Guidance for run-of-river hydropower development

February 2016

We are the Environment Agency. We protect and improve the environment and make it a better place for people and wildlife.

We operate at the place where environmental change has its greatest impact on people's lives. We reduce the risks to people and properties from flooding; make sure there is enough water for people and wildlife; protect and improve air, land and water quality and apply the environmental standards within which industry can operate.

Acting to reduce climate change and helping people and wildlife adapt to its consequences are at the heart of all that we do.

We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

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Contents

1. How to use our guidance

This guidance will help developers understand the environmental protection safeguards you will need when designing and installing a hydropower scheme.

It's our role to ensure that hydropower development is sustainable. We do this by:

- advising developers
- assessing how schemes might affect the local environment
- ensuring schemes are compliant with environmental legislation
- issuing licences and consents

We make sure that appropriate safeguards are put in place to protect the environment and, if this can't be done, we don't allow schemes to go ahead.

Our guidance can't cover every eventuality and some sites may require additional or alternative environmental protection safeguards. If your proposal departs from our guidance, we will require you to provide additional information to demonstrate that you can provide and maintain equivalent levels of environmental protection.

Further guidance on how we license hydropower schemes is available on GOV.UK.

Structure of the guidance

This document provides detailed technical guidance about the environmental issues you need to consider when designing your scheme. There is a glossary of technical terms that we use at the end of this document.

This guidance covers:

- Flow and abstraction management
- Screening requirements
- Fish passage
- Water Framework Directive
- Impoundments: the use of weirs
- Geomorphology (including weir pools)
- Nature conservation and heritage
- Flood risk
- Monitoring

2. Getting started

Key messages for developers:

- **choose sites carefully and follow our guidance**
- **make protecting the environment a priority within your scheme design and budget**
- **understand that we are less likely to accept proposals in sites of high environmental sensitivity**

Pre-application advice

Pre-application gives you an opportunity to discuss your proposal with us before you formally apply for a licence, permit or consent. We will advise you on any changes you should make to your scheme design to make it more likely that we can issue you a licence. We will confirm the information you need to submit to make a valid application that we can assess. We offer up to 15 hours of free pre-application advice and we may charge for any advice beyond this.

We're here to help you

We'll assign an Account Manager to your scheme

Throughout the pre-application and application processes, your Account Manager will be your single point of contact. Their job is to help you understand our requirements and to highlight any areas of environmental concern.

We'll offer advice based on your initial proposal

Based on the information you have provided, we'll consider the following issues:

- the best use of available water
- possible local and wider environmental effects, such effects may be positive or negative
- the assessment of flood risk and the proposals for mitigating that risk
- the impact on other water users in terms of the effects on the protected rights of existing abstractors, on the existing lawful uses of water by others for agricultural, industrial, public supply or recreational purposes, and on requirements of fisheries, navigation or land drainage
- what licences you will need

We'll look at the best available evidence on how abstraction, impoundment, flow modifications and flow diversions will affect river-based habitats and the associated ecology. We'll also consider effects on the river dynamics (known as geomorphology), such as the passage of sediment, bed and bank stability and physical habitats. We'll use professional expert judgement to interpret this evidence. We may visit your site at this stage.

We recommend that you use our pre-application advice to finalise your scheme design before applying.

Competing schemes

The Environment Agency sometimes receives applications for hydropower schemes which are competing for, or potentially competing for, abstraction or impoundment of water at the same site. We have produced guidance to explain our general approach when this happens.

We will encourage applicants to consider a shared scheme or a split scheme and if neither of those options is possible we will compare the schemes and decide which (if any of the schemes) is most desirable in the public interest and/or of greater benefit.

For a copy of this advice, Competing hydropower schemes (LIT 7517), please contact us at enquiries@environment-agency.gov.uk or speak to your Account Manager.

3. Applying for licences and consents

What are the licences and consents for hydropower?

You will require licences and consents for your hydropower scheme. We have a duty to ensure that schemes comply with relevant environmental legislation. For instance, we grant water resources licences (abstraction and impoundment) under the Water Resources Act 1991 (WRA).

Abstraction licences

For most schemes, you need our permission to take water from the river to flow through a hydropower turbine.

We will grant either a full or transfer abstraction licence, depending on how your scheme uses water.

Full licence

You will need a full licence to abstract water from a watercourse unless you are transferring it to another watercourse. You will also need a full licence if you want to abstract water from a river via a piped off-take or off-take structure to a turbine. We charge for hydropower abstractions if your scheme has a peak output of more than 5 MW.

Transfer licence

You will need a transfer licence when you are transferring water from, for example, one watercourse to another without using the water for another purpose. For example, a hydropower scheme may move water between channels. There is no annual abstraction charge for a transfer licence.

New abstraction licences are normally time limited to a common end date for the catchment. See our Catchment Abstraction Management Strategies (CAMS) to find out the time limit for your catchment.

Impoundment licence

You will need an impoundment licence if you're making changes to structures or works which obstruct, hold or store water, such as weirs and sluices, or if you're building new structures in the watercourse. If you're refurbishing existing unlicensed turbines, or reinstating derelict mill structures/equipment, you may require an impoundment licence.

Fish pass approval

We will require you to install a fish pass and appropriate flow management to allow fish to pass safely up and down the river on rivers where your scheme could make upstream or downstream fish passage worse. We will need to approve both the design and installation of your fish pass.

Flood defence consent

You must apply for a flood defence consent when your scheme is sited on a main river. You will also need our consent for any works near a main river or a flood defence. This will include both the construction works and the finished scheme.

If your scheme isn't on a main river you may require an ordinary watercourse consent from your Lead Local Flood Authority, normally your local authority or Internal Drainage Board.

Further guidance is available on GOV.UK.

Water Resources Act (WRA) agreement

We may also require an agreement with you under Section 158 of the WRA to regulate the way a hydropower scheme is operated. These agreements could cover rights of access, controlling river levels, maintaining the weir and river structures, fisheries and other environmental protection matters.

Which licences apply to your scheme?

Scheme layouts can be complex and will affect which licences you will need. The scenarios in Figure 3.1 overleaf illustrate the licences required for some typical scheme arrangements.

Your Account Manager will confirm the licence types that apply to your scheme.

Environmental report

When applying for your scheme we will expect you to provide an environmental report describing how your scheme might change or damage the river or the surrounding environment and the measures you have included to avoid or mitigate harm.

Your environmental report must address the potential effects of your scheme by including:

- a hydrology assessment (see Flow and abstraction management)
- details of fish screening measures (see Fish screening)
- details of provision for fish passes (see Fish passage)
- details of the bywash channel (see Fish screening)
- an ecological survey (see Monitoring)
- a Water Framework Directive (WFD) assessment, incorporating when necessary a geomorphology/weir pool assessment (see Water Framework Directive and Geomorphology including weir pools)
- for some schemes, a water quality assessment

Figure 3.1 Licences required for some typical scheme arrangements[1]

<table>
<tr>
<th>Scenario A
(Abstraction only)</th>
<th>Scenario B
(Abstraction only)</th>
<th>Scenario C
(Abstraction only)</th>
<th>Scenario D
(Impounding only)</th>
<th>Scenario E
(Abstraction and impounding)</th>
<th>Scenario F
(Abstraction and impounding)</th>
</tr>
<tr>
<td>Abstraction around an existing, unchanged in-river structure such as a weir, sluice or lock, via gravity through an intake structure to a penstock pipe at C to a turbine.</td>
<td>Abstraction around an existing, unchanged weir structure, via gravity through an intake structure (C) to an open channel which is considered to be a source of supply. A turbine is located within the open channel.</td>
<td>Abstraction with Archimedean screw turbine (also applies to other types). Water is diverted into turbine forebay from main river at C. New fish pass is proposed at D. There is an existing, unchanged weir across the main river.</td>
<td>In-river impounding works with turbine located within disused wheel-pit structure (C). May or may not be water level control structure across main weir. Wheel-pit within curtilage of main river.</td>
<td>Abstraction with the piped turbine off-take (D) located off main river channel. Existing weir structure across main river. New fish pass to be installed at C within existing weir.</td>
<td>Abstraction around new in-river structure. Abstraction via gravity through in-take structure to penstock/pipe.</td>
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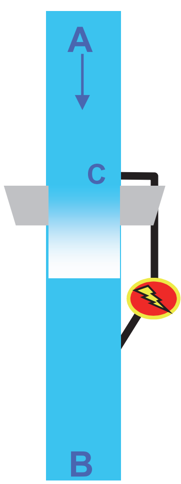
<td>
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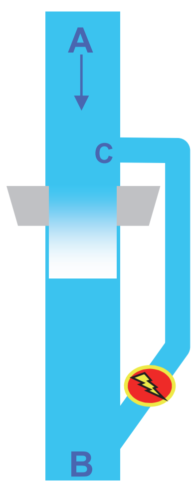
<td>
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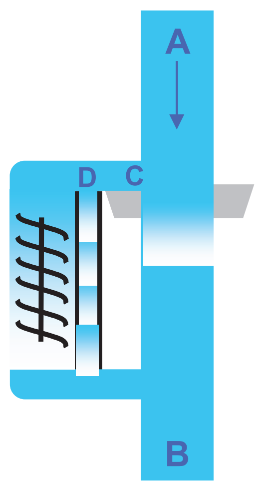
<td>
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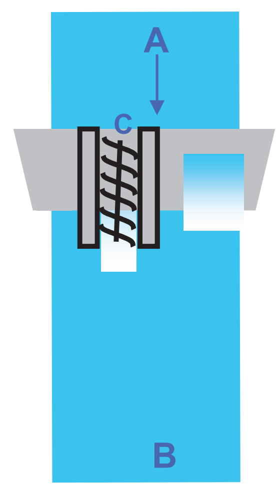
<td>
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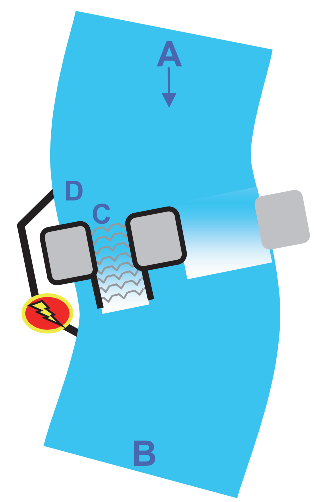
<td>
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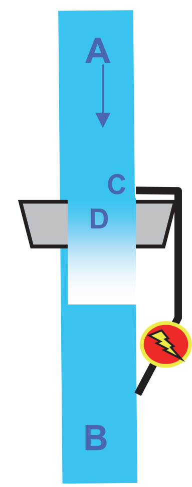
<td>
</td>
</tr>
<tr>
<td>Full licence for abstraction at C.</td>
<td>Transfer licence for abstraction at C.

Turbine may need an impounding licence.</td>
<td>Full licence for abstraction at C.</td>
<td>Impoundment licence for altering existing impounding structure at C.</td>
<td>Impoundment licence for modifying existing weir at C. Full licence for abstraction at D.</td>
<td>Full licence for abstraction at C. Impoundment licence for new in-river structure at D.</td>
</tr>
</table>

[1] In all scenarios, the main river flows from A to B.

4. Flow and abstraction management

There is a limited supply of water to meet the needs of people, businesses, agriculture and the environment and so we license the amount of water that abstractors, or water users, can have. You will need to apply for a licence to authorise the amount of water you can use for your hydropower scheme.

We base our abstraction licensing on our Catchment Abstraction Management Strategies (CAMS). CAMS use the Environmental Flow Indicator (EFI) to indicate where and when water is available for new abstractions. It sets different percentages of flow that can be abstracted, depending on the sensitivity of an area to abstraction.

We have assigned each water body in England to an Abstraction Sensitivity Band (ASB): High (ASB3); Medium (ASB2); and Low (ASB1). Our starting point in assessing the amount of water you can use for your hydropower scheme will depend on the ASB assigned to your site. You will be allowed to abstract more water at sites with lower sensitivity and less in highly sensitive areas.

In licensing hydropower schemes we will normally agree:

- a maximum flow (Qmax)
- a minimum flow, the hands off flow (HOF)
- the volume of water you can divert to a turbine

What you need to do

Read our guidance below to understand the default design flows that we have set for hydropower schemes, and the situations where schemes may apply for more water.

Ask your Account Manager for details of the ASB that will apply to your scheme.

Carry out an environmental assessment and provide an environmental report to confirm that the level of abstraction you are applying for will not damage the environment including fish and eel populations.

Provide hydrological information in your application for an abstraction (full or transfer) licence or impoundment licence to tell us:

- the amount of water you propose to abstract
- how you will control your abstraction
- any mitigation measures that are part of your operating regime

Flows for hydropower schemes

Table A sets out our starting point for flow management for hydropower schemes. We will start with these flow allocations for all schemes, although applications for higher levels of abstraction will be considered (see below). However, we may also need to set a more protective flow if:

- your scheme could affect a weir pool that is highly important to the status of the water body or wider catchment
- reducing flow is likely to have an impact on fish passage

TABLE A DESIGN FLOWS FOR HYDROPOWER SCHEMES						
	High sensitivity ASB3		**Medium sensitivity ASB2**		**Low sensitivity ASB1**	
River type Q95 / Qmean value	Low/med base flow Below 0.2	High base flow 0.2 & above	Low/med base flow Below 0.2	High base flow 0.2 & above	Low/med base flow Below 0.2	High base flow 0.2 & above
HOF	Q95	Q97	Q95	Q97	Q95	Q97
Maximum abstraction	1.3 x Qmean	Qmean	1.3 x Qmean		1.3 x Qmean	
% take above HOF	35%		40%		45%	

Applying for higher levels of abstraction

If you wish to apply for higher levels of abstraction than those shown in Table A you will need to provide supporting evidence in your environmental report to demonstrate that your scheme will:

- not prevent the achievement of Water Framework Directive objectives at water body level (see Water Framework Directive)
- maintain or improve fisheries and fish passage (see Fish passage and Screening requirements)
- not have unacceptable impacts on protected sites or species (see Nature conservation and heritage)
- not have unacceptable impacts on the rights of other water users, including anglers

The amount of additional flow we may allow above the design flows in Table A will depend on:

- the potential risk to the environment
- the mitigation measures you propose to avoid environmental damage.

Examples of mitigation measures include:

- – increasing the HOF
- – reducing the maximum abstraction level or the percentage abstraction above HOF
- – seasonal variations in abstractions
- – actively managing the abstraction to maintain flow variability

The sections below indicate the additional levels of abstraction that we may license for different types of scheme. They are indicative only and we will assess each scheme on a case by case basis.

On or around weir

These are schemes with turbines sited at or alongside an existing weir where there will be no significant flow depletion within the natural watercourse. These schemes discharge water back into the weir pool. Based on your environmental assessment and any mitigation measures you propose, we may allow abstraction as shown in Table B.

TABLE B HYDROPOWER SCHEMES AT AN EXISTING WEIR Indicative departures from Table A	
Hands off flow (HOF)	Q95 (or Q97 for very high base flow rivers)
Maximum abstraction	1.3 x Qmean
% take above HOF	100%

Low head with depleted reach

Diverting water away from the natural river channel may introduce risks for fish passage and ecological connectivity, as well as changing sediment transport. The risks are also higher where the depleted reach contains ecologically and environmentally sensitive features and where you want to take more flow for longer periods of time. Based on your environmental assessment and any mitigation measures you propose, we may allow abstraction as shown in Table C.

TABLE C LOW HEAD WITH DEPLETED REACH Indicative departures from Table A				
Baseflow type Q95/Qmean value	Flashy river Less than 0.1		Med/low base flow Between 0.1 & 0.2	High/very high base flow 0.2 upwards
	Fish migration issues	No fish migration issues		
Hands off flow	Q90	Q90	Q95	Q95
Maximum abstraction	Q40	Qmean	Qmean	Qmean
% take above HOF	100%	100%	100%	100%

High head

These schemes can create long depleted reaches which increase the risk of environmental deterioration at water body level. We are more likely to agree higher levels of abstraction for hydropower in steep, upland tributaries of low ecological sensitivity with no migratory fish. In less steep or more ecologically sensitive rivers, there is likely to be less scope for departures from the Table A values.

Based on your environmental assessment and any mitigation measures you propose, we may allow abstraction as shown in Table D.

TABLE D HIGH HEAD SCHEMES Indicative departures from Table A	
Hands off flow (HOF)	Q95 (Q90 for sites where the wetted area is significantly reduced at flows below Q90)
Maximum abstraction	1.3 x Qmean
Protection of flow variability	Where necessary, the ratio of the downstream (depleted reach) to the upstream flows to be maintained at the ratio of at least Q80 to Qmean *The flow split can be calculated using the following formula:* *Flow Split % = (1 - (Q80/Qmean)) x 100*

Applying for flow above 'indicative' departures

Tables B, C and D are indicative only. We will consider applications for levels of abstraction outside this guidance on a case by case basis, assessing the evidence provided in the application and the environmental sensitivities of the site.

Designated nature conservation sites

Nature conservation legislation requires a more precautionary approach to permitting schemes that affect designated conservation sites, such as Special Areas of Conservation (SAC) and Sites of Special Scientific Interest (SSSI). We therefore have to be more cautious in our permitting decisions and will assess flow criteria according to the requirements of the designated habitat and species features of each site. For further information see Nature conservation and heritage.

Providing hydrological information

When you apply for your abstraction licence you will need to submit detailed information about the existing hydrological characteristics of the river. You should provide:

- Flow Duration Curve (FDC) statistics and the mean flow value
- details of how these flow estimates have been derived and validated
- the base flow of the river
- details of the proposed abstraction regime
- hydrographs showing the impact of the scheme on river flows

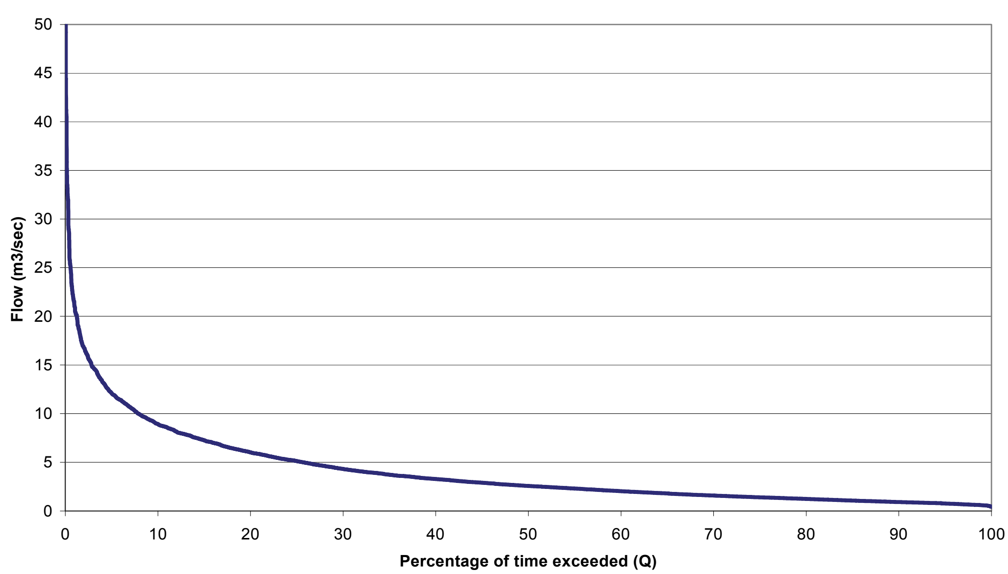
Flow duration curve (FDC)

You must provide the FDC for the river at your proposed abstraction site together with the table of data used to construct the FDC.

The FDC (see Figure 4.1) represents the statistical availability of any given flow, by showing the amount of time for which a given flow is equalled or exceeded in a given period of time:

- the x (horizontal) axis shows the percentage of time that a flow is equalled or exceeded
- the y (vertical) axis shows flow rates
- we use Q as the symbol for flow and a number to represent the percentage that the flow will be equalled or exceeded. For example,Q30 is the flow that will be equalled or exceeded for at least 30% of the time, or in other words, for 110 days in a year.

Figure 4.1: FDC showing the natural flow in a hypothetical river



Normally we will ask you to provide natural flow statistics at the proposed abstraction point as we base licence conditions on natural river flows (what the river flow would be if there were no abstractions or discharges). However, in some cases we may ask for influenced/actual flow statistics. Ask your Account Manager which type of flow statistics you need to provide.

Mean Flow (Qmean)

You must provide details of the mean flow for the river at the proposed site of your scheme. This is the average of all the flow measurements taken over a period of time at a particular point in a river. Relative to the FDC, mean flow typically can range between Q30 and Q40 depending on the type of river.

The mean flow will vary from year to year. You must make sure that the statistics you provide are representative of the long term average, typically be in excess of 10 years and preferably 25 years.

Deriving the flow statistics

You must provide a detailed description of how the flow duration statistics have been produced and explain any modelling assumptions you have made.

Ask your Account Manager if we can provide you with data from our flow gauging stations. If we do not have gauged data for your site, you can apply other hydrological techniques to estimate an FDC. You may need to use commercially available computer modelling but the results may have high levels of uncertainty. We recommend that you discuss your modelling approach with us before commissioning the work.

Validation of flow statistics

We may require you to carry out additional gauging of the local river flow, over a range of flows and we will confirm this at the pre-application stage.

The quantity and quality of any gauging we require will be proportionate to the scale of your scheme and the environmental risk.

Base flow

You need to estimate the base flow characteristic of the river where you are proposing to construct your scheme. This indicates how much the river flow is affected by stored water sources in the catchment. We use the base flow characteristic of the river to set standards for different types of hydropower schemes.

To simplify the assessment of the base flow characteristic, we use the ratio Q95:Qmean in this guidance. However, in some cases we may ask you to carry out a more detailed assessment to establish the Base Flow Index (BFI) of the river.

Base flow characteristics	
Q95 : Qmean	**Description**
<0.1	Flashy base flow
0.1 to 0.2	Medium/Low base flow
0.2 to 0.4	High base flow
>0.4	Very high base flow

Abstraction regime

You need to confirm details of your abstraction regime to describe the way in which you will take water from the river. This may include:

- the maximum amount of water that can be abstracted at any time (usually the design or maximum turbine flow)
- the minimum amount of water that can be abstracted at any time (usually the lowest flow rate at which the turbine will operate, sometimes described as turbine start-up flow)
- the proportion of river flow being abstracted
- changes in abstraction within a day or between seasons

Hands off flow (HOF)

We will set a hands-off flow (HOF) as a condition for your scheme, such that when the flow or level falls below the set value, you must stop abstraction. This ensures there is always a minimum flow to continue over the weir and down the depleted reach.

You can maintain the minimum flow in a number of different ways, such as:

- hard engineering through a physical arrangement such as a notch or pipe in the weir set to pass the HOF
- measuring the level of water by setting a ‘control level’ of water over the weir and using a gauge board

Flow pulsing

Your turbine design and control system must ensure that flow pulsing does not happen. This is when the water level falls below the crest level of the weir because flow has continued to be diverted to the hydropower turbine below the specified HOF level. When generation subsequently stops, water will build up behind the weir until it rises sufficiently to reach the level required for turbine start up. It may then rapidly fall again and repeat the cycle.

You can prevent pulsing by maintaining a specified flow over the weir while generating and complying with the HOF at which generation must cease.

Turbine start-up flow

A water turbine only achieves a worthwhile efficiency when it can pass a good proportion (typically between 15-30%) of its design flow, depending on the machine type. The turbine will also shut down when the available flow falls below this minimum operating value or start-up flow. You will need to ensure that your turbine control system adds an additional margin so that the turbine won't repeatedly start up again immediately after it has shut down, known as 'hunting'. This additional margin above the HOF sets the ‘start up flow’.

To maintain the HOF, the hydropower turbine will be unable to start generating until the flow exceeds the HOF and achieves the start up flow. Generation cannot take place when flows are below the HOF.

Hydrograph

You need to produce a hydrograph of the variation of flow on a daily (or sub-daily) basis.

A hydrograph plots daily (or sub-daily) flows over a specific period of time. Flow rates may be either Daily Mean Flows (DMF), the mean of flow measurements taken over a day, or sub-daily flows recorded at periodic time intervals. For example, our gauging stations record flow every 15 minutes.

Hydrographs help to identify the potential effects of a scheme on:

- flow variability
- changes to summer low flows and winter peaks

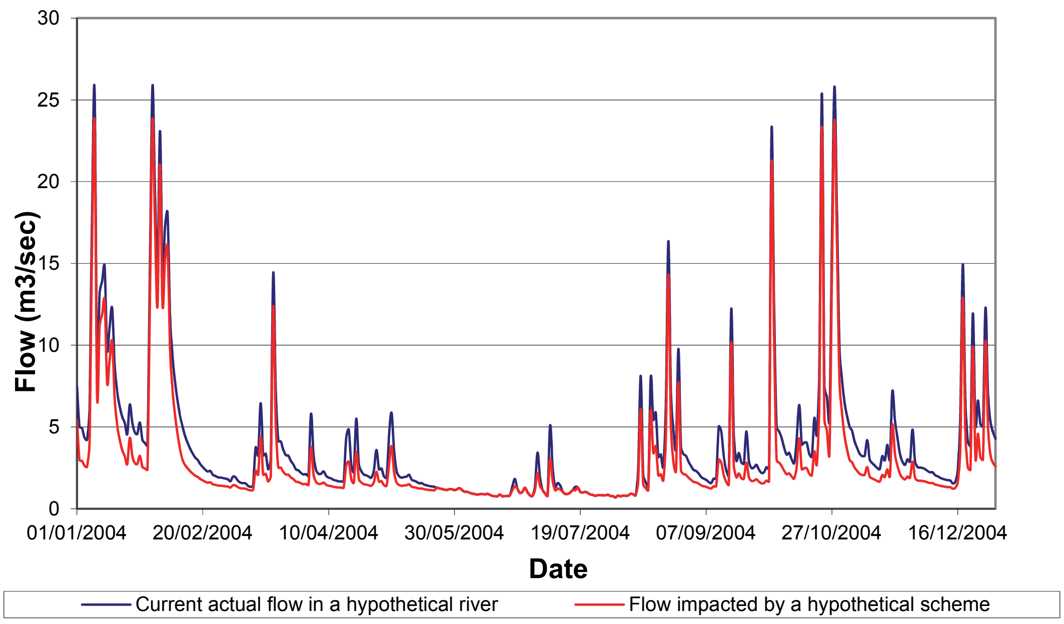
From this information we may decide there are periods of the year when we can't permit abstraction, or periods when we can allow abstraction to reduce or increase.

We'll normally ask you to provide three hydrographs; for a wet, a dry and an average year.

You should compare the hydrograph of the actual (current) flows with one showing the expected impact of the proposed scheme.

We'll give more detailed advice at the pre-application stage of scheme development.

Figure 4.2: Hydrograph



This graph shows current flows in a hypothetical river compared to flow impacted by a hypothetical hydropower scheme based on a 50% flow split, maximum turbine flow of Qmean, and Q90 hands off flow.

5. Screening requirements

What are the issues?

The turbines in hydropower schemes may harm fish that pass through them. If this is considered to be a risk in your scheme, you will need to fit fish screens and an appropriate bywash. Screens may be needed to protect fish moving both downstream and upstream.

In most cases the screens used will form a physical barrier. These screens are known as ‘positive exclusion screens’. However, the screens themselves may harm fish if they are poorly designed or if water is flowing too quickly where the fish approach the screen. When designing your scheme, you will need to make sure this ‘approach velocity’ is appropriate for the species of fish that need to be protected.

Poorly designed screens and bywashes can also delay downstream fish migration, so that it may be more difficult to meet the environmental objectives for the species to be protected.

Key aspects of fish screen design

This section sets out our standard, default requirements for fish screens for run-of-river hydropower schemes. You need to adhere to these requirements or justify your decision to vary the design. If you don’t do this, we will not approve your scheme proposals.

The design requirements for different parts of England can vary. This reflects regional variations in climate and geology that affect fish growth. In particular, salmonid smolts tend to be smaller in colder areas and in places with low levels of nutrients. Table S1 sets out our default requirements that will be appropriate for most hydropower schemes.

In some cases it may be necessary for you to choose a screen with a different size of gap (‘aperture’) or design. Your decision should be based on the shape and size (‘morphology’) of the fish which require additional protection. If you consider the default screen size to be inappropriate, you will need to provide evidence to support both your view and your proposed alternative.

A good design for downstream passage, which should not delay migrating fish, will combine:

- effective screening and diversion and
- a safe bywash route

When choosing the right screen for your scheme, you must take account of the criteria for approach velocities (also known as ‘escape velocities’) and for bywash provision.

Where fish will pass through the turbines in your scheme, you must ensure that the design of any downstream screens allow fish to pass downstream while creating a barrier to fish migrating upstream.

Intake screening

The type of turbine used will determine the level of impact on the fish passing through. Generally, the smaller the turbine size, the more damaging the effect is likely to be.

Table S1 sets out our default screening apertures for hydropower schemes and assumes that screening best practice is followed (e.g. screens are angled to the flow where appropriate). Tables S2 to S8 provide information on screening for specific turbine types.

Table S1 - Summary of intake screens

Situation	**At intake – fish screening requirements**		
Traditional waterwheel Most Archimedes screw designs	Trash screen (100mm) - see also detailed guidance in Tables S6, S7 and S8 as in some cases smaller aperture screens will be needed to provide protection for larger fish.		
Impulse turbines, such as Pelton and Turgo	Drop through screens ≤ 3.0 mm (for example Coanda style)		
All cross-flow turbines and other turbines with a maximum turbine flow < 1.5 m3 per second	Migratory salmonids	Environment Agency Areas	Screen aperture
		Yorkshire Northumberland, Durham and Tees Cumbria and Lancashire Greater Manchester, Merseyside and Cheshire Devon and Cornwall	≤10.0mm
		All other Areas	≤12.5 mm
	Other species, including eels	≤ 12.5 mm (see notes)	
	Where protection of salmonid parr or young of year coarse fish (O+) is required.	Default is 6.0mm This screening can be used for part of the year when parr or young of the year fish require protection.	
Any other turbine with a maximum turbine flow ≥1.5 m3 per second (excluding cross-flow turbines)	Migratory salmonids	Environment Agency Areas	Screen aperture
		Yorkshire Northumberland, Durham and Tees Cumbria and Lancashire Greater Manchester, Merseyside and Cheshire Devon and Cornwall	≤10.0mm
		All other Areas	≤12.5 mm
	Other species, including eels	≤ 12.5 mm (see notes)	

Notes

Further information can be found in our fish screening guidance Screening for intake and outfalls: A best practice guide

The screen aperture necessary to protect eels is dependent upon the size of eels and the orientation of the screen (its angle to the flow). Screen apertures for adult eels can range from 9 mm to 20mm. For further guidance, please refer to tables S2 to S8 and our eel screening guidance, Screening at intakes and outfalls: measures to protect eels.

Further protection may be required for species protected under specific legislation – such as lampreys, shad and bullhead where they are designated features of Habitats Directive sites.

If there are no eels or salmonid smolts present, a default screen aperture size of 12.5 mm is recommended. Where protection of young of year fish is needed, smaller screen apertures may be required depending upon the type of turbine used. The use of other screen aperture sizes must be based on evidence and linked to the size of fish which need to be prevented from passing through the screen.

Screening requirements for specific turbine types

Table S2 - Pelton and turgo turbines	
Where used – type of installation	Normally used on high-head systems.
Survival rate	Almost no fish survive if taken into turbine.
Notes	In most cases, operators use a 3mm (e.g. 3 mm Coanda-effect, wedge wire or perforated sheet) screening drop through a self-cleaning screen. This prevents the entry of debris that will damage the turbine.
Screens required for:	
Salmonid fry, under-yearling coarse fish, lamprey ammocoetes, salmonid parr, young of year coarse fish, or silver eels.	Max 3mm

Table S3 - Cross-flow turbines	
Where used	Low-head schemes
Survival rate	The shape of the turbine and blades and the high rotation speed mean that very few of the fish taken into the turbine would survive.
Screens required for:	
Salmon and sea trout smolts, adult eels	10/12.5mm screens (based on size of smolts)
When salmonid parr or young of year coarse fish are present or occur at the site	Default is 6mm from May to September

Table S4 Smaller reaction turbines – for example Kaplan, Francis and other propeller turbines	
Where used	Kaplan – used in high-flow and low-head conditions. Francis – used in a wide variety of flow and head conditions.
Survival rate	The shape of the turbine and blades and the rotation speed mean that few of the fish taken into the turbine would survive.
Notes	If the turbine flow is less than 1.5m3/sec-1, you will require screening to a similar specification to that required for cross-flow turbines – especially where there are autumn migrating smolts and juvenile trout. We will be able to help provide evidence for this need. For other propeller turbines, the risk to fish posed by the size and rotational speed of the turbine should be considered before appropriate screening is determined.
Screens required for:	
As default Salmonid parr, young of year coarse fish **Otherwise** Salmon and sea trout smolts	6mm (May to Sept) 10/12.5mm screens (based on size of smolts)
Eels Small adult eels (>30cm and < 50cm in length) Large adult eels (>= 50cm in length)	9mm screens (where screen angles are >20 degrees). These are likely to be found lower down in the catchment. 15mm screens (where screen angles are > 20 degrees) Full details on screening for eels can be found in our guidance: Screening at intakes and outfalls: measures to protect eels.

Table S5 Larger reaction turbines – for example Kaplan, Francis and other propeller turbines	
Where used	Kaplan – used in high-flow and low-head conditions. Francis – used in a wide variety of flow and head conditions.
Survival rate	These larger turbines are considered to be safer for fish passing through. The damage rate for fish passing through a propeller type of turbine depends on the size/capacity of the turbine and the length and species of the fish at risk.
Notes	If you plan to use large Kaplan turbines (turbine flow > = 1.5m3/s) with screens that differ from the default size below, you will need to carry out a risk assessment to demonstrate that the same degree of protection will be provided. The older type of low-head Francis turbine is less damaging to fish, but this type is no longer manufactured. Where re-furbished ones are used, a 10/12.5mm screen is necessary – to exclude smolts, other similarly sized fish, and eels. For other propeller turbines, the risk to fish posed by the size and rotational speed of the turbine should be considered before appropriate screening is determined.
Screens required for:	
Salmon and sea trout smolts, adult eels	10/12.5mm screens (based on size of smolts)
Eels Small adult eels (>30cm and < 50cm in length) Large adult eels (>50cm in length)	 9mm screens (where screen angles are >20 degrees). These are likely to be found lower down in the catchment. 15mm screens (where screen angles are > 20 degrees). These are likely to be found in more upstream catchments. Full details on screening for eels can be found in our guidance Screening at intakes and outfalls: measures to protect eels.

Table S6 Archimedean screw turbines (3, 4 and 5 blade)	
Where used	These are suited to low-head sites.
Survival rate	Archimedean Screw Hydropower Turbines (ASHTs) have been shown to cause minimal damage to fish, as long as there is appropriate protection on the leading edge of the screw and they are designed within acceptable limits.

Notes

We will normally approve the use of ASHTs according to the table below. Schemes designed within these parameters are likely to require only trash screens. Protection to the leading edge of the blade will be necessary.

As the licences for hydropower schemes are based on site specific information and the risk assessment associated with those turbines, the diameter and maximum speed of the turbine will need to be specified in the licence.

Turbine diameter and rotational speed

Number of blades	Minimum diameter of turbine (m)	Maximum rotational speed of turbine (rpm)
5	3.0	24
4	2.2	30
3	1.4	32

Variable speed ASHTs are preferred to fixed speed as they pose lower risks to fish for much of the time when they are operating at less than maximum power.

Where the diameter of the turbine is less than that specified in the table or the rotational speed is greater than in the table we will require fish screens and appropriate by-wash to be included in the scheme design. Screen apertures will need to be sufficient to prevent passage of large fish at risk of being struck by turbine blades. An assessment will need to be undertaken to consider whether such species are present and require protection (e.g. eels or salmon and sea trout kelts or large rheophilic coarse species).

Screening will be specific to the fish requiring protection. Please note that fish of less than 60 cm in length are not considered to be at risk from damage through being struck by a turbine blade providing it is fitted with an appropriate compressible rubber bumper, see below.

Screw turbines with tip speeds at or above 3.5 m/s (approx. 2.5m diameter) should have compressible rubber bumpers fitted to the leading edges to safeguard the passage of large fish

Turbines with tip speeds below 3.5 m/s should have compressible rubber bumpers fitted although harder compounds may be acceptable. However, where there is a risk of large fish passing through the turbines, softer rubber bumpers will be required.

Table S6 (continued)

Maximum tip speeds

Tip speeds should not exceed a speed that would result in unacceptable impact forces. Based on current evidence turbines with a tip speed greater than 5m/s and/or a diameter exceeding 5.0 m will require additional protection for large fish, such as the inclusion of appropriate screening and by-wash facilities.

If you propose a scheme that falls outside these requirements, you will need to submit a risk assessment providing justification for any departure that shows equivalent levels of protection are provided.

Information required

Hydropower developers will need to provide information on various aspects of the ASHT design when submitting an application. These should include: the diameter, the number of blades, the rotational speed (rpm), the pitch of the screw, and whether it is fixed or variable speed. The type of compressible rubber bumper fitted and the gap between the blade and turbine housing will also need to be provided.

Installation and maintenance

It is essential that ASHTs are designed and maintained to specific standards. The following points should be addressed and where necessary appear as conditions within the licence:

the leading edge must be at least 10mm within the perimeter of the trough before rubber bumpers are fitted

the appropriate type of rubber bumper must be fitted correctly and must sweep within 5mm of the trough

the gap between the turbine blade and the trough must be maintained to agreed tolerances throughout the length of the turbine (e.g. 5mm)

the rubber bumpers fitted must be maintained in good condition

To ensure these points are addressed it is recommended that they form part of the ongoing compliance assessment of schemes.

The clearance between the screw and the trough in which it runs must be checked at routine intervals and compared to permissible tolerance. An increase in the gap will increase the risk of injury to fish (and lead to a reduction in efficiency of the turbine).

Where checks indicate remedial action is required, operation must stop until remedial work has been completed. Remedial action can include the installation of screens and associated by-wash to prevent fish from entering the ASHT. The operator could choose to fit screens during the installation of the ASHT, in which case, the requirement to include rubber bumpers or regularly check design tolerances is removed.

Licence conditions

- The abstraction or impoundment licence will specify:
- the diameter of the turbine
- the number of blades.
- the maximum rotation speed
- fixed or variable speed
- the magnitude and tolerance on the gap between screw and trough and the frequency of checks
- the type of compressible rubber bumper fitted to the leading edge of the blades

Table S6 (continued)

Screens required for ASHTs

Where the diameter of the turbine is less than that specified in the table or the rotational speed is greater than in the table, we will require the provision of fish screens and appropriate by-wash. We are also likely to require screening and by-wash if the diameter of the turbine exceeds 5.0m.

Screen apertures must be sufficient to prevent the passage of large fish at risk of being struck by turbine blades.

Screening will be specific to the fish requiring protection. An assessment will be required to consider whether such species are present and require protection (e.g. eels or salmon kelts).

You will need to submit evidence to confirm the size of fish present. We can then assess the need for fish screens and/or a bywash.

Fish of less than 60 cm in length are not likely to be damaged by impact with turbine blades, providing that appropriate compressible rubber bumpers are fitted, (see below).

Table S7 - Waterwheels

Overshot, backshot and breastshot

Overshot, breastshot and backshot waterwheels typically use buckets to transfer the water. These usually pose little risk to fish, providing that suitable gaps exist between the buckets and the housing of the wheel.

We recommend 100 mm trash screens for traditional overshot, breastshot and backshot water wheels. However, where there is an insufficient gap to protect fish smaller aperture screens will be needed.

In all cases, take account of the species and size of fish that will have to pass the wheel and consider the risk of their being damaged and/or trapped. Where fish will be damaged or trapped, appropriate screening will be required.

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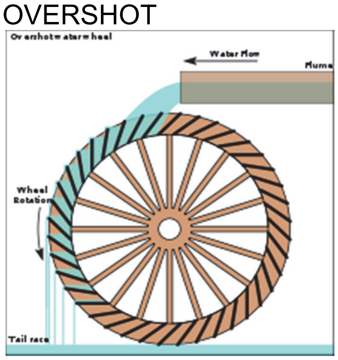
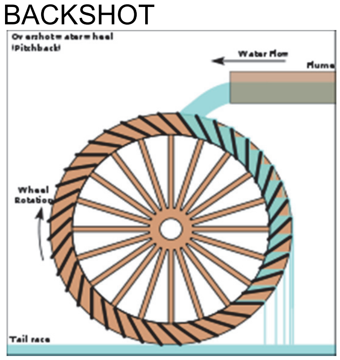
OVERSHOT



BACKSHOT



BREASTSHOT

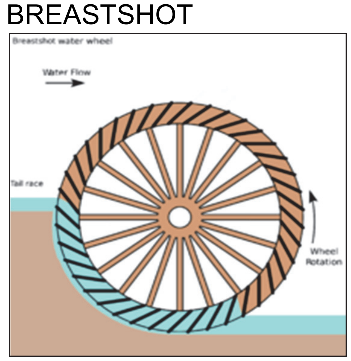
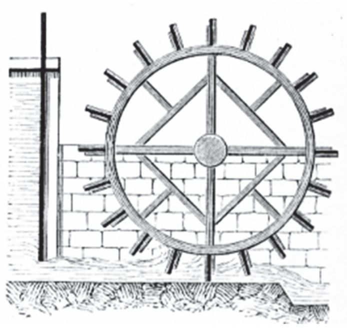
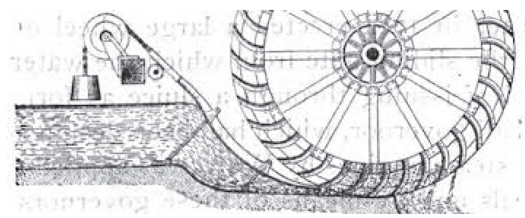


Table S8 - Waterwheels Undershot and poncelet	
Undershot and poncelet waterwheels are typically used where there is a very low head. The wheels (and paddles) in undershot and poncelet designs need to be a close fit in the channel to obtain good efficiency. The limited clearance around the wheels creates a significant risk of damage to fish. Screening will therefore be required. In all cases, take account of the species and size of fish that will have to pass the wheel and consider the risk of their being damaged and/or trapped. Where fish will be damaged or trapped, appropriate screening will be required.	
UNDERSHOT 	PONCELET 

Screen design and orientation

The main design requirements for fish exclusion screening are:

- Select the mesh size to ensure exclusion of the minimum target fish size, based on preventing penetration of the fish’s head;
- The screen should be flush with the river bank for a lateral river intake or, when placed across a channel, angled (in plan view) relative to the channel to guide fish into a bywash. An angle of 30 degrees or less provides the best screening properties. The angle is calculated such that the flow vector normal to the screen face is below the required escape velocity for the target fish species and sizes
- Screens may be also be angled horizontally, as viewed from the side, but may require smaller screen apertures. A bywash is still required, and this should be located towards the top of the screen.
- Provide a suitable bywash if the screen is placed across the channel.
- Ensure the water velocities ahead of the screen are low enough to allow fish to escape without injury.
- Drop-through screens, typically used for high head schemes, can have different arrangements (see Screenings for intakes and outfalls: a best practice guide).
- Ensure that there is a suitable depth of water below a drop-through screen where fish are present.

The figures in the Tables S2 - S8, with the exception of those for impulse turbines, are based on what is appropriate for screens constructed with either vertical or horizontal bars or a mesh-type arrangement.

If you use small screens – for example screens that are up to two metres across – you may align them at right angles to the flow. However, if you do this, there must be a bywash right next to the screen and the bywash flow must be at the upper end of the acceptable range.

Where screens are positioned at right angles to the flow they offer no behavioural advantages to the screening process and have an increased risk of blinding. You will need to ensure that the screen apertures can prevent the relevant size species of fish from passing through or being trapped on the screens. These are likely to be smaller for those presented in Table S1 (excluding drop through screens)

Rectangular section bars or perforated plates are preferable to round-section bars. The latter are likely to trap fish by their gills and if used a smaller aperture between bars would be required. Bars need to be sufficiently stiff to maintain the design spacing right across the screen, you may need to fix horizontal tie-bars across the back of the screen.

Screen orientation and design should comply with our screening guidance:

- Screening for intake and outfalls: a best practice guide
- Screening at intakes and outfalls: measures to protect eels

Behavioural barriers and guidance methods

Fish deterrent systems are commonly known as ‘behavioural barriers’ or ‘behavioural screens’. In some cases these can be used as a substitute for, or supplement to, more conventional positive exclusion or physical fish screens. Some positive exclusion screens, when operated and maintained correctly, can keep all sizes of fish out: behavioural screens cannot achieve this.

Fish have a number of well-developed senses. They can detect and react to light, sound and vibration, temperature, taste and odour, pressure change, touch, hydraulic shear, acceleration, electrical and possibly magnetic fields. Fish deterrent methods use one or more of these stimuli to divert fish from the immediate area of the water intake. In some cases it will also guide them past the intake into a bywash or to a point downstream.

A risk assessment will be required for this type of screen or combination of screen types (see below).

There is further information on this in Screening for Intake and Outfalls: a best practice guide.

Tailrace screens

Fish that are migrating upstream may be attracted into tailrace channels. This may delay or stop their migration and must therefore be prevented, unless there is a co-located fish pass. You may also have to install tailrace screens to direct fish away from a long tail race, prevent fish from entering a turbine or direct fish towards a fish pass.

Physical or electric barriers are acceptable as tailrace screens for salmonid or coarse fish, although electric barriers should not be used where fish are allowed to pass through the turbine. We recommend physical barriers if there is a risk that fish could enter the turbine from the tailrace.

In general, tailrace screens should be upright, placed close to the edge of the river bank at the point where the water from the turbine discharges back into the river and be designed to guide fish to a fish pass entrance where appropriate.

Base your decision on the need for a tailrace screen on:

- the layout of the scheme, and
- the migratory fish species present.

Many turbine channels will require a screen at the downstream exit to ensure that upstream migrating fish do not try and ascend the flow coming through the turbines. In cases where downstream migrating fish are allowed to pass through the turbine you must ensure that screens to prevent upstream migration do not prevent downstream migrants from re-joining the river downstream of the structure.

Summary of tailrace screens

Table S9 - Turbine type and default requirements for tailrace screens	
Screen type	**At outfall – fish screening requirements**
Electric barrier	Only use these where fish cannot pass downstream through the turbines. Barriers with graduated field types are preferred. It is essential that these barriers are always in operation, even when the hydropower plant is not running. Otherwise fish may enter the turbines and be present when they re-start. There must be an externally visible indicator light, or other means of checking, so that the operator or regulator can confirm that barrier is switched on. Check the voltage field annually in the water using a suitable test device. Compare the reading to the specification, in order to ensure that electrodes are in good condition.
Physical bar screens	These should have a 40 mm spacing for salmon, or 30 mm where there are sea trout (exceptionally where many small sea trout are present 25mm screens may be required). The spacing required to protect other species should be determined on a site-by-site basis. Construct screens from wedge wire, square or oblong metal bars. Round or oval bars are more likely to gill fish.

Proposing a different screening regime

You may wish to propose different screen spacings to the default settings given here. This would be based on the specifics of your scheme design, the local environment and associated ecology. If you do, you must complete a risk assessment which will be assessed by the Environment Agency.

Risk assessment

This risk assessment should consider

- the species and size ranges of the fish that need protecting (including resident, migratory and recovering species)
- the deflection rates of the screens
- the mortality rates associated with the type of turbine to be deployed at the full range of scheme and river flow rates
- the overall effect that the proposed scheme may have on the fish population or on other animals that need to be protected.

Your risk assessment must show that your proposed screening arrangements would provide the same level of protection as the default screen requirements set out in Tables S1 to S8. If they do not, the proposal will be rejected.

The risk assessment should include:

- an assessment of how efficiently the screen deflects the fish species to be protected
- show how the 'deflection efficiency' may vary
- the mortality and /or injury rates for fish that pass through the turbine
- an assessment of how any additional mitigation measures, such as behavioural screens or cessation periods, would further increase the proportion of fish diverted to safety (the 'additional deflection efficiency'

Other mitigation measures

A number of mitigation measures may be compatible with using an over-spaced screen. These mitigation measures include:

- stopping the turbines at times when there is a risk of entrapment or entrainment
- the use of behavioural barriers, such as bubble curtains or strobe lights; these have been shown to be effective deterrents when used with a physical screen.

Further advice on this subject can be found in our Screening for Intake and Outfalls: a best practice guide.

Screen Approach Velocity

The ability of a fish species to swim (its 'swimming performance') is strongly influenced by the length of the fish and by water temperature. Fish approaching an intake need to be able to swim fast enough and for long enough to ensure their escape through the bywash – or by any other route provided to return them to the main river flow.

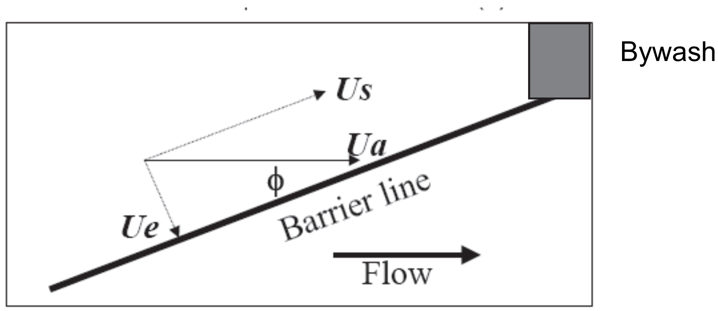
If you place the fish exclusion screen at a diagonal angle to the flow (as viewed from above), fish can be guided to the lower end of the diagonal, where a bywash can allow their safe transit downstream. The angle of the screen can be set to ensure that the escape velocity is kept below required design value.

A fish exclusion screen which is set at a diagonal angle to the flow will be better at diverting the fish towards the bywash than one set at right angles to the flow. You will need a bywash where the screens (including trash racks) are not located in the normal course of the river. If you have this arrangement and don't plan to have a bywash in these circumstances, you will have to submit evidence that the scheme provides an adequate downstream passage for fish in another way.

Figure 1 shows the relevant velocity components for an angled fish barrier. For the purposes of designing the screen, the approach velocity Ue (also known as the 'escape velocity') is defined as the velocity 10 cm upstream of the screen, at right angles to the screen face. Where screens are not angled to the flow, approach velocities may need to be reduced.

If the screen is installed in a headrace, angle the screen diagonally across the flow. This enables the approach velocity to remain low even when the axial channel velocity (Ua) in the headrace is high. This has the added benefit of guiding fish towards the bywash entrance. Note that where you need to protect more than one species of fish, the approach velocity must be low enough for all the species to be protected.

Figure 5.1 Flow velocity components in front of an angled fish barrier



Ua is the axial channel velocity; Ue (=UsinΦ) is the fish escape velocity; and Us (=UcosΦ) is the sweeping velocity along the face of the screen.

Fish species	The maximum acceptable approach velocity towards any part of a screen (in metres per second)
Salmonid	0.60 m/s
Coarse fish and shad	0.25 m/s
Eel	0.50 m/s
Lamprey	0.30 m/s

Accounting for debris

Screen apertures can become blocked by debris. When this happens, the speed of the water as it approaches the screen increases – particularly if the screen is at right angles to the flow. This reduces the ability of the screen to divert fish to safety. You need to make sure that the water hitting the screen is not flowing so fast that fish cannot escape – in technical terms it must not exceed the target ‘approach velocity’, also known as the ‘escape velocity’.

Screen cleaning options

- Automatic screen cleaning – the inclusion of an automatic screen cleaner will reduce the problem of debris. However, when deciding on the overall screen size, you will still need to assume that 10 per cent of the screen may be blocked.
- Manual clearance – if you plan to clear screens manually, you will need to be confident that the target approach velocity can be maintained even if up to 50 per cent of the screen is blocked.
- Self-cleaning drop-through screens.

Screen bywash

The term ‘bywash’ describes the arrangement of flow that is needed to prevent fish becoming trapped by, or caught up in, the screening at a hydropower scheme and allow them to be safely delivered downstream.

Your hydropower scheme will need a screen bywash if the fish exclusion intake screen is not located in the normal course of the river – in other words if it is within the headrace.

Where your screen is angled, locate the bywash entrance at the downstream end of the screen. This takes advantage of the direction in which fish will be guided. Vertical screens would have the bywash at the top of the screen.

Make sure your bywash is designed to work effectively. Bywash flows should be in the range of 2-5 per cent of the scheme's design flow, based on the effectiveness and efficiency of the scheme design.

This percentage may need to be higher if the design of the bywash is poor – for example if the screen is aligned at right angles to the flow, the bywash is located away from the end of the screen, or if the hydraulic conditions at the entry to the bywash are poor.

A good design for a screen and bywash will:

- have a sweeping velocity that increases smoothly into the bywash entrance
- have an adequate entrance size – at least 0.4 - 0.5 m wide and deep
- avoid the creation of sharp shadows, particularly at the entrance to the bypass
- provide a smooth and safe conduit that avoids damaging the fish in transit and delivers the fish safely downstream
- prevent fish from trying to ascend the bywash

We will accept some types of fish pass instead of a bywash – provided that they can be suitably positioned. Suitable types include Larinier, Vertical-slot, Pool and traverse, or nature-like fish passes. However, Denil, Alaskan A, or side-baffle passes might cause abrasion to the fish and are therefore not suitable for use as a bywash.

The point at which the bywash returns to the main channel (the 'bywash return point') should be sufficiently deep to prevent fish being stranded or damaged on impact. It should be at least 25 per cent of the difference between the height of the river up and downstream (the 'differential head') and no less than 0.3m deep.

Bywash entrances for adult eels should open at bed depth, preferably via a full-depth opening.

This section, apart from depth and delivery point, does not apply when drop-through screens are used (typically in high head schemes) since they should be designed to allow fish to safely pass over the screen.

Other turbine types

From time to time new technologies are proposed for hydropower generation. We will give regulatory guidance on the evidence we require before any new technology is deployed on rivers and watercourses in England. We may require the developer or promoter of the technology to carry out a risk assessment.

The risk assessment is a staged process and is designed to assess risks by building on the existing evidence base, rather than replicating previous work. Depending on the results of a desk-based assessment, we may require that further evidence is provided.

We will require the installation of fine screening if a risk assessment indicates unacceptable risk to the passage of fish.

Developers may choose to commission further evidence gathering without first carrying out a risk assessment.

We encourage developers to discuss plans with us at an early stage if considering development or use a turbine type or technology not outlined in the screening tables.

6. Fish passage

The natural movement of fish within river systems is critical to the health and maintenance of populations. Artificial obstructions are the principal reason for the loss of biological connectivity. Species that make long-distance migrations are more obviously affected by this loss and include Atlantic salmon, sea trout, eels, river lamprey and shad. Other species of fish need to move within and between river reaches for breeding, feeding and shelter. These movements may be in the;

- upper reaches – for example brook lamprey and bullhead
- middle reaches – for example dace, chub and barbel
- lower reaches – for example roach and bream
- between the sea and lower river reaches – for example sea lamprey, twaite shad and mullet.

Hydropower schemes are typically associated with impounding structures that impede the movement of fish. In most situations a new hydropower scheme will need to address the issue of fish passage. Where a fish pass is required, the presumption is that it will allow the effective passage of multiple species and sizes of fish unless local circumstances dictate otherwise.

When a fish pass is needed

A new hydropower scheme should not make it more difficult for fish to move up or downstream. We will require developers to install a fish pass and appropriate flow management on rivers where upstream or downstream fish passage is made worse. In some cases this may require provision of an additional pass while maintaining passage in an existing pass facility.

In deciding whether fish passage would be made worse by the introduction of the scheme, we will take account of the scheme design, the environmental legislation relevant at the site and the species of interest.

A fish pass will also be required where fish passage is not made worse by the introduction of a hydropower scheme but improved fish passage is needed to fulfil the requirements of legislation such as the Salmon and Freshwater Fisheries Act and the Eels Regulations.

In determining water resource licences (abstraction or impoundment) we also have a duty to secure the requirements of the Water Framework Directive (WFD), which includes resolving failures due to obstructions to fish passage. We may require a developer to fund fish passage improvements as part of a scheme where improved fish passage is needed to meet the objectives of the WFD, even though the introduction of the hydropower scheme may not make fish passage worse and no species specific legislation applies.

For example, we may require a fish pass where there is currently total obstruction to fish passage and even though a hydropower scheme cannot make the situation worse a scheme can provide the opportunity to make it better. We will apply, where appropriate, the tests of costs and benefits in making any decisions on schemes.

Flows and fish passage

As well as increasing physical barriers to fish migration, hydropower schemes may also affect fish movements by causing changes to the distribution of water flows in the watercourse. Scheme proposals need to manage flows to ensure that they support the fish passage requirements at the site. For example, site-specific flows should not attract migrating fish away from the entrance to a fish pass or from a principal migration route.

Where a depleted reach is created in the design of a hydropower scheme, the flows in the depleted reach need to be sufficient to support fish populations and allow migration where required.

A fish pass must have sufficient flow passing through it to allow for efficient fish passage. To work effectively and efficiently a fish pass must also have sufficient hydrodynamic attraction properties for fish to find it and be encouraged to enter it. Attraction can be a combination of a number of stimuli, but the principles ones are location, flow and velocity (momentum). The ‘residual flow’ calculation in your application will need to include the flow required to service an appropriate ‘upstream fish pass and/or downstream fish bywash’

Upstream fish passage

Where there is existing provision for fish passage, approved or otherwise, any hydropower development must maintain the effectiveness and efficiency of the pass or passage through the site. When existing fish passes are to be used, but are known to be inefficient, we shall expect developers to address opportunities for improving fish passage.

In some cases, the introduction of a hydropower scheme may compromise the efficiency of an existing pass. An example is where hydropower is developed on the opposite bank from an existing fish pass. If the efficiency of an existing pass cannot be maintained, more than one fish pass may be required.

We will expect a fish pass to be provided as part of any scheme developed on a river that is frequented by migratory salmonids, even if no fish pass is currently provided. This includes rivers that are recovering or rehabilitated.

We will require improved passage for eels where we have identified the need to improve upstream passage for eels, in support of our eel management plans.

On other rivers, a fish pass will be required where we consider that any reduction in fish passage would occur or where failure to improve fish passage would prevent delivery of WFD objectives.

We are working to identify existing barriers where fish passage must be improved to achieve the delivery of WFD objectives. Where there are multiple barriers to fish passage within a catchment, we will refer to this work to ensure that improvements to fish passage are consistent with the wider aims for the catchment.

Where a fish pass is required, or an existing pass requires modification, the design and associated flow requirements must be approved by the Environment Agency. Where a fish pass is provided, the licence holder will be required to maintain the pass.

Design considerations for fish passes in hydropower schemes

The following sections provide examples of the different types of arrangement of hydropower schemes and fish passes.

Low head scheme, on-weir

Where a fish pass is already present, or where a fish pass is to be provided as part of the scheme, the downstream fish pass entrance should be co-located with the discharge from the turbine(s). The turbine flow will help attract more fish to the vicinity of an adjacent fish pass entrance. Any competing flow, away from the fish pass, will reduce the effectiveness and efficiency of the pass and will not be acceptable.

Where the entrance and discharge are co-located, a suitable pass attraction flow is between 5 and 10 per cent of the maximum turbine flow, dependent on the effectiveness and efficiency of its design. This is subject to the minimum flow required for the pass to attract and convey the numbers and sizes of fish expected.

A fish pass can be made more effective by providing augmentation and/or auxiliary flows. An augmentation flow is one where flow is added directly to the fish pass, so that higher levels of flow leave the fish pass entrance and draw fish into the fish pass. An auxiliary flow is a separate flow which runs beside the pass. This increased flow will help to attract fish towards the entrance to the fish pass.

However, an auxiliary flow is a flow competing with the fish pass discharge and is less effective than an augmentation flow.

The flow through a fish pass is considered to be part of the residual flow.

Further details are available in the Institute of Fisheries Management Fish Pass Manual.

Low-head leat system

Where the hydropower scheme is to be located within a leat system a fish pass may need to be located next to the turbine within the leat system and/or on the weir within the main channel of the river, or both.

The preferred solution is to retain the fish in the main river channel and the appropriate location for the fish pass should therefore be in the main river channel. This can be achieved with effective flow and screening management. The final design will depend on the requirements of the species that should be present, the management of flow at the site and the relevant environmental legislation.

During periods of fish migration, the majority of the flow through the scheme should be in the route of the fish pass to attract the fish. Flow through the site must be managed to ensure effective and efficient fish passage.

High-head scheme

Where a fish pass is needed for a high-head scheme, it should be sited at the impounding structure. Sufficient flow should pass through the fish pass and the depleted reach for the effective and efficient passage of the relevant fish species.

No fish pass requirement – other future considerations

If a fish pass is not a requirement of a scheme, we may still require you to make allowance for the installation of a fish pass in the future. When this is necessary, you will need to make sure that suitable space for a fish pass is safeguarded and sufficient flow is reserved for its future operation.

Downstream fish passage

Salmon and sea trout migrate downstream after spawning to return to the marine environment. Some species of coarse fish, particularly rheophilic species, will also move back downstream after spawning. If such fish have to pass over weirs (or other impounding structures) at your proposed scheme, you will need to consider the minimum depth of water passing over the weir and the size of fish that are likely to be passing downstream.

Where the minimum depth of water passing over the weir is less than the depth at which fish can pass freely, your development must make provision for these fish to pass without delay or injury.

It is acceptable to create a notch, or notches, within the weir crest that will allow fish to pass safely and without delay. Notches will need to be located in appropriate locations and be of an acceptable size.

Where this is not possible, and all fish cannot be guided to pass via a bypass channel, you must increase the minimum height of the water passing over the weir to an acceptable level. Consider the timing of any downstream migrations and whether the flow then passing over the weir could be too low.

What you need to do

The requirement for a fish pass will depend upon the fish species that are present or that migrate through the site of the hydropower scheme. Where rivers have impacted or recovering fish populations you may also need to consider the species of fish that should be present.

You will need to know which fish species are relevant to that location – and their migratory needs. You may need to consult with local Environment Agency fisheries staff to establish what is needed. You should do this through your account manager.

Additional information and guidance on fish passage

We advise developers to consult us early in the development process about the need for a fish pass.

Further information is available from:

- **Institute of Fisheries Management Fish Pass Manual**

  The Institute of Fisheries Management (IFM) has published a Fish Pass Manual as a guide for developers and designers.

  The manual contains background information on fish passes and the requirements of different species of fish, and gives examples of designs which may be suitable in different circumstances.

- **Environment Agency guidance for elver and eel passage**

  A guide, Elver and eel passes identifies solutions for improving passage of eels and elvers.

Statutory requirements

There is a range of legislation relevant to fish passage. The legislation serves two purposes, both identifying those cases where improved fish passage is needed and providing the powers to require its inclusion.

Salmon and Freshwater Fisheries Act 1975

The Salmon and Freshwater Fisheries Act 1975 states that, in waters frequented by salmon and sea trout, a pass can/will be required if:

- a new impoundment is constructed, or
- an impoundment is rebuilt or reinstated over more than half its length, or
- an existing impoundment is raised or otherwise altered, or any other obstruction to the passage of salmon or migratory trout is created, increased or caused.

Where an existing impounding structure is partially passable, removing flow from it to a hydropower scheme will in most circumstances reduce passage for fish. It may prevent passage altogether or, which is more likely, reduce the window of opportunity for fish to pass.

Eels (England and Wales) Regulations 2009

Under the Eel (England and Wales) Regulations 2009, the Environment Agency has powers to make provision for the passage of eels through dams and other obstructions. This is to enable the delivery of the Eel Management Plans required under the EU Eel Regulation.

Water Framework Directive 2000/60/EC (WFD)

Our permitting process for hydropower developments must ensure that no WFD objectives will be compromised and that the current status for each element of a water body (including environmental standards) is maintained.

The Environment Agency has a legal duty under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 to exercise its functions, such as the licensing of hydropower schemes, so as to secure compliance with the requirements of the Water Framework Directive to ensure WFD objectives are met.

A fish pass will be required where failure to include one would result in:

1. a deterioration in the status of the water body in which the hydropower scheme is situated or associated upstream and downstream water bodies, or

2. preventing the achievement of Water Framework Directive objectives (e.g. Good Ecological Status or Good Ecological Potential)

A fish pass may also be required where a hydropower scheme is built on an existing barrier to fish migration that has been identified as a reason for a water body failing to achieve its WFD objectives. This includes situations where the introduction of the hydropower scheme does not make fish passage worse, but improved fish passage is still needed.

Water Resources Act 1991

Fish passage can be made worse, either by an increase in the physical barrier or changes to the site that results in a delay or reduced cues to migration. This includes the potential effect of depleted reaches on fish migration, such as where leat systems are used or in high-head applications.

In these cases a fish pass may be required as a condition of an abstraction licence or impoundment licence granted under the Water Resources Act 1991.

Section 6(6) of the Environment Act 1995

The Environment Agency has a duty to maintain, improve and develop fisheries. Where the introduction of a hydropower scheme would impact on a fishery through changes to fish passage, a fish pass may be needed to ensure that duty is met.

Protected Areas

There may be other legal obligations where the sites or species affected have nature conservation designations. For example, Special Areas of Conservation or Special Protection Areas under the Habitats Directive, Ramsar sites or Sites of Special Scientific Interest.

7. Water Framework Directive

The Water Framework Directive (WFD) is European legislation that requires Member States to plan and act to protect and improve the water environment.

Water in rivers, lakes and estuaries, around our coasts and under the ground in aquifers are protected and improved under measures set out in our river basin management plans. They describe the main issues affecting the water environment and the actions we all need to take to deal with those issues.

WFD status and objectives

The principal objectives of the Water Framework Directive are to:

- achieve good status or potential in inland and coastal waters and groundwater
- prevent deterioration in the status or potential of water bodies
- achieve compliance with standards and objectives set for designated sites (see Conservation objectives for land-based protected sites in England)

The Water Framework Directive applies to:

- all inland surface freshwaters, including lakes, streams, canals and rivers
- all groundwater
- all transitional waters and estuaries
- all coastal waters out to one nautical mile from the low-tide mark

For the purposes of implementing the Water Framework Directive, waters are divided into water bodies. Each river water body has a defined catchment. Each water body is classified in terms of its condition or ‘status’. A range of biological and non-biological elements are assessed to determine the current status of the water body.

What you need to do

You can find out the baseline status or potential of the river where you are proposing your scheme on the 'What's in Your Backyard' facility on GOV.UK. Your Account Manager will have access to current data.

You need to understand the scale and the nature of the potential changes to the environment that your scheme may cause. Follow our guidance to help you to reduce the risks.

Submit a pre-application form to us and talk to your Account Manager to help you to develop the scope for your environmental report.

Include in your environmental report a WFD assessment demonstrating that your scheme will not compromise the objectives set out in the river basin management plan.

WFD assessment

Provide your WFD assessment as a section within your environmental report. Your assessment must demonstrate that your proposed hydropower scheme will not:

- contribute to a deterioration in the current status or potential of the water body or water bodies affected by your scheme
- prevent the achievement of objectives set for the water body or water bodies affected by your scheme

In preparing your assessment you will need to draw on a range of information, which may include:

- details of provision for fish passes (see Fish passage)
- details of the bywash channel (see Fish screening)
- details of fish screening measures (see Fish screening)
- an ecological survey (see Monitoring)
- a geomorphology/weir pool assessment (see Geomorphology including weir pools)
- a hydrology assessment (see Flow and abstraction management)
- for some schemes, a water quality assessment

How we assess the effects of your scheme

The Water Framework Directive requires that we assess all the impacts of your scheme, including biological, chemical, morphological and flow-related elements.

We need to establish that all new modifications, and certain existing ones:

- will not contribute to a deterioration in status or, for water bodies that have been designated as artificial or heavily modified, potential
- do not prevent the achievement of the status objective set for a water body

We will not normally accept a change to the environment which will reduce the status of any element, for example from good to moderate. Our assessment is based on expert judgement, supported by the environmental report that you provide.

If, as a result of our initial assessment, we consider that your proposal may prevent the achievement of WFD objectives then we will require you to carry out further detailed investigation and provide us with an additional report. We are unlikely to approve your application if your additional report indicates that your scheme will prevent the achievement of the WFD objectives.

8. Impoundments - the use of weirs

An impoundment (also known as 'Impounding Works') on a watercourse obstructs or impedes the flow of water. Weirs and dams are examples of impoundments. These structures create an impounded area of water upstream and change the physical nature of the watercourse both upstream and downstream of the impoundment.

Weirs typically disrupt the longitudinal connectivity of rivers. They also tend to change the nature of the physical habitat above and below the structure. This can sometimes affect a significant length of river. Reduced connectivity can have a significant impact on fish migration.

However there are many other potential impacts that we also have to consider. These include looking at whether the structure:

- restricts migration
- interrupts sediment transfer through river systems
- changes patterns of erosion and/or deposition

River Basin Management Plans

Within River Basin Management Plans, the Environment Agency will aim to introduce morphological restoration schemes in water bodies that are failing to meet the objectives of the Water Framework Directive or a designated site. The aim of the schemes will be to enable the water bodies to meet those objectives. Restoration schemes will seek to re-establish, as far as possible, the natural functioning of the river system and to deliver multiple benefits.

We have identified that some existing impoundments are a reason for a water body either not achieving good ecological status under the Water Framework Directive or, if it is within or affects a designated site, not meeting the objectives for the site. We may therefore identify such impoundments as needing removal or modification, irrespective of any hydropower proposals.

If the weir has been targeted for removal, we are unlikely to approve a hydropower scheme on the site. However, we would weigh up the relative social, economic and environmental benefits of the options. In order to proceed, the scheme may have to comply with the stringent tests set out in Article 4.7, 4.8 and 4.9 of the Water Framework Directive.

The situation is different if the weir only requires modification in order for the objectives of the Water Framework Directive or the designated site to be achievable. In such cases, we may consider a hydropower scheme on the weir. However, it will normally have to incorporate the required improvements. No scheme must prevent the achievement of the objectives of the Water Framework Directive or of a designated site. If the addition of hydropower to an existing weir is likely to reduce the ability of fish to pass the barrier, a fish pass will normally be required.

Some barriers have identified uses, such as for navigation, flood risk management, or abstraction. These will be more likely to remain in place.

Existing weirs

Hydropower schemes on existing weirs are more likely to be approved where:

- the existing weir is in a serviceable condition
- the weir is not within, or does not affect, designated sites
- the objectives of the Water Framework Directive are being achieved and future achievement is not compromised

- there is no risk of deterioration to the status of water bodies from the proposed works
- the weir cannot be removed

In authorising hydropower schemes that use existing weirs, we will need to assess whether the weir is causing or contributing to a failure to achieve the objectives of the Water Framework Directive (WFD) or a designated site. If this is the case, we may need to ask for modifications to, or even the removal of, the structure in order to achieve these objectives.

If a weir has an existing and necessary use, it is unlikely to be targeted for removal. We may still ask for it to be modified, provided the existing use can be maintained.

We do not encourage hydropower proposals that would involve raising the height of an existing weir.

We may accept small increases in weir height if the primary aim is to compensate for turbine draw-down or to improve fish passage. However, any application to raise the height of a weir must include an assessment of the potential implications in an appropriate environmental report demonstrating no prevention of achievement of the WFD objectives for any affected waterbodies.

New weirs

New weirs on lowland rivers

Given the likelihood of adverse effects on the environment – and the nature of these effects – we are unlikely to approve the construction on lowland rivers of new weirs that are solely for hydropower. This also applies to the reconstruction of weirs that have ceased to be serviceable.

If an application is made to construct a new weir it must include an assessment of the potential implications in an appropriate Environmental Report. This would need to focus on:

- the cumulative effects of weirs on fish migration
- the ecological effects of creating a ponded reach within a river – ‘ponding’
- the disruption of in-stream processes such as the transport of sediment
- the effect on flood risk
- the effect on fisheries and conservation
- the effects on navigation rights
- the effects on designated habitats and species
- the effects on other people’s rights to, and uses of, water
- how the objectives of Water Framework Directive are to be met.

New weirs on upland watercourses

We recognise that new small weirs on upland watercourses may have fewer effects – and that these effects may be more easily mitigated. New weirs in these locations are generally less than 1.5 metres high for flow division purposes. These may be accepted if their height is minimised. However, they can be associated with the creation of lengthy depleted reaches, the disruption of sediment transport, channel erosion and sediment deposition patterns, as well as specific local ecological effects.

You will need to set out the potential effects of any depleted reach in an environmental report. We will need to consider these effects and any proposed mitigation measures carefully and be satisfied that there will be no risks to WFD objectives, or the rights of other users. Any requirements for fish passage will need approval.

What do you need to do?

Any proposal to construct a new weir, or significantly alter an existing weir, with or without the creation of a depleted reach, will require an assessment for potential ecological and geomorphological effects. Schemes introducing a significant amount of bed and/or bank reinforcement may also need to be assessed for potential impacts.

Developers should talk to their Account Manager as soon as possible, as part of our pre-application process.

The information required to support the WFD assessment will need to be included in the environmental report for the scheme to adequately demonstrate that all obligations will be met. You may need to employ suitably qualified ecologists and geomorphologists to carry out surveys and advise on design options and mitigation measures.

9. Geomorphology (including weir pools)

The physical form of the water environment (such as river banks and beds) and the processes of sediment erosion, transport and deposition are collectively known as geomorphology[2]. These changes can alter physical habitats in rivers and could cause fish, aquatic plants and invertebrate populations to deteriorate. As part of our abstraction and impoundment licensing process for proposed hydropower schemes, we may require you to undertake a geomorphological assessment to help identify any possible environmental impacts that may compromise the objectives of the Water Framework Directive (WFD) or other environmental legislation. The geomorphology assessment will form a core component of your WFD assessment.

You should talk to your Account Manager as soon as possible as part of our pre-application process to determine whether this applies to your scheme.

How hydropower schemes can affect geomorphology

Weirs

Weirs can reduce or stop the development of natural channel forms or physical habitats by:

- reducing the movement of sediment downstream and changing patterns of sediment transfer, thus changing the supply of material that builds and maintains physical habitats
- reducing flow variability within upstream impounded reaches, thus reducing the processes by which channel features and physical habitats are created and maintained
- creating areas of bed scour immediately downstream of a weir face

Weir pools are typical features that develop in response to bed scour below a weir. We have provided specific guidance for assessing possible impacts to weir pools and their ecology at the end of this section.

Depleted reaches

In combination with the potential impounding effect of weirs, reduced flows in depleted reaches may alter natural channel forms and critical physical habitats such as fish spawning gravels.

The length of a depleted reach, the nature of the flow alteration and the geomorphological characteristics and sensitivity of the reach can determine the extent of geomorphological impact.

Associated infrastructure

A hydropower scheme may involve engineering works on the bed and banks of the channel and may affect important geomorphological processes. For example, introducing bed and bank reinforcement upstream or downstream of the impounding structure might cut off the source of

[2] Geomorphology may also be referred to as morphology or hydromorphology. Geomorphology and morphology are interchangeable terms and relate specifically to the physical form of a river, whereas hydromorphology also includes components of flow.

sediment which forms physical habitat in the river. It may also cause erosion elsewhere within the channel.

When do you need to carry out a geomorphology assessment?

You should expect to complete an assessment for most schemes if:

- your scheme will change the way water and/or sediment moves through the river channel
- you construct a new weir or impoundment (see Impoundments: the use of weirs)
- you raise the height of an existing weir /or the level of impoundment upstream of the weir
- you create a depleted reach
- you significantly reduce the flow over the weir and/or affect the characteristics of the weir pool
- your scheme (including associated depleted or impounded reaches) is within or close to a water body with river improvement or restoration plans that are designed to achieve WFD or designated site objectives and may be compromised by your proposals[3]

The list above isn't exhaustive; we may ask for a geomorphology assessment in other circumstances. These may relate to particular aspects of the scheme, site sensitivity or other legal requirements (see Water Framework Directive).

What you should include in your geomorphology assessment

Scope

The scope of any geomorphology assessment will depend on the specific details of your scheme.

Talk to your Account Manager to help define the specific requirements of your assessment.

Table 9.1 highlights some of the key areas to consider in defining the scope. Your answers should demonstrate that your scheme will not damage the environment. This list isn't exhaustive and these considerations will not be relevant to all schemes.

Style and level of detail

You should present your assessment as a component of the WFD assessment within your environmental report. If appropriate, you should include a non-technical summary. You may need to employ suitably qualified geomorphologists to carry out surveys and advise on design options and mitigation measures.

The level of detail in your assessment and report will reflect the complexity of your scheme, the proposed abstraction regime and the characteristics or sensitivity of the site/catchment to potential environmental impacts. Table 9.2 gives examples of different levels of assessment we may require. This list isn't exhaustive; we may ask for other forms of assessment.

[3] Refer to the River Restoration Centre website for details of the Restoring Designated Rivers project.

Table 9.1 What to include in a geomorphology assessment

Assessment	Considerations to help define your geomorphology assessment
Flows	What are the effects on water levels, flow diversity and physical habitats (for example bar features, marginal habitats) within the impounded reach?
	What is the likely extent of sedimentation within the impounded reach, upstream of the weir?
	What are the implications of the scheme on channel forming flow events within the depleted reach? Will key geomorphological processes and resultant channel forms be impacted?
	Will 'flushing' or maintenance flows (particularly during the summer months) decline in frequency and impact the quality of physical habitats (for example for fish spawning, invertebrates and aquatic plants)?
Sediment dynamics	What are the implications for sediment movement over the weir and through the off-take pipe/channel?
	If a depleted reach is created, what effect will the altered flows and impounding structure have on sediment transport, deposition and erosion?
	What are the effects of the weir and any associated infrastructure on flows dynamics in and around the structure? Will any changes lead to increased rates of erosion/deposition?
Bed / bank erosion	Will any flow or sediment depletion lead to bank erosion, scour or collapse?
	Will any associated structures (for example bank revetment, channel realignment work) lead to bed or bank erosion immediately upstream or downstream of the structures (including tailrace or outfalls)?
Riparian zone	Will the structure and composition of the riparian zone be affected as part of the scheme works (especially during the construction phase?). Are any impacts likely to be permanent?
Scale of geomorphological impacts	What is the spatial extent of any likely geomorphological impact? This needs to be considered at the water body scale and impacts to any other `connected` water bodies.
	What is the duration or permanency of any likely geomorphological impact?
Ecological impact	What are the ecological consequences of any potential geomorphological impacts? These should be considered in relation to WFD objectives and other environmental objectives.

Table 9.2 Levels of geomorphology assessment

Level of assessment	Example	Typical tasks
Light-touch review: desk-based	Minor amendment to existing hydropower scheme	• discussion with Environment Agency • short review of scheme proposals and any related environmental reports • short statement or report highlighting any issues
Detailed review: desk-based with site visit where necessary	Turbine installation on or adjacent to existing weir, utilising former wheel pit.	As above, plus: • expert review of proposals • geomorphological reconnaissance survey of the site if appropriate (e.g. habitat mapping, photographic survey) • reporting of assessments undertaken
Bespoke data collection and analysis	New high head hydropower scheme incorporating new weir and off-take	As above, plus: • site-based data collation and mapping (topographic survey, sediment character, detailed physical mapping) • bespoke sediment and geomorphology modelling

Standard information

You must include standard information in your report. We suggest you use the following requirements as section headings in your report. The level of detail we require in each section will depend on the proposed scheme design and site characteristics. A light-touch, desk based review, for example, may typically only require a short statement against each heading. Your Account Manager will help you define the scope of your assessment.

Geomorphology site overview

To describe and quantify the geomorphological characteristics. The nature of your proposals and site characteristics will inform the scale of your assessment, but is likely to include an evaluation of:

- channel forms and processes
- channel bed and bank sediment characteristics
- flow quantities and dynamics
- existing artificial structures or modifications

River Basin Management Plan baseline data

To help determine if the proposed scheme will impact on the current status and future objectives for the water body and any adjacent water bodies. You should indicate how far any potential impacts from your scheme will reach. Ask your Account Manager for the most up-to-date data.

Scheme description to include:

- a summary of the purposes of the work
- a description of the proposed work including relevant design drawings hydrographs/flow duration curves and temporary works
- a description of any proposed mitigation or enhancement measures

Impact assessment

An assessment of likely geomorphological and associated ecological impacts of the scheme within the water body and adjacent water bodies, if applicable:

- Considered at the short term (including construction phase), medium term (geomorphological adjustment following construction) and long term (including operational and decommissioning phase).
- Including the ecological consequences of any predicted geomorphological impacts at the site, along the depleted reach, and at the weir outlet.
- Including the geomorphological or ecological mitigation measures you will put in place to manage any predicted impacts. You should also describe any additional enhancements you propose that will contribute to WFD objectives.

Concluding statement

Your geomorphological assessment should clearly demonstrate that your proposed hydropower scheme will not:

- contribute to a deterioration in the current status or potential of the water body or water bodies affected by your scheme
- prevent the achievement of objectives set for the water body or water bodies affected by your scheme
- compromise the achievement of designated site conservation objectives

You must submit a summary of the evidence you have used and justify the level of confidence in your judgement.

Weir pools

A weir pool is an area of water below a weir (or similar impounding structure) that is influenced by the flow of water over the weir. They form as a consequence of geomorphological processes (scour and deposition) and are therefore important features to consider as part of your geomorphological assessment.

Weir pools can be important habitats for plants, invertebrates and fish. They are used for spawning and fry development of several river-based species, such as trout, barbel, dace, chub, bullhead and stone loach. They can provide valuable and popular recreational fisheries.

The weir pool habitat may contribute to the status of the fish population, wider ecology and recreational fisheries for a distance downstream. It may also contribute significantly to the WFD status of the river water body.

What do you need to do?

If there's a weir pool associated with your scheme you need to understand how it affects the local ecology and design your scheme to take account of this. Factors that could affect a weir pool include:

- the location of the turbine tailrace
- the management of flows across the scheme, including turbine flow, flow over the weir and fish pass flow where relevant
- the local bed and bank material and structure, and changes in sediment supply

It's important to avoid changes to a weir pool that might adversely affect compliance with the relevant environmental legislation or the rights of existing users. Examples of unacceptable adverse change include:

- a deterioration in the WFD status of the associated water body
- preventing the water body from achieving its environmental objectives under the WFD
- a harmful change for existing users of the river, including riverside (‘riparian’) use such as a fishery, rights of navigation and legitimate amenity use

Ecologically important features

Before you undertake detailed ecological and geomorphological survey, try to establish what is already known about the nature of the weir pool. If possible, we will try to make decisions on the basis of existing data and information you supply, together with expert judgement. Where this isn't possible, we may require you to carry out surveys and modelling to provide the necessary information.

To understand the ecological significance of a weir pool, it's necessary to understand both the type of habitat associated with the weir pool and the species that use it. In relation to the WFD, where a weir pool contributes to the ecological status of a water body, we need to consider any potential changes to the flow and geomorphology within it that would be caused by the introduction of a hydropower scheme.

Table 9.3 highlights some of the key areas to consider.

Table 9.3 Important ecological features in weir pools

Feature	Considerations
Substrate	Fish use gravels for spawning. Gravels are typically found at the tail of the weir pool. Presence and distribution of gravels are maintained by flows through the weir pools: • large flows can significantly alter their distribution • low flows can result in sediments being deposited • medium flows help maintain spawning gravels by keeping them clean and well oxygenated
Fish and other biological interests	Many species can utilise weir pool habitats for a range of purposes. The biology found in weir pools can contribute to the assessment of ecological status under the WFD. Fish and other biological interests can be designated features of protected areas and may require additional protection.
Ecologically significant habitat	Habitats change depending on location and flow regime. Not all weir pools will have the same ecological value. Large, deep weir pools with large boulders are unlikely to contribute to the wider ecology of the river. Changes to flow are less likely to affect the overall status of the stretch of river. Flow of water over the weir creates increased oxygen levels. Water-borne food can be channelled through the tail of a pool and so provide an attractive habitat for fish.
Lawful uses, such as a fishery	Weir pools are often the site of recreational fisheries. Changes to the design and management of flows within such habitats might alter the distribution of fish within the weir pool, to either worsening or improving the fishery. Where a fishery exists, we need to consider the likely effect of the revised flow regime through the site.

Features elsewhere within the river section

Where similar habitat features are prevalent throughout the stretch of river, the contribution from the weir pool may be relatively small. In these cases, changes to a weir pool are less likely to affect the ecology of the river section as a whole and would be unlikely to cause a deterioration in the status of the water body in which it's found or with which it's associated.

In other cases, for example in lowland impounded rivers, the important habitat associated with the weir pool may not be prevalent in the rest of the river. In these situations, the weir pool habitat is even more valuable. Changes that would damage this habitat are more likely to be unacceptable. Not all changes have the potential to cause an ecological impact, some may be beneficial.

How can you assess the weir pool habitat?

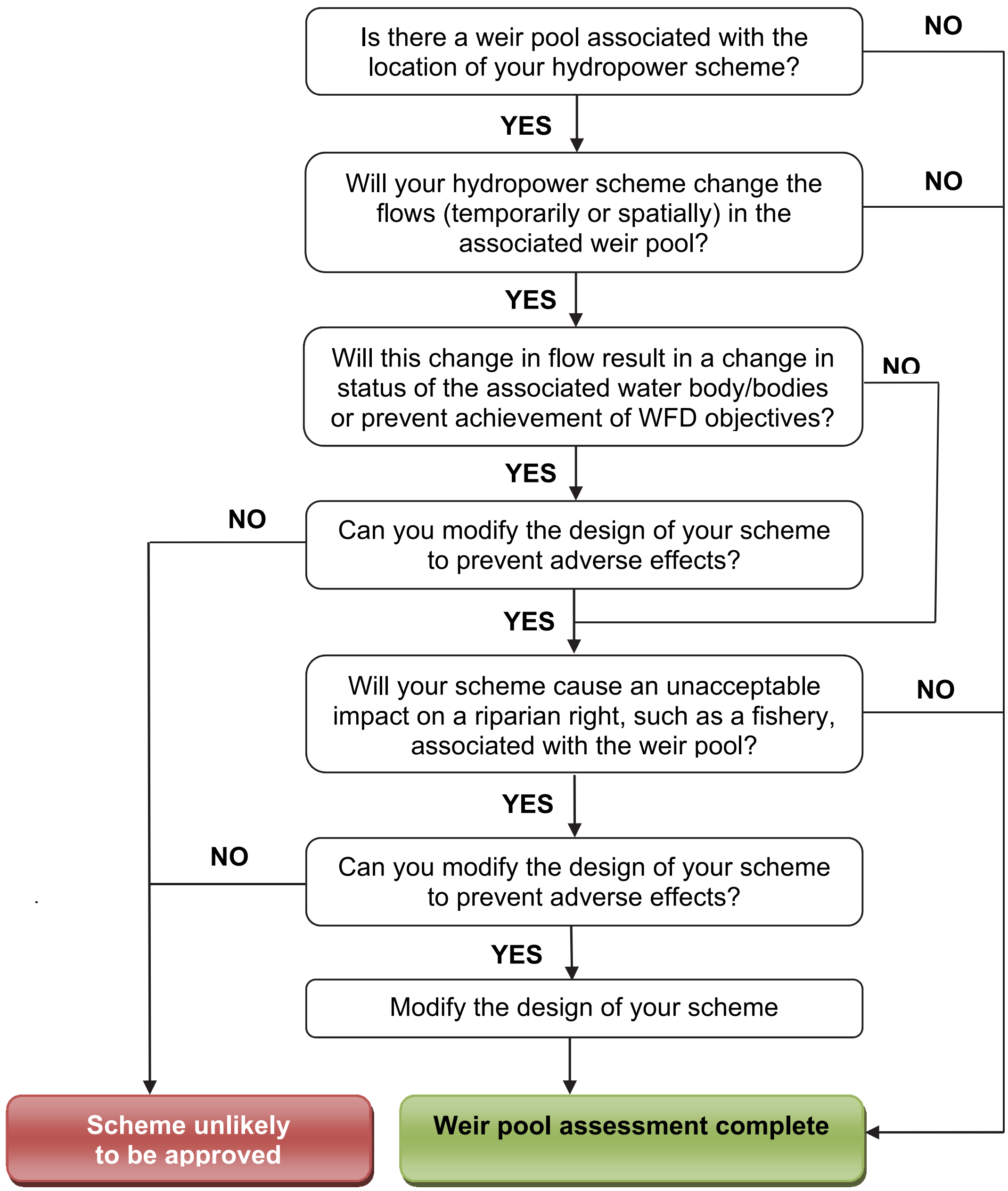
For each weir pool, you must consider the following elements:

- which ecologically important features are contained within the weir pool
- the contribution these features make to the ecological status of the river
- whether there is a fishery (or other existing use) associated with, or affected by, the weir pool

How do you do this?

Figure 9.4 shows how to design your scheme to take account of the associated weir pool.

Figure 9.4 Decision tree to support weir pool assessment



10. Nature conservation and heritage

Statutory framework

We have a duty, when exercising our functions, to conserve biodiversity, through the following legislation:

- Conservation of Habitats and Species Regulations 2010
- Countryside and Rights of Way (CRoW) Act 2000
- Environment Act 1995
- Natural Environment and Rural Communities Act 2006 (Sections 41 (England))
- Wildlife and Countryside Act 1981

We must determine if developments within or close to heritage and nature conservation sites could result in harm.

The heritage and nature conservation sites that we screen for include:

- the Natura 2000 network of European sites, such as, Special Areas of Conservation (SACs), Special Protection Areas (SPAs), candidate Special Areas of Conservation (cSACs), potential Special Protection Areas (pSPAs), Ramsar sites; and Marine Conservation Zones (MCZs). Refer to magic.defra.gov.uk for further details of designated sites
- Sites of Special Scientific Interest (SSSI)
- National Nature Reserves (NNR), which are also SSSI
- local nature reserves (LNR)
- national parks (NP)
- areas of outstanding natural beauty (AONB)
- scheduled ancient monuments (SAM)
- heritage coast
- local wildlife sites (LWS)
- ancient woodland

We also screen for internationally and nationally protected species and habitats, wherever they occur. We need to ensure that an application will not, for example:

- damage or destroy their habitat, for example, breeding site or areas used for shelter or protection
- disturb them in a way that will significantly affect their ability to survive
- impair their ability to hibernate or migrate
- affect their local distribution or abundance

Hydropower schemes have the potential to affect species and habitats, during all stages of scheme development. These include:

- Construction effects, such as impacts on habitat, damage and disturbance to protected species, changes to vegetation and drainage caused by pipeline construction, ancillary construction damage to site for example sediment release.
- Operational effects, such as low flows, depleted reaches of the river, obstruction to migration of aquatic animals and desiccation of mosses and liverworts.

Table 10.1 lists some of the adverse effects on species and habitats which your scheme must avoid by including suitable mitigation measures (limits or controls that prevent harm).

Table 10.1 Potential effects of hydropower on species and habitats	
River habitats	Hydropower can affect river ecosystems by: • making physical modifications to the river channel • altering the natural flow Schemes can adversely affect riverine and riparian habitats, both downstream and upstream of the installation, and associated flora and fauna, including fish, invertebrates, lower plants (mosses and liverworts) and higher plants (rooted, flowering). This can occur from changes to high and low flows, as well as flow variability.
Biological connectivity	The natural movement within river systems of animals, plants ('biota') and sediments is critical to maintaining healthy aquatic communities. Together with fish, many invertebrates which do not have a flying life stage are affected by obstructions to movement. Examples include crustaceans and molluscs. Maintaining or re-establishing biological connectivity increases the resilience of biological populations to climate change.
Lower plants	Reduced flows in a depleted reach can reduce the amount of spray or humidity that is essential for some lower plants to survive. These plants include some ferns and flowering plants but also a significant number of mosses, liverworts and lichens (collectively known as 'lower plants'). The humid environment required by these species limits the number of places where they can grow. Some of these species are very rare across the UK, Europe and globally. Certain lower plants grow on rocks that are covered by water when river levels are high, but exposed on low flows. Changes to flow levels in a depleted reach can leave streamside rocks drier for longer.
Adjacent terrestrial habitat	Working corridors and access may affect nature conservation and heritage sites and species. For example, woodlands and wet flushes.
Species	Changes to the bank side or modifications to water level can have negative effects on species. Otter, for example, can have their food source disrupted and their holts (breeding areas) flooded.

How we will assess your proposal

We use a risk-based screening tool, using electronic maps and records, to identify applications that could pose a risk to nature conservation sites and species. The assessment approach we take varies according to the type of heritage and nature conservation sites identified.

Natura 2000 sites

We will consult Natural England and/or Natural Resources Wales where we identify likely significant effects of a scheme on Natura 2000 sites.

We will take account of the likely impact of your scheme on these designated sites in light of their conservation objectives. We assess schemes using two tests:

- firstly, that the proposed project is not likely to have a significant effect alone or in combination
- secondly, if a significant effect is likely, that the development will not adversely affect the integrity of the site

All relevant competent authorities (including the Environment Agency, Natural England and your Local Planning Authority) will need to assess your proposal, working together to complete the Habitats Regulations Assessment for the scheme. Only those schemes which will not have an adverse effect on the integrity of a European site will be permitted.

Typically the standards of environmental protection relevant to designated sites are more protective than elsewhere, especially for Natura 2000 sites. We therefore have to be more cautious in our permitting decisions, due to the precautionary nature of the tests in the Conservation of Habitats and Species Regulations 2010.

We may also need to apply these more protective flow targets to areas outside non-designated sites, for example to protect migratory fish species that may use the entire river system and migrate to and from the sea.

SSSI sites

We will consult Natural England and/or Natural Resources Wales where we identify that a scheme is likely to damage SSSI sites.

We will take account of the likely impact of your scheme on these sites in light of the condition status of the features for which the SSSI is designated.

Other Nature Conservation and heritage sites

Our screening exercise may identify a variety of other nature conservation and heritage sites and species, each of which we have a duty to conserve. We will gather information about these sites and assess the potential risks from your proposal, in consultation with the relevant organisation for each protected site.

Cumulative and in-combination effects

We do not look at proposals for hydropower schemes in isolation. We will need to consider how they will affect the environment in combination with other past, present and future developments.

These changes could bring benefits to the environment, or harm it, or do both. They are sometimes divided into ‘cumulative’ and ‘in-combination’ effects:

Cumulative effects are the effects of the same type of activity or stress in a number of locations added together. The relevant 'competent authority' (the Environment Agency or Natural England) will consider cumulative effects as and when appropriate.

In-combination effects are the effects of different types of activity or stress added together. When assessing a proposal for a hydropower scheme we will consider these effects with other activities that can reasonably be expected to interact, either in an additive or synergistic way, to adversely affect the environment. This includes activities:

- of a similar and/or different type
- authorised by other authorities
- that may not have a significant effect when considered alone
- for which permission is currently being sought
- proposed or authorised but not yet fully implemented
- that are regularly exercised and have continuing effects

How we will assess cumulative and in-combination effects

Key pieces of legislation require us to look at the cumulative or in combination effects of hydropower schemes. These include the Water Framework Directive and the Conservation of Habitats and Species Regulations 2010.

We are required to carry out a specific assessment of ‘in-combination’ effects for SACs, SPAs and Ramsar sites. This involves evaluating your scheme in combination with other permissions, plans or projects. We do not have an explicit legal obligation to assess in-combination effects for Sites of Special Scientific Interest but we apply similar technical considerations as for SACs, SPAs and Ramsar sites.

We consider the magnitude of the environmental effects that each current or planned scheme causes and the size of the area that would be affected. Effects may include:

- reductions in fish stocks, for example through damage to or loss of habitat or obstructions to migration
- the loss of natural changes to morphology caused by static flows and the flushing of nutrients and sediment at times of low flow

We will assess each scheme on its own merits. You may not have all the evidence or information that we need to consider cumulative or in-combination effects. However, you will need to contribute to our assessment, which will consider:

- the number of existing hydropower schemes in a catchment
- the number of known proposals for hydropower schemes in a catchment
- the environmental objectives for the catchment
- whether the proposed scheme, in combination with other activities, could impact on water body objectives under the Water Framework Directive (namely cause deterioration in ecological status/potential or prevent the achievement of improvements in status)
- whether the proposed scheme, in combination with other activities, could affect a designated site
- whether there are other impacts, such as impoundment or flow depletion independent of your own scheme

What you need to do

We recommend that you talk to your Account Manager as soon as possible before you formally apply. We will pick up on any specific issues associated with your development to help you understand the issues and what is involved. If your scheme is in or near a designated site, you should also contact Natural England at an early stage. Contact Natural Resources Wales if the designated site lies wholly or partly in Wales.

When you formally apply, your environmental report must address the issues identified in pre-application discussions and in our hydropower guidance. You may need to employ suitably qualified ecologists and geomorphologists to carry out surveys and advise on design options and mitigation measures.

11. Flood risk

Flood risk assessment

A hydropower scheme may increase flood risk or affect what would happen during flooding.

It's likely that you will need to carry out a Flood Risk Assessment. This assessment will form part of your planning application to your local planning authority (LPA). Ask your Account Manager to explain what you need to do and when. We recommend contacting your LPA as early as possible.

Further guidance about the application process is available on GOV.UK.

Flood defence and ordinary watercourse consent

You must apply for a flood defence consent from us when your scheme is sited on, or within a specified distance of, a main river. This distance is set by local byelaws and generally ranges between 8m to 20m.

A main river is a watercourse that is shown on a main river map and includes any structure or appliance for controlling or regulating the flow of water into, within or out of the channel. Refer to our flood map to find out if a watercourse is a main river.

Watercourses that are not designated as main rivers are called ordinary watercourses. You may require an ordinary watercourse consent from either the Lead Local Flood Authority, usually the county council or unitary authority, or the Internal Drainage Board. Table 11.1 gives details of the responsible authorities for different types of watercourse.

Examples of work that may need Flood Defence consent are:

- works to strengthen the river banks
- works associated with the impoundment, for example a weir,
- works associated with the intake and outfall structures, for example, sluice gate or fish pass
- building other structures such as a penstock pipe or powerhouse
- maintenance not covered by riparian responsibilities
- dredging the watercourse and removing materials
- culverting a watercourse
- temporary works, including scaffolding and cofferdams (watertight enclosures) across a watercourse, or temporary diversions of water while work is carried out

Table 11.1 Responsibilities for main rivers and ordinary watercourses

	Who to apply to	**What to apply for**
Main river	Environment Agency	Flood Defence Consent
Ordinary watercourse	Lead Local Flood Authority	Ordinary Watercourse Consent
Ordinary watercourse within an Internal Drainage Board area	Internal Drainage Board	Ordinary Watercourse Consent

What you need to do

Read our general guidance for carrying out flood risk assessments:

For development in Flood Zones 2 and 3 see Flood risk assessment in flood zones 2 and 3. Further information about development and flood risk is also available from the National Planning Policy Framework and practice guidance. A Flood Risk Assessment for this type of activity may not be that onerous and we advise you to contact your Account Manager to discuss the scope of the assessment.
Pollution Prevention Guidance 5: Works and maintenance in or near water provides advice on how to avoid pollution to the water environment, how to manage waste and how to respond to an incident when planning works near water.

Apply for separate flood defence or ordinary watercourse consents

You need separate flood defence or ordinary watercourse consents for individual structures/elements of work.

For permanent works, the environmental report you prepare for your scheme will form part of your application for flood defence consent or ordinary watercourse consent. For most schemes you will need to include an assessment of flood risk to demonstrate that there is no increase in flood risk.

For temporary works, you will need to provide a method statement for the works explaining how and when they will be carried out. Include any specific measures you plan to take while the work is being carried out to:

- keep disruption to a minimum
- minimise obstruction to river flows
- reduce any unwanted effects such as siltation
- prevent pollution
- prevent the spread of invasive species and enforce biosecurity

Your application should include plans to show the location of the proposed works to an appropriate scale, including a location plan, a site plan and detailed drawings.

Include details of the calculations and/or modelling on which your assessment is based.

12. Monitoring

Licences for hydropower installations include conditions about operational control and monitoring. Operators are responsible for ensuring on-going compliance with licences and may be required to provide us with records to demonstrate this. This forms part of our **compliance monitoring**.

We may also ask for **environmental monitoring**, to ensure that individual schemes don't harm the environment. You can also use any environmental monitoring evidence that you have gathered when you apply to renew your abstraction licence.

We will ask for monitoring of site-specific safeguards and make site visits.

What you need to do

Pre application

At the pre-application stage we may require you to carry out ecological surveys. This will help you understand the ecological sensitivity associated with the site and should address any potential impacts of your scheme on these features. This information will be used to help determine aspects of your scheme design. This information should be submitted within your environmental report.

We may also require you to monitor your site before we determine any licence application so that you have baseline data which we can use to set conditions if any licence is granted.

Pre- and post-installation

If you follow the advice in this guidance, we are less likely to require you to monitor the environmental effects of your scheme during operation. We may only require you to carry out operational monitoring (described in the section on compliance monitoring below).

We may ask you to monitor environmental effects before and/or after we make our decision on licensing your scheme in locations where it's unclear whether the scheme design will adequately protect particular species or hydrological and morphological conditions.

You will be required to undertake and pay for any monitoring specified in the licence.

Compliance monitoring

There are two main aspects of compliance monitoring:

- **installation compliance monitoring** demonstrates that the scheme has been built and installed as licensed
- **operational compliance monitoring** provides evidence that the scheme continues to operate as licensed, complying with environmental and ecological safeguards and with the requirements for flow management

Installation compliance: key points

We must be satisfied that schemes are built, installed and maintained in accordance with our licence conditions. We may need to visit your scheme to confirm details on site. We may check that you have:

- built the scheme in accordance with licence conditions

- installed the turbine and associated infrastructure in accordance with the method statement
- met the requirements for safeguarding the ecology
- complied with the conditions set down for the scheme’s design, such as flow and level constraints

Operational compliance monitoring: key points

When we grant licences, we specify requirements for operational controls and monitoring:

The developer should demonstrate compliance with the licence conditions. These may include the quantity of water that can be used, and the measurement of flows and water levels.

The precise method chosen to measure and record such flows or levels may be different for each site.

We will expect the operator to have a system in place to control and monitor the flows in their schemes. The data from this system must be properly recorded so it can be used to demonstrate compliance with licence conditions.

The Water Resources Act 1991 requires us to specify the maximum volumes of water that may be abstracted on full abstraction licences, in terms of daily and annual abstraction rates. We may also specify the maximum volumes of water that may be abstracted on transfer abstraction licences.

We may also require monitoring systems to demonstrate that specified safeguards, such as fish passage flows and behavioural systems for screening fish, are operating in accordance with the licence conditions.

Compliance monitoring: flows

We will require you to monitor flows to show that the scheme is complying with your licence conditions, that:

- the hands off flow does not fall below the required level
- the maximum licensed flow volumes are not exceeded

Where electronic controls are used to control flows and water levels, you must archive the data and be able to provide it when asked. We will aim to agree with you how often and when we will require data. We will specify these requirements as part of your licence conditions. This may include:

- operational compliance data (for example on levels or flows) either at intervals of 15 minutes, or at other specified intervals
- volumetric data for weekly, monthly and annual periods, or for any other specified periods

The level and frequency of data we require will reflect the level of risk the scheme poses to the watercourse, to the ecology and environment, and to other licensed and lawful users.

If you don't control and monitor operations electronically, we shall specify other verifiable control and compliance systems you can use to demonstrate you are complying with the licence conditions.

You will need to assess the volumes of water your hydropower scheme uses and how much electricity it generates.

You can assess flow by converting the records of electricity generated. You will need to calculate the conversion factor for your site, as explained in our Flow Measurement Analysis guide. Ask your Account Manager for a copy of the guide.

Environmental monitoring

We need to be sure that individual schemes don't harm the environment. For some schemes, we will ask for environmental monitoring to help manage any risks from these potential changes. Any monitoring we request will be proportionate to environmental risk. We will ask you to set up a suitable monitoring programme, which we will agree with you.

Your monitoring programme must define:

- the specific risk you are assessing and how it can be distinguished from other environmental pressures
- whether you need to collect new data or data from existing programmes
- how you will analyse data and what results you will generate
- your timescales for monitoring and submitting results to us

We will work with you to identify how the monitoring outputs will influence how your scheme operates, including:

- the triggers for action
- operational changes (for example inform renewal, cessation clause, additional screening)

Normally we only ask for environmental monitoring to be carried out for a set period of time. However, we may extend this period if we need to gather clear evidence of the scheme's effects, or lack of effects, on the environment and ecology.

Timescales may need to be long enough to allow for the natural variations which might occur over time. We may need monitoring for several years or even the lifetime of the licence. Examples of monitoring required over long periods include:

Fish populations can fluctuate significantly from year to year due to natural variations. You may need to monitor and assess these natural changes in order to establish any direct effects of your hydropower scheme on fish populations.

It may be several years before we see the effects on populations of sensitive lower plants and ferns (see Nature conservation and heritage for more information). Some plant populations are dynamic, so you may need to monitor potential new areas of growth as well as directly monitor existing growth.

If environmental monitoring demonstrates that your scheme is causing environmental damage, we may need you to amend how you operate your scheme.

Glossary

Abstraction	The removal of water from a watercourse.
Abstraction Sensitivity Bands (ASBs)	There are three abstraction sensitivity bands assigned to each water body in England and Wales: ASB1 low sensitivity; ASB2 moderate sensitivity and ASB3 high sensitivity.
Account Manager	Throughout the pre-application and application processes, your Account Manager will be your single point of contact. They will help you understand our requirements and provide initial advice.
Approach velocity	The speed at which the water flowing towards an intake hits the fish screen. Also known as 'escape velocity'.
Base flow	The component of stream flow that originates from storage within the catchment, for example, groundwater, and supports stream flows during long periods with no rainfall.
Base flow index	The ratio of annual baseflow in the river to the total annual runoff.
Biota	Animals and plants.
Bywash	The arrangement of flow that is needed to prevent fish from becoming trapped by, or caught up in, the screening at a hydropower scheme.
Catchment	An area with several, often interconnected, water bodies (rivers, lakes, groundwater and coastal waters). There are 93 catchments in England, six of which cross borders with Wales.
Catchment Abstraction Management Strategies (CAMS)	A framework to assess resource availability to produce a licensing strategy on a catchment scale.
Coarse fish	A freshwater fish that isn't a member of the salmon family.
Cofferdam	Watertight enclosure across a watercourse.
Competent Authority	The public body (such as the Environment Agency) which has responsibility for assessing the potential impact of a development on water bodies or protected nature conservation sites.
Depleted reach	This is the section of a watercourse between the point where water is taken out of the river and the point at which it's returned.
Designated site	These include Sites of Special Scientific Interest, Special Areas of Conservation, Special Protection Areas and Ramsar sites. These sites have designated features which have various degrees of legal protection.

Ecological connectivity	Refers to the connected system of open space throughout an ecosystem and adjacent ecosystem. For example, the ability for fish to move within river systems to complete their life cycle.
Ecological potential	The Water Framework Directive classifies all Heavily Modified or Artificial Water Bodies in terms of their ecological potential.
Ecological status	The Water Framework Directive classifies water bodies in terms of their ecological status.
Ecosystem	The interactions of a community of living organisms with their environment.
Environmental Flow Indicators (EFI)	Identifies where abstraction pressure may start to cause an undesirable effect on river habitats and species.
Environmental report	Report that presents various types of supporting information, submitted with the formal application form.
Environmental statement	Where a proposed development is the subject of an Environmental Impact Assessment, you will be required to prepare an Environmental Statement. This is likely to present information in order to assess the likely environmental effects of your proposal.
Escape velocity	The speed at which the water flowing towards an intake hits the fish screen. Also known as 'approach velocity'.
Expert judgement	Our staff use their professional knowledge and expertise to interpret available evidence.
Fish pass	A structure that allows fish to move upstream or downstream of a barrier. There are many types of fish pass.
Fish passage	To allow free movement of fish and eels
Flashy flow	Frequent, heavy flows of short duration in a river or watercourse.
Flow Duration Curve (FDC)	The statistical availability of any given flow, based on the best available information.
Forebay	A pond/pool where water is diverted before entering the turbine.
Geomorphology	The form and processes which make up the physical structure and habitat of the river channel. This defines its ability to allow migration of aquatic organisms and maintain natural sediment transport, and physical features of the channel. (See also Hydromorphology).
Hands off flow (HOF)	This is the minimum flow that needs to flow over the weir and down the depleted reach when abstraction and/or impoundment is taking place.

Hydrograph	A graph showing changes in river flow over a period of time.
Hydromorphology	The form and processes which make up the physical structure and habitat of the river channel. This defines its ability to allow migration of aquatic organisms and maintain natural sediment transport, and physical features of the channel. Hydromorphology and geomorphology can be interchangeable terms, although the former includes a greater emphasis on flow. Hydromorphological quality elements are important for assessing compliance with Water Framework Directive objectives.
Impoundment	Where water is obstructed, held or stored behind a structure or works, such as a weir, dam or sluice.
Intake	The point at which water is diverted from the river towards the hydropower turbine.
Integrity (of a designated site)	Legal term for maintaining the ecological conditions within a designated site.
Invertebrates	Animal species that don't develop a spinal column.
Leat	A man-made water channel.
Main river	A main river is a watercourse that is shown on a main river map and includes any structure or appliance for controlling or regulating the flow of water into, in or out of the channel. Refer to our flood map to find out if a watercourse is a main river.
Material considerations	Impacts that planning authorities must consider as they assess planning applications.
Mitigation measures	The measures taken to reduce or remove the risk of activity causing damage.
Morphology	The form and function or physical structure of the river channel. This defines its ability to allow migration of aquatic organisms and maintain natural sediment transport, and physical features of the channel. Morphology puts a greater emphasis on the form of the channel rather than the processes operating within the channel. (See also Geomorphology and Hydromorphology).
No deterioration	The Water Framework Directive requires that water bodies must not deteriorate from one status class to a lower one.
Ordinary watercourse	Any watercourse that doesn't form part of a main river.
Pre-application	Pre-application is an opportunity to discuss your proposal with us before you formally apply. We recommend that you follow our pre-application advisory procedure.

Qn	The natural river flow that is exceeded for a percentage (shown by n) of the year. For example, Q95 is the natural river flow you would expect to be exceeded for 95% of the year.
Qmean	The mean flow of a river. It is usually calculated from the daily mean flows for a given period.
Reach	A continuous stretch of river.
River Basin Management Plan	River Basin Management Plans set out measures to improve water in rivers, estuaries, coasts and aquifers in a river basin district under the Water Framework Directive. They are produced every six years.
River dynamics	(see Morphology)
Riverine/riparian habitats	The ecology found along the banks of rivers.
Run-of-river	Hydropower in rivers, where there is little or no storage of water,
Salmonid	A fish of the salmon or trout family.
Screen	Fish screens can be physical barriers that block fish passage or behavioural screens that steer fish away from danger.
Sediment transport	Movement of solid particles such as sand and mud in rivers.
Special Area of Conservation	Special Areas of Conservation (SACs) are strictly protected sites designated under the EU Habitats Directive.
Turbine	Converts the energy from flowing water into electricity, Many different types of turbine are used in hydropower schemes.
Water body	The division of units of water into manageable areas for which objectives are set under Water Framework Directive.
Water Framework Directive (WFD)	This EU legislation requires member states to plan and act to protect and improve the water environment. It has significant implications for hydropower schemes.
WFD objectives	The objectives of the Water Framework Directive are to: • achieve good status or potential in inland and coastal waters and groundwater • prevent deterioration in the status or potential of water bodies • achieve compliance with standards and objectives set for designated sites.
Weir pool	An area of water below a weir (or similar impounding structure).

Acknowledgements

This guidance has been produced by the Environment Agency with input from the Hydropower Working Group. This group brought together key representatives from industry and interest groups and partners to consider hydropower and its potential impacts on the environment.

Feedback

If you have questions or comments about this guidance or its associated advice notes, or suggestions about how we could improve it. Please email us at enquiries@environment-agency.gov.uk, phone us on 03708 506 506 or write to us at:

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