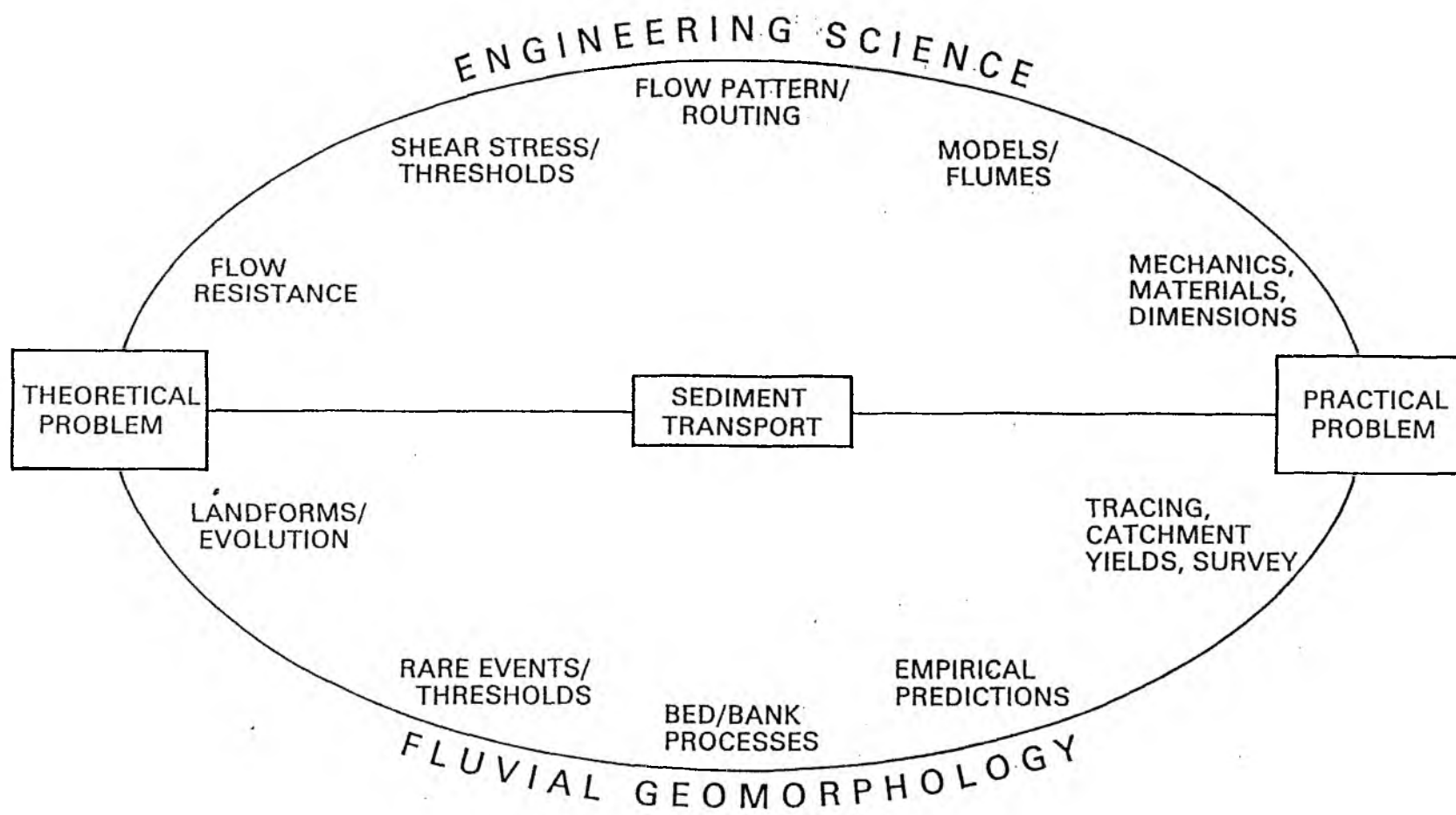


Figure 1 - Relationship between geomorphology and engineering science in creating the knowledge base for practical river engineering

Figure 2 - Some key national NRA Research and Development Projects influenced by geomorphological expertise

Project	NRA Function	NRA Project Leader	Dates	Contractors	Key Outputs
Bank erosion on navigable waterways (Phase I)	Recreation and Navigation	Dr A Brookes	1990-91	University of Portsmouth (Hooke, Clifford, Bayliss)	Preliminary guidance on bank protection techniques and an assessment of the suitability of each technique for different types of location Bibliographic review held on database
Bank erosion on navigable waterways (Phase II)	Recreation and Navigation	Dr A Brookes	1991-93	University of Nottingham (Thorne, Doornkamp and Reed)	Analysis of rates spatial distributions and temporal variations of bank retreat. Method for assessing bank erosion processes based on geomorphology and river mechanics and recommendations for alternative and appropriate management techniques.
Sediment and gravel transport in rivers, including the use of gravel traps (Phase I)	Flood Defence	Dr A Brookes	1990-91	University of Newcastle (Newson and Sear)	Database of sedimentation problems, costs and remedies in rivers in England and Wales. Preliminary report on use of geomorphology in river engineering
Sediment and gravel transport in rivers, including the use of gravel traps (Phase II)	Flood Defence	Dr A Brookes	1991-93	University of Newcastle (Newson and Sear)	Analysis of problems from different environments. Method for fluvial auditing (linking cause and effect) and geomorphological input to management solutions.
Stream bank protection in England and Wales (Phase I)	Flood Defence	Mr D Rooke	1992-93	University of East Anglia (Hey, Heritage, Tovey, Boar, Grant and Turner)	Review of bank protection practices. Establishing cost-effectiveness, environmental sensitivity and range of application. Guidelines for designing and installing bank protection

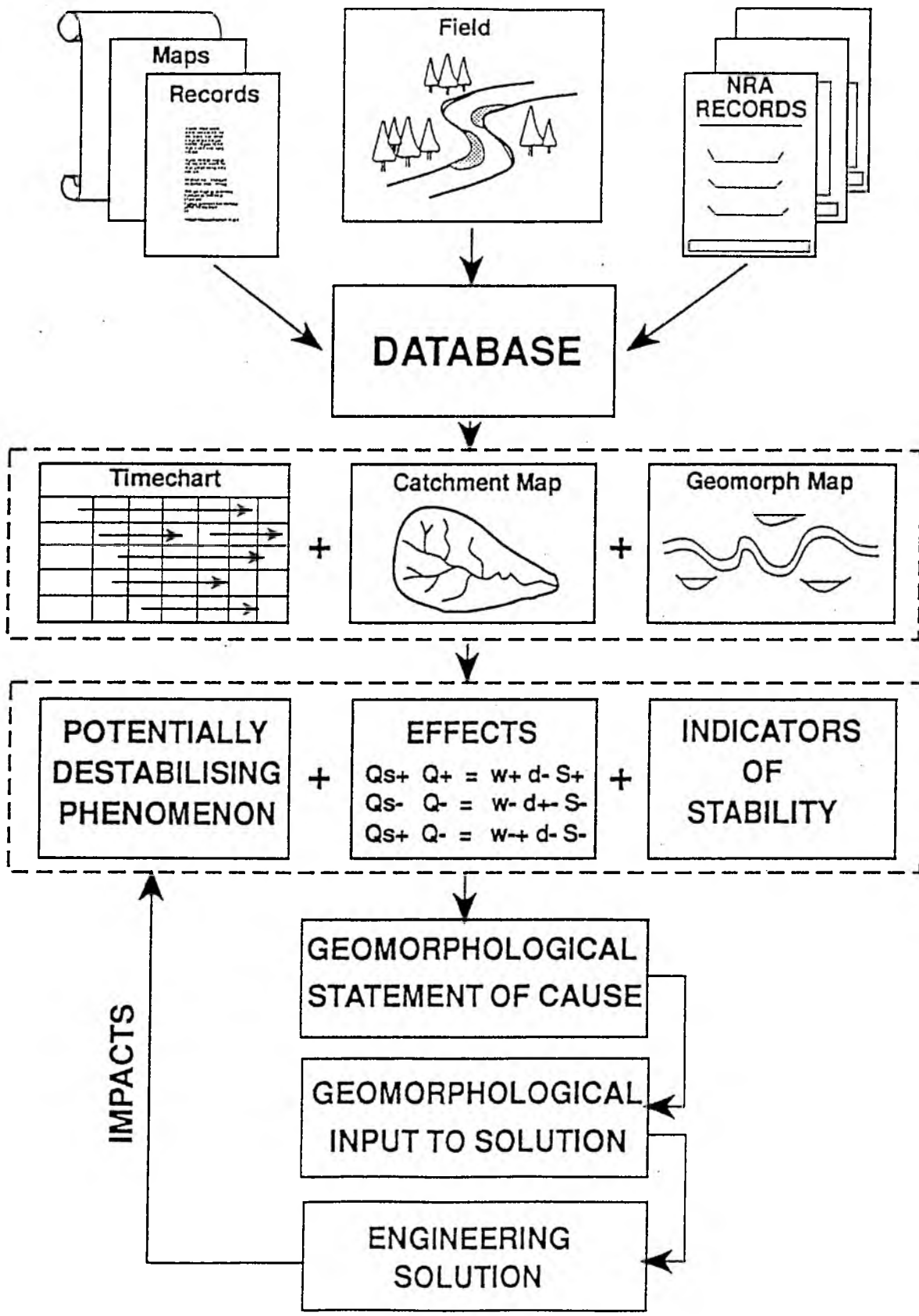


Figure 3 Geomorphological Procedure : Fluvial Audit
 This procedure is recommended in NRA R&D Report C5/384/2.

Plate 3: River Wandle looking upstream



Plate 4: Surface substrate sample of the River Wandle



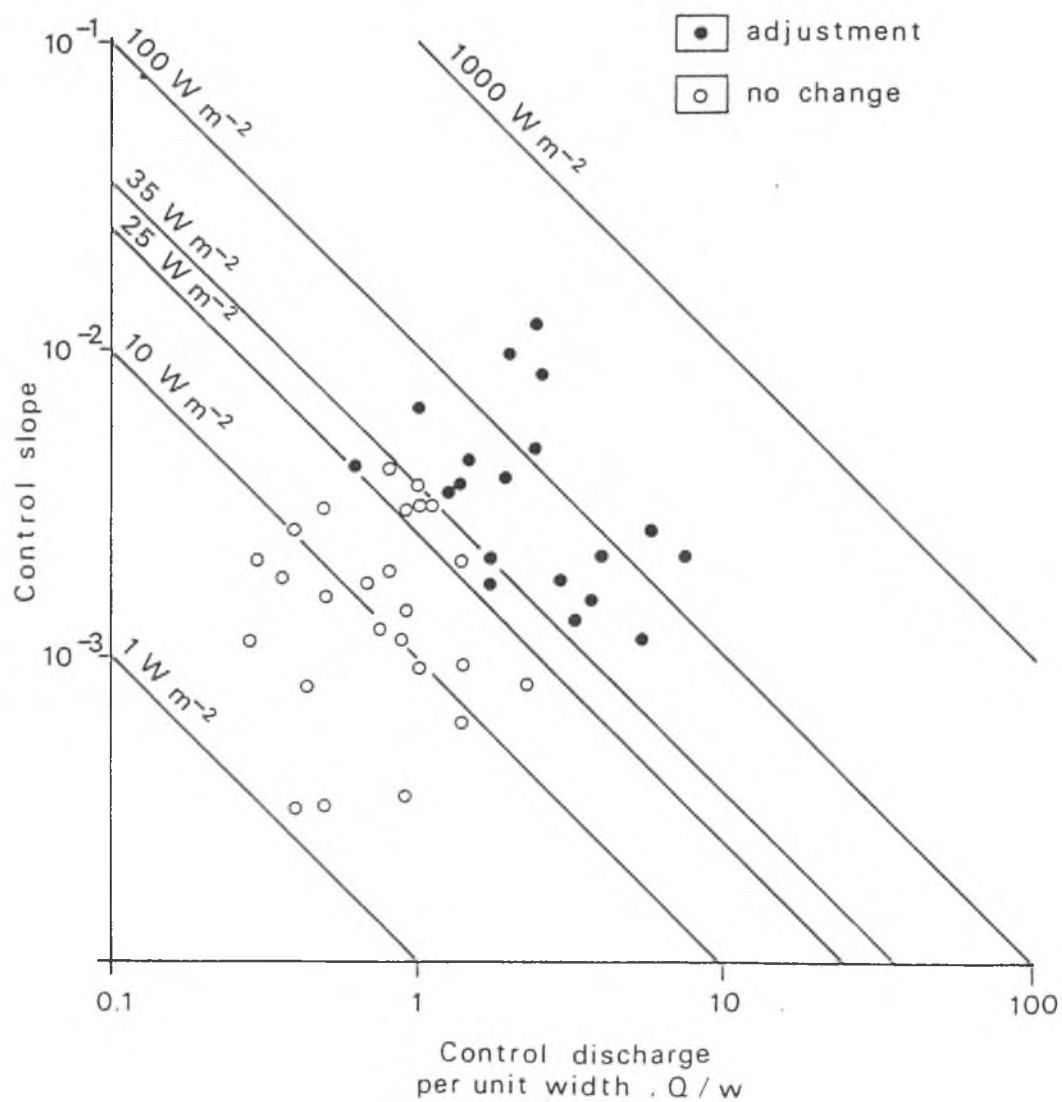


Figure 5 - Relationship between bankfull discharge per unit width and water slope for natural control reaches of eroded and non-eroded sites of river engineering projects in England and Wales. Lines of equal specific stream power are superimposed

Visible Erosion of Thames River Bank (as a percentage of channel length)

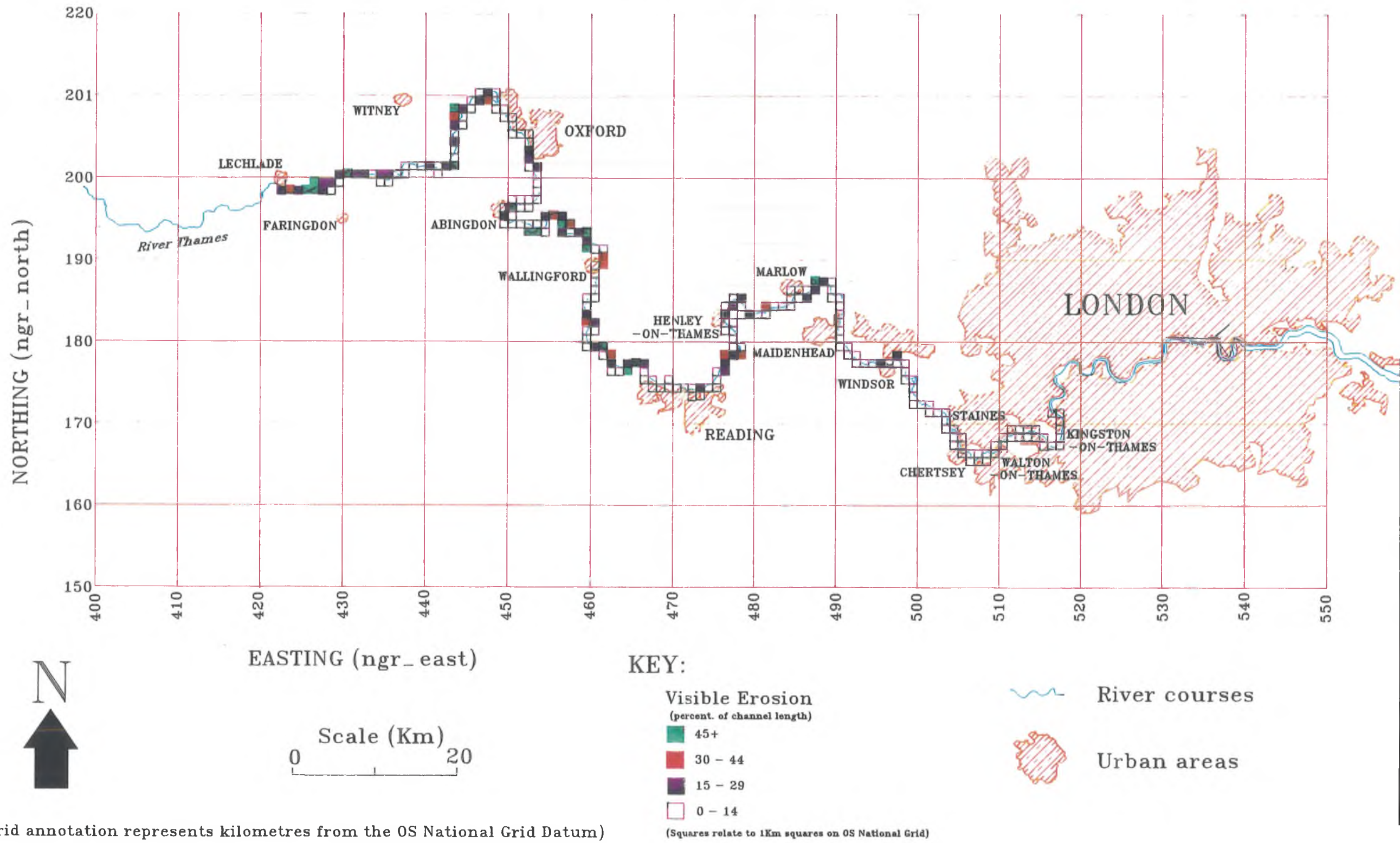


Figure 6

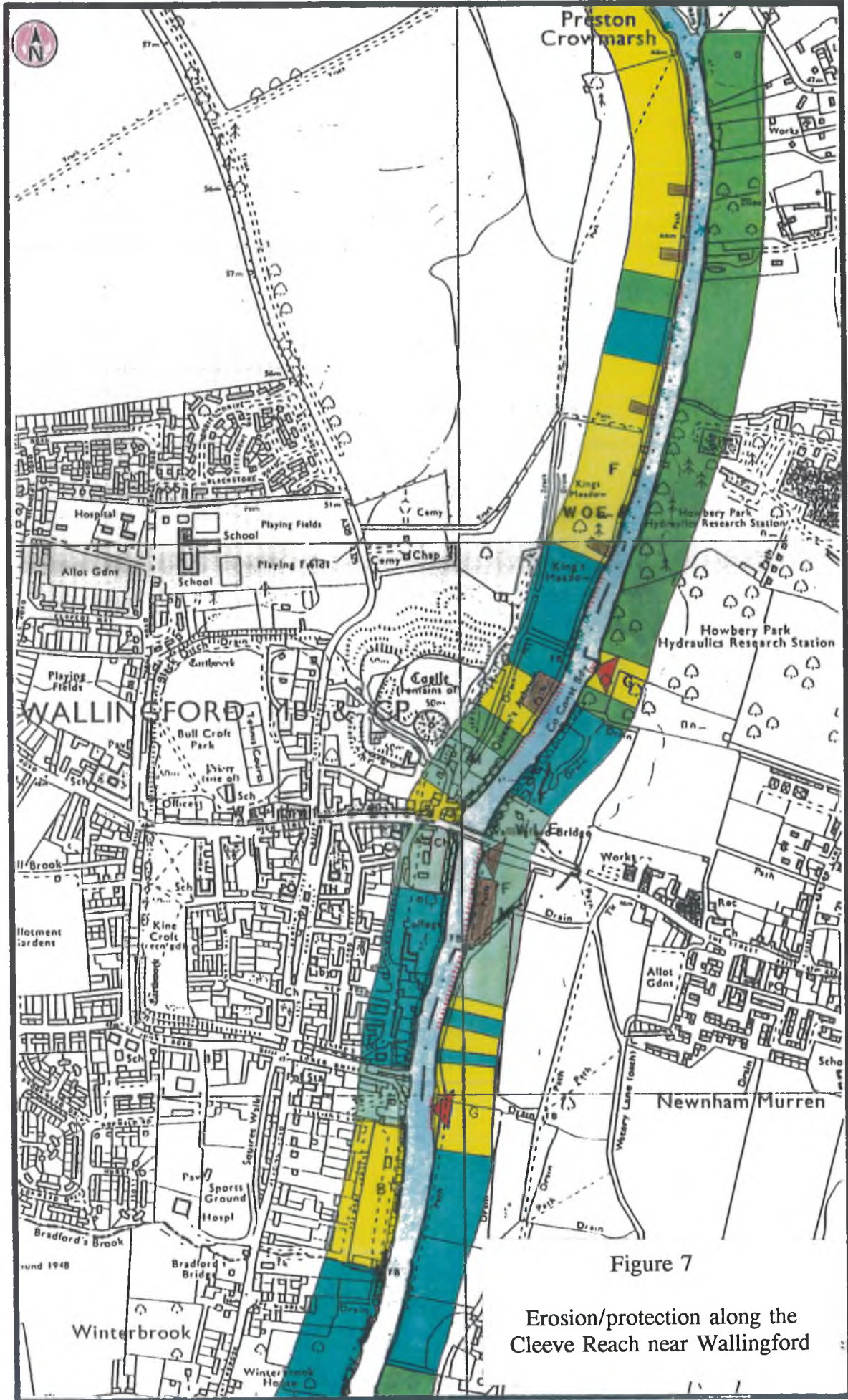


Figure 7

Erosion/protection along the Cleeve Reach near Wallingford

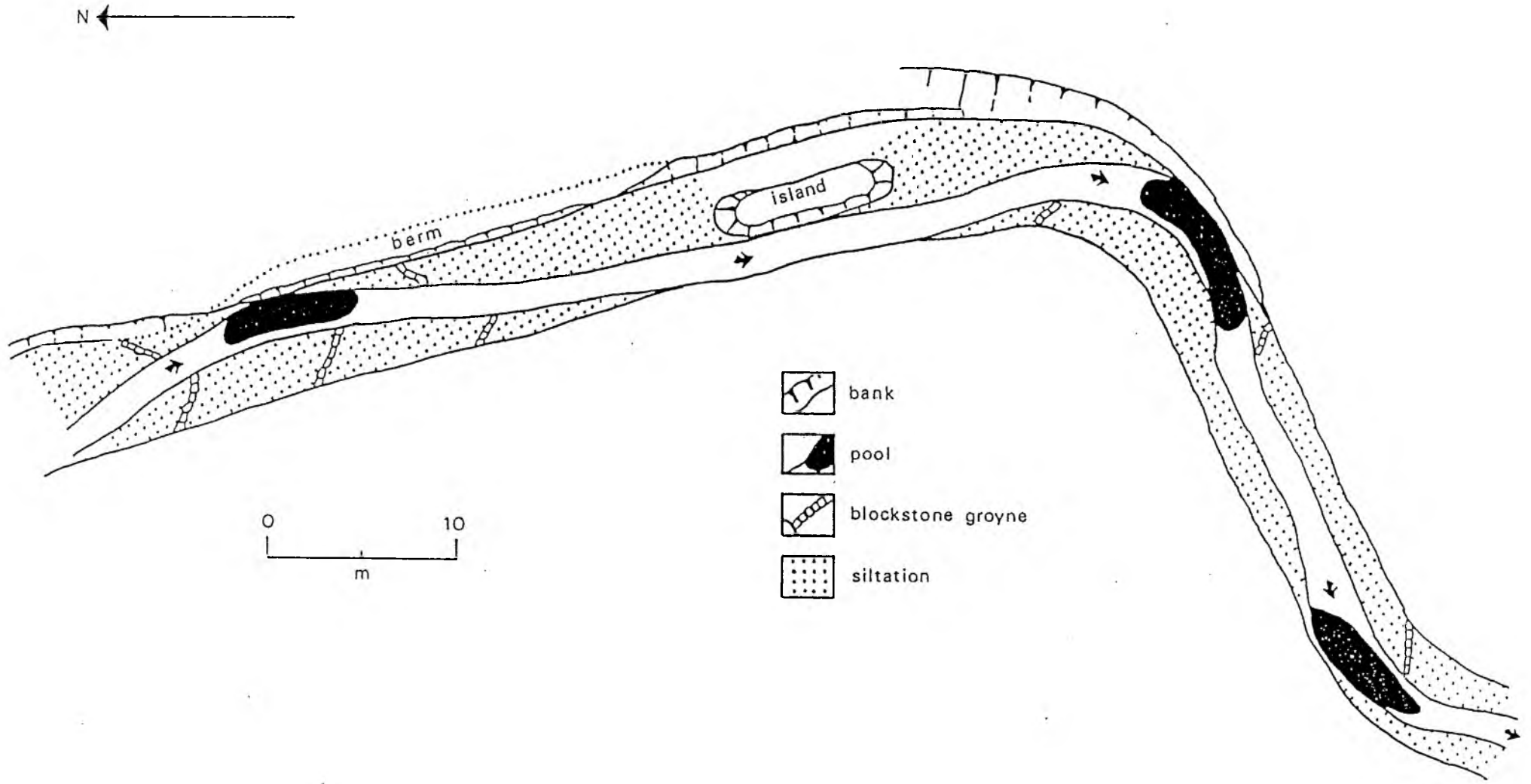


Figure 8 - Geomorphologically-based design: Wraysbury River (Lower Colne Flood Alleviation Scheme)

Figure 9

Cost Benefit of geomorphological solutions:- First approximations based on 10 year time period of river maintenance.

Scheme	Maintenance Cost (over 10 years)	Geomorphology Survey + Report	Cost of Solution (over 10 years)
Mimmshall Brook	£ 100 000	£ 1500	£ 25 000
River Wansbeck	£ 7000	£ 1000	£ 0.000
Shelf Brook	£ 25 000	£ 1250	£ 5000 ₁
River Derwent	£ 20 000	£ 2000	£ 8000 ₂
River Laver	£ 10 000+	£ 1250	£ ? ₃
River Ure	£ 50 000	£ 1250	£ 25 000
River Avon	£ ?	£ 500	£ ? ₄
River Sence	£ 20 000	£ 1500	£ <15 000
Afon Tawe	£ 37 750	£ 1250	£ 0.000 ₅

1. Costs only for reduced maintenance. Reductions on Capital Scheme 40K.
2. Costs estimates for tree planting, cost of land use management covered by MAFF setaside water fringe option.
3. Costs of accommodating shoal development may be >20K but if geomorphology had been used in design stage of gauging station then maintenance costs could have been prevented.
4. Costs unknown but refer to siltation behind mill weirs - management plan suggested, costs unknown.
5. Refers to Ystradgynlais shoal only. A stabilising scheme upstream has been saved money by geomorphological advice which prevented unnecessary gravel trap construction and maintenance. Costs unknown.