

*National Rivers Authority*

# Hydropower

## A Handbook for NRA Staff

VOLUME 027



# NRA

Guardians of the Water Environment



*National Rivers Authority*

# **Hydropower**

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**VOLUME 027**

March 1995

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# Hydropower

A handbook for NRA staff

## CONTENTS

1. INTRODUCTION .....	3
1.1. Who this handbook is for .....	3
1.2. The National Hydropower Group .....	4
1.3. Other guidance .....	4
1.4. Relationship with planning and other regulatory authorities and interests .....	4
1.4.1. Planning .....	5
1.4.2. Land ownership, boundaries etc. ....	5
1.4.3. Safety .....	5
1.4.4. Longer term impact .....	5
2. HYDROPOWER: AN OVERVIEW OF THE NRA'S CONCERNS .....	6
2.1. The NRA's duties .....	6
2.2. Impacts of hydropower .....	7
2.3. Assessment of environmental effects (EA) .....	8
2.3.1. The EA process .....	9
2.3.2. The EA Report .....	11
2.3.3. EA: conclusion .....	11
3. WATER RESOURCES CONSIDERATIONS .....	12
3.1. Time limited licences .....	13
3.1.1. Duration of time limited licences .....	13
3.2. Operating agreements .....	14
3.3. Minimum acceptable flows .....	15
3.3.1. IFIM and PHABSIM .....	15
3.3.2. Surface Water Abstraction Licence Policy .....	16
3.3.3. Determination of minimum acceptable flows .....	17
3.4. Measurement, monitoring and controls .....	17
3.4.1. Measurement of abstracted quantities .....	17
3.4.2. Residual Flows .....	17
3.4.3. Controls .....	18
3.5. Abstraction charges .....	18
3.6. Acceptability of proposals and applicant's reasonable requirements .....	18
3.6.1. Administrative consequences .....	19
3.6.2. Deciding on reasonable requirements .....	20
3.7. Effects on NRA hydrometric installations .....	21

4. WATER QUALITY CONSIDERATIONS	21
4.1. Areas of Concern	21
4.2. Control and regulation	22
4.3. The legal controls	23
4.3.1. Section 85	23
4.3.2. Section 90	23
4.4. Operation of these controls in practice	24
4.4.1. Biocides etc.	24
4.4.2. Maintenance	24
4.4.3. Scour releases	24
4.5. Further information	25
5. FISHERIES CONSIDERATIONS	25
5.1. Fish passes for migratory fish	25
5.2. Fish passes in non-migratory trout and coarse fish waters	26
5.3. Impact on fish population	26
5.3.1. Catchment diversion	27
5.4. Minimum flows	27
5.5. Screening and diversion of fish	27
5.5.1. Types of screen and gratings	28
6. FLOOD DEFENCE CONSIDERATIONS	29
6.1. Design of hydropower works	29
6.1.1. Development within flood plain areas	29
6.1.2. Use of existing sites	30
6.1.3. New sites or modifications to existing sites	30
7. CONSERVATION CONSIDERATIONS	30
7.1. Likely environmental impacts	31
7.1.1. Low-head schemes	31
7.1.2. High-head schemes	31
7.2. Mitigation	31
7.3. Surveys	31
7.3.1. General watercourse character	32
7.3.2. Plants, grasslands, woods. etc. of the riparian zone and river corridor	32
7.3.3. Vegetation and animal species and communities	32
7.3.4. Ditches and dykes	32
7.3.5. Trees	32
7.3.6. Invertebrates	33
7.3.7. Birds	33
7.3.8. Mammals	33
7.3.9. Amphibians and reptiles	33

7.4. Archaeology .....	34
7.5. Landscape .....	34
7.6. Consultees .....	34
7.7. Monitoring .....	34
8. RECREATION CONSIDERATIONS .....	35
8.1. Angling .....	35
8.2. Public rights of way .....	35
8.3. Navigation .....	36
8.4. Local plans .....	36
8.5. Consultees .....	36
8.6. Monitoring .....	36

## 1. INTRODUCTION

Hydropower proposals have been very limited in number for many years. But they are increasing, in response to the Government's initiative to promote the use of sustainable, non-polluting energy sources. Proposals can be controversial and, unless properly controlled, can tie up water resources, and lead to problems with water quality, flood defence, fisheries and conservation. Also, developments affect recreational interests, to the advantage of some and disadvantage of others.

Understandably, developers want to take best advantage of opportunities offered by government policy under the Non-Fossil Fuel Obligation (NFFO)<sup>1</sup>. So they exert pressure on the NRA and planning authorities – together, the main regulators for hydropower proposals – to give the necessary permissions, consents, and licences.

As there have not been many run-of-river hydropower installations in the UK, there is naturally a lack of experience and expertise in formulating, assessing and regulating schemes. The oft-conflicting interests mean that dealing with them demand best efforts in integrated environmental management. This handbook looks at that from the NRA's perspective.

### 1.1. Who this handbook is for

This handbook is primarily to help NRA staff who have to deal with hydropower

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<sup>1</sup> NFFO obliges the regional electricity generating companies to secure a certain quantity of the electricity they supply from non-fossil fuel sources. These nuclear and renewable energy sources (which besides hydropower include, for example, windpower) receive a guaranteed premium price, so there is an incentive to invest in the necessary works.

proposals. NRA staff tend to be specialist in a particular function. The handbook outlines their own functional duties and enables them to have a good working knowledge of the concerns of colleagues in other functions. There is a particular need for this with hydropower proposals, which affect so many NRA responsibilities.

The handbook is, however, publicly available. It may be particularly helpful to developers putting forward hydropower proposals to help explain the NRA's approach to hydropower. They will want to know what the NRA asks of them when developing proposals, and why.

For the wider public, this handbook should give reassurance that the NRA carries out its part of regulating the activity in a balanced and responsible way.

## **1.2. The National Hydropower Group**

An internal NRA working group, the National Hydropower Group, prepared this handbook. The NRA set up this group in response to the many<sup>2</sup> impounding and abstraction licence applications anticipated following the Government's third NFFO initiative.

The group was formed from representatives from each of the NRA's technical functions concerned with the regulation of hydropower developments, as well as a representative from ETSU (Energy Technology Support Unit, Department of Trade and Industry) who provides the link with the Government organisations concerned with NFFO.

## **1.3. Other guidance**

This handbook is only an overview. Each function has a large reserve of personal experience and more detailed written guidance relating to its particular concerns.

A full list of references is in Section A of the Appendix.

## **1.4. Relationship with planning and other regulatory authorities and interests**

The NRA is only one of the decision makers potentially involved with hydropower

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<sup>2</sup> Nearly 200 enquiries were initially received by the Non-Fossil Purchasing Agency in response to the NFFO initiative. The NRA has so far received some 20 formal applications, and draft applications or firm enquiries have been made in respect of a further 10 to 15 sites.

developments. However, while at least some NRA functions will *always* be involved, other authorities will not necessarily have an interest.

#### 1.4.1. Planning

Often, planning permission will be required for the development. This, and related procedures (such as building regulation approval), is the responsibility of the local planning authority. As discussed below, the planning authority may also be the authority formally requiring the developer to carry out an environmental assessment. However, NRA staff should make it their business to liaise closely with the planning authority over this and other aspects so the developer does not needlessly duplicate his efforts.

#### 1.4.2. Land ownership, boundaries etc.

The developer will need to make arrangements for whatever land ownership, access arrangements etc, the project requires. Watercourses often form property boundaries and ownership of banks and structures may be complex.

Special permissions<sup>3</sup> may be required for building on common land or in the region of a scheduled ancient monument. Developments in national parks will require the involvement of the National Park authority in question.

#### 1.4.3. Safety

Design and operating arrangements for the project will have to comply with the Health and Safety at Work Act 1974, and the Electricity at Work Regulations 1989<sup>4</sup>.

When a large reservoir (>25,000 m<sup>3</sup>) is involved, which in practice will be rare for smaller hydropower developments, the developer must comply with the provisions of the Reservoirs Act 1975. The county council is currently<sup>5</sup> the responsible authority for that.

#### 1.4.4. Longer term impact

The NRA has the best overview of river developments. So it is up to the NRA to consider the potential impact of a proliferation of hydropower installations on the

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<sup>3</sup> From the Department of Environment or Welsh Office, but the planning authority should be able to advise in the first instance.

<sup>4</sup> SI No. 635.

<sup>5</sup> There are proposals to alter this. Check the current position in relevant cases.

river regime. Such impacts should be weighed carefully and should be brought to the attention of planning authorities so that their policies in Local and Structure Plans can be clearly formulated and stated with the benefit of the NRA's views.

## **2. OVERVIEW OF THE NRA'S CONCERNS ABOUT HYDROPOWER**

In a nutshell, the NRA is responsible for making sure that any proposal affecting waters in England and Wales is satisfactory. This means assessing the impact of the proposal on the environment and other water users, and making sure that the development is designed so its construction and operation is acceptable.

This section of the handbook therefore outlines the NRA's legal duties, the impact of hydropower, and its approach to environmental assessment.

### **2.1. The NRA's duties**

The NRA has a wide remit, as set out in the Water Resources Act (WRA) 1991. These include general duties for management of water resources in England and Wales. The WRA 1991 expresses these in wide terms. First, there is specific encouragement to act in an environmentally sensitive way. Section 2 requires the NRA to promote, to such extent it considers desirable:

- The conservation and enhancement of the natural beauty and amenity of inland and coastal waters and of land associated with such waters.
- The conservation of flora and fauna that depend upon an aquatic environment.
- The use of such waters and land for recreational purposes.

There are also specific legal obligations which force the NRA to attend to certain matters when dealing with applications for consents and licences. These include—

- The conservation duty in s.16 WRA 1991. This says that when "formulating or considering any proposals relating to its functions", the NRA has a duty to:
  - Exercise its powers so as to further the conservation and enhancement of natural beauty and the conservation of flora, fauna and the geological or geographical features of special interest.
  - Have regard to the desirability of protecting and conserving buildings, sites and objects of archaeological, architectural or historic interest.
  - Take into account any effect which the proposals would have on the beauty or amenity of any rural or urban area or on any such flora, fauna, features, buildings, sites or objects.
- General duties under s.19 WRA 1991 to take "all such action as it may consider ... necessary or expedient" for conserving, redistributing, otherwise augmenting,

- and securing the proper use of water resources.
- A duty under s.20 WRA 1991 to make arrangements with water undertakers for securing the proper management or operation of waters, reservoirs, apparatus or other works used by water undertakers.
  - The points set out in s.38-40 WRA which the NRA must consider when granting impounding and abstraction licences. These include the reasonableness of applicant's requirements, representations from the public, the possibility of derogation, the requirements of existing lawful users ie. agriculture, industry, water supply or other purposes, and effects on water flows. In essence, these must provide enough water of adequate quality to safeguard public health, to meet the requirements of existing lawful users (including agriculture, industry, water supply or other purposes), and the requirements of navigation, fisheries and land drainage<sup>6</sup>.
  - To achieve water quality objectives<sup>7</sup>.
  - To have regard to the interests of fisheries, including sea fisheries<sup>8</sup>.
  - To exercise a general supervision over all matters relating to flood defence<sup>9</sup> and in relation to main rivers act as the consenting authority for the erection of structures in, over or under a main river<sup>10</sup>.
  - Duties in relation to some watercourses as a navigation, harbour or conservancy authority.

## 2.2. Impacts of hydropower

The effects of hydropower proposals can be far reaching, and they usually cut across the responsibilities of most of the NRA's functions.

The *water resources* function controls impoundments and abstractions, and a licence for one or both is likely to be involved in a hydropower scheme. These licences, and operating agreements associated with them, provide core control. That is not only on the use of water itself, but also in the design and operation of measures to avoid water quality, conservation and other problems which are primarily the concern of other NRA functions.

The NRA's *flood defence* function is concerned about hydropower schemes from the point of view of their possible effects on land drainage and flood defence.

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<sup>6</sup> See also s.21 WRA 1991.

<sup>7</sup> See s.84 WRA 1991.

<sup>8</sup> See s.105(3) and 114 WRA 1991.

<sup>9</sup> See s.105(1) WRA 1991.

<sup>10</sup> See s.109 WRA 1991.

Depending on the nature of the scheme, the legislation may require a separate consent from flood defence.

Impacts of hydropower on *water quality* vary. Sometimes, hydropower will result in improved oxygenation and so have a beneficial impact on water quality. On the other hand, reduced and/or altered flows may have adverse effects, while substances used in the operation or maintenance of the hydropower works may pollute the water. Although consents to discharge may be important for dealing with the latter "conventional" pollution, careful design of the scheme is the best way to handle other water quality impacts.

Hydropower can adversely affect *fisheries*. Installations can act as a barrier to migratory fish going upstream, and kill fish in adult and juvenile stages passing down through turbines. They can also alter fish habitat, as part of wider effects on matters of *conservation* concern. Angling is one *recreational* interest likely to be affected: impacts on recreation can be both positive and negative. The same is true for *navigation*.

All these are concerns of the NRA. In addition, there are *planning* and *landscape* considerations, which are the concern of the local planning authority, and sometimes other bodies such as national parks authorities. In certain cases county councils have an interest in view of responsibilities for *safety* under the Reservoirs Act 1975.

All these need systematic assessment to determine whether the scheme is acceptable and/or what design changes or mitigation measures are required. Assessment of such effects is known variously as environmental impact assessment, environmental assessment, and environmental appraisal. The next section outlines the NRA's approach to what is referred to here as "EA".

### 2.3. Assessment of environmental effects (EA)

There is a legal basis<sup>11</sup> for requiring EA for certain types of projects, including hydropower developments. EA however is rooted in the experience that, properly done, it works for the benefit of both the developer and the environment. In particular, it enables problems with a proposed development to be identified at an early stage. The earlier this happens, the easier it will be to design a scheme to overcome them. If there is no satisfactory solution, the developer can pull out with loss of a smaller investment than might otherwise be the case. Looked at another way, EA can be a useful vehicle for consultation between the developer, the

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<sup>11</sup> Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.

regulators, and the concerned public.

EA may be formally required by the local planning authority. Alternatively the NRA may ask for it, or information equivalent to it. The various consenting authorities (ie. the local planning authority and various functions within the NRA) should make it quite clear to the hydropower developer what they require to be covered in his report on environmental impact (usually known as an "environmental statement", also known within the NRA as an "environmental report") and that one report will be shared between them. This will be more efficient from everyone's perspective and will not annoy the developer by needless duplication.

There are many publications which give advice on techniques and best practice for EA<sup>12</sup>. The key point is to encourage developers to regard EA as something which *evolves in stages*. It is inefficient for everyone if the developer is merely given a long list of questions and points to consider and told to go and produce a thick report. EA is first and foremost a *decision-aiding process*, which *involves* the production of a *report*.

### 2.3.1. The EA process

The following is a summary of the steps involved:

- **Screening the proposal.** *"Is it possible, in principle, to have a hydropower development, there?"* By approaching the NRA with this question at an early stage, the developer can set off in the right direction. He can know whether his proposal is hopeless or, if not, what sort of requirements, including for environmental information, there will be.
- **Scoping the assessment.** *"If you want to build works there, you will need to cover these concerns."* The developer should draw up a list of possible impacts, covering all NRA functions, and discuss these with the NRA. (He should do the same with the planning authority.) In theory there will always be more impacts than resources available to study them, and this stage enables studies to be best focussed.

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<sup>12</sup> See for example: the NRA's own manual *Environmental Appraisal in the NRA* (in draft, 1994); chapter 4 of the *Licensing Manual* explains the approach in the water resources function in detail, together with a background to the complex legislative provisions and points of water resources concern to cover; the Department of the Environment have (at the time of writing) recently issued a consultation paper with guidance; and the DoE's booklet *Environmental Assessment: A Guide to the Procedures* (1989) remains useful general background. The Institute of Environmental Assessment (Address: The Old School, Fen Road, East Kirkby, Lincolnshire PE23 4DB; Tel: 0790 763613; Fax: 0790 763630) is also a good source of information on environmental assessment and related matters.

- **Baseline studies.** *"What will the main environmental impacts be and what will cause them?"* This may include river corridor surveys, water quality data, fisheries information, river hydrographs, and flooding information. The NRA should help the developer by providing him with its information about these. Usually the developer will have to use consultants to fill in the gaps and provide a complete picture.
- **Impact prediction.** *"A development there will have these impacts."* The developer has to predict the impacts he is likely to cause. Where possible, the developer should quantify impacts making clear what assumptions he has used. To some extent however this process involves use of qualitative data and value judgments, ie. informed guesswork. The NRA can give its views.
- **Choice of option.** *"If you build it here you will make this level of profit and have minimum impact on the river."* The developer is likely to look for the best option from an economic and technical point of view, while the NRA's job is to add environmental balance to ensure the right decision is reached. ***This is a very important point for NRA input***, to advise the developer on what (if anything) may be acceptable: missing out may make it very difficult for the NRA to change minds later on. EA becomes much less valuable if (as often happens) it begins only after a "preferred option" is already identified.
- **Mitigation measures.** *"How can we reduce the impacts which we know will occur to a minimum?"* This stage is for working out how to minimise or eliminate adverse environmental impacts. It involves hard work from the point of view of design, selection of materials, and identification of best working practices. The NRA should look critically at the likely success of proposed mitigation measures (eg. "will the trees proposed for planting grow?"). There will also quite likely be discussion between the developer and affected third parties (such as anglers) over compensation.
- **Decommissioning and restoration.** *"What will happen when the scheme comes to an end?"* Hydropower schemes may make potentially permanent alterations to the river environment. These may be acceptable and mitigable so long as the scheme is in operation. However, when that stops, it may be desirable eg. to remove the structures, pipework etc. involved, or otherwise restore the environment to its previous state. This long term problem is a very real one<sup>13</sup> and the developer should be made aware of it and the need to plan and budget for it at the planning stage.

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<sup>13</sup> As, in a comparable context, the decommissioning of North Sea oil platforms is beginning to show.

- **Responsibilities.** "Who will be responsible for what?" The developer will be primarily responsible for all aspects of the scheme. However situations may arise ie. in emergencies, or at the decommissioning stage, where it will be appropriate to identify some fall back responsibility and scope for cost recovery (for example if the NRA has to go in and do necessary works). The matrix in Section B of the Appendix may assist in working out these responsibilities and incorporating points as necessary in an operating agreement<sup>14</sup>.

### 2.3.2. The EA Report

The above process should be encapsulated in a report, known as an environmental statement or environmental report. EA is an evolving science and the style and format of reports varies. The "bottom line" is that it should provide a fair and accurate description of the proposal, its likely effects, the aspects of the environment likely to be affected, mitigation measures, and possible alternatives. There should also be a non-technical summary to make the report intelligible to lay readers.

The more "significant" the likely effects of the proposal, the more likely it is that comprehensive information should be included. EC Directive (85/337/EEC) gives<sup>15</sup> general details, but these include aspects not directly related to the aquatic environment (eg. air, noise etc) which may be irrelevant.

Section C of the Appendix contains the current NRA guidance on this topic in relation to hydropower developments. Note that this may be updated from time to time and one should check for the current version.

### 2.3.3. EA: conclusion

***The importance of thorough and thoughtful EA cannot be over-emphasised.*** The way EA is approached by all parties is likely crucially to affect the developer's attitude towards the project and the NRA, and can make the difference between a project that is acceptable rather than undesirable or positively harmful.

Each function of the NRA should, as appropriate, feed its perspective on the issues arising into these various stages of the EA process. The following sections set out these functional perspectives.

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<sup>14</sup> See below, section 3.2.

<sup>15</sup> At Annex III; substantially replicated in Schedule 3 to the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988.

### 3. WATER RESOURCES CONSIDERATIONS

Hydropower needs water, so the water resources function tends to be the first "port of call" for hydropower developments. Schemes vary widely, but they usually affect water resources management and will normally require licensing. For example, some schemes, particularly in upland catchments ("high-head"), require weirs etc. to divert water. Schemes can exercise total control on the flow of the river between the diversion and return points, which can be a considerable distance apart. Usually, the weir will require an impounding licence and an abstraction licence will control the flow arrangements.

Hydropower works on lowland rivers ("low-head") may have little effect on flows. Water tends to be abstracted immediately upstream of the structure and discharged immediately downstream of it. The main effect of these schemes is on the rights of other uses and users of the structures, such as navigation, fisheries, and amenity.

When such works are "in river" structures, ie. weirs or dams, and water does not flow into, or divert from, any other channel besides the immediate conduit to the hydropower device itself, there is no abstraction of water and so no need for an abstraction licence. Where there is no abstraction, a development will not enjoy protected rights<sup>16</sup> status. However it will be a lawful use of water to take into account when considering other licensable developments upstream.

On the other hand, changes required to an existing weir by installing a turbine and associated control arrangements will require an impounding licence. The NRA can therefore have control over the operation<sup>17</sup>.

The NRA considers the need for licensing in each case on its merits. Full guidance is in the *Licensing Manual*, but particular hydropower-related issues are discussed in the following sections:

- Time limited licences
- Use of operating agreements
- Minimum acceptable flows
- Measurement and control of abstractions
- Acceptability of proposals/reasonableness of requirements
- Abstraction charges

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<sup>16</sup> Note that an impoundment does not give rise to protected rights. These only relate to abstractions: see s.48(1) WRA 1991.

<sup>17</sup> Which it can maintain using an agreement under s.158 WRA 1991: see below, section 3.2.

### 3.1. Time limited licences

Although many abstraction licences are granted in perpetuity, it is often best to grant a licence which expires at a particular time. The reasons for doing this (relevant to hydropower) are—

- Where there are uncertainties about the effects of the development. The NRA must be able to review the licence in the light of experience and operational data. A time limited licence in effect offers a monitoring period.
- Where the life of the development has a fixed term.
- Where a licence for large volumes compared to the dry weather flow of the river would sterilise the resource to users upstream<sup>18</sup>.

The reasons for time limited licences in the first two cases are self-evident. In the third situation, time limiting enables the hydropower development to take place provided upstream uses are not sterilised. The NRA's approach is two pronged:

- First, to agree with the developer an amount which the NRA could license upstream without the developer<sup>19</sup> making any claim against the NRA for derogation of a protected right. This will normally be expressed as a daily volume. In effect, this allows an agreed, built-in derogation from the licence<sup>20</sup>.
- Second, to time limit the licence so that there is an opportunity to review the volume agreed for derogation at the end of the period. If necessary, the NRA will only grant a renewed licence if the developer agrees to a further derogable tranche. (It will probably still be time limited, however.) This would be a further amount which can be licensed upstream without the developer making a protected rights claim.

#### 3.1.1. Duration of time limited licences

Developers may argue that any time limit could have adverse consequences for the viability of a scheme. On the other hand, the NRA considers it wrong to have the resources of a catchment tied up in the control of one hydropower developer. Indeed, it might be failing in its own duties to allow it. There is a balance to be struck, and policy is to relate the time limit to the length of time which the agreed upstream licensable tranche is predicted to satisfy upstream demands. The licence should also last no longer than the proposed life of the development.

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<sup>18</sup> Ie. owing to the need to protect the required volume as a protected right.

<sup>19</sup> Ie. including his successors and/or others interested in the hydropower development. The agreement will be in a s.158 agreement.

<sup>20</sup> This is allowed under s.39(1) WRA 1991.

Usually it will be possible to achieve this balance without difficulty. The volume reserved for future licensing is likely to be small compared with the total volume requirements of the hydropower scheme. Thus any reserved quantity will probably have little impact on the scheme's viability.

In order to allow for pay-back on the scheme, the time limit will usually be 15 to 20 years, and possibly longer. The more confident the NRA can be that the conditions on the development will properly contain or mitigate its effects, so the time limit can be less restrictive.

### 3.2. Operating agreements

Hydropower works — operation of sluices, weir obstructions, sudden closure of turbines etc. — can exercise significant control over the flow regime of a river. Many of these influences will have effect when electricity generation is not taking place. So it may not necessarily work simply to try to control these by conditions on the impounding and/or abstraction licence.

There can also be legal problems with relying on conditions in an impounding licence<sup>21</sup>. To overcome these problems, which can lead to serious resource difficulties, NRA policy is to require the hydropower developer to enter into an agreement under s.158 WRA 1991<sup>22</sup>. This will set out how he should operate the reservoir, impounding works etc. It will include and clarify responsibility for each element of the works, for example in relation to ownership, maintenance, replacement, refurbishment, and operation in normal and emergency situations<sup>23</sup>. It will also cover any agreed derogation.

Such an agreement *is* enforceable and should be registered as a land charge, which will mean it is enforceable against any future owners of the works. The agreement can include controls and any other appropriate provisions which will have effect at any time, ie. not simply when hydrogeneration is occurring.

The NRA will make the grant of the impounding and/or abstraction licence conditional on first entering into an operating agreement under s.158. It is possible

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<sup>21</sup> Or, possibly, the impounding aspects of a combined abstraction and impounding licence. This is because impounding licences are not transferable: the succession rules do not apply. With abstraction licences, the succession rules (see s.49 and 50 WRA 1991) mean that conditions can be enforced in perpetuity.

<sup>22</sup> The requirement can best be made effective by making the grant of the licence conditional on entering into such an agreement: see below section 3.6.1.

<sup>23</sup> Appendix C contains a matrix which may be helpful for this purpose.

that the applicant for the licence will object to the grant of the licence on this basis. However the approach should be sustainable on appeal, provided the requirements of the proposed agreement are reasonable and necessary for the discharge of the NRA's functions.

Section 158 agreements are site specific and tailored to meet individual circumstances. More information about them is in Section D of the Appendix; for full details see Chapter 8 of the *Licensing Manual*.

### 3.3. Minimum acceptable flows

Owing to the potential for complete diversion of flows through turbines, in all cases there should be provision for prescribed flows in the reach between the water intake and outlet (or over the weir in lowland sites) at all times. In some cases the requirement may be purely for amenity or visual reasons, but, in other sensitive areas, ecological protection of the deprived reach will be a primary consideration. The impact of prolonged reductions in flow in sensitive locations will require careful consideration and a cautious approach should be adopted, including (probably) a time limit to enable future review<sup>24</sup>.

The NRA will consider flow requirements on a site-by-site basis. There are several initiatives in progress relating to procedures and guidelines for the assessment and implementation of minimum acceptable flows. When completed, these may further help determine minimum flow considerations in hydropower applications. This section summarises these initiatives.

#### 3.3.1. IFIM and PHABSIM

The Instream Flow Incremental Methodology (IFIM) is an American concept which considers ecological demands when determining recommendations for flow regimes. The Physical Habitat Simulation Model (PHABSIM) is a suite of computer programs which uses IFIM methodology to simulate relationships between streamflow and available habitats for various species.

PHABSIM has been used widely in the United States. It is accepted there as a method which can be used as a negotiation tool and has been defended successfully against legal challenges. The NRA has also used it for several low flow studies.

Its potential use for hydropower proposals is to assess flow regimes required to

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<sup>24</sup> See section 3.1 above.

protect and sustain river ecology between the abstraction and return points of high-head schemes. The problem is that the method requires calibration surveys which need a lot of time and resources. One also needs expert local knowledge to apply the method to specific sites.

PHABSIM is being developed for use by the NRA by the Institute of Hydrology and will soon be available in all regions, together with training in use of the software.

Whether one can reasonably expect developers to do this sort of modelling themselves will in practice depend on the experience of the developer, the size of the scheme, and the NRA's own experience with the software. What is practical will become clear when NRA staff have had an opportunity to use and evaluate it.

### 3.3.2. Surface Water Abstraction Licence Policy

This is an r+d project<sup>25</sup> entailing—

- Review of current policy and practices followed by NRA regions in determining applications for abstractions from surface water.
- Consultation within the NRA and with other interested groups.
- Development of a licensing methodology which will be consistent throughout England and Wales and useful for all licensing situations.

This project builds on licensing policy for Yorkshire Region developed in the mid-1980's which—

- Expresses environmental quality of river sub-catchments in numerical terms. It uses a weighting system which assigns scores to features of fisheries importance, ecological value, amenity, etc.
- Provides a volumetric limit on aggregate annual net abstractions from sub-catchments. It considers the natural dry weather flow and the environmental weighting score.
- Provides a prescribed flow for each new licence. This will protect upstream river environments and rights of existing users. It will also offer adequate dilution to maintain river water quality.

The existing system is primarily concerned with protecting low flows, rather than the full range of the flow regime. The current project will develop it to embrace the full range of river types and abstractions.

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<sup>25</sup> A report is expected in 1995.

### 3.3.3. Determination of minimum acceptable flows

This r+d project<sup>26</sup> focusses on the overall effectiveness of MAF's as contemplated by current legislation, and considers how best to approach protection of the river environment in terms of flows. The project mainly focusses on the right practical and legal approach to determining appropriate flows, rather than being of immediate relevance to current hydropower proposals.

### 3.4. Measurement, monitoring and controls

It is essential for the NRA to have full information about instrumentation and intake works to enable effective measurement and monitoring of the hydropower operation. The developer and the NRA must agree these at an early stage in the licence application procedure. The NRA will also carry out site checks during the construction phase to ensure that the developer meets its requirements.

#### 3.4.1. Measurement of abstracted quantities

There must be satisfactory means of measuring and recording how much water the hydropower scheme abstracts. Integrating flow meters are likely to be best for high-head sites involving pressure conduits. These devices should be connected at the upstream end of pipelines.

In low head situations, the most effective method may be to calculate quantities on the basis of the hydraulic characteristics of the site together with the performance characteristics of the turbine. The developer will need to provide information about the turbine as well as satisfactory calibration data for the site. Instruments to record turbine running times and changes in head are also necessary.

The developer must install all devices in accordance with the manufacturer's specifications.

#### 3.4.2. Residual Flows

There will normally be residual flow(s) conditions on the licence. If so, the developer must provide full details of the measurement and intake structures, including calibration of the measuring device. The licence should normally specify that the measuring device be installed in accordance with BS.3680 *Flow Measurement in Open Channels*. There must be suitable means of indicating and/or recording the

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<sup>26</sup> A report is expected in 1995.

residual flow. An external gauge board or similar indicator should be in place so the flow can be checked without access to the turbine house.

The arrangement of the intake weir(s), pipeline and residual flow structure should ensure that the required value(s) of residual flow are reliably discharged at all stages of river flow.

### 3.4.3. Controls

Hydropower installations are such that many sites will stay unattended for prolonged periods. The developer must therefore be able to show that the control system for the abstraction will meet the licence conditions, and that there will be no adverse effect on flow in the watercourse in the event of a machinery or control failure.

### 3.5. Abstraction charges

A fee is payable when applying for a licence to impound and/or abstract water for hydropower purposes. However there is no annual charge provided the scheme generates not more than 5 megawatts<sup>27</sup>.

### 3.6. Acceptability of proposals and applicant's reasonable requirements

A particular problem from a licensing point of view is where a developer applies for a licence to impound and/or abstract for hydropower purposes but in fact has little or no prospect of carrying out the work. The effect of a licence, if granted, may be to tie up large quantities of water. It might prevent some other hydropower developer or other water user from carrying out works for which he does have all the necessary rights etc. in place. Compensation issues would arise if for some reason the NRA sought to revoke or modify a licence. For example:

- The developer may have access to the point of abstraction, and to where he intends to generate, but no access to lay pipework across intervening land.
- The scheme will not be developed unless a NFFO contract (or other electricity sale arrangement) is in place.

There is nothing stopping someone applying for an abstraction licence provided he has access to, or occupies, the point of abstraction. The NRA cannot refuse to

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<sup>27</sup> See NRA's Scheme of Abstraction Charges and s.125(1) WRA 1991.

consider an application if a developer shows he has the necessary entitlement to apply<sup>28</sup>. On the other hand a key consideration<sup>29</sup> in dealing with a licence application (whether for impoundment or abstraction) is the "requirements of the applicant in so far as they appear to the Authority to be reasonable requirements"<sup>30</sup>. Even though the applicant's requirements for water may be reasonable given the nature of the proposals, the reasonableness of the requirements may also be considered in the light of their chances of being implemented.

### 3.6.1. Administrative consequences

This has two consequences from an administrative point of view:

- (a) It may in practice affect how the determination process is carried out. The rule is that determination of a licence should take place within three months of the date of receipt of an application, unless an extension of time is agreed<sup>31</sup>. However it is pointless doing all the work necessary for a determination if it is clear at the outset that there is some fundamental obstacle to the scheme and therefore reasonable requirement for the water, such as lack of rights to run pipework across other people's land. Determination should therefore proceed until a point like this becomes apparent (it may be obvious very early on). One should point out the problems to the applicant and, depending on the situation, suggest a way forward. This is likely to be one of—
- Trying to agree an appropriate extension of time. This will be appropriate if the obstacle seems to be one which has a good chance of being overcome soon.
  - Determining the application by refusing it. It is unnecessary to go through all the normal process of determination if there is some obstacle which the NRA knows means the applicant cannot have a reasonable requirement for the water.
  - Suggesting that the applicant withdraws the application altogether and reapplies as appropriate. There may be no advantage to the applicant in keeping the application "live"; there is only limited scope for amending an application once submitted without re-advertising.

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<sup>28</sup> I.e. by virtue of the rules in s.35 WRA 1991. Impounding licences are technically not subject to the same restriction but in practice access or occupation is clearly necessary.

<sup>29</sup> See s.38(3)(b) WRA 1991.

<sup>30</sup> See s.38(3)(b) WRA 1991. Note that this is not the same as making value judgments as to whether the purpose is itself a reasonable use of water.

<sup>31</sup> Regulation 10(4) Water Resources (Licences) Regulations 1965.

It is unsatisfactory simply to leave the application in abeyance, even though — despite right of appeal for non-determination after three months — the applicant might not mind. Owing to the NRA's policy of granting licences on a first-come, first-served basis, this would have the effect of tying up resources that might be useful to other better placed applicants.

- (b) The grant of the licence may be made dependent upon the reasonable requirement for the water being in place. The NRA may be satisfied that the applicant is likely to, but does not yet, have a reasonable requirement for the water, and that in all other respects there is no reason why a licence should not be granted (eg. there are resources available). In this case the recommended approach is to grant a licence but subject to the necessary conditions being fulfilled within a particular time. This may include entering into an agreement under s.158 WRA 1991. For example:

Further conditions: (1) This licence shall only take effect so as to authorise abstraction provided XXXXXX has taken place within one year of the date of issue of this licence. (2) This licence shall only take effect so as to authorise abstraction provided the licence holder has entered into an agreement with the NRA under s.158 Water Resources Act 1991 in relation to the abstraction referred to and related works within one year of the date of issue of this licence. (3) This licence shall cease to be of any effect if the abstraction to which it relates has not commenced within three years of the date of issue of this licence.

"Open-ended" licences should not be granted. If no development takes place, the licence will be extant and tying up resources, and only revocable on payment of compensation.

### 3.6.2. Deciding on reasonable requirements

Deciding how to proceed will depend on the individual circumstances, the question being "are the applicant's requirements for water as applied for reasonable, considering the information before us?" and "what are the prospects of the situation changing?". As a guide, the NRA's position will normally be as follows:

- Where the scheme involves a NFFO contract, the contract should have been let before the licence is granted. The NFFO scheme specifically allows generous time after the contract has been let for consents, licences etc. to be put in place, so there is no need for developers to have these in advance of a NFFO contract or as a pre-condition to getting a NFFO contract.
- In other cases, ie. not involving the NFFO scheme, the developer should show that there is a realistic chance of the scheme coming about.

- All necessary rights of access, ability to lay pipes across land etc. (easements) should be in place. The developer should provide proof of this, with copies of relevant legal documents, as appropriate.

Applications for licences which cannot be used in the foreseeable future should be refused on the basis that the applicant has no reasonable requirement for the water. In other cases grant of the licence may be made subject to the relevant condition being fulfilled or obstacle overcome, as outlined above.

### 3.7. Effects on NRA hydrometric installations

If development proposals will have an impact on existing NRA level recording, flow measurement, or other installations, the developer will have to fund all necessary alterations to ensure their continuous and effective operation. If alterations are not practicable, this may be grounds for refusing the application for licence(s).

## 4. WATER QUALITY CONSIDERATIONS

The NRA's water quality function has the prime objective of achieving a continuing improvement in the quality of rivers, estuaries and coastal waters through the control of pollution<sup>32</sup>. This is also important in relation to other NRA aims: for example, its conservation duties<sup>33</sup>, its duties in relation to fisheries, and the need to achieve standards of water quality that are commensurate with the needs of abstractors.

Hydropower schemes can affect water quality in several different ways, both directly and indirectly. These potential impacts are very site specific. In view of the complex issues involved they need identifying at an early stage – preferably before submission of planning and licence applications.

### 4.1. Areas of Concern

As water quality effects can be very site specific, proposals require individual assessment. In *general*, the most likely areas of concern will be-

- Effects on water quality classification<sup>34</sup> and compliance with water quality

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<sup>32</sup> NRA Water Quality Strategy.

<sup>33</sup> See s.16 WRA 1991; above section 2.1.

<sup>34</sup> General Quality Assessment (GQA) Scheme.

- objectives based on statutory requirements, for example EC Directives<sup>35</sup>, and the Surface Waters (Rivers Ecosystem) (Classification) Regulations 1994<sup>36</sup>.
- Effects on existing effluent discharges into the affected river reach. These may include reduced available dilution for sewage works discharges, and effects of modified flow patterns on the impact of storm sewage overflows.
  - Implications for other possible or proposed developments, such as future water company investment programmes.
  - Effects on the quality of water to be abstracted for water supply and other uses, such as fish farms, industrial and agricultural abstractions.
  - Effects of changes in suspended solids - for example, impact on fish spawning areas (siltation), visual amenity, and light penetration.
  - Water quality implications where water will be transferred between rivers, including transfer of pollutants and changes in water quality that will affect the ecology of the recipient river.
  - Changes in flow regime which may affect water quality indirectly, such as enhanced algal growth or siltation.
  - Changes in water temperature, such as caused by discharge of cold bottom water from impoundments.
  - Effects of operational practices associated with the hydropower development. These may include discharges from pipe/tunnel cleaning and the use of biocides and anti-fouling preparations.

## 4.2. Control and regulation

Many of the concerns outlined above result from physical flow diversion and alterations to flow patterns. Water quality legislation is not designed for these problems. Usually the best way of preventing adverse water quality impacts will be for NRA water quality staff to make an effective input into the impoundment and/or abstraction licensing process and local authority planning consultation.

Note however that diversion of surface water from a natural channel into an artificial channel, pipe or tunnel (ie. as will often occur in hydropower schemes) still means the water is protected under the pollution legislation<sup>37</sup>. The following sections discuss these controls.

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<sup>35</sup> 75/440/EEC (surface water abstracted for potable supply), 78/659/EEC (freshwater fisheries); 76/464/EEC (dangerous substances) and its daughter directives; 91/71/EEC (urban waste water treatment – sensitive areas); 91/676/EEC (nitrates).

<sup>36</sup> SI 1994 No. 1057.

<sup>37</sup> It is still a controlled water as it would be a "relevant river or watercourse" as defined by s.104 WRA 1991.

### 4.3. The legal controls

Sections 85 and 90 WRA 1991 are the relevant parts of the water quality legislation.

#### 4.3.1. Section 85

This makes it an offence to pollute controlled waters and (in effect) requires a discharge consent from the NRA where polluting matter, trade effluent or sewage effluent may enter controlled waters.

The NRA's view is that the mere presence of a hydroelectric turbine does not turn discharge from a generating plant into a trade effluent. In principle the situation is no different from the use of waterwheels in natural or artificial watercourses. The discharge is also not sewage effluent, obviously.

However, although a hydropower scheme therefore does not, in principle, require a consent to discharge, it may still result in contraventions of s.85, because—

- Effluents arising from maintenance operations are trade effluents and will require a consent to discharge. They include periodic removal of deposits and accretions on the walls of pipes and tunnels, and the application of protective coatings. These discharges are especially likely on high-head schemes where head loss is critical to generating efficiency.
- Substances may find their way, under normal operating conditions, into the water. These include biocides and other anti-fouling/protective compounds, oils and grease on the turbines and other parts of the plant, including pipes and tunnels.

It is therefore important for a developer to consider, at the design stage and in discussion with the NRA, what collection, treatment and disposal facilities may be necessary to cope with these potential pollutants. He may wish to apply for a discharge consent to protect himself against prosecution by applying for a consent under s.88(1) WRA 1991<sup>38</sup>. The NRA will consider whether it can grant such a consent, and if so what conditions should attach.

#### 4.3.2. Section 90

This section is designed, in this context, to prevent scouring from releases of water. Without the NRA's consent, it is an offence to "remove from any part of the bottom,

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<sup>38</sup> Such polluting matter could potentially fall within s.85(1) (general prohibition against discharging polluting matter into controlled waters) or s.85(3) (trade effluent). However this makes no difference to the need for a consent.

channel or bed of any inland freshwaters a deposit accumulated by reason of any dam, weir or sluice holding back the waters" and to do so "by causing the deposit to be carried away in suspension in the waters".

There is no prescribed consenting process comparable to the requirements for ordinary discharge consents<sup>39</sup>. For one-off releases which may result in the prohibited scouring action occurring, operators would normally write to the NRA and request permission, which would be given by letter. In regular or more complex situations, it may be appropriate to issue a more formal and structured document, similar to a discharge consent.

Careful forethought at the design stage can usually control the effects of scouring.

#### **4.4. Operation of these controls in practice**

##### **4.4.1. Biocides etc.**

General use of biocides and toxic protective coatings that leach into the waterbody is unlikely to be justified, due to downstream uses that may be affected and general environmental considerations. The NRA will therefore always be reluctant to grant consents for discharge of these substances.

##### **4.4.2. Maintenance**

Many schemes will need cleaning and painting. High-head schemes especially can suffer from head loss from biologically mediated deposition on pipe and tunnel walls, as well as corrosion and scouring, all resulting in significant reductions in generating efficiency.

Operators will therefore probably require consents to discharge in due course. So it is advisable for them to consider this need and any collection, treatment and disposal facilities needed at the design stage.

##### **4.4.3. Scour releases**

As mentioned above, this problem too should be considered at the design stage. If the developer or the NRA foresees problems which design cannot overcome, then a continuing (ie. as opposed to one-off) consent under s.90 will be appropriate.

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<sup>39</sup> Ie. as provided by Schedule 10 WRA 1991.

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#### 4.5. Further information

The NRA has many publications which deal with water quality issues. This is a constant focus of NRA r+d efforts. A convenient first point of reference is the internal guidance document *The NRA Programme for the Monitoring of Water Quality*<sup>40</sup>. This gives details of the water quality criteria required to meet statutory obligations and water quality classification (GQA scheme). For information on r+d outputs, the NRA r+d co-ordinator will have full information. The *National Consents Manual* will<sup>41</sup> cover general consents issues.

### 5. FISHERIES CONSIDERATIONS

Regulation of fisheries, both under the WRA 1991, the Salmon and Freshwater Fisheries Act (SFFA) 1975, and other legislation is one of the NRA's core functions<sup>42</sup>. Hydropower schemes can potentially disrupt fisheries. So, preventing or minimising this is a key part of the design of schemes.

#### 5.1. Fish passes for migratory fish

Where a hydropower scheme is in any waters frequented by salmon or migratory trout, and creates or increases obstruction to the passage of such fish, the NRA can require the developer to install a suitable fish pass<sup>43</sup>. The need for this will, in practice, be at the discretion of the regional NRA fisheries function.

The fish pass needs to be of such form and dimensions as will meet with the approval of the Ministry of Agriculture, Fisheries and Food or the Secretary of State for Wales<sup>44</sup>.

It is an offence for the owner or occupier of the installation not to make such a fish

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<sup>40</sup> NRA 1994.

<sup>41</sup> At the time of writing, this manual has not been published, but is expected in the foreseeable future.

<sup>42</sup> Section 114 WRA 1991 provides: "It shall be the duty of the Authority to maintain, improve and develop salmon fisheries, trout fisheries, freshwater fisheries and eel fisheries".

<sup>43</sup> See s.9 SFFA 1975.

<sup>44</sup> For detailed specifications, see MAFF publication, *Fish Pass Design - Criteria for the design and approval of fish passes and other structures to facilitate the passage of migratory fish in rivers*. by M.H.Beach, MAFF Fisheries Research Technical Report No.78, Lowestoft, 1984.

pass, or not to maintain it in an efficient state<sup>45</sup>.

## 5.2. Fish passes in non-migratory trout and coarse fish waters

The fish pass provisions of the SFFA 1975 apply to salmon or migratory trout. Where a fish pass is necessary to protect non-migratory trout, coarse fish or eels as a result of hydropower works creating or increasing an obstruction, it may be made a condition of the impounding and/or abstraction licence that a suitable fish pass is installed.

Design criteria for passes suitable for coarse fish and eels are not as clearly defined as are those for migratory salmonids, but valuable information is contained in a recent French publication, *Bulletin Francais de la Peche et de la Pisciculture*<sup>46</sup>. NRA r+d Report No.5, *Fish Pass Design and Evaluation*, is also useful.

## 5.3. Impact on fish population

The hydropower developer must be able to demonstrate the impact of the operation of the scheme on the fish population.

The high-risk area is the length of river between the water intake and return point, particularly if there is an impoundment.

It is possible to assess impact by detailed study of the population dynamics of the various fish species. This would involve quantifying how significant the flow and the flow regime is to particular species. However, these types of in-depth studies are usually long-term and may well not be practical when dealing with a particular proposal.

It is possible to assess impact using habitat models like Instream Flow Incremental Methodology (IFIM)<sup>47</sup>. IFIM assumes that aquatic species have habitat preferences which one can describe in terms of flow, water depth, substrate or cover. By measuring these, and knowing the preference of the species concerned for each, one can compute the amount of useable habitat for a range of discharges. One can then predict changes in the amount of useable habitat. This may or may not relate to

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<sup>45</sup> See s.9(2) SFFA 1975.

<sup>46</sup> Gestion des Ressources Aquatiques, Numeros 326-327, 3e et 4e trimestre 1992. An English translation of this publication is/will soon be available within the NRA.

<sup>47</sup> See section 3.3.1 above.

changes in the stock, however, as other factors may limit the population.

The problem with this for proposals currently with the NRA is that habitat suitability curves have not been developed adequately for British species, and appropriately modified software is not readily available. However, these difficulties may soon be overcome as a result of the NRA r+d projects on ecologically acceptable flows and PHABSIM.

Whether or not he uses these methods, the developer must assess the impact the scheme will have on habitat availability and quality by changes to flows. Changes may involve the wetted width and area of stream, water depth and velocity. The assessment should include predictions as to how these will change over time, eg. in wet and dry periods, by season, etc. Quantitative information on the existing fish populations is highly desirable, if practical. The applicant should also agree<sup>48</sup> to monitor fish populations after the scheme comes into operation.

### 5.3.1. Catchment diversion

Where the scheme involves diversion of water from one catchment to another, there are further considerations relating to the basic ecology of the fish. Salmonids are known to use smell to home to their natal river system for spawning. Diversion may affect this homing ability and potentially the size of the stock.

## 5.4. Minimum flows

For salmonids, flow reduction may impact all life stages, from egg to adult. Many people think that the ecology of a stream can be protected provided there is a 95%ile flow (ie. the flow which is exceeded for 95% of the time). This can be a dangerous assumption and the preferred approach is to estimate minimum survival and migration flows by reference to measurements of river bed width<sup>49</sup>.

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<sup>48</sup> This may be appropriate for a s.158 agreement.

<sup>49</sup> Full details of this approach are in Stewart L. *Criteria for safeguarding fisheries. Fish migration and angling in rivers.* [1969] Proceedings of the Institute of Water Engineers 23: 39-62. It was pioneered in the former Lancashire River Authority area, where a flow of 0.03 cumecs per metre width of stream bed was regarded as an absolute survival flow for salmonids. Information from fish counts on several rivers indicated that upstream migration of salmon typically commenced at a flow of 0.08 cumecs per metre width, and reached a peak of intensity at a flow of 0.2 cumecs per m. width.

## 5.5. Screening and diversion of fish

Some say that fish such as salmon smolts can always pass through turbines without significant losses. This is not true. Studies show that mortality of smolts can range from a few % to over 50% as a result of passage through turbines. Mortality rates are likely to be particularly high when turbines are running at less than maximum power output.

To prevent unacceptable losses, hydropower developers should take steps to exclude migrating salmon and sea trout smolts from turbine intakes. Section 14 of the SFFA 1975 requires gratings across intakes and outfalls<sup>50</sup>.

The rules for screening for non-migratory trout, coarse fish and eels are the same as for fish passes: a licence can be made subject to an appropriate condition. The developer should be made aware of s.2(2) SFFA 1975 which makes it an offence knowingly to kill or injure immature freshwater fish.

### 5.5.1. Types of screen and gratings

Although the SFFA 1975 requires gratings to meet officially approved standards<sup>51</sup>, there are none as yet set. Scottish Hydro-Electric plc uses, to apparent good effect, standard smolt screen meshes with 25 mm gaps between vertical bars and 12.5 mm gaps between horizontal bars, with maximum approach velocity of 30 cm per second. Where abstraction of large volumes of water takes place, a large area of screen is needed to ensure that approach velocities are not exceeded<sup>52</sup>.

Fixed screens need regular cleaning, and it is advisable to have double sets of screens and guides so that intakes are not left unscreened during cleaning operations.

At some sites, diversion screens may divert descending smolts away from intakes, particularly where the velocity of water is sufficient to carry fish into a by-pass channel. Louvre screens with 15 cm gaps set at an angle across the channel are successful with water velocities in the range 0.7 to 1.1 m/sec.

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<sup>50</sup> It requires the owner or occupier of any mill (which includes, see s.41(1), "any erection for the purpose of developing water power") which diverts water from any watercourse frequented by salmon or migratory trout to place and maintain, at his own cost, a grating or gratings to prevent the descent of salmon or migratory trout, unless the NRA grants an exemption.

<sup>51</sup> I.e. as approved by the Minister (ie. MAFF or the Secretary of State for Wales).

<sup>52</sup> A useful reference is Solomon D.J. *Diversion and entrapment of fish at water intake screens and outfalls* NRA r+d Report No.1. See also Turnpenny A.W.H. *An analysis of mesh sizes required for screening fishes at water intakes* Estuaries, vol.4, no. 4 p. 363-8 December 1981.

## 6. FLOOD DEFENCE CONSIDERATIONS

The modern approach towards river management is to move away from heavy engineering and canalization towards restoring more natural rivers with soft engineering techniques. Hydropower developments, particularly the recent increase in low-head proposals, tend to work against this objective.

The NRA's flood defence function becomes involved in hydropower developments for two reasons—

- As part of its general responsibility for river management, it is there to ensure that proposals are not detrimental to the river, either locally, or to the river system as a whole.
- Where proposed works affect a main river and require a consent under s.109 WRA 1991 or an ordinary watercourse under s.23 Land Drainage Act 1991. In the latter case the NRA or the relevant Internal Drainage Board may be the responsible body.

### 6.1. Design of hydropower works

The NRA evaluates structures and works proposed for hydropower installations as it does any other similar river works. However, some aspects do require special consideration. High-head proposals (greater than 20m head) tend to pose fewer problems for flood defence.

#### 6.1.1. Development within flood plain areas

The NRA's policy of no building within flood risk areas may be relaxed in appropriate situations because the very nature of hydropower requires structures in and adjacent to watercourses. However, impact must be minimised, and therefore—

- Size of buildings must be the minimum necessary to house equipment.
- Plant must be selected with due regard to size.
- The location, orientation and level of buildings and other structures must create minimum obstruction to both in-channel and flood flows. Optimum arrangement may require modelling.
- The developer must compensate for any adverse effects such as obstructions to flow and infilling in the flood plain. He may achieve this, for example, by providing additional channel flow capacity, flood plain flow capacity, or flood plain compensatory storage on a level for level basis.

### 6.1.2. Use of existing sites

A low-head scheme, involving, for example, renovation of an old mill site with an existing "fall" and a building to house equipment, is unlikely to be of much concern to flood defence. However, there must still be a check to make sure it will not prejudice the scope for future flood defence or land drainage improvement schemes. The presence of an operating, licensed hydropower installation will constrain options for future improvements.

### 6.1.3. New sites or modifications to existing sites

The NRA will treat works for a hydropower proposal as it will any other proposed structure or works in a watercourse. However, these schemes do make for several areas of potential conflict with flood defence policies, and particular attention is required to the following—

- There must be no overall reduction of channel capacity.
- Obstruction of flood flows and any reduction of flood plain storage must be fully compensated for.
- There must be no detriment to land drainage as a result of raising water levels.
- There must be no impact on water level recording and flow measurement installations.
- Any deepening of the channel downstream to add to available head must have due regard for conservation, recreation, landscape and fisheries impacts, as well as stability of banks and structures. Similarly, siltation processes may change if bed gradients alter and this aspect must be considered too.
- Proposals must not prejudice scope for future flood defence or land drainage improvements.

Modelling may help optimise design and overcome possible impacts.

## 7. CONSERVATION CONSIDERATIONS

Almost all hydropower proposals need environmental assessment<sup>53</sup>. This is a general concern, cutting across all functions. However assessment of impact will particularly involve the NRA's conservation function. So, pointers to assist with EA are provided here.

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<sup>53</sup> See section 2.3 above.

## 7.1. Likely environmental impacts

### 7.1.1. Low-head schemes

These are usually on large rivers with high flows and use existing structures (eg. weirs) for head. Likely impacts will include—

- Bed scouring and changes in gravel/silt shoals.
- Changes to flow patterns and velocities.
- Severe disturbance to marginal and bank vegetation.
- Bank revetment (sheet piling etc.).
- Raising upstream water levels if weir height increased.
- General loss of habitat — tree felling, bank loss, grassland disturbance etc.

### 7.1.2. High-head schemes

These are generally on small upland watercourses. There will usually be a small impounding structure with pipework to take excess flows. Likely impacts will include—

- Normal winter high flows reduced or lost.
- Changes in humidity conditions with effects on bryophytes and other moisture dependent plants.
- Habitat reduction and knock-on effects (eg. drying up adjacent upland marsh and loss of, or changes to, its invertebrate and other communities, loss of food sources for fish and birds etc.).

Many of these sites will be in National Parks, Sites of Special Scientific Interest, Areas of Outstanding Natural Beauty, etc. It will therefore be necessary to consult particularly carefully with the planning and conservation bodies concerned.

## 7.2. Mitigation

It is important that mitigation measures are considered in detail *before* proposals receive the go-ahead ie. with planning consent and grant of necessary licences. Such measures may include re-creation of lost habitats, shallow riffles, shoals, trees, and bankside and marginal vegetation.

## 7.3. Surveys

Key to environmental appraisal is good base-line data: "what is there *now* that will

be affected?". The developer will need to do surveys, which he should carry out according to the guidelines described below. The level of detail and matters to concentrate on will differ from site to site and will be matters for the NRA and developer to agree. The NRA's *Review of Nature Conservation Survey Methodologies*<sup>54</sup> describes these in more detail. Essentially, it is necessary to have information about the following topics—

### **7.3.1. General watercourse character**

River corridor surveys should follow the NRA's *Conservation Technical Handbook 1*.

### **7.3.2. Plants, grasslands, woods. etc. of the riparian zone and river corridor**

This survey, following English Nature guidelines<sup>55</sup>, will classify and map all habitat types based on vegetation, as well as physical and substrate features. Phase I surveys have been carried out over most of England and Wales<sup>56</sup> by Trusts or local authorities.

### **7.3.3. Vegetation and animal species and communities**

This, the Phase 2 vegetation survey<sup>57</sup>, is more detailed, classifying vegetation types with full species lists.

### **7.3.4. Ditches and dykes**

Ditch surveys should be based on methods described by Alcock and Palmer<sup>58</sup>. The survey should record information about species on the DAFOR scale<sup>59</sup> as well as give information about physical features and management.

### **7.3.5. Trees**

Tree surveys should involve a detailed plan showing the species, girth, age, height, location, canopy cover, and general condition of each tree.

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<sup>54</sup> R+d note 107.

<sup>55</sup> Phase 1 Habitat Survey (Nature Conservancy Council 1990).

<sup>56</sup> The County Records Office should hold details of what information is available and where it can be found.

<sup>57</sup> National Vegetation Classification.

<sup>58</sup> 1985.

<sup>59</sup> I.e. Dominant, Abundant, Frequent, Occasional, Rare.

### 7.3.6. Invertebrates

The Joint Nature Conservation Committee maintain an Invertebrate Site register. There is a report for each county, normally held at the county's Biological Records Centre. This is a useful guide for important areas and target species.

Aquatic invertebrate sampling, particularly in running water, is usually carried out by a standard three minute kick sample. Other techniques include nets, grabs, dredges, cores, etc<sup>60</sup>. Terrestrial invertebrates found in the shingle, shoal riparian areas can be sampled using pitfall traps<sup>61</sup>.

### 7.3.7. Birds

Bird surveys require a minimum of 3 km river visited 9-10 times during the breeding season, and overwintering sites if appropriate<sup>62</sup>.

### 7.3.8. Mammals

Mammal surveys will in the first instance involve consulting the County Mammal Recorder<sup>63</sup>. It is important to pay particular attention to otters and mink<sup>64</sup>, water voles<sup>65</sup>, bats<sup>66</sup>, and badgers<sup>67</sup>.

### 7.3.9. Amphibians and reptiles

There are six British amphibians in inland waters: common frog, common toad, natterjack toad, smooth newt, palmate newt, great-crested newt. Surveys should take place in the spawning period.

Assessment of reptile numbers should be based on sightings. The British reptiles are: grass snake, adder, smooth snake, common lizard and slow worm.

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<sup>60</sup> The Joint Committee for the Conservation of British Invertebrates issues guidelines on invertebrate surveys.

<sup>61</sup> See Stubbs and Chandler (1978), Cootes (1991).

<sup>62</sup> See British Trust for Ornithology, *Waterways Bird Survey* (Taylor 1982) and *Common Bird Census* (Marchant 1983).

<sup>63</sup> Contact the County Council or county Wildlife Trust.

<sup>64</sup> Reference: National Otter Survey.

<sup>65</sup> Reference: National Water Vole Survey.

<sup>66</sup> Information is available though local bat groups, who also undertake survey work.

<sup>67</sup> To determine the location of their setts and feeding areas.

#### 7.4. Archaeology

The developer should always consult the county archaeologist in case the proposal will affect sites of archaeological value.

The county archaeologist will also advise about the likely extent of unknown sites. Continual monitoring of excavation works may be appropriate. The developer may need to employ an archaeologist to appraise sites and recommend mitigation works.

#### 7.5. Landscape

For reference, see *NRA Technical Note 2 on landscape assessment*. The Institute of Environmental Assessment in conjunction with the Landscape Institute is (1995) publishing *Guidelines* for landscape and visual impact assessment<sup>68</sup>. The developer should consult the local authority for advice on constraints and opportunities.

#### 7.6. Consultees

Usually, the NRA will consult with the following bodies over hydropower proposals—

- Countryside Council for Wales
- English Nature
- Countryside Commission
- Council for the Preservation of Rural England
- Council for the Preservation of Rural Wales
- County wildlife trusts
- Royal Society for the Protection of Birds
- County ecologists
- Local planning authorities
- English Heritage (where listed structures and Scheduled Ancient Monuments are involved); CADW in Wales.

#### 7.7. Monitoring

Environmental assessment should not be seen as a "snapshot". Developers should have a monitoring programme, which will update baseline surveys and record changes

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<sup>68</sup> For details of the IEA, see footnote 12.

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over 1, 2 and 5 years. On upland sites, there should be a further survey after 10 years. This may be incorporated in a s.158 agreement.

## 8. RECREATION CONSIDERATIONS

Hydropower schemes can both disrupt recreation and create new opportunities for it. What might happen as a result of any given scheme will depend on the exact circumstances: effects vary greatly. Schemes may affect more than just water-based recreation, such as public access and visual amenity.

On upland streams, fishermen<sup>69</sup>, walkers and climbers will usually be most affected. There are usually more recreational users on low-head sites so effects may be more pronounced.

### 8.1. Angling

Changes in flow direction, as well as bankside works and revetment may affect angling and habitat. It may become impossible to fish. The developer will be expected to agree with the owner of the fishery or fishing club what changes there will be, and what, if any, compensation is appropriate.

### 8.2. Public rights of way

The development may divert these (temporarily or permanently). The developer should consult with the county council Footpath Officer, who deals with footpath diversions and new footpaths.

There may also be safety issues. For example, if the right of way passes steep drops, safety railings may be necessary.

Concerns about public rights of way may partly depend on the location of the works – for example, whether they are close to an urban area, whether children are likely to play near them, etc.

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<sup>69</sup> For the effects on fish themselves, see section 5 above.

### **8.3. Navigation**

Where the watercourse is used for navigation, it is important to consult boat users.

- Sailing (including landing stages/marinas) may be affected by changes in flow directions and water levels.
- Canoeists may wish to use tailrace water as a fast water site. If so, it is important to have the right sort of bank revetment to accommodate them.
- Rowing may be affected by changed water flows.
- Cruisers may experience difficulties in using locks if flow directions alter.

### **8.4. Local plans**

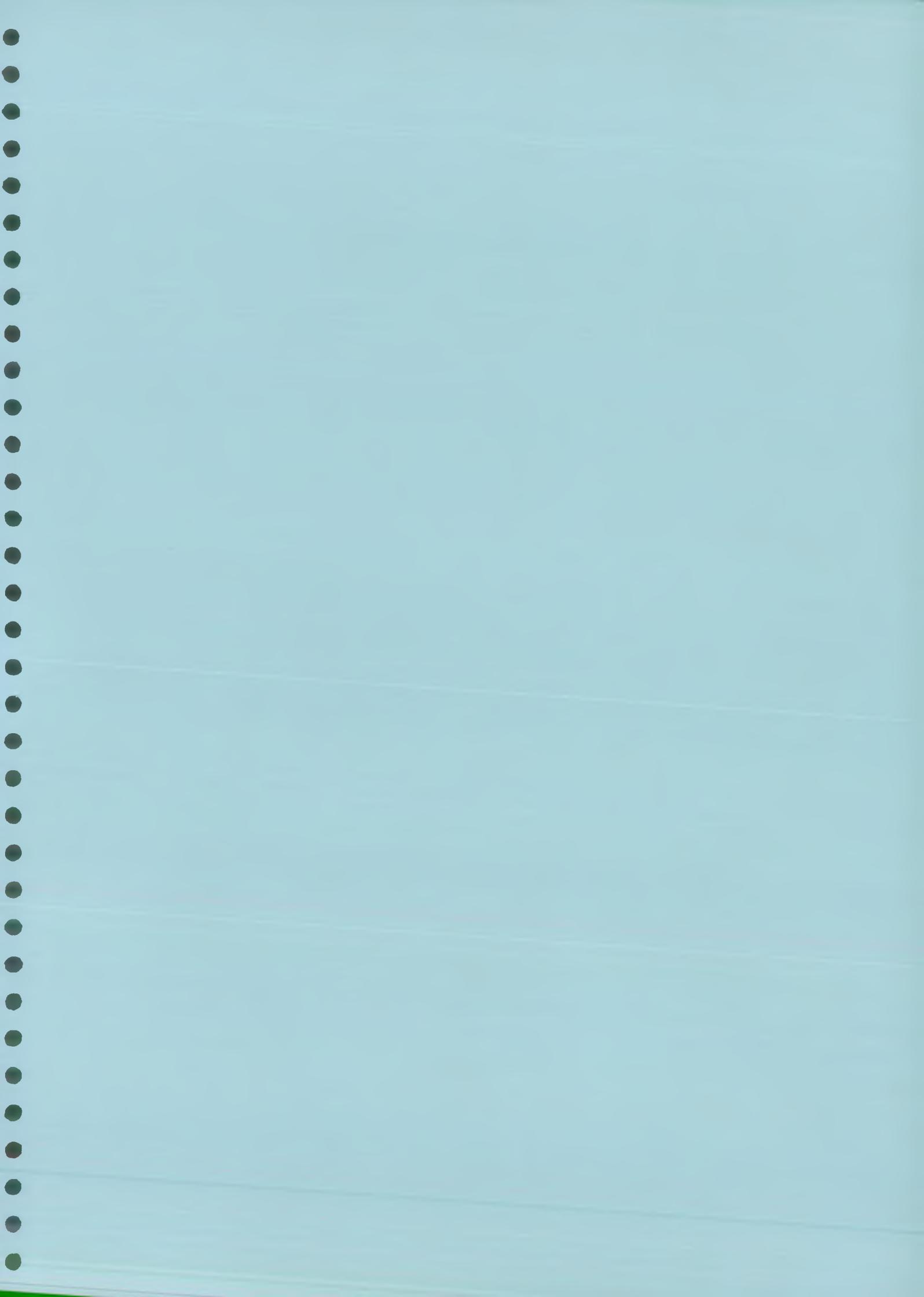
Local Plans or other development etc. plans for the area or region may be relevant to recreational issues.

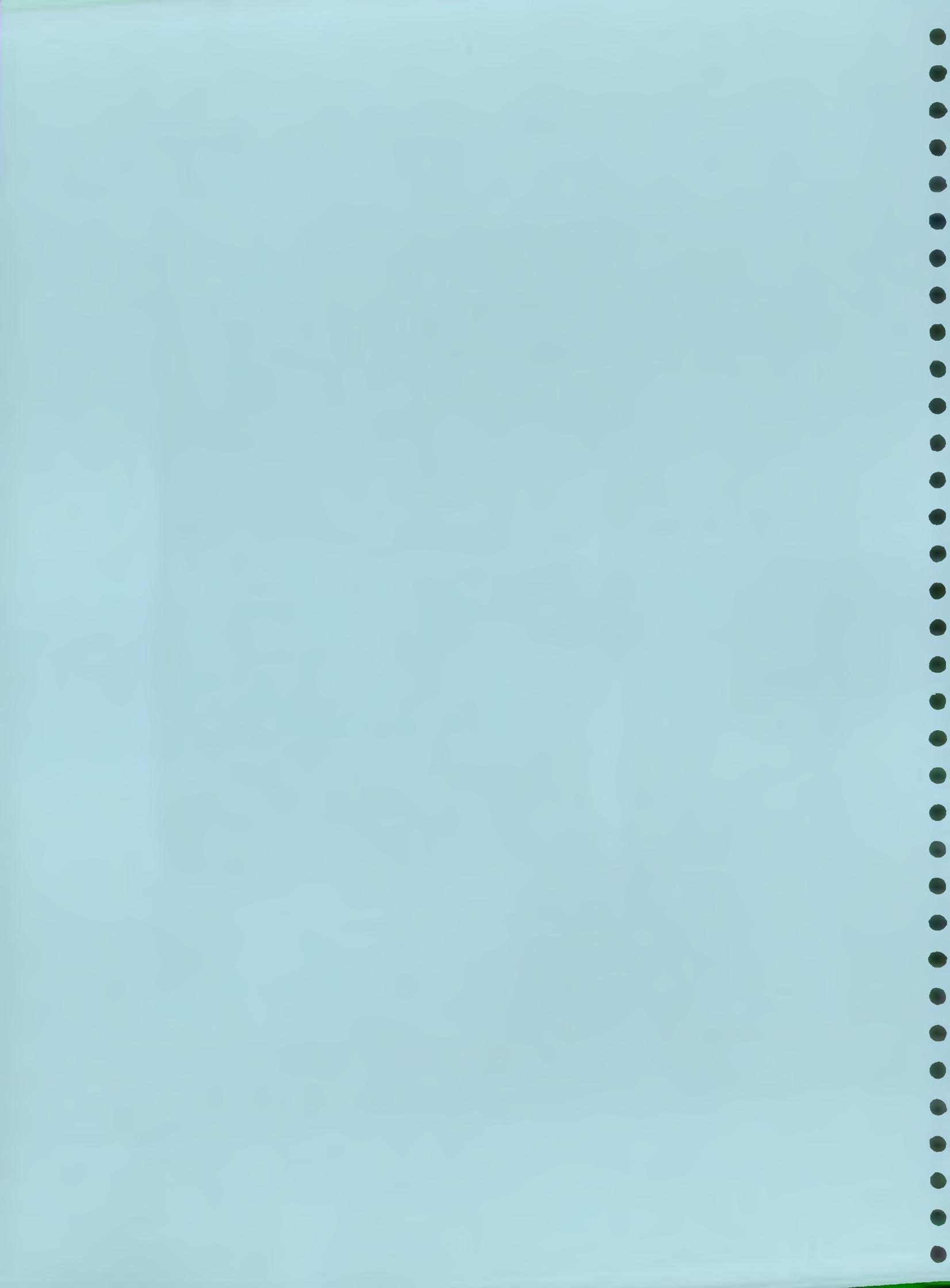
### **8.5. Consultees**

For local plans etc., the local planning authority will have information.

Other consultees will include (as appropriate)

- Local angling clubs
- National Federation of Anglers
- Local sailing, boating, canoeing, rowing clubs
- Local marinas
- Royal Yachting Association
- British Canoe Union
- British Waterways Board
- Inland Waterways Association
- Amateur Rowing Association
- British Water Ski Federation
- Sports Council





## Hydropower handbook: Appendix section

### Contents

A — REFERENCES .....	1
B — RESPONSIBILITIES MATRIX .....	4
C — GUIDANCE TO APPLICANTS ON ENVIRONMENTAL INFORMATION REQUIRED .....	5
D — SECTION 158 AGREEMENTS .....	10

### APPENDIX A — REFERENCES

(See section 1.3 of main part of handbook)

#### HYDROPOWER - GENERAL

*An assessment of the potential for small-scale hydropower in the UK.* Report ETSU-SSH-4063, 1989. Available from Renewable Energy Enquiries Bureau, ETSU.

*Small-scale hydropower: study on non-technical barriers.* Report ETSU 5511 4073. Available from Renewable Energy Enquiries Bureau, ETSU.

*Micro-hydropower: A guide for development workers.* IT publications, 1991. ISBN 1 85339 029 1.

*Micro-Hydro Design Manual: A guide to small-scale water power schemes.* IT Publications, 1994. ISBN 1 85339 103 4.

*Renewable Energy: Planning for the Future. A Guide for Local Authorities.* Department of Trade and Industry. Available from Renewable Energy Enquiries Bureau, ETSU.

*Renewable Energy Information list No. 2: Organisations involved in the development of small-scale hydro energy in the UK.* Department of Trade and Industry. Available from Renewable Energy Enquiries Bureau, ETSU.

*Water Power: Small Scale Hydro. Renewable Energy Case Studies.* A series of

pamphlets describing particular hydropower sites. Department of Trade and Industry. Available from Renewable Energy Enquiries Bureau, ETSU.

*Small-scale Hydro power: Technology Status Report 002.* Department of Trade and Industry. Available from Renewable Energy Enquiries Bureau, ETSU.

*Planning Policy Guidance Note: PPG-22 Renewable Energy.* Department of the Environment and the Welsh Office. HMSO Publications.

*Layman's Guidebook on How to Develop a Small Hydro Site (Parts 1 and 2).* European Small Hydropower Association (ESHA) for the Directorate General for Energy (DG XVII) of the Commission of the European Communities. HMSO Publications.

*Renewable Energy Bulletin Number 5: Information on the Non-Fossil Fuel Obligation for Generators of Electricity from Renewable Energy Sources.* Department of Trade and Industry. October 1993. Available from Renewable Energy Enquiries Bureau, ETSU.

*Financing Renewable Energy Developments: A Guide for Developers.* November 1993. Available from Renewable Energy Enquiries Bureau, ETSU.

*Hydropower and The National Rivers Authority.* NRA. Available from NRA Head Office and Regional Offices.

*Assessment of Low Head Hydropower Developments.* WS Atkins Consultants Ltd for NRA, Severn Trent Region. Available from NRA, Severn Trent Regional Office, Solihull.

#### ENVIRONMENTAL ASSESSMENT

*Hydropower Developments: Guidance on Environmental Information Required.* National Rivers Authority. Available from NRA Head Office and Regional Offices.

*Environmental Assessment, a Guide to the Procedures.* Department of the Environment and the Welsh Office, 1989. HMSO. ISBN 0 11 752244 9.

#### FISHERIES

*Small Hydropower and Fisheries.* American Fisheries Society. Proceedings of 1985 symposium.

*Fish Protection at Steam and Hydroelectric Power Plants.* Electric Power Research

Institute, California. Proceedings, 1988.

*Turbine-Related Fish Mortality: Review and Evaluation of Studies.* Electric Power Research Institute, California

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Appendix B — RESPONSIBILITIES MATRIX (see section 2.3.1 of main part of handbook)

	Capital spend	Ownership	Routine maintenance	Replacements and repairs	Emergencies	Decommissioning and restoration
Intake bay, screens, stoplogs						
Pipeline and associated structures						
Buildings and equipment						
Outlet structure						
Weir incl. tailgate, Fletcher boards						
Fish pass						
Telemetry flow, level measure, alarms etc.						
River channel (beds and bank)						
Other						

## APPENDIX C — GUIDANCE TO APPLICANTS ON ENVIRONMENTAL INFORMATION REQUIRED

(See section 2.3.2 of main part of handbook)

**NOTE: Freestanding copies of this should be available at Regional and Area offices as a handout to potential licence applicants.**

The NRA is responsible for the management and protection of all aspects of the water environment. It has a duty to give full consideration to the range of potential impacts that may arise from hydropower development. Some of these effects may be significant.

Developers must therefore provide adequate technical information to enable the NRA to assess hydropower proposals in terms of effects on water resources, fisheries, conservation, recreation, water quality, flood defence and navigation. This will normally be in the form of an appropriate environmental report.

This note gives a check list of topics which it may be necessary to cover in such a report and is intended to assist developers in providing the environmental information required by the NRA. The scope of the report required in each case will need to be agreed with the NRA beforehand. Developers should contact the appropriate NRA Regional/Area office **at an early stage** in order to discuss proposals and to receive guidance regarding environmental information requirements. Lack of information may result in delays or refusal of applications. The NRA will seek the minimum amount of information necessary to determine the application and in some cases a brief report may be adequate.

The NRA may be able to assist by providing environmental information which it holds, for example river flow data. A charge may be payable for this.

Developers should also contact the Planning Authority to discuss its requirements (if any) for environmental information. These may include aspects of the proposals which are not of direct concern to the NRA.

### **Format of Environmental Information**

The NRA will advise developers about how to present the information required. This will depend on matters such as the size of the scheme, location of the site, and requirements of the planning authority. We recommend that environmental reports are prepared in accordance with good practice for environmental assessment

methodology. The following general topics should be considered—

- Description of the project
- Description of the site and its environment
- Hydrological information
- Assessment of the effects of structures, abstractions and discharges
- Proposed mitigating measures
- Risks of accidents and hazardous development
- Environmental action programme

### **Scope of Environmental Information**

The following list sets out the main areas of impact that need to be considered and the potential scope of required information. What is required in a particular case should be agreed beforehand with the NRA.

### **Hydrological Information**

The most significant impacts of hydropower schemes arise from the change of flow regime resulting from abstraction and/or impounding of water. In order to assess potential effects on the water environment, the following types of information relating to flow may be required, including—

- Catchment hydrology: average rainfall, losses, run-off
- Hydrometric data, where available
- Flow duration curve, mean flows, dry weather flows
- Seasonal variation in flows
- Assessment of monthly overspills
- Reduction in downstream levels
- Residual flows downstream of intake needed to safeguard river interests

In considering applications, the NRA will need to ensure that river interests are safeguarded during periods of low flow and that any changes in the higher flow regime are within acceptable limits. Accordingly, licences may include conditions which restrict or prohibit operations under certain flow conditions.

### **Structural details**

- Design of intake and discharge structures
- Impoundment details
- Proposed measurement, recording and control arrangements

### Water Resources

- Survey of existing uses of resources:
  - within the upstream catchment
  - between the abstraction and discharge points
- Assessment of the effect of the proposal on abstraction rights
- Assessment of the effect on gauging sites and flow measuring structures

### Fisheries

- Impact on movement of fish
- Impact on migration of fish
- Provision of satisfactory fish passes where fish movement/migration is likely to be impeded
- Quantitative assessment of the loss of fish habitat, including spawning/nursery habitat and predicted impact on fish populations
- Impact of flow changes, including spate reductions, on fish populations between abstraction and discharge points
- Impact of changes in flow regime and water quality on fish populations downstream of discharge points
- Adequacy of screening of intakes and outfall and provision of bypass channels to minimise ingress of fish and the likelihood of fish passage through turbines
- Timing of construction works with regard to spawning/migrating fish

### Conservation

#### Surveys of flora and fauna—

- River corridor surveys — flora, species of note, habitat, statutory sites, etc.
- Tree surveys, including life expectancy of trees
- Invertebrate survey — aquatic and riparian
- Waterway bird survey
- Survey of mammal habitats and data from County Mammal Recorder
- Amphibian survey — breeding

Surveys should be carried during the appropriate season.

#### Landscape survey—

- Landscape assessment and character
- Geomorphological survey
- Survey covering geological, palaeontological and physiographic features

Survey of historical features—

- Listed buildings and structures
- Planning conservation areas
- Scheduled ancient monuments and Sites and Monuments Register

**Recreation**

Survey of recreation and public access—

- Water rights: access, fishing, mooring
- Common rights
- Footpaths, fishing pegs, slipways, canoeing
- Public safety

**Navigation**

- Survey of navigation rights
- Measures proposed to safeguard navigation

**Water Quality**

- Assessment of the effect on existing effluent discharges into any affected reach
- Effects on river classification, statutory water quality objectives, river classification and Environmental Quality Standard compliance
- Implications for proposed developments
- Implications for quality of water supply
- Sediment/suspended solid changes
- Inter-river transfers — crop or fish disease transfer, species transfer, pollution transfer
- Control measures for use of biocides and anti-fouling preparations
- Effect of changes in flow regime on algal growth
- Effect of changes in flow regime on siltation
- Temperature changes

**Flood Defence**

- Effect of structures on channel capacity, flood plain and flooding problems
- Effect of variation in water levels on land drainage
- Channel alterations, bank stability, scour and deposition
- Impact on existing structures adjacent to the river channel
- Impact of changes in flow due to operation
- Provisions for "fail safe" operations to protect minimum upstream water levels

- Formal agreements regarding method of operation/water level management
- Compliance with local Land Drainage byelaws

### **Environmental Monitoring**

Where uncertainties exist regarding impact upon the water environment, proposals should include provision for the developer to undertake a continuing environmental monitoring programme.

**APPENDIX D – SECTION 158 AGREEMENTS**

(See section 3.2 of main part of handbook)

1. Hydropower developments can exercise significant control over the flow regime of a river. This is due to operation of sluices, weir obstructions, sudden closure of turbines etc. Many of these influences will occur, or will have consequences, when electricity generation is not taking place and may therefore not be controllable simply by means of a condition on an abstraction licence. An impounding licence is not transferrable and there can be difficulties in ensuring that any conditions associated with such a licence can be enforced in perpetuity.
2. Section 158 of the Water Resources Act 1991 allows the NRA to enter into agreements with the owner or operator of any reservoir or works as to the manner in which the reservoir or works are to be operated. The agreement is registerable as a land charge which ensures that its provisions are enforceable against any person owning the works. The agreement can also include controls at any time, not only when hydrogeneration is occurring. Where detailed operational control is required which may not be achieved in a wholly satisfactory way via an impounding and/or abstraction licence, grant of an appropriate licence can be made subject to the owner/occupier first entering into an agreement which may include whatever provisions relating to the operation of the reservoir/works as are required in the circumstances. Provided that such requirements are reasonable and are necessary for the discharge of the NRA's functions, this approach should be sustainable at appeal.
3. Points that may be covered in s.158 agreements include (this list is not exhaustive):
  - Details of reservoir and impounding works ownership, maintenance, replacement, refurbishment, and operation in normal and emergency situations.
  - Obligations for emptying and filling of reservoir, release and discharge requirements, maintenance of flows, extent of drawdown permitted, rate of recovery in storage pound.
  - Agreed derogation, ie. agreement for no claim against NRA up to agreed limit of derogation.
  - Checking of levels.
  - Measures to avoid flooding.
  - Measures to avoid of scour.
  - Maintenance and replacement of gauges.
  - Indemnification of NRA against claims by third parties.
  - NRA's default powers.

- Obligations on decommissioning ie. removal of works, reinstatement etc.
  - Ecological and recreational monitoring programme(s) relating to the effects of operation of the development.
  - Relationship between the s.158 agreement and grant of the licence (and revocation).
4. Section 158 agreements are site specific and must therefore be tailored to meet individual circumstances. See the *Licensing Manual* (Chapter 8) for the format of these agreements and further details of procedure (eg. registration as Land Charges). The following are extracts from the schedule to an existing agreement which illustrate the some of the sorts of conditions which may apply:

#### SCHEDULE – PART 1

##### POWER GENERATION

The generating plant shall be operated with regard to the mean daily flow (MDF) in the River \_\_\_\_ as measured at the Authority's Gauging Station at \_\_\_\_\_ (NGR: \_\_\_\_\_) at 0900 GMT for the previous 24 hours and made available to the Company as its cost by the Authority in such manner as may be agreed between the parties from time to time as follows:-

- 1 When the MDF is less than 400 MI/d (Megalitres per day) generation shall only take place if:-
  - 1.1 The water level in the storage pound (is at or above) the crest level of the main weir.
  - 1.2 The water level in the lower pound above the lower weir marked C on the plan ("the lower pound") shall not fall below a level of 59.74m AOD as indicated by the red line marked on the staff gauge at point "B" on the plan at any time.
  - 1.3 The water levels in the storage pound and the lower pound shall be monitored at intervals not exceeding four hours, using either a telemetry system or visual inspection.

PROVIDED THAT when generation is taking place and either or both of the conditions in paragraphs 1.1 and 1.2 are not satisfied, the generating plant shall be shut down in such a way, and/or other sluices operated such that the rate of recovery of the level in the storage pound is not greater than 10mm per hour.

- 2 When the MDF is greater than 400 Mld but less than 1100 Mld generation may take place provided that:-
  - 2.1 The levels in the storage pound and at the staff gauge at point B are checked at intervals of not more than 24 hours.

**PART I (cont)**

- 2.2 The maximum drawdown of the storage pound below the crest of the main weir shall not exceed the amount shown in the Table below, being a uniform increase from zero drawdown at 400 MI/d MDF to a maximum of 50mm at 1100 MI/d MDF.
- 2.3 The rate of recovery of the level in the storage pound shall not exceed 20mm per hour up to the crest level of the main weir.

Table 1

Maximum drawdown of storage pound permissible for flows in the River \_\_\_\_\_ as measured at \_\_\_\_\_

Mean daily flow for previous 24 hours to 0900 measured at _____ (MI/d)	Maximum drawdown of storage pound below crest of main weir (mm)
400	0
500	7
600	14
700	21
800	29
900	36
1000	43
1100	50

(Intermediate values to be obtained by linear interpolation)

- 3 When the MDF is greater than 1,100 Mld:-
- 3.1 The levels in the storage pound and at the staff gauge at point B are checked at intervals of not more than seven days.
- 3.2 The maximum drawdown of the storage pound below the crest of the main weir shall not exceed 50mm.
- 3.3 The rate of recovery of the level in the storage pound shall not exceed 50mm per hour.
- 4 The Company will compile keep and make available to the Authority such records of power generation as the Authority shall require, the content and format of such records and the place at which they are kept to be as agreed between the Company and the Authority.

**PART II****EMPTYING AND REFILLING THE STORAGE POUND**

When generation of electricity is not taking place:-

- 1 The storage pound shall not be emptied nor refilled by the Company without the prior written consent of the Authority which shall not be unreasonably withheld, and the Company shall give seven days' notice to the Authority except in an emergency or to comply with a statutory requirement.
- 2 The Authority's consent may be given unconditionally or subject to such reasonable conditions as the Authority shall require to secure the proper management of the River \_\_\_\_.
- 3 The Authority reserves the right to require the Company to modify, restrict or cease emptying or refilling operations to prevent or alleviate environmental damage as a consequence of the actions of the Company or of other parties.
- 4 The Company will compile keep and make available to the Authority such records of emptying and refilling of the storage pound as the Authority shall require and the content and format of the records and the place at which they are kept shall be as agreed between the Company and the Authority.
- 5 Emptying and refilling operations are to be closely monitored and controlled at all times throughout the operations by a competent person under the control of the Company subject to adequate and continuous communication between the Company and that person at all times.
- 6 No refilling shall take place when the MDF is below 400 MI/d even if emptying has been in response to emergency or statutory requirements in paragraph 1 above.
- 7 Paragraph 6 above shall not apply if the Company makes arrangements with \_\_\_\_\_ plc ("the water company") (with the prior written agreement of the Authority) for the water company to make available water to fill the storage pound by additional compensation releases from its storage reservoirs or by operational adjustments. The Company shall be responsible for all arrangements with the water company including any charges levied by it for water made available to the Company.

**PART III****AVOIDANCE OF FLOODING**

The Company shall use its reasonable endeavours to prevent the level of the storage pound exceeding 275mm above the level of the main river.