Introduction

1 The Manual of River Restoration Techniques

Welcome to the third edition of the Manual of River Restoration Techniques (the Manual) produced by the River Restoration Centre (RRC) based in the UK. This update has been funded by the Environment Agency (EA), Scottish Natural Heritage (SNH), Scottish Environmental Protection Agency (SEPA), the Rivers Agency (RA), Natural England and the EU-LIFE+ Information and Communications project RESTORE. The overall aim of the Manual is to promote good practice in river restoration and management so as to support a healthy river ecosystem and, wherever possible, work with natural processes. The updated Manual contains 64 technique examples from 35 different project sites across the UK illustrating a wide range of approaches for different types of river.

Each example describes (a) how a particular objective of river restoration or management has been planned and developed by using a particular technique, (b) what the completed works comprise, and (c) how the technique performed and how it has subsequently evolved.

The work to update the Manual was carried out by RRC in 2012/13 with significant assistance from practitioners associated with the different sites. Seventeen new technique examples from different project sites have been added to the 47 existing examples described in the second edition (RRC, 2002). The new technique examples have deliberately been written in a more technical, but equally accessible, style to the existing entries. Examples range from civil engineering work on large projects to small-scale interventions using local labour and equipment.

The existing examples were updated wherever possible in the light of the performance of the techniques and the evolution of the site concerned. In both the existing and new technique examples, technique costs are based on the information provided at the time of the project completion. No inflation has been factored in. Additional information comprises a 2013 update page and a box which includes WFD, environmental designation status and monitoring information. Overall however, whilst the existing techniques have been converted to the new Manual style, with the exception of some very minor changes and, the addition of both common and the accompanying Latin terms for species, they have not been reworded.

In this new electronic version of the Manual, each section of this Introduction can be selected individually. There is an **Interactive map** of all sites. Furthermore technique examples can be viewed by River name, Site Designation, Technique and WFD mitigation measure (**here**). Techniques can be searched for using a simple table format to allow for easier navigation on mobile devices.

Whilst this Manual provides a stand-alone document it is recommended that it should, where necessary, be used in conjunction with other valuable information that is available from a range of sources. As such the RRC has compiled a **reference list** of supporting documentation, guidance and tools which is linked to this Manual. Additionally, where specific information is available that relates to a technique example, this can also be accessed directly from the specific study.

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Critically, the Manual is not a design manual: the techniques cannot be transferred to another site without due consideration and appropriate design (*see Section 4*).

These techniques were developed to suit site specific criteria and may not apply to other locations

2 How to use The Manual

The Manual is aimed at all river restoration and river enhancement project practitioners who might include river engineers and managers, environmental practitioners, planners and river trusts. It is an aid to identifying potential techniques for use in river restoration projects or for ensuring that river management works comply with ecological or geomorphological requirements. In many of the examples the primary driver has been to achieve a required degree of river restoration.

However, other examples demonstrate how environmental features and natural fluvial processes have been incorporated into projects whose primary purpose is, for example, flood risk management or urban development.

Within each of these sections, different techniques are illustrated through the examples. For example, in *Part 1 - Restoring meanders to straightened rivers*, eleven different techniques are shown: e.g. (*1.1*) *New meandering channel through open fields*; (*1.9*) *Reconnecting a remnant meander*; etc. See **Table of Contents** for the full list.

In this updated edition of the Manual, the river site in each example has been given a generic classification (*see below*) to help the user understand the type of river in which the technique is used. With due consideration, the user might conclude that the technique, or elements of it, can be used successfully in other types of river.

The techniques are divided into sections of broadly similar restoration or management objectives

1 – *Restoring meanders to straightened rivers*
2 – *Enhancing redundant river channels*
3 – *Enhancing straightened river channels*
4 – *Revetting and supporting river banks*
5 – *Modifying river bed levels, water levels & flows*
6 – *Managing overland floodwaters*
7 – *Creating floodplain wetland features*
8 – *Providing public, private and livestock access*
9 – *Enhancing outfalls to rivers*
10 – *Utilising spoil excavated from rivers*
11 – *River diversions*
12 – *Removing or passing barriers*

The generic classification describes

(a) the natural substrate in the locality, expressed as:

- Silt/clay
- Gravel
- Chalk
- Sand
- Estuarine

And (b) the stream energy, for which mean longitudinal slope of the river is used as a surrogate:

• High energy	slope above 1%	(steeper than 1 in 100)
• Medium energy	0.125% to 1%	(1 in 800 to 1 in 100)
• Low energy	slopes below 0.125%	(gentler than 1 in 800

Therefore an upland river with large gravel substrate in a steep catchment would be classified as 'High energy, gravel' and a small lowland chalk stream would be classified at 'Low energy, chalk'.

Each case example has a drop down box that identifies which Water Framework Directive (WFD) mitigation measure(s) the technique might deliver. These measures are different for England and Wales, Scotland and Northern Ireland - **see reference list**). Each example also indicates whether the river has any designation for nature conservation. For example, the site may be a Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar or a Local Nature Reserve (LNR).

When using the Manual, the planner or designer must consider whether the use of any single technique or combination of techniques, or some element of one or more techniques, is appropriate to the overall restoration or management objectives and to the type of river at their site. In most cases, such consideration will be part of the investigation, planning and design work associated with a project as described in *Section 4*.

3 Understanding your site

Use of any technique must be considered in the context of your site and its catchment, including:

- Natural environmental processes (e.g. hydrological, geomorphological, ecological);
- Existing development, land ownership and future development plans;
- Functional use (e.g. conservation, amenity, flood risk management, angling);
- Local site conditions (e.g. existing flora and fauna, river flows and levels, sediment movement, geotechnical);
- Operational window of opportunity (e.g. weather, budget and time); and
- Relevant policies, strategies, designations and regulations.

The objectives for river restoration or the management of a site must sit logically within the policies and plans for the catchment. These include, in particular, the plans for the relevant WFD catchments, development plans, flood risk management policies, and plans of established local groups seeking to implement a catchment-based approach.

Catchments can be rural, urban or a mixture of both. The river flow regime, which is characterised by river slope and dominant catchment geology (as reflected in the generic classification for case example sites), impacts on the sediment movement and habitats at the site. Urban development and land management practices in the catchment can further significantly affect the flow and water level regime, the water quality, the riparian zone, and the sediment movement at the site. These in turn affect the potential for improving habitat and ecological quality at the site.

The mechanisms of river sediment movement are complex. Overall, sediment movement depends on the stream power generated by the river and the sources of sediment. However, channel shape and flow patterns also influence sediment erosion and deposition locally. For example, the outside of a meander bend is a zone of erosion, whereas the inside of the bend is a zone of deposition. Also, zones of high turbulence – for example downstream of a weir or other structure – will tend to result in localised scouring, while areas of slack water – for example behind a flow deflector – will tend to result in localised deposition. This is a simplistic explanation for a very complex process and the geomorphology of the river where techniques are to be used needs to be fully understood (*see the* **Environment Agency Sediment Matters Handbook**).

In many places, existing development and associated modification of natural river features may preclude comprehensive river restoration. For example, river banks may have hard revetment or the river itself may have been engineered to the detriment of the biological continuity and habitat. A key part of achieving ecological improvements in such locations will be to introduce features and modifications to the channel so as to create new habitats, improved biological continuity and more 'natural' flow conditions. Several case examples in the Manual illustrate such techniques.

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4 Planning, design and management of restoration works

As explained in *Section 1*, the techniques in the Manual might be used in works ranging in size from small-scale interventions using local labour and equipment to large civil engineering projects. Some projects will have additional objectives such as flood risk management and amenity in addition to river restoration. Whatever the scale or type of restoration works, there is a necessary sequence of activities which might include feasibility assessments, outline design, detailed design, implementation, post project monitoring and assessment and maintenance.

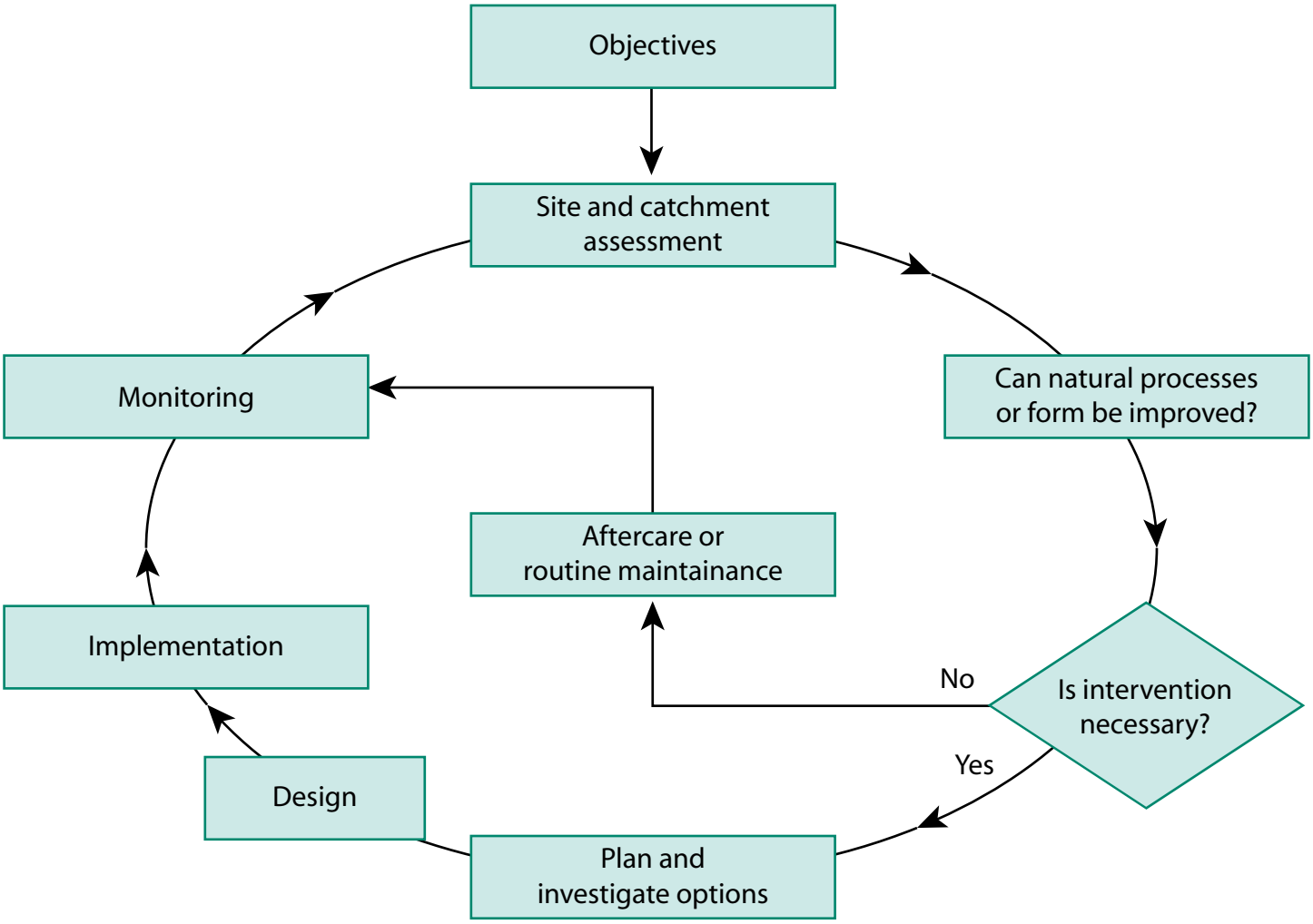

Figure 1 shows a generic 'management cycle for river restoration works' in which some form of restoration is implemented at a river site. The activities of the management cycle apply to both the river environment (e.g. ecological processes) and to the physical works involved with the technique (e.g. designing a bed control structure). Adapted from **EA Fluvial Design Guide**.

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Key points related to carrying out restoration works are given below:

- The starting point for considering the use of any river restoration technique is to develop clear objectives bearing in mind, among other factors, the assessment of the existing site and relevant attributes of the catchment.
- The initial assessment of the works site will build on past assessment, survey or monitoring activities to decide the degree of restoration that can be achieved.
- Detailed assessment is likely to require further specific studies to plan and investigate options once the decision to make an intervention is made. 'Plan and investigate' may cover environmental studies, feasibility assessments, engineering studies (e.g. foundation investigation, hydraulic loads, etc.) and socio-economic studies. The term 'intervention' is used to describe an action that changes the physical state of the river).
- Some design activities must always be carried out to establish the composition, size and location of the physical works and to specify appropriate aspects of implementation and maintenance. The extent and the output of this design work will depend on the nature and scale of the physical works and how they are to be implemented and maintained.
- In all cases, the design and implementation must be fit-for-purpose and include multiple design phases depending on the project complexity. Large civil engineering projects need to involve appropriately qualified engineers and specialist contractors. This is particularly important where the elements of the works are subject to significant loading or public safety is involved (e.g. CDM regulations). At the other end of the spectrum, some river restoration works will necessarily be low-cost and carried out with volunteer labour and simple equipment, but still to a predetermined design.
- When the works are completed, an appropriate monitoring and maintenance cycle should be established to appraise success and the requirement for any adaptive management. The **RRC's River Restoration Monitoring Guidance** can assist in determining the appropriate level and type of monitoring.
- Where restoration techniques involve establishing vegetation (e.g. bankside willows or marginal reeds), aftercare should be available until the plants are well-established, or allowance for the lag-time associated with natural colonisation must be made explicit.

The process of monitoring the state of the site following the restoration works should lead to (a) confirming that the objectives have been achieved and there is no need for further intervention, and (b) a simple on-going cycle of monitoring and maintenance. Often, however, some further small intervention may be needed to 'fine tune' the state of the site if the environmental objectives are not being achieved. This process of making successive interventions to optimise or modify the restoration works is referred to as 'adaptive management'.

For further guidance on river engineering works, see the Environment Agency's **Fluvial Design Guide**.

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