# River Weirs – Good Practice Guide

## Guide - Section B3

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## 2.4 Environment

### 2.4.1 Introduction

#### (i) General

Weirs have formed one of the fundamental means of controlling rivers for centuries. They have been constructed for diverting flows to provide power to water-mills; creating a deliberate obstruction to allow fish to be caught; as a means of channelling water for its use in potable water supplies and electricity generation; or simply as a means to create increased depth to allow navigation. When weirs have occasionally been introduced solely for conservation purposes, it has generally been in the upper river valley to vary habitat by creating longer glides and pools, or on lowland rivers to reduce the impact of low flows and to retain wetland. With the advent of alternative modes of transportation as well as a reduced reliance on water as a source of power, the need to control rivers with weirs diminished and with it the commitment to maintain many of Britain's weirs. The exception is perhaps the large number of weirs that form an integral part of Britain's waterways. The continued maintenance and ultimate replacement of these weirs is fundamental to the operation of the canal and navigable river system, which is going through a phase of renewed interest and investment.

**Figure 2.23 A mill weir**

Outside the waterways system, the declining requirement for weirs raises the commonest single environmental problem associated with weirs (see Case Study E). Over time they may have become valued for themselves as historic features, or as the means whereby water has been impounded and now supports adjacent wetlands. They are often more of a liability than a benefit in terms of flood control but for environmental reasons their preservation and frequent repair become desirable. River managers are therefore frequently faced with the decision as to whether to undertake expensive repairs to crumbling weirs or knock them down. Except for weirs associated with flow gauging stations, the construction of a new weir is a relatively rare event. However entire replacement of an existing weir on a closely adjacent site is not uncommon. All these options will have both positive and negative environmental impacts and a strategy for action needs to be established on the merits of each individual case.

The requirements set out in both national and international environmental legislation to conserve the environment are steadily increasing, but should not be considered especially onerous in relation to weirs. However, there is a clear requirement to carry out an Environmental Impact Assessment (EIA) for any scheme to construct, rehabilitate or demolish a weir. Very few individual weirs are listed but they may be protected as part of a listed historic landscape, such as an eighteenth century landscaped park, or else require protection as an integral part of a wetland SSSI. With careful planning and the inclusion of environmental assessment at an early stage, the long-term viability of a preferred engineering option (construct from new, refurbish or remove) should be enhanced.

To focus the reader's attention, Section 2.4.2 first introduces the positive and negative impacts of weirs. Then specific environmental issues are discussed in relation to landscape, fisheries, heritage, water quality, recreation, and nature conservation.

### (ii) Sustainability

There are lots of different interpretations of the concept of sustainability. The basic definition of "providing for today's needs without compromising the ability of future generations to meet theirs" can be applied in many ways, and is far too esoteric for a practical guidance note on weirs.

In the context of weirs, sustainability is more likely to be achieved if all the stakeholders have been consulted, and their views taken account of in the development of the project.

Specific sustainability issues relating to weirs might include:

- Avoiding creating a structure that has a high maintenance requirement
- Making provision for fish and other wildlife
- Making the best use of recreational opportunities provided by the weir (a facility that is valued and well-used is much more likely to be sustainable than one that is regarded as a constraint on recreational activities)
- Ensuring that the structure does not pose a safety risk to users of the river and its environs
- Ensuring that the works add to the environment rather than detract from it.
- Paying due attention to materials and construction methods
- Taking account of future development proposals that could be affected by the weir, or that could have an impact on the weir.

**Figure 2.24 Low weir for environmental improvement**

*This low weir was constructed for environmental enhancement. It has a modest drop so as not to obstruct fish movement, an uneven crest to create interest, and dumped rock on the banks downstream to resist erosion. However, the designer has neglected to confine the river upstream, and there is a risk of the weir being by-passed on the far bank. Construction of a low stone wall would easily solve this problem.*

### 2.4.2 The direct impacts of existing weirs

Table 2.2 below presents the principal physical and environmental effects associated with the operation of weirs (i.e. once they have been constructed).

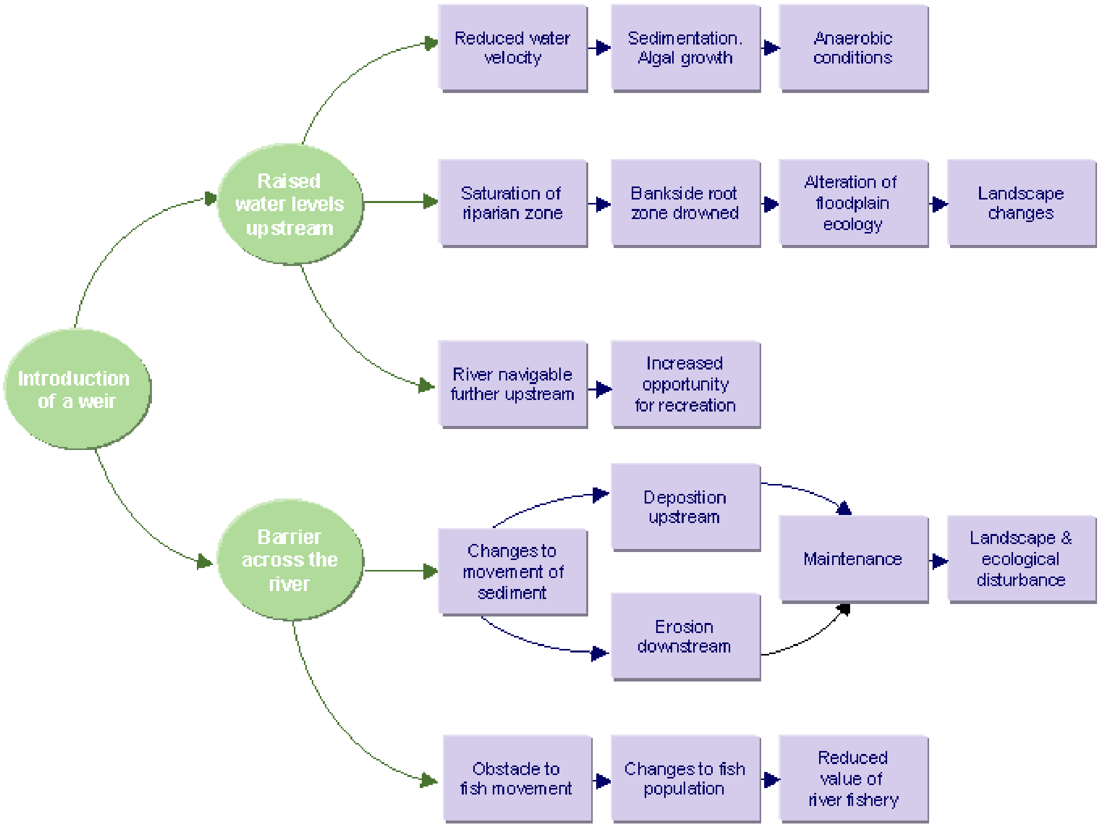
**Table 2.2 Principal physical and environmental effects associated with weirs**

| Parameter | Upstream of the Weir | At Weir | Downstream of the Weir |
|---|---|---|---|
| **Velocity of flow** | Slower and more uniform | Rapid | Turbulent and varied |
| **Depth** | Deeper with little variation | Shallow | Variable |
| **Wetted area** | Consistent area, even at low-flow | Uniform or varied according to design; notches and fish passes reduce area at low-flow | Varies in response to changes in flow |
| **Water levels** | Variation tends to be relatively small over a wider range of flows, especially for gated weirs | Fall in water level at weir is highest at low flows, and tends to reduce with increasing flow | Water level in the channel downstream varies in response to the flow |
| **Effect on flora and fauna** | Maintained high water table for floodplain wetlands. Animals and plants favoured by ponded conditions and fine sediment predominate – e.g. water lily, swan mussels. However, the overall impact may be lower diversity of habitat for flora and fauna, and water quality may suffer in low flow conditions. | A weir may present an obstruction to the movement of fish and other species. Increased depth of water upstream may drown fish spawning areas. However, exposed surfaces can provide habitat for algal and moss growth. Where slopes are not steep and fissures are present, rooted crowfoot can take hold. Walls are favoured sites for dipper nests | Gravel river beds and tugging currents create habitat for milfoil and invertebrates such as blackfly and stoneflies.<br><br>Sedimentation frequently creates spawning areas, particularly for salmonids and rheophilic species. |

Further guidance on the environmental impact of river works can be found in the Environment Agency publication Scoping the Environmental Impact of River Channel Works and Bank Protection (2001).

The primary effect of a weir, to increase the depth of water upstream, can cause a significant change to the character of a river. Figure 2.25 below illustrates some of the impacts on a river resulting from the operation of a weir (as opposed to the construction process).

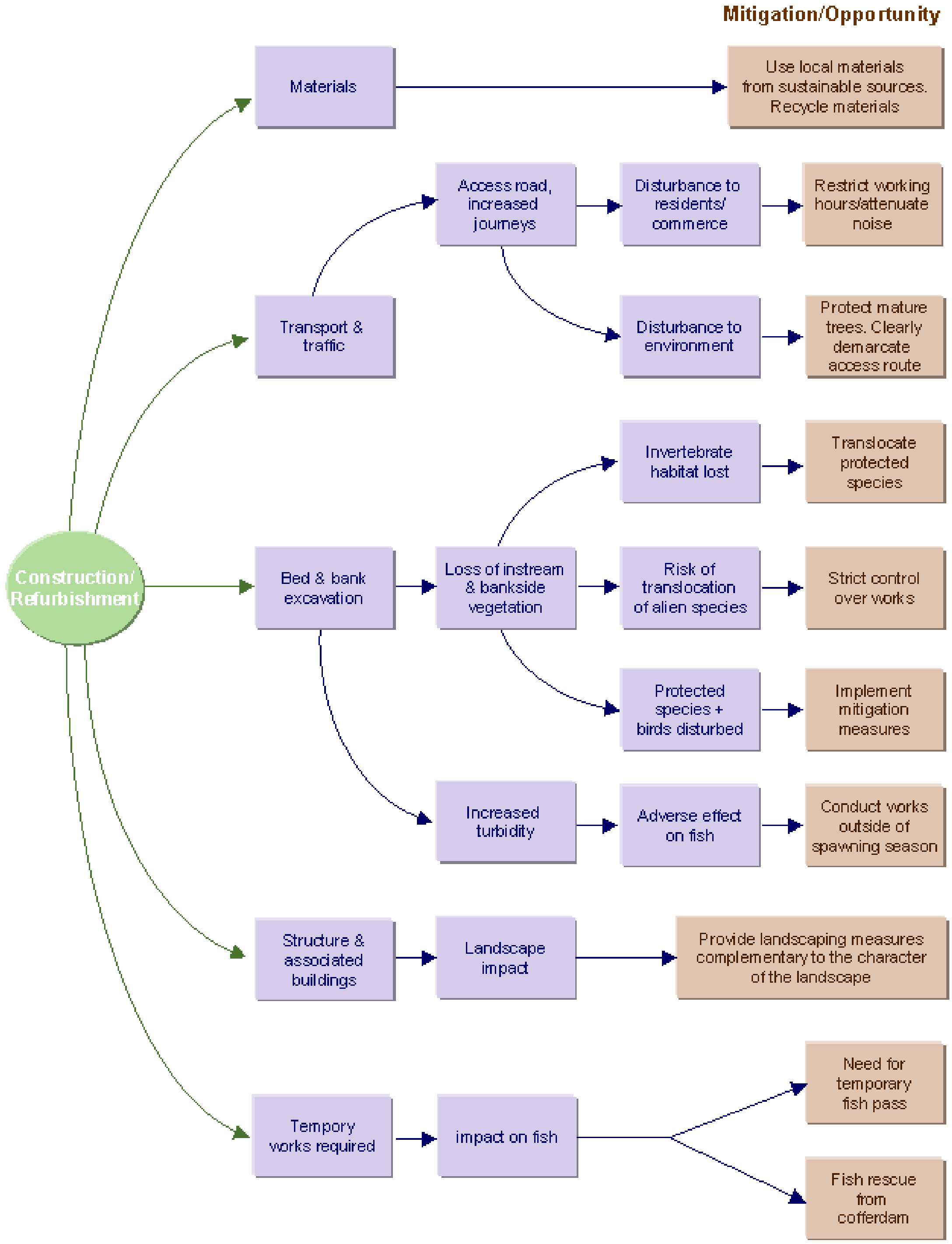
**Figure 2.25 Examples of environmental impacts resulting from the introduction of a weir**




Slowing and deepening a river in the upper reaches of the river valley may give it characteristics similar to those experienced in the middle reaches. Weirs create a more uniform environment in the river upstream, with consequential more uniform ecology and biodiversity. Areas that typically exhibit distinguishable characteristics lie immediately downstream of a weir where there is fast, broken water synonymous with the upper river valley. Hence weir pools often hold fish species more commonly found further upstream, including trout and barbel. Coarse sediment deposited downstream of the weir pool may be similar to that found in the upper river course, allowing fish that would not normally spawn so far downstream to deposit ova. In such an instance the weir has firstly created an upstream habitat (a primary impact) and subsequently allowed an upper river valley species to extend its territory thereby creating competition between species (a secondary impact).

Table 1.1 in the introductory section presents positive and negative potential impacts resulting from the existence of a weir. The impacts presented do not include those that may occur during the construction, refurbishment or de-commissioning of a weir. These are processes that may have short and long-term impacts, and which should be identified through an appropriate level of environmental assessment. Figure 2.26 presents some of the impacts commonly associated with construction process and introduces the concept of including ‘opportunities’ for mitigating an impact.

**Figure 2.26 Examples of impacts resulting from the construction of a weir**




The majority of impacts that result from construction works can generally be mitigated. Mitigation measures are addressed in outline in Section 1.4. The secret of success rests with identifying the potential impacts in the early stages of planning, and developing appropriate mitigating measures in full consultation with stakeholders. A maintenance programme similar to an environmental management plan may be developed as part of a duty of care, to ensure that the mitigation measures are permanent. When a weir is removed to return a river reach to its original form, mitigation measures, other than those required to ensure channel stability, may not be necessary.

### 2.4.3 Environmental issues

The main scenarios of repair, new construction or demolition were introduced in Section 1.4. They are discussed in more detail below, with an emphasis on the environmental issues to be addressed.

#### (i) Repairing/maintaining weirs

This is the commonest situation involving weirs. Detailed considerations will include:

- Initial survey and consultation. This is the most important first step and should involve discussion of whether to repair as well as how to do it, or indeed, whether to do nothing apart from maintain the structure in a safe condition. Ecological and archaeological features of the weir, which give it value, need to be well understood in order to protect and enhance them. These might include, for example, nesting grey wagtails or historic features such as fish traps or mill sluices. Engineers should not proceed with repair without consulting the relevant environmental bodies, including fisheries officers to establish the need for fish passes. A structured approach to environmental screening should be adopted, which may lead to the need for an EIA.
- Use of materials and design sympathetic to the existing weir. Thus crude patching with concrete may be inappropriate though concrete may be used if carefully designed and/or disguised, for example, by masonry facing (see Case Study M). Introduction of steel sheet piling to a weir where none is already present will similarly need careful design. At the repair stage, opportunities may arise to enhance an existing weir, by for example cladding an ugly concrete structure in timber.
- Careful consideration of associated features. Many historic mill weirs are connected with a complex of mill-races and subsidiary weirs and pools, which are of ecological and historic importance. These should not be swept away as part of the restoration process. Similarly repair of bridges and lock structures, and the construction of associated new headwalls and fencing, need to be carried out sympathetically. “Scaffold-tube” fencing should be avoided whenever possible (see Figure 2.27 and contrast this with Figure 1.3).

Maximum opportunity should be taken for enhancements as part of restoration (see Case Study M). Most commonly this may involve creation of fish passes and establishment of nest sites and roosting ledges. However it may also involve maintenance to mill ponds or associated tree planting.
If a weir already exists there may be opportunities for local small-scale energy generation. Such an opportunity for sustainable power generation may tip the balance in favour of rehabilitation as compared with demolition (see Section 2.3.11).

**Figure 2.27 Unattractive fencing**

*There may be sound safety reasons for the proliferation of fencing at this side weir, but the end result is very unattractive, with the fencing dominating the scene. Wherever possible use should be made of more natural materials such as timber, or a more attractive design of fence (see Figure 1.3).*

### (ii) Constructing new weirs

The most common reason for the construction of a new weir is for flow gauging (discharge metering) stations, although low weirs are also sometimes built to improve habitat diversity and in association with current deflectors to reduce erosion. In addition replacement of existing weirs can involve starting entirely afresh on an adjacent site. In the latter situation there is a need for a sympathetic understanding of and reference to the structure that is being replaced.

The first decision will be whether to construct a weir at all and this should be taken with the help of the relevant environmental bodies. If sensitive habitats or other features are likely to be affected by the higher water level immediately upstream of the weir, then careful consideration will be needed before deciding to go ahead. However in environmental terms impounding upstream areas is often a wetland enhancement opportunity. New weirs should be located in a way that their construction does not involve the felling of mature trees or removal of other valuable features.

Any new weir will create a new obstruction and so it is important that appropriate provisions are made for the passage of fish and boats. The layout of the different elements of the weir should be considered carefully, for example in the context of providing conditions suitable for fish and canoeists. Otter passes may sometimes be necessary so that otters are not forced to cross adjacent roads at periods of high flow. (see Figure 2.31)

As with repair of weirs, the associated infrastructure is often visually and sometimes ecologically more problematic than the weir itself. New head walls and wing walls should be set within the line of a bank and be married into the surroundings. River banks downstream of a weir are often subject to erosion. Heavily engineered solutions to this problem should be avoided, so solutions such the use of willow and reed may be preferable to concrete or very crude stoning. Fencing and signage should be visually consistent. Footbridges require consistent and sympathetic design for handrails, kick-boards, ramps and steps.

Materials should be carefully selected. In many areas, stone, brick and timber are generally most appropriate to the river landscape although these may be needed in association with concrete in order to provide a sufficiently robust and durable structure.

The walls beside a weir are often very steep and visually raw for some time after construction especially if capped by crude steel railings. In these circumstances planting climbers to hang over the edge is desirable and relatively cheap. Native plants might include wild clematis, ivy or honeysuckle although in an urban situation, vigorous plants such as *Rosa mulliganii* or even Russian vine may have a place. Appearance can also be improved by adopting a less uniform finish to concrete surfaces, such as exposed aggregate. Whatever the final form of the works, it is important to make sure that the scale is appropriate to the setting, and that any maintenance requirements are fully appreciated from the outset.

Weirs are especially valuable for birds such as dipper and grey wagtail, and plants such as mosses and liverworts if there are chinks, holes and uneven surfaces. Clearly too many holes imperil the structure but it should still be possible to design in pipes, bars and ledges for nesting birds and not automatically create smooth surfaces everywhere.

Weirs by their very nature will be silt traps and this may lead to the need for regular maintenance, which is both expensive and creates regular disturbance to habitat. Keeping a watercourse as natural as possible may ultimately be more sustainable

**(iii) Removing weirs**

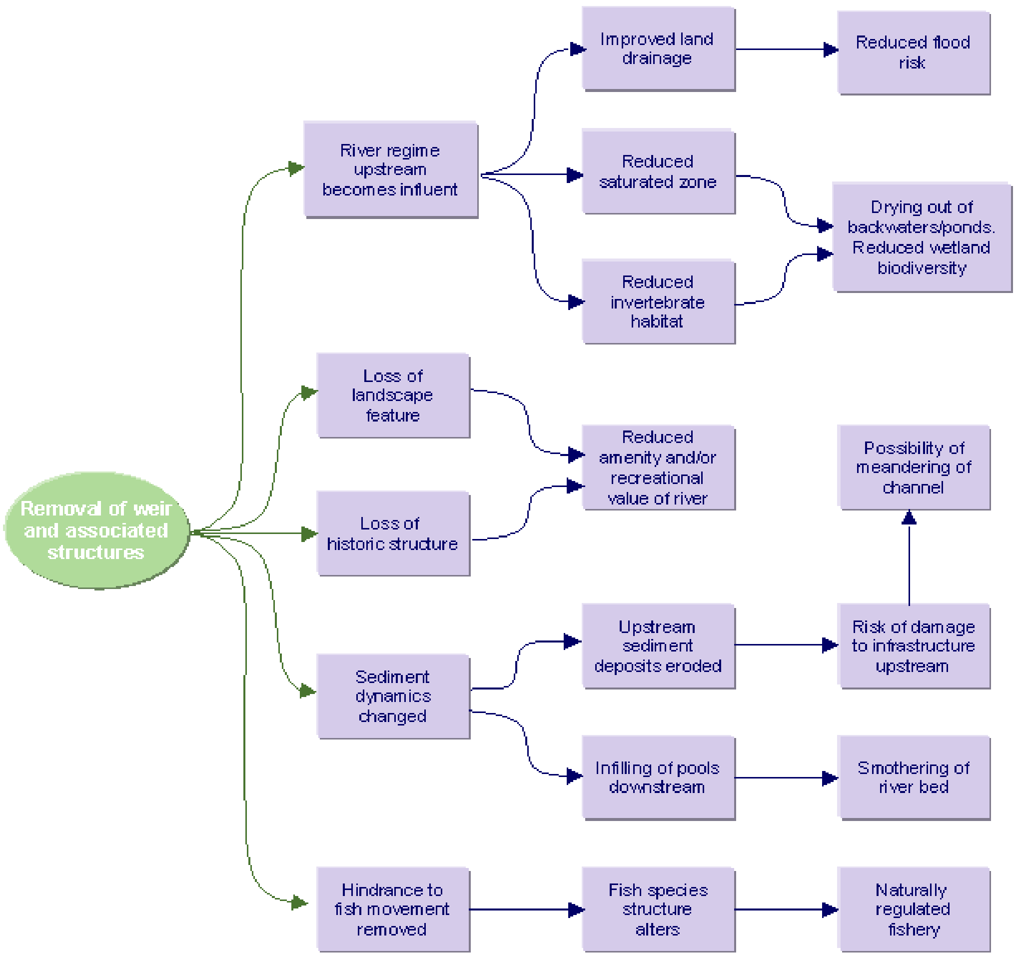
The circumstances for removing a weir are generally associated with a reasonable desire to return a river to its natural form. In Europe and America there is increasing support for the idea that an unmodified river is more dynamic and therefore likely to support a wider range of habitats and biodiversity. However, to return a river to its natural form would require more than simply removing a few obstacles. For instance to return the River Thames to its natural, braided form in the lower valley would require the removal of structures introduced by the Romans two millennia ago, which channelled as well as deepened flow. Nonetheless there are many circumstances, notably upland chalk streams, where weir removal is a benefit. It is important to make decisions based on a fundamental understanding of the geomorphology of a channel.

River managers who consider removing a weir may find themselves facing a conflict of values. While returning the river to a more natural state might have an overall benefit for habitat and landscape, the weir may have intrinsic historic or landscape interest. It may also support navigation or adjacent wetland as well as providing ecological niches for certain specialists such as grey wagtails nesting in the walls or water voles dependent on impounded water immediately upstream. There is also a debate among fishermen between those who favour a wilder river with smaller fish and those who prefer a more artificial system impounded by weirs in which fish are stocked and where there may be fewer of them but larger specimens. Occasionally, the removal of a weir may allow the migration of coarse fish species into a trout fishery, which would clearly be an unwelcome consequence. In all such circumstances there will need to be proper consultation and discussion between environmental specialists and stakeholders before the decision is taken to remove any weir, and removal will tend to be easier to achieve on smaller more upstream reaches of watercourses and in rural areas where river movement may be less of an issue. Where they exist, Water Level Management Plans will also be an important tool in decision taking.

When taking a decision to retain or remove a weir, the first question to ask is 'Why is it there?' If it is not needed for flood defence or to prevent erosion upstream, and the original reason for its existence is unknown or now invalidated, then the logical next step may be to remove it. That is, provided that it is of no intrinsic heritage interest and does not impound water to create important wetlands. The second stage is then to carry out a survey of the river in order to establish whether the removal of the weir would imperil the foundations of buildings or risk the survival of dependent wetland habitat. Sometimes it is just as easy to reduce the height of the weir crest, which is cheaper and also leaves some archaeological interest in the river-bed. If there is a risk that the removal of the weir would lead to a chasm-like watercourse, then berms which grade into the channel may mitigate this.

Figure 2.28 presents some positive and negative environmental impacts that may result from the removal of a weir. It should be appreciated that certain positive aspects on one river may be negative on another.

**Figure 2.28 Examples of impacts that may result from the removal of a weir**



### 2.4.4 Landscape and visual issues

Perhaps the most visually important structures on rivers are bridges, many of which have long been listed and protected. Weirs however may often come a close second in importance on the river scene. Many of them are equally historic and some, such as the spectacular medieval mill weir below Warwick Castle, form an integral part of important listed landscapes. The drama of falling water has been exploited by landscape designers from earliest times from the makers of Moghul gardens to the English eighteenth century landscape school. Very occasionally there have been inspiring modern weirs, one of the best in Britain being the weir below Pulteney Bridge in Bath designed by Sir Hugh Casson (see cover photograph). Yet weirs are seldom valued on a par with bridges. When building a new weir, the opportunity to make something really spectacular is seldom seized or budgeted for. When repairing an historic structure, it is often crudely patched in concrete or steel. Landscape architects or architects should be involved in design or repair of all weirs of reasonable size.

Section 16 of the Water Resources Act 1991 imposes a duty of care on the Environment Agency to protect sites of nature conservation interest and to take account of any proposals that may impact upon their amenity. Furthermore, there is a requirement to promote conservation to enhance the quality of the aquatic and related environment for the benefit of wildlife and people. A respect for the visual quality of a weir and its river setting is embraced by this duty of care. The following specific issues should be considered:

**Scale.** The structure should fit comfortably into the river setting. It can be dramatic but over-dominant structures such as bridges and gantries should be minimised.

**Plan**. A weir does not always have to take a right angle route from bank to bank. A diagonal or curved weir is often attractive - Casson's famous weir at Bath curves across the river at a deliberately oblique angle from the bank (see also Case Study K).

**Materials**. In terms of cost and construction, concrete and steel may often be necessary, but especially when repairing old weirs built of other materials, brick facing or stone copings to concrete walls should be considered. Timber can also be used to mask the cruder features of some modern weirs. When concrete is adopted it should be used imaginatively. In comparison to the world of architecture and structural engineering, there is often a lack of basic knowledge of the different concrete finishes that are available to engineers responsible for weirs. The need for consultation with specialist companies and also training is evident in this area (see Case Study M).

**Clutter**. Associated fencing, signs, operational buildings, lighting, bank protection, certain kinds of fish pass and access roads all need to be considered in relation to the overall design.

### 2.4.5 Fisheries

#### (i) General

Many weirs are constructed low down in a river's course where stream velocities and surrounding landuse practices differ significantly from those in the headwaters. By altering the regime of a river, weirs may interfere with its natural ecological progression. The rivers of England and Wales are often described by a fish zone classification system that reflects the type of water synonymous with, rather than the actual species present. Upland headwaters are referred to as the "trout zone," downstream of which is the "grayling zone," below which is the "barbel zone," and finally the "bream zone" in the lower river course above the tidal zone. The construction of weirs may extend one zone at the expense of shortening another.

In England and Wales river fisheries are mainly of interest to anglers. The 'coarse' fish species, that include pike, carp, chub, roach, dace, bream, barbel, perch and gudgeon are no longer captured for consumption. They once were, and were the reason for many weirs being constructed to allow the installation of fish traps. Due to the diminishing returns of eels and elvers to Britain's rivers, traditional eel fisheries are no longer an integral part or reason for the function of a weir.

The migrational habits of salmon and sea trout are vital to their continued existence and are well understood. However, it is increasingly evident that all fish species have a need to migrate, although the distances involved are generally not so great. Fish migrate for a variety of reasons, including spawning, colonisation, feeding and shelter. Where obstacles limit the movement of certain coarse fish species the ability to form large spawning shoals is reduced and lower stock recruitment, population depletion and isolation may follow. This can be exacerbated during flood events when fish swim down weirs to take refuge in the main channel. If there is no fish pass in the weir, these fish may not be able to return upstream.

The ability of fish to swim upstream over a weir is dependent on the type of fish, its size and physical condition, the drop in water level, the velocity of flow of the water, and even the temperature of the water. Case Study G gives some guidance on this subject.

**(ii) Angling**

Angling is one of Britain's most popular pastimes, and it goes without saying that the interest of anglers should be considered when any works on weirs are being planned. Indeed, anglers are likely to be attracted to weirs because fish tend to congregate in the water downstream of the weir. However, it should be appreciated that the interests of anglers and those of fisheries officers do not always coincide. Early consultation with both groups offers the best way to avoid problems when weir works are undertaken, particularly in the case of rehabilitation or demolition of an existing weir that is known to be used by anglers.

### 2.4.6 Heritage and Archaeology

The Romans introduced water mills to England and the 'Domesday Book' records almost one million water mills. The vast majority of these mill sites can still be accounted for. A classic group of historic weirs, mill races and sluices, which has been respected by the modern water industry, can be seen on the Great Ouse at Godmanchester.

From the seventeenth century, weirs were constructed on many of our major rivers to allow sufficient draft for boats. On the Thames there were flash locks made of vertical timbers called rymers against which rested wooden paddles with long handles. When a boat was to pass, the paddles were pulled up and the rymers removed. The water which previously been dammed behind the weir poured through in a torrent or ‘flash’, the boats shooting the rapid like a canoe. Amazingly there are an estimated 11 surviving paddle and rymer weirs on the Thames. The conservation of these is undoubtedly important.

In the Industrial Revolution many weirs were adapted or built for textile and paper mills and these in turn have begun to be valued as part of our industrial heritage. At the same time weirs were built to impound lakes in parks and gardens. At Ashburnham in 1762, Capability Brown adapted the old mill weirs for a series of cascades. Many of these weirs are now in a poor state of repair. At Honington Hall in Warwickshire in 1987, the then Water Authority rescued from imminent collapse an eighteenth century weir adorned with sculptures of water gods.

Many weirs contain the foundations of earlier weirs buried within them well preserved in the permanent damp conditions. Repairs carried out in 2001 to the weir at Greenham Mill on the River Kennet revealed Elizabethan timbers at the base of the structure. Having been de-watered it was too late to save them but they were accurately surveyed in association with English Heritage and dated by dendro-chronology. Weirs sometimes impound adjacent areas and so preserve related structures that remain buried in the saturated ground. These include fish traps that formed an integral part of some weirs, designed to catch the loosely named “coarse” fish as well as elvers (migrating upstream), and silver eels (on their way down), lampreys, salmon and trout. Weirs are often part of a larger historic river landscape including bridges and sluice gates. They are often an important part of the amenity of a valuable mill house, which is also someone’s home.

When considering repairing or removing a weir, the first stage in heritage terms is to do a search of the Sites and Monuments Record (SMR) and consult the County Archaeologist. The latter will be found within the County Archaeological Services in England and Welsh Archaeological Trusts in Wales. If the weir turns out to be part of a Scheduled Ancient Monument or listed historic landscape, then English Heritage may need to be involved. However it is a remarkable fact that very few weirs, except those that form part of larger important historic landscapes, are listed in any form and very often little is known about them. An archaeologist with good local knowledge can generally do a valuable map regression and there are sometimes good papers on the water mills of a particular river in the County archives. There is a pressing need to set up an asset register survey of these sites. Such a project is being commenced in the Thames Region. The best national audit of weirs is arguably that which is held by British Waterways but it is of course restricted to their navigable waterways.

Following a desk-top search it is desirable that an archaeologist maintains a watching brief and if divers go down to check foundations for structural problems, they should ideally be trained to look out for signs of archaeological interest such as old timbers. Any finds should subsequently be recorded and as much as possible left in-situ.

With the exception of Treasure Trove, ownership of artefacts lies with the riparian owner who should be informed of discoveries and advised of their rights of ownership.

Case Study M, in Appendix C, presents an excellent example of restoration of a mill weir.

### 2.4.7 Water Quality

It is often said that a weir will improve water quality through aeration of the flow as it cascades over the structure. It is undoubtedly true that water is aerated as it passes over a weir, especially if the flow is turbulent (Figure 2.29), and that this aeration is beneficial to water quality. However, the construction of a weir in a river or stream flattens the gradient, and reduces the opportunity for natural aeration by creating deeper more placid conditions upstream. Many rivers support an effective pool and riffle system, and the riffles are quite effective in aerating the water. In situations where the quality of the water in a river is poor, it is unlikely that the construction of a weir will have a significant impact on the water quality. Indeed, it may create secondary problems such as foaming, which until recently was a common feature downstream of weirs on many of our rivers that pass through industrial areas.

**Figure 2.29 Virginia Water**

*Opportunities to construct weirs like this are very rare. The aeration effect of most weirs is modest, and is certainly not a primary benefit.*

Where weir works are being considered in rivers that still exhibit poor water quality, the design should attempt to mitigate the problem. For example, provision should be incorporated for removing the debris that floats down our urban streams and tends to accumulate at weirs. Leptosporosis, or Weil's disease is one of the main areas of concern with regard to the risk posed to people who come into contact with polluted water. Weil's disease is caused by a bacterium that is transmitted through rats' urine. Humans may become infected when open cuts or mucus membranes come in contact with urine contaminated water. The favoured environment for its survival and transmission is warm water such as is found in sewers, but may also occur in the summer in water impounded by weirs. If there is any reason to suspect that the water at a weir is likely to harbour the bacterium, members of the public should be warned by appropriate means to avoid contact with the water.

### 2.4.8 Recreation, amenity and navigation

#### (i) Recreation and amenity

Recreational activities on rivers in the 21st century probably do not differ enormously to those enjoyed by the characters as depicted in 1908 by Kenneth Graham in "The Wind in the Willows," but with the decline of commercial river traffic on Britain's waterways, a river's uses today are dominated by leisure activities. The main limitations to recreation in the proximity of weirs are associated with safety and water quality. Substantial weirs with powerful flows of water may be prone to having undertows; and water quality is compromised through the extensive use of rivers for regulated disposal of treated wastewater and other effluents including road run-off and industrial discharges.

As well as the visual amenity created by water cascading over a weir, weirs are often important recreational resources for canoeists and anglers. During the environmental assessment consultation should be conducted with national bodies and local interest groups, including local canoe clubs and angling clubs, to determine the importance of a weir and river reach as a recreational resource. There are health and safety issues associated with recreational activities conducted at or in close proximity to weirs (see Sections 2.1 and 2.3.9). Where a canoe club relies on a weir for its activities it may be more beneficial if the weir is refurbished or reconstructed to be safer rather than demolished so as to remove the risk and liability to the owner of the structure.

**Figure 2.30 Weir with a canoe pass on the River Medway**

*This gated weir not only has a fish pass (far left) but also incorporates a canoe slide*

#### (ii) Navigation

Weirs are key to the continued flow of water where navigation locks create impoundments on either the main channel or an associated cut permitting traffic to pass up and downstream. So long as the locks are operated efficiently the weir should ensure that a minimum depth is maintained upstream to permit the navigation of vessels.

In the same way that road traffic surveys are conducted prior to works being carried out on Britain's roads, consideration should be given to timing works on weirs for periods in the year when navigation is at its lowest. The preferable period for works is during the summer months whilst flows are at their lowest and daylight working hours longest. However, this tends to be the time of the year when navigable rivers are at their busiest, predominantly with leisure craft.

On some rivers, for example the Thames, there is a statutory right of navigation, and restrictions on the works that can be carried out on weirs and other river structures. Clearly in such cases it is essential that the navigation authority is consulted when any works to weirs are planned, whatever the scale or ultimate purpose of the works.

### 2.4.9 Integrating Nature Conservation with Weir Design and Construction

The integration of environmental improvement into schemes serves two purposes:

1. Off-setting construction impacts
2. Off-setting operational impacts

It is relatively simple to identify construction impacts, and many of these can be mitigated through the application of standard best practice methods for the construction industry. However, careful thought is often required to provide appropriate operational impact mitigation measures. For instance, how should the permanent loss of a sand martin colony be mitigated when engineering design requires the crumbling river-cliff to which they return annually to be protected against erosion? How can water quality be guaranteed upstream of a weir during periods of summer low flow? How can fish passage be preserved during differing flow and water level conditions?

The design of mitigation measures to improve wildlife habitat should be conducted in conjunction with English Nature (CCW in Wales), the Environment Agency and the local branch of the Wildlife Trust. The involvement of English Nature is obviously of paramount importance should the work being conducted be within a statutory designated area, but under other circumstances English Nature may rely on the local Wildlife Trust to help them reach a decision.

Where mitigation measures include the planting of vegetation to screen a weir and its associated structures, it may be necessary to obtain approval from the Countryside Agency. Again, this is of particular relevance should the works area and mitigation measure be situated within an Area of Outstanding Natural Beauty or other statutory designated landscape.

**Figure 2.31 Otter ramps**

*Otter ramps have been retro-fitted to this gauging weir. This particular design is rather flimsy and could collapse under the weight of a child (or several fat otters?). Had the ramps been considered from the outset, they could have been engineered much more effectively.*

As with the construction of many structures to the side of a river or stream, there are often opportunities to improve habitats (see Case Study B). These may include:

- Sand martin burrows in the wingwalls upstream and downstream of the weir;
- Nesting ledges for dippers to the side of the weir;
- Overhangs beneath which swallows, swifts and martins can construct their nests;
- Damp conditions to either side of the channel for the proliferation of bryophytes and lichens;
- Overhangs immediately above the water to provide refuge to fish from predators;
- Low in-stream obstructions set into the bed of the river such as heavy boulders, downstream of which deeper areas and slack water should form (but note that such features may present risks to human water users, including canoeists and swimmers).

Opportunities for habitat creation as a mitigation measure specifically related to the design of the weir are not always available. Under such circumstances alternative mitigation measures should be considered that indirectly benefit the flora and fauna of the river and riparian zone.

A simple mitigation includes the use of neighbouring structures, such as a bridge or a building, for providing nesting boxes for dippers, flycatchers and wagtails. Often a lost habitat may be impossible to replace, in which case biodiversity should be increased in other ways. Backwaters may be created in which fish can shelter during floods, or improved bankside planting to benefit invertebrates as well as to stabilise banks. Roosting sites for bats can perhaps be created in old buildings. Where there has been considerable loss of habitat through weir construction and associated bank protection there may even be an opportunity for the creation of a pond to the side of the stream and an associated marshland (See Case Study B).

## Figure 2.32 Weir on the Jubilee River

*The Jubilee River is a man-made flood diversion channel for the River Thames. It has a modest perennial flow to improve its environmental value. The weir in the photograph has been provided to maintain a high water level so that ground water levels in the surrounding area are not drawn down.*

## APPENDIX A – BIBLIOGRAPHY

Armstrong et al (2003). *Fish Pass Manual.* Environment Agency
Beach (1984). Fish counter design - criteria for the design and approval of fish counters and other structures to facilitate the passage of migratory fish in rivers. Ministry of Agriculture Fisheries and Food. Fisheries Research. Technical Report 78.

British Trust for Conservation Volunteers (1990). *Waterways and wetlands – a practical handbook.* Wembley Press.

Chow, Ven Te (1959). *Open Channel Hydraulics.* McGraw Hill.

The Countryside Agency (2001). *Increasing access to the wider countryside for disabled people*. Draft guidance for Countryside Managers.

DETR (2000). Environmental impact assessment – a guide to procedures. Thomas Telford.

DoE (1977). *Crump weir design.* DoE Technical Memorandum No 8.

Environment Agency, Thames Region (1997). Strategic overview of impounding structures – discussion paper.

Environment Agency (2002). Public Safety Risk Assessment for River Structures.

Environment Agency (2001). Scoping the environmental impact of river channel works and bank protection.

Federation francaise de canoe-kayak (undated). *Slides and passes for canoes* (English translation available from Claire Quigley, Anglian Region).

Fisher and Ramsbottom (2001). *River diversions – a design guide.* Thomas Telford.

Hemphill and Bramley (1989). *Protection of River and Canal Banks*. CIRIA.

Hindle, Kirby and Treadgold,. *Refurbishment of Five Ancient Weirs on the River Avon.* Journal of CIWEM Volume 12 No 4 August 1998.

HR Wallingford, 2002 (Draft). The investigation and specification of flow measurement structure design features that aid the migration of fish without significantly compromising flow measurement accuracy, with the potential to influence the production of suitable British Standards. Environment Agency R&D Project W6-084.

Jungwirth, Schmutz and Weiss (1998). *Fish migration and fish bypasses.* Fishing News Books, Oxford.

May, Ackers and Kirby (2002). Manual on scour at bridges and other hydraulic structures. CIRIA.

May, Bromwich, Gasowski, Rickard (2003). *Manual for the hydraulic design of side weirs*. DTI.

Morris and Simm (2000). Construction risk in river and estuary engineering - a guidance manual. Thomas Telford.

Nicholson et al (1995). *The design and use of fish counters.* NRA R&D Note 382.

Paish and Howarth (1999). *The potential for generating hydro-electricity from weirs and sluices*. Environment Agency R&D Technical report W186.

Petts, Heathcote and Martin (2002). *Urban Rivers – our inheritance and future*. Inland Waterways Association/Environment Agency.

The River Restoration Centre (1999). Manual of river restoration techniques
RSPB (1994). *The New Rivers and Wildlife Handbook.*