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Flow and abstraction management

This document is part of our set of advice notes to help you design your hydropower scheme. You should read our Guidance for run-of-river hydropower development first, which contains an overview of our guidance and a glossary of technical terms.

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, based on a percentage of the natural flow above Q95, the flow that is exceeded for 95% of the year, or for high baseflow rivers, we use Q97

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, nature conservation and heritage)
- maintain or improve fisheries and fish passage (see Fish passage and Screening requirements)
- not have unacceptable impacts on protected sites or species (see Water Framework Directive, 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. For example, increasing the HOF; reducing the maximum abstraction level or the percentage abstraction above HOF; seasonal variations in abstractions; or 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 upward
	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 upstream to the downstream (depleted reach) flows to be maintained at the ratio of at least Qmean to Q80 *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-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 our advice note on Water Framework Directive, 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

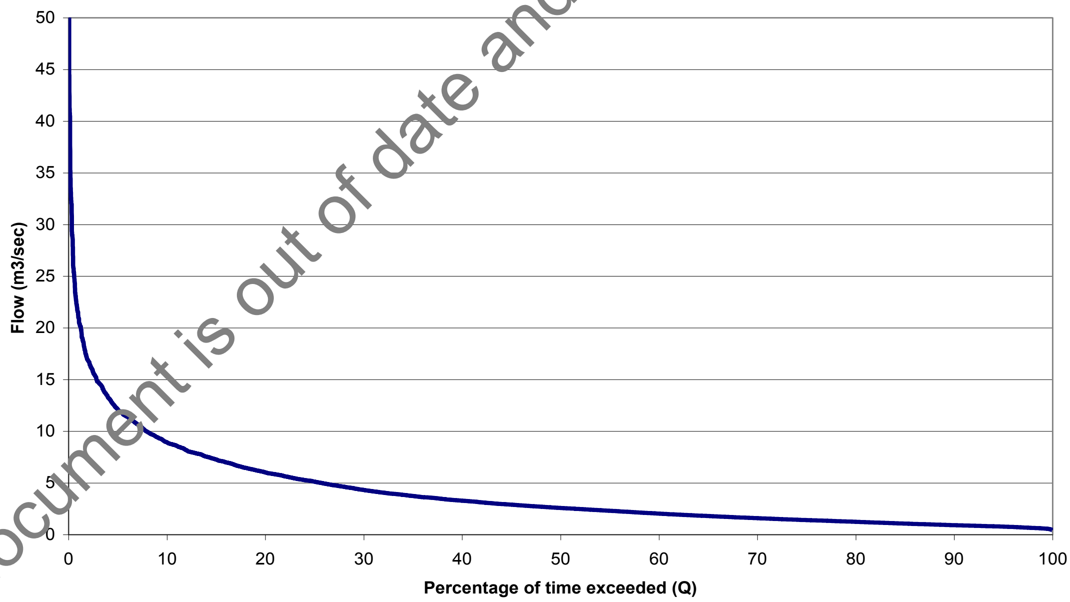
Flow duration curve (FDC)

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 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 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.

As with all flow duration statistics, 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. This will 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

Depending on the technique you use to produce flow duration statistics, the sensitivity of the catchment and the potential impact of the abstraction, we may require you to carry out additional gauging of the local river flow, over a range of flows. 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 at the location you are proposing to construct your scheme. This indicates how much the river flow is affected by stored sources within the catchment.

We use the base flow characteristic of the river to set standards for different types of hydropower schemes. For the purposes of making a simple assessment of the base flow characteristic, the ratio Q95:Qmean is used 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.

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

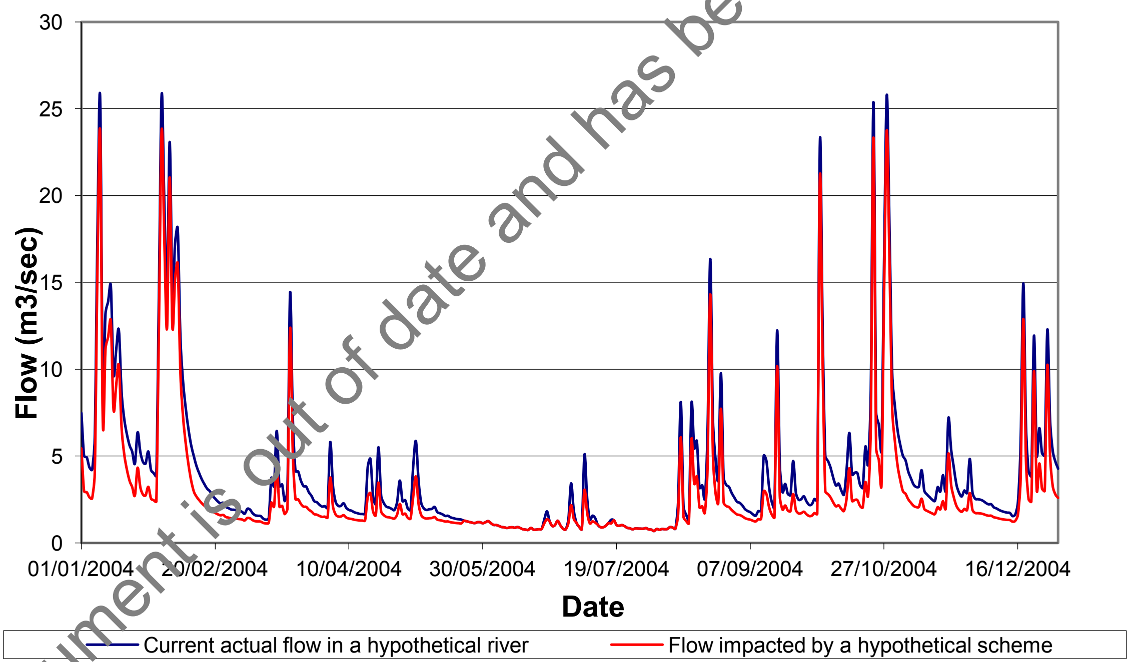
From this information we may decide there are periods of the year when we can't permit abstraction, or periods when we can allow abstraction to reduce or increase.

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 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.

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