

R&D Project 336

Bank Erosion on Navigable Waterways

**University of Nottingham
Draft R&D Note 336/2/T**

BANK EROSION ON NAVIGABLE WATERWAYS

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This is a Draft R&D Note and it provides information on bank erosion on navigable waterways and is a possible precursor to a future NRA policy document.

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EXECUTIVE SUMMARY

There are concerns that bank erosion is a "bad" thing and that steps should be taken to control or eliminate it. Historically, in the case of navigable rivers and waterways, it has been generally perceived that observed bank erosion may be attributed to boat wash and that solutions based on hard engineering are required to deal with bank erosion and instability. This study of bank erosion has shown the situation to be less clear cut and the results of field observations indicate that hard engineering is not an appropriate first response to bank erosion problems.

Bank erosion occurs along all natural and most artificial waterways to a greater or lesser extent. However, rates of bankline retreat due to natural erosion tend to be low in Britain and seldom attract or deserve structural stabilisation outside urban areas. In fact, unless a dwelling or structure is directly threatened by natural erosion, a policy of managed retreat to accommodate the natural tendencies of the river will usually be advisable.

Most serious bank retreat is the result of local or reach scale acceleration of natural erosion processes due to human activities. Boat wash is only one of the activities likely to accelerate erosion, others include: concentration of flow due to the presence of hard structures; boat mooring; angling; uncontrolled access by cattle or other grazing stock and other activities which weaken or remove natural riparian and emergent aquatic vegetation on the bank. These human activities are amenable to management and so managerial solutions may represent cost-effective alternatives to structural protection when dealing with an erosion problem.

When bank management will not solve the problem, selection of the best structural response to a bank erosion problem must be made in the context of management of the entire river channel and flood plain and in consultation with specialists from all relevant NRA functions. This suggests a three-pronged policy of:

- * managed retreat where bankline stability is not critical;
- * responsible use of the river and riparian zone, to minimise accelerated erosion;
- * structural protection using the most acceptable soft or hard solution where erosive attack cannot be avoided and bankline retreat cannot be allowed to continue.

Adoption of such a policy would require some policy revisions by the NRA. Of particular importance are the need to monitor bank morphology and the effectiveness of past, present and future engineering interventions along navigable waterways and the integration of considerations of bank stability and bank environments into other aspects of river management. These tasks would require establishment of computerised databases for information storage and retrieval, training of existing personnel and the appointment of at least one geomorphologist by each NRA Region to coordinate monitoring programmes, interpret the results and liaise with staff in various functions that have an interest in bank management.

Finally, active management of the bank requires a clear understanding of the need for management and the role of enforcement of managerial and operational procedures by NRA officers and bank users who are directly affected. This highlights the need for a wide ranging programme of staff and public education.

KEY WORDS

Bank erosion Bank protection Boat wash Education
Geomorphology NRA policy Navigable waterways
River management Staff training

1. BANK EROSION PROBLEMS AND SOLUTIONS

1.1 Introduction and background

There are currently concerns that:

- * bank erosion of navigable waterways is "bad";
- * such erosion is predominantly the result of boat wash;
- * conventional solutions based on hard structural engineering are not always appropriate;
- * changes in policy are required to cope with problems of bank erosion.

This study into bank erosion on navigable waterways has shown that:

- * bank erosion is not always a "bad" thing;
- * boat wash may not be the predominant cause in all cases;
- * new and innovative solutions may be attractive alternatives to hard engineering in many situations;
- * there is a need to re-examine policies which relate to bank erosion.
- * working practices in dealing with the LPAs over planning applications may need to be changed
- * education is required amongst NRA staff and the main users of navigable waterways.

1.2 The reality of a bank erosion problem

1.2.1 Bank erosion in the fluvial system

Rivers naturally transport sediment along their courses. This sediment may be derived indirectly from the catchment that drains to the river channel, or it may come directly from erosion by the river of its bed and banks. These processes are part of the dynamic fluvial system which is constantly responding to changes in flow conditions, land use in the catchment and changes in the erodibility of river channel banks. However, as catchment and channel conditions are themselves constantly changing, true equilibrium is seldom attained.

- * River erosion is a natural process in the continuous search for a dynamic equilibrium within the river system.

The processes of erosion, transport and deposition of sediment, if disturbed, will cause the river to adjust its channel form and seek alternative sources for its sediment load. By this means protection of one place from natural erosion may trigger a change of channel form that causes erosion to commence in adjacent reaches.

- * The natural tendency for a river to erode, transport and deposit sediment must constantly be borne in mind when thinking about river management policies.

1.2.2 What is serious bank erosion ?

While some bank erosion is a natural facet of all river systems, it may still be unacceptable when its rate is high and/or its extent is great. River management has to take on a more pro-active role when serious bank erosion is taking place, and as a result is threatening to cause a significant channel instability, destruction of property, economic loss or degradation of an environmentally valuable site. Such accelerated rates of erosion often have a human cause, and sites of accelerated erosion are not uncommon on navigable waterways.

The rates of bank erosion which can be measured in such circumstances of accelerated erosion may be of the order of a metre of bank retreat per year, or in exceptional cases, several metres per year. This may be compared with natural rates of only centimetres over the same period. However, such rates are highly variable both in space and time.

1.2.3 The extent of serious bank erosion

Because bank erosion tends to be concentrated along specific sections of a bank or short reaches of the navigable waterway there is always a suspicion that it must be related to local causes. In general this is true.

In alluvial rivers it is also possible for system-wide adjustments to appear as changes concentrated at a few key locations. However, on regulated lowland rivers large-scale instability is suppressed so that site-specific erosion is in fact usually a local problem.

1.2.4 The causes of bank erosion

Serious bank erosion is usually associated with one or more of the following:

- * concentration of flow (eg. due to the presence of a hard engineering structure, such as a section of concrete bank protection, in the immediate vicinity);
- * mooring sites for leisure craft;
- * access points for anglers (for example at competition "pegs");
- * access points for cattle and/or other grazing livestock;
- * other points where there is an absence of bank vegetation.

Most of these relate to human actions and may, therefore, be affected by management policy on bank and land-use practices.

Policy matters should, therefore, address these specific issues.

1.2.5 The range of methods used to deal with bank erosion

Policies must have due regard to the range of alternative methods for dealing with bank erosion problems.

These include not only the obvious (though often the least appropriate) methods, such as the creation of hard structural protection, but also the softer protective measures such as the use of vegetative materials. Control can also be exercised through policies regarding the use of the waterway, its banks and riparian zones:

- * In dealing with serious bank erosion the best response appears to be the combined use of selected engineering solutions with appropriate policy and management practices.
- * This suggests a three-pronged managerial strategy of:
 - i) managed bank retreat, to accommodate the natural tendencies of channel behaviour where bankline stability is not critical;
 - ii) responsible use of the river, bank and riparian zone, to minimise and localise accelerated erosion, and;
 - iii) structural protection (using the most acceptable "soft", "hybrid" or "hard" solution) where erosive attack cannot be avoided and erosion cannot be allowed to continue.

1.3 Guiding principles of bank management

- * Identify the cause of the bank erosion problem. If it is purely due to natural erosion as part of the fluvial system then, if possible, allow it to continue. Avoid intervention unless bankline retreat is absolutely unacceptable;
- * Where retreat cannot be allowed, and especially if the cause is human activity, seek a solution through active bank management, and only intervene with structural protection when this alternative approach is not acceptable;
- * When active management or structural intervention are justified, match the scope, strength and length of bank covered by the solution to the cause, severity and extent of the problem. Active bank management and soft engineering, although desirable, are not appropriate for locations of intensive bank attack. Every unsuccessful managerial or soft solution detracts from the credibility of the approach and damages the image of alternative solutions.
- * When reacting to a bank erosion problem and deciding on a course of action, bear in mind the responsibility to balance conflicting goals in river management to achieve the optimum solution in terms of the four E's:

Efficacy, Economy, Engineering and the Environment.

2. OUTLINE RECOMMENDATIONS FOR POLICY AND POLICY CHANGES

At present there is no integrated policy on the management of bank erosion problems on navigable rivers. It is therefore recommended that:

- * **A national policy and management framework for consideration of bank erosion problems on navigable waterways is established.**

It is important that a coherent and carefully considered strategy be developed, so that there can be consistent reaction to problems as they arise. While every region, river and bank erosion problem is to some extent unique and requires an individually tailored plan, a piecemeal or ad hoc system whereby each case is treated in isolation should be avoided.

At present there are gaps in NRA policy and practice in several key areas. It is recommended that these are addressed through:

- * **Monitoring of bank morphology to supply data on current bank condition, recent and historical bankline movement, past engineering and management projects and post-project appraisal of success or failure.**

Sound and effective bank management cannot be performed in a vacuum. Reliable data on the past and present condition of the banks are essential. In particular, information on the history of the bank problem and the success or failure of past attempts to control bank retreat are crucial to the selection of appropriate strategies for future intervention.

- * **Appointment of a geomorphologist to the NRA staff in each Region to supervise bank problem assessments, interpret the observations and data on bank erosion processes and suggest appropriate management and protection strategies for solving bank problems.**

The requirement for historical and contemporary morphological studies of conditions and problems involved in bank monitoring reveals a significant skill shortage in the NRA. In-house staff with the training and experience to undertake morphological studies and field reconnaissance are relatively rare. Contracting such work out may not always be feasible or desirable. The recruitment of a trained geomorphologist in each region would be a significant step towards addressing this problem.

- * **Integration of consideration of bank erosion problems and related issues into broader aspects of river management.**

The bankline marks an extremely significant boundary between the channel and the flood plain. Since any active management or engineering intervention along the bankline has direct and indirect impacts on both the channel and the flood plain, it is vital that these measures be factored into the broader framework of Integrated Basin Management.

- * **Increased liaison between NRA staff with a common interest in bank management, but employed in different sections. Such staff include those concerned with: recreation and conservation, navigation, fisheries, flood defence and land drainage.**

Situations where bank protection must be undertaken for the single purpose of stabilizing the bankline at all costs are relatively rare. In practice, almost every worthwhile project will have benefits beyond simply fixing the bankline, but will also have drawbacks in a number of other aspects of river usage. Hence, a multi-functional approach is called for, and this implies interaction between staff in different NRA functions.

- * **Training of relevant NRA staff in the basic aspects of fluvial geomorphology necessary to relate bank form to erosion processes, river regime and human activities.**

While the recruitment of a geomorphologist to each NRA Region is seen as an essential first step in improved bank management, it is unrealistic to expect one individual to be able to perform all of the work involved in bank monitoring, historical analysis and interpretation in a region with hundreds or even thousands of miles of main river. Conversely, the appointment of significant numbers of new personnel is unlikely to be possible. The best alternative is to train appropriate in-post staff in geomorphology, equipping them with the skills necessary to perform basic studies and report their findings to the Regional Geomorphologist. That individual would then be able to concentrate on the interpretation of bank conditions and the formulation of recommendations for action.

- * **Public education on the impacts of human activities on bank stability and the need to conserve bank and riparian habitats through active bank management.**

Many of the practical approaches to active bank management proposed on the basis of this study allow for, or even rely on, public co-operation and support. In order to secure the public's positive involvement, a successful programme of education aimed at raising public awareness is essential.

3. MANAGEMENT ISSUES

3.1 Introduction

There is a balance that needs to be struck between the cost of serious erosion and the price of dealing with it. This price, however, cannot be seen as just the cash price of the "remedy", it must also include budgets for operational maintenance and for post-construction monitoring, the effectiveness of the solutions implemented. Not only is this good management, but it provides essential data to support improvements to the decision-making process in future years. It is the way to ultimate cost-effectiveness and best management practice.

3.2 Monitoring erosion problems

The first requirement of any management scheme is information on the severity and extent of bank erosion along the waterway. This can only be obtained by monitoring the condition and position of banks.

In practice the best form of monitoring may be through morphological mapping of the river banks. Experience gained in this study indicates that a mapping scale of 1:10,000 is ideal because it is large enough to record the important features, but small enough that long reaches of channel can be covered in a few map sheets. To keep the morphological maps up to date, it would be necessary to repeat the observations on an annual basis. The nature of the mapping should be the same as that employed in the map folio which accompanies this study.

3.2.1 The continuation of serious erosion

If interventions are undertaken to prevent erosion, and despite the measures implemented serious erosion continues at a site, then further action will be required. In this case the hard won experience gained from the failure of past interventions must not be wasted but should be used in the planning of further measures. A thorough system of morphological mapping and bank observation can underpin this experiential approach by producing a reliable documentary record of the history of erosion problems and sequence of intervention events.

3.2.2 Changes in the location of serious erosion

If intervention is successful and serious erosion ceases at the original site, it is imperative to monitor the surrounding reaches to check that the intervention has not led to erosion being triggered at another site.

3.3 Monitoring the effectiveness of protective measures

There is no other way of determining how effective any protective measures have been in the reduction of serious erosion except through monitoring. Such monitoring has to be on a sufficiently broad scale to pick up the possible shift in serious erosion to an adjacent site which previously may have been unaffected.

In particular effectiveness has to be considered separately for sites treated differently under each of the three levels of bank protection.

- * Areas where a "managed retreat" policy has been adopted;
- * Areas of structural protection using soft and bio-engineering solutions;
- * Areas of structural protection using "hard" engineering structures.

3.4 Monitoring the effectiveness of navigation policies

Similarly, policies implemented in respect of navigation should be assessed for their effectiveness in preventing serious bank erosion. Such monitoring should have regard to:

- * Boat wash due to normal passage of craft;
- * Within-channel manoeuvring;
- * Boat mooring;
- * Bank-side boating operations such as boat removal.

3.5 Monitoring the effectiveness of controls on the use of banks

The same argument is equally true for assessing the effectiveness of bank management. In particular these need to be considered in relation to:

- * Angling;
- * Livestock access for grazing and watering;
- * Public access - and use for recreation;
- * Conservation areas;
- * Footpaths and tow-paths.

4. PROCEDURAL ISSUES

4.1 Introduction

Dealing with bank erosion on navigable rivers requires a clear understanding of:

- * the allocation of responsibilities,
- * the role of enforcement in management and operational procedures,
- * the need for reviews,
- * the role of monitoring.

Each of these aspects is discussed in the following sections.

4.2 Allocation of responsibilities

There are several causes of bank erosion which may combine to generate significant land loss or damage to important structures. The responsibility for channel care must lie with all users that control these key causes of erosion. Amongst these users are:

- * the users of pleasure craft;
- * developers of sites that include access to the river margins;
- * land owners who introduce bank protection;
- * farmers who allow cattle access;
- * anglers.

It would be useful if this leaflet could be issued to every developer during any discussions which may be held prior to the submission of a formal planning application.

Recommendation: The leaflet prepared as part of this study, which gives guidance on sensible river use, should be made available to each of these groups, so as to increase awareness and encourage individual responsibilities. Furthermore, this leaflet should be distributed to all LPAs with an encouragement to treat the matter of bank erosion as a "material consideration in the planning process".

4.3 Enforcement

Within the powers held by the NRA to enforce channel bank care amongst river users, there should be a concern to minimise bank erosion. Activities that should be policed include boat operations, angling, recreation on the banks, and clearing or cutting of riparian vegetation.

Recommendation: There should be a directive to this effect issued within the NRA to all of the officers who hold an enforcement role.

The NRA should also require early warning from the LPAs of any matters that relate to bank care.

Recommendation: The NRA should inform all LPAs that they wish to be informed, as a matter of priority, of any planning applications which are likely to have an impact on

river banks. Where such developments are likely to have a disturbing effect the NRA should make this clear to the LPA before the application is determined.

Recommendation: The NRA should introduce spot checks, during construction, on any development where a condition has been placed on limiting the impact on the river and/or its banks.

4.4 Review procedures

The NRA will need, from time to time, to review the effectiveness of its policies and practices, with regard to river use and bank integrity.

Recommendation: The NRA should keep a record of all river bank issues with which they are involved. Any of these which require supplementary action or compliance with regulations should be singled out for review as and when necessary.

Recommendation: The NRA should initiate an annual review of the effectiveness of its procedures in terms of safeguarding river banks from excessive erosion. In particular it should review its relationship with both users and the LPAs.

4.5 On-going monitoring

In all of these procedures it is essential for on-going monitoring to establish:

- * sites of active bank erosion
- * structures likely to suffer as a result of bank erosion
- * significant land or amenity losses as a result of bank erosion
- * significant departures from acceptable practice by river users or LPAs.

Recommendation: Data are systematically collated on each of these matters, and scrutinised during the annual review.

5. TRAINING AND EDUCATION

5.1 Introduction

The proper understanding of the nature and causes of bank erosion is a specialised branch of the science of geomorphology. However, the essentials and basic principles of such erosion and its management should be basic knowledge to NRA staff. In addition, the basic principles of responsible behaviour in and around erosion-susceptible river banks can and should be passed on to river users.

5.2 Staff training

Recommendation: As a first step towards improved awareness of these issues this report should be circulated to all appropriate NRA staff.

Recommendation: In addition, staff training should be undertaken through short courses on:

- * the principles of bank erosion processes (causes and mechanisms);
- * the effect of land and river uses on bank erosion.

Recommendation: In addition a series of technical manuals (supported by seminars and field demonstrations) should be prepared on:

- * recognition of serious bank erosion;
- * measuring bank erosion;
- * mapping bank erosion;
- * recognising the causes of bank erosion;
- * dealing with bank erosion.

5.3 Public education

Most of the use of navigable waterways is by the general public involved in leisure activities. This public needs to be informed of:

- * the seriousness of excessive rates of erosion;
- * the principal causes of such erosion;
- * good behavioural practice;
- * the policies and legislation that affects their activities;
- * what the NRA is doing to counter excessive erosion.

Such education can be effectively carried out through:

- * Exhibitions;
- * Publications;
- * Lectures;

* Demonstrations.

In particular these should be available at regional information centres located where a large number of river users would normally congregate, or pass through.

5.4 Increasing awareness amongst Local Authority Officers

While it is true that Local Authority Planning Officers will refer to the NRA for comment on any development proposals that are likely to affect navigable waterways (or which are sited in areas which may be subject to flooding), such officers also have a positive role in respect of planning activities.

It is important that their awareness of river channel processes, including serious bank erosion, should be raised to a level where they can recognise problems in the field and anticipate possible impacts on the bank environment in general, and on bank stability in particular, during the development control process.

5.5 Developers and their consultants

The need to increase awareness of the potential for triggering or exacerbating problems associated with excessive bank erosion amongst developers is clear from the number of cases where their actions have either caused such problems to occur or failed to deal with existing instability in an appropriate fashion. It is a matter not only of public interest that they should have their awareness raised, but also one of their own self-interests. For example, bank erosion will usually adversely affect their development site, with costly consequences, while money wasted on over-designed or unsuccessful protection works may be critical to the success or failure of the company.

In particular, however, there is a case for demonstrating to developers how they may inadvertently bring about excessive erosion through their own actions, and this can be avoided by having a proper understanding of the problem.

6. WHAT NEXT?

6.1 The need for continuous monitoring

The greatest single need is for a programme of monitoring (including mapping) of bank erosion on those navigable waterways where it is believed to be generating adverse financial and/or ecological consequences.

The context for this monitoring is defined in Section 3.2 above. It should include the monitoring of:

- * existing bank erosion (to show its severity and extent);
- * bank protection sites (to establish their status, effectiveness, and any associated positive or negative impacts);
- * bank management sites (where management techniques and practices are used instead of engineered structures).

There should be an annual map up-date in order to provide relevant and current management information.

In addition, as policies for improving the situation are introduced, there needs to be a periodic audit of the effectiveness of such policies. This will provide useful information as policy reviews take place.

6.2 The need for policy revisions

There will always be a need for policy revisions, and excessive bank erosion should be the subject of an annual report and policy review.

There is a need to develop an evolving policy framework that responds to the experience gained and to developments in methods of protection and management.

6.3 The development of a computerised data bank

Management relies on convenient access to relevant information. Much useful information can be stored in a computerised data bank, which, if available through a terminal (or even a stand-alone PC) on the manager's desk, can be an invaluable day-to-day working tool in effective management. Such data banks, if they contain a geographical referencing system, are normal data sources for use within Geographical Information Systems (GIS).

6.3.1 Valuable data for every-day river management

For example, during the course of research into bank erosion data have been collected, for most of the navigable River Thames on:

- * the erosive state of channel banks;
- * bank side land use;
- * the vegetation on/near the channel banks;
- * protective works;
- * angling and public access to the bank;

- * boat moorings

These data, and other relevant river or bank data, can be stored within a computerised data bank (with, or without a GIS link) for immediate retrieval, display and analysis for both management and decision support functions.

6.3.2 Research data

In addition, these same data can be used for the research function. They provide field data against which research concepts can be tested. Such concepts may relate to basic river dynamics, river engineering, bank protection, or the effectiveness of policy implementation. The basic data set is a necessary requirement, and can be shared by many users in a multiplicity of research needs.

6.3.3 A direct link to Geographical Information Systems

Because such data can be stored by geographical co-ordinates (such as the O.S. National Grid), they can be used directly within Geographical Information Systems. This will strengthen the research capabilities of, and provide a knowledge base for, many of the NRA divisions, including Technical Support, as both contemporary and historical records could be stored in the same system. The approach advocated here is entirely consistent with the creation of a data base for the whole river basin. A file showing river bank conditions could nest comfortably within a much larger archive covering many aspects of the river and its riparian corridor.

6.3.4 The cost savings in data access

Although it is impossible to quantify either the costs of "loosing data" (as may happen due to changing personnel or re-organisation of departmental responsibilities), or the costs of manually searching for data through paper records, the general experience of those working with computerised data banks is that they are extremely cost-effective in terms of tracking down data, and in enabling the data to be accessed very rapidly.

6.4 The need for operational guidelines for each region

The recommendations and observations contained in this **Policy Guidance Note** need to be tailored to the specific needs of each NRA region. For example, adjustments may be required to accommodate differences between navigation on the Thames and navigation on the Broads. Each region will wish to adapt these **Notes** as is appropriate for their own circumstances.

Finally, it is **recommended** that a review is undertaken of all rivers to establish those sections which are most sensitive to change. It is these sections where most concern should be expressed if affected by development proposals or subject to intensive pressure by those using the river for whatever purpose.