GAUGING STRUCTURE REPLACEMENT OR REMOVAL

Assessment of Issues and Options Relating to the Removal or Replacement of Gauging Structures

For

Environment Agency

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Disclaimer

These notes are compiled on the basis of RRC's extensive expertise. RRC seeks to provide advice and suggestions to facilitate river restoration progress, but is careful not to produce detailed design drawings. In this way the Centre limits its liability. Liability for any restoration designs should be with the consultants tasked with the detailed technical feasibility and design work which will be necessary to take forward any options identified in this document.

RRC is a national centre for information and advice and the National River Restoration Inventory (NRRI) is a database of river restoration works. To inform this database please let us know of any projects which are carried in the future. Please send any information to the RRC (rrc@therrc.co.uk).

The report is based on the outcomes from a workshop held on 1st March 2012 and information collated from the Environment Agency and Natural England.

Executive Summary

The Current Situation

Gauging structures provide a tried and tested way of deriving flows by measuring water levels and calculating the related flow using stage discharge equations, or theoretical structure formulas for British standard structure structures. Structures can however significantly affect natural physical river processes and flow conditions and prevent/reduce fish passage; in essence a structure creates a loss of sediment and ecological continuity along rivers and hence becomes one of the barriers to achieving Water Framework Directive requirements. In addition, the Environment Agency's Mitigations Measures Manual and recent whole river Special Area of Conservation (SAC) / Sites of Special Scientific Interest (SSSI) restoration strategies (Nar, Wensum, and Avon) have identified structures as a major pressure to achieving Good Ecological Potential (GEP) and favourable condition on SSSI. Any opportunity to remove them or reduce their impact (especially where structures are failing) therefore needs to be considered as an option/opportunity.

The removal of structures, whilst good for ecology, morphology, fish, and in some instances to improve flood capacity, can be a problem where a structure is being used for gauging purposes. Long term flow and level data may be required for both operational (for example flood and drought monitoring, water resource management, environmental management) and strategic purposes (for example climate change modelling, hydrological modelling for long term water resource management). A conflict can exist where structures are used to collect this valuable data, but also have a detrimental effect on aquatic ecology and geomorphological connectivity.

Overall Project Aim and Objectives

The aim of this project is to help develop guidance for removal of gauging structures, or where the ability to gauge flows needs to be retained, to identify alternative gauging options that minimise impacts on flow and sediment dynamics and biological connectivity. Suitable alternatives will be considered primarily by developing case studies, taking into account river type, location and flow gauging needs.

Objectives

1. Outline the current review procedure and decision making process in the UK relating to gauging station removal.
2. Identify and provide a range of options that will benefit physical river processes and flow conditions and ecological connectivity (for example lowering, gauged diversion channels, or other innovative gauging techniques).
3. Short list potential gauging structure removal or alternative options and present these as case studies, outlining the technical feasibility and estimates of option costs.
4. Demonstrate the benefits of structure removal for fish, hydromorphology, ecology and Flood and Coastal Erosion Risk Management (FCERM).

Project Approach and Summary

The project Steering Group included Jenny Wheeldon (Natural England/Environment Agency), Karen Fisher (Independent consultant) Judith Crompton and Mike Porter (Environment Agency) and the River Restoration Centre.

The output from the workshop (Environment Agency, April 2013, Gauging Weir Workshop Output Final) identified a number of issues including the importance of gauging station records for both strategic and operational purposes both internally in the Environment Agency and externally. The impact and potential issues of structure/structure removal both in terms of the effect on the aquatic environment (ecology, geomorphology and fisheries), and with regards to maintaining an appropriate hydrometric network were discussed.

The drivers for structure removal (including gauging structures) were identified and the challenges discussed. These included the issues of accuracy of flow estimation using structureless gauging stations; the need for a clear strategy for assessing gauging stations for potential removal or replacement; the need for better dialogue between hydrometric team and the Fisheries and Biodiversity and geomorphology teams within the Environment Agency; a better understanding within the Environment Agency of the importance of the gauged flow records outside of the hydrometric and hydrology teams and their 'customers'.

An overview of gauging structure network management and an explanation of the decision making process between the National, Regional and Area Hydrometric teams is given. This may also include asset teams in Regions where they have overall responsibility for the asset.

A précis of previous and current relevant research and development work is given including The Non Invasive Techniques for Flow Measurement (SC030230/SR - 2005) and more recent work such as Southampton University who are looking at gauging structures in terms of fish passage. There is also a hydrometric review currently being undertaken by the Adur/Ouse pilot project and the Midlands Fish Passage Project. In addition the Field Hydrometry and Telemetry Monitoring - National Monitoring Service are also looking at developing a decision making tool for the removal of structures.

The uncertainty associated with the various flow measurement methods is summarised as;

Weir Structure;

- Larinier fish pass 3%;
- Crump and flat v structures 3-6%;
- V Notch thin plate structure 6%;

Non-invasive techniques;

- Multi path time of flight ultrasonic gauges 7-10%;
- Doppler flow gauges 10%;
- Electromagnetic flow gauges 10 – 15%;
- Open channel 10% plus;

The Environment Agency national hydrometric team has developed a sophisticated access database which holds information about each of its flow and level gauging stations. The database, which each area hydrometric team has a copy of, holds information about each individual site in terms of site details and the benefits (both potential and actual) of the recorded flow data for different Environment Agency functions (for example flood risk management, water resources and environmental management). Also if they are strategic gauging stations with long records and are part of the National River Flow Archive held by the Centre for Ecology and Hydrology (CEH).

Issues and benefits of structure removal are discussed and will be available in detail in an Environment Agency R & D project produced by the RRC on structure removal, lowering and modification (SC070024/R), contact is Natallie Phillips (EA project manager). The effects on geomorphological processes, ecology and hydrology are all highlighted.

The Gauging Station Assessment in Section 4 outlines a set of eight key statements to guide the discussion of removal/replacement between the relevant fisheries/biodiversity and hydrometric teams. This is accompanied by a set of summary flow charts to give an overview of this process (Appendix B). The Hydrometry & Telemetry Data & Information Acquisition Plan (H & T DIAP) database is an access database holding a variety of information on flow and level gauging stations, including site details and the benefits (both potential and actual) of the recorded flow data for different Environment Agency functions. It can therefore provide key quantitative information on gauging structures, which should be the basis for discussion of removal/replacement with regard to the hydrometric considerations. In addition the ecological and morphological requirements of the river also need to be assessed.

This initial assessment should broadly involve the consideration of: the effect of the structure on fish and eel passage, geomorphology, biodiversity, archaeology, water quality, socio-economic implications and suitability of upstream habitats. Once this information has been collected it can then be used to rank structures in terms of both their importance to the Hydrometric or Asset Team (where appropriate), their 'customers' and the extent of their negative effect on ecology, morphology and fisheries.

Following this, the potential factors which need to be considered to proceed with the range of removal/replacement options (for example natural bypass channel, replacement with structurless gauge) have been outlined to help guide the process of implementation. It is essential to assess the catchment scale impacts of both the existing structures and any proposed changes, as structures can create sediment management issues over different spatial scales, which often involve a wide range of stakeholders including Defra, Natural England (NE), Environment Agency (EA), local authorities, land owners, property owners, angling societies, water companies, local conservation trusts etc. Any actions which effect sediments should also consider multiple timescales i.e. short and long term.

The report has two case studies, one for Castle Rising gauging station on the River Babingly in Anglian Region and one for Shaw gauging station on the River Lambourn in Southeast Region. The Castle Rising site is thought to present a problem to fish migration and the initial assessment for this site is set out in this report. Shaw gauging station has already been through an assessment by Atkins and the outcome from this is also included in this report.

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1. Introduction

The River Restoration Centre (RRC) was asked by the Environment Agency Water Framework Directive Delivery Team at the Blandford Office and Natural England to put together a guidance document for officers involved in habitat restoration projects. The guidance was to set out how to approach the issue of assessing whether a gauging station structure was affecting a watercourse in terms of fisheries, ecology or geomorphology, and to explore potential alternatives for the site. This information is important not just to the Fisheries and Biodiversity teams, but to all the functions which use the hydrometric data within the Agency (for example water resources, flood risk management, asset teams) and externally (for example the Centre for Ecology and Hydrology and water companies).

The removal of in-channel structures such as weirs, whilst potentially good for ecology, morphology, fisheries, and in some instances to improve flood capacity; can be problematic where the structure is being used for gauging purposes. A conflict exists between the obvious need to collect the valuable on-going, long-term data for operational and strategic water resources and Flood and Coastal Erosion Risk Management (FCERM) purposes; and the need to improve geomorphological processes and connectivity to enable rivers to reach their full potential. In some instances structures can be replaced with non-invasive methods but the accuracy of the gauged flows is reduced, so such methods are not appropriate in all instances.

1.1 Context and Drivers

The drivers for considering changes to gauging structures include the Water Framework Directive (WFD), Habitats and Birds Directive (HD), the Biodiversity Strategy (England) and water resources (WR) and FCERM network management. From the WR and FCERM perspectives the gauging structures network can provide operational and strategic information. WFD objectives are different from those of WR and FCERM but do not necessarily need to be conflicting. There are in existence some documents which seek to bring together the WFD, FCERM and WR outcomes and show how each can complement the other. The Environment Agency's Mitigations Measures Manual is one of those documents where measures for a river catchment can be identified and implemented to achieve both FCERM and WFD objectives and benefits.

A number of recent whole river restoration strategies for Site of Special Scientific Interest (SSSI) restoration (http://www.therrc.co.uk/rrc_designated.php) identify in-channel structures as a major barrier to achieving good ecological status or potential (GES/GEP) as required by the WFD and favourable condition on SSSIs. Any opportunity to remove them or reduce their impact (especially where structures are failing), needs to be considered as an option/opportunity.

In order to help achieve WFD objectives, and contribute to achieving favourable condition on SSSI rivers, it would be beneficial to;

- Provide a comprehensive review of the issues around replacing gauging stations from all viewpoints, including a strategic assessment of gauging station accuracy requirements and what alternative measuring techniques could be used;
- Build on examples of where gauging structures have been removed or replaced to enhance the river morphology and ecology, providing technical evidence of how to do it, and the level of success;

- Provide guidance through case studies for replacing/adapting gauging structures that can improve WFD and SSSI status and demonstrate where this is beneficial for flood risk management;
- Ensure that where gauging station structures can be removed, a sustainable hydrometric network is maintained.

1.2 Aim

The main aim of this project is to help develop guidance for removal of gauging structures, or where the ability to gauge flows needs to be retained, to identify alternative gauging options that minimise impacts on flow and sediment dynamics and biological connectivity. Suitable alternatives are illustrated with case studies, taking into account river type, location and flow gauging needs.

The overall project objectives are summarised as follows;

- Objective 1 - Outline the current review procedure and decision making process in the UK relating to gauging station removal.
- Objective 2 - Identify and provide a range of options that will benefit physical river processes and flow conditions and ecological connectivity (for example lowering, gauged diversion channels, or other innovative gauging techniques).
- Objective 3 - Short list potential gauging structure removal or alternative options and present these as case studies, outlining the technical feasibility and estimates of option costs.
- Objective 4 - Demonstrate the benefits of structure removal for fish, hydromorphology, ecology and FCERM.

1.2.1 Drivers for structure removal

Water Framework Directive, the Habitats Directive, and the England Biodiversity Strategy targets are the key drivers for removal.

Currently Environment Agency gauging stations have been assessed for accuracy and fitness for purpose and all this information is recorded in the hydrometry and telemetry data and information acquisition plan (H & T DIAP) database which is nationally available to all hydrometric teams. In terms of water resources the driver is to ensure the hydrometric network is fit for purpose and that inaccurate and obsolete gauging structures (which cost money to maintain) are not retained. Some area offices, for example SW Region's Bodmin office and the SE region's Wallingford office have looked at some gauging stations with respect to fish passage and recommendations for removal and replacement have been given accordingly. These assessments have been somewhat *ad hoc* and the process needs to be formalised and carried through nationally.

1.3 Approach and Method

The approach in the project was to undertake a desk study to collect and collate data and knowledge to meet objectives 1 to 4. The desk study was complemented by a workshop for the experts and stakeholders in this field.

A workshop was held on the 1st March 2012 to help deliver objective 1 of this project and provide information to deliver objectives 2 to 4. The findings from the workshop and subsequent questionnaires helped to formulate the main aspects of the work. A report summarising the workshop (Environment Agency, April 2013,Gauging Weir Workshop Output Final) set out the work to be taken forward in

producing this report. The steering group for this project included Jenny Wheeldon (Natural England/Environment Agency), Judith Crompton and Mike Porter (Environment Agency), Karen Fisher (KR Fisher Consulting Ltd) and the River Restoration Centre (RRC).

The workshop provided an understanding of the broad knowledge in the subject area. Along with other sources of expertise from within RRC and expertise from steering group and EA, objectives 1 to 4 have been met and collated into this report. The key elements, challenges and benefits which were identified from the workshop are expanded into more detail in Section 2 in this document.

2. Benefits, Impacts and Challenges of Structure Removal

In addition to the workshop, part of this project included a literature review and an assessment of the potential impacts of structure removal as well as the benefits associated with potential gauging structure removal, replacement or mitigation. A key source of information was the River Restoration Centre weir removal, lowering and modification best practice guidelines developed for the Environment (SC070024/R) (this paper is not yet published- contact Natalie Phillips at EA for a draft).

2.1 Importance of Gauging Structures for Data Acquisition

In order to assess the benefits, impacts and challenges of structure removal, modification or mitigation at a site, it is important to understand the strategic importance of the gauging station. Strategic gauges have long historic records used to identify and assess climatic trends and arguably the need for long term accurate hydrometric data has never been greater. Without a careful decision making processes the loss of strategic gauges in particular could negatively impact this important data set. Nonetheless, many gauges are not fit for purpose and could be de-commissioned and replaced with alternative technologies.

The purpose of collecting flow gauging data for strategic and operational decision making (e.g. flood forecasting, water resource management, drought management) needs to be understood at the outset of the process. The 'customers' of gauged data need to be considered in order to help to determine the level of required data accuracy, and the appropriate gauging methods.

2.2 Benefits and Impacts of Removal

Structures affect geomorphological processes and hydrological connectivity, flow regimes, biological connectivity and ecological processes. These impacts need to be well understood before removal of a structure or introduction of alternative technology. If the holistic benefits of structure removal are understood more widely, the case for removal could be communicated and viewed positively. Equally if the impacts are not understood this could lead to long lasting issues for example maintenance requirements, such as sediment removal, could increase.

The impacts of structures on geomorphology, hydraulics and hydrology, aquatic biology and ecological processes are given below with the positive impacts listed first, then those with possible positive or negative impacts depending on the circumstances and finally the negative impacts. Table 2.1 summarises the benefits and dis-benefits.

The geomorphological effects of structure removal include;

- Sediment redistribution can restore a river and its habitats to pre-structure conditions, revealing natural gravels underneath accumulated sediment held up by a structure.
- Changes in sediment dynamics which may take several decades to adjust following the initial adjustment and are dependent on local bed gradient and sediment load;
- Increase in sediment load may raise local downstream bed elevation and increase floodplain connectivity which can be beneficial for the colonisation of aquatic species but may increase flood risk;
- Sudden mobilisation of sediment may release contaminants into the water column and affect water quality;
- Structure removal may cause severe head-cutting upstream;

- Removing contaminated sediment from behind structures needs to be considered in any removal operation and this can potentially greatly increase costs if contaminants need to be taken off site.
- At some locations structures may be preventing alien species from spreading upstream. This may need to be considered alongside an eradication programme.

Effects on hydrology and hydraulic processes include;

- Lowering of water levels upstream which can be beneficial for flood risk, but detrimental to foundations of bankside buildings if it leads to drying out of foundations;
- Change in velocity reduction in backwater/impounded length/height (could be negative when effecting a wetland SSSI, but can be positive);
- Controlling levels or flow diversion for an abstraction may prevent removal;
- Super saturation of gases in the stored water upstream of a structure can occur briefly if the reservoir is removed too rapidly (due to increased velocities and air pressures). The effect of the increase in total dissolved gases is short and can be avoided if the level of water behind the structure is released slowly.

Effects on aquatic biology and ecological processes include;

- Improve migration and prevent disruption to migration patterns;
- Reduces energy spent by migratory fish overcoming barriers, which in turn means more successful spawning, or higher survival rates for eel;
- Decreases genetic isolation;
- Rivers regain a more natural lotic state, which leads to the development of a more natural aquatic ecology;
- Reduced overcrowding of fish populations downstream of a structure and the resulting reduction of fish parasites and diseases;
- Allow fish to move away from potential pollution events;
- Temperature increase in the impounded section upstream of the structure.

Table 2.1 Benefits and Dis-benefits of Structure removal

Type	Description	Outcome
Geomorphological	Sediment re-distribution	+ve
	Changes in sediment dynamics	+ve or -ve
	Increase in sediment load	+ve or -ve
	Sudden mobilisation of sediment	-ve
	Headcutting	-ve
	Mobilisation of contaminated sediment	-ve
	Removal of barrier to invasive species	-ve
Hydrological	Lowering of water level	+ve or -ve
	Change in velocity	+ve or -ve
	Reduction in backwater impoundment effect	+ve or -ve

	Structure acting as control level	-ve
	Release of super saturated gases	-ve
Ecological	Improve fish migration	+ve
	Reduce energy spent by fish and eels during migration	+ve
	Decrease genetic isolation	+ve
	Development of more natural aquatic ecology	+ve
	Reduce overcrowding in fish population	+ve
	Allow fish to escape from polluted waters	+ve
	Reduce temperature in summer	+ve

2.3 Challenges

Challenges for achieving structure removal or replacement include;

- Alternative ways to gauge should be considered taking into account accuracy requirements of each gauging site. What influences these requirements needs to be fully understood for each gauge;
- Need for a hydrometric network which minimises morphological and biological impacts but produces an acceptable quality and accuracy of data;
- A clear strategy is needed for identifying which gauges can be removed, which ones can be replaced with a less accurate measuring device and which need to be maintained. This assessment needs to be done at a range of scales; at the national strategic network level, at catchment level and on a case-by-case basis;
- Fish ladders and passes which are currently often the default option for mitigating the impact of structures may only allow passage of salmonids and operate at certain flows, and do not address the impacts of structures on fluvial morphological processes. There is a need to address the effect of structures on morphology and also to improve passage for the full range of fish species and eels, so fish passes are not always the best option;
- Need to understand where the high profile gauges are and cross match these against WFD failures;
- Structureless gauging stations (for example hydro-acoustic sites) often require weed and silt removal so maintenance may be greater than for a structure although weed cutting is also required at a number of lowland gauge sites;
- More discussion/research is needed on alternative structures, including assessing what methods are used in other European Member States and worldwide, and guidance on the level of accuracy associated with different gauging options;
- Better dialogue between hydrometry/hydrology and ecology/fisheries is needed. Clear guidance is needed on how to assess the strategic importance of gauging stations so that ecology and fisheries teams can ask the right questions.

There is a need to know how decisions are made at national level to allow conflicts to be resolved at the local level. The Environment Agency is in the process of developing a decision tool to look at the possibility of removing gauging stations. The process has been completed within asset management teams but is not suitable for local prioritisation.

3. Overview of Gauging Structure Network Management

Decisions are made at national/regional and local level on the management, maintenance and operation of the hydrometric network. Decision making is aided by use of the Environment Agency national hydrometric team's database called the Hydrometry & Telemetry Data & Information Acquisition Plan (H & T DIAP). The H & T DIAP is available to all the Environment Agency hydrometric teams. It holds a range of information about each gauging station, including accuracy of the station, fitness for purpose, and any strategic of operational requirements for the gauge.

Thus far, projects that look to remove or modify gauging stations have tended to be driven by local area fisheries and biodiversity teams to meet WFD or SSSI objectives, as opposed to the water resources teams. Fisheries and Biodiversity teams can, with the help of the hydrometric teams, use the information in the H & T DIAP to help inform these decisions.

3.1 Decision Making Process

Where a gauging station has been identified as potentially impacting on WFD and SSSI status, and changes may be proposed, the Environment Agency hydrometry team will need to consider the strategic importance and operational use of the gauge. Decisions about potential changes to gauging stations are made at several levels:- national, regional and local.

3.1.1 National

The national team influences how the area hydrometric team operate and is responsible for any conflict resolution. The national team also set the terms of reference (service level agreements) between the hydrometric teams and their customers i.e. other Environment Agency functions and external data users. The following actions have been identified for the national team to progress in order to ensure that decisions related to gauges also take into account WFD objectives for morphology and ecology;

- The national Terms of Reference need updating to reflect WFD, Habitats Directive, Eel Regulations and European Biodiversity Standard (EBS), including SSSI objectives;
- Produce guidance notes on how to assess risks relating to the requirement of accuracy of gauging station data and the overall risk of making changes to the network.

3.1.2 Regional

Environment Agency Regions (except North East) have had hydrometric user group panels for the past few years. The user groups provide guidance on the management of the hydrometric network (i.e. whether to increase, reduce the network and approve fish passes where required). A Senior Environment Agency Area Manager chairs the group with functional representatives from fisheries and biodiversity, water resources and FCERM. NE Region had a pre-existing setup which is slightly different from this model.

3.1.3 Area

Area teams have access to the national H & T DIAP. This is a database that stores meta-data information about all hydrometric sites. A network review of all flow sites was undertaken several years ago which identifies the national, local, strategic importance and potential benefit and use of flow and level data from all the gauging sites the Environment Agency operate. This data is held on

the H & T DIAP, and used both internally and externally. The H & T DIAP is available to all Areas/Regions, but is a subset of that Region's data alone. It is maintained regularly by Keith Garrett who is based at the Environment Agency Exeter.

In some areas (for example South West Area Bodmin office and South East Area Wallingford office) WFD requirements have prompted an assessment of gauges for fish passage. The Bodmin office commissioned APEM to assess each gauge for the suitability of passage for salmon, trout and eels. The burst swimming capabilities of these species were estimated using the SWIMIT v 3.3 software. From the EA's Fish Pass Manual it is estimated that if the difference between the crest height of the structure and the downstream water level is < 0.5m then the structure is passable by salmonids. For three flow ranges (high i.e. >Q30, moderate Q30 to Q70) and low <Q70) using the stations rating curve the depth of water over the crest was estimated and compared to the height of the water downstream, thus the passability of the gauge could be assessed. Both upstream and downstream migration was assessed. Options for improving fish passage were then given and a preferred option selected. For this preferred option outline designs were then drawn up.

In the South East Region's Wallingford office options for improving SAC rivers such as the River Lambourn brought to a head the desire to remove a number of gauging stations which had been identified as contributing to an SAC or SSSI river being in unfavourable condition. Shaw gauging station on the River Lambourn was identified as one such structure. The hydrometric team are seeking to replace this structure with a non-invasive gauging device. The Wallingford office are now planning to carry out an Area and possibly Regional strategic assessment of all gauging structures.

3.1.4 Asset Management Team

In a number of regions there is an Asset Management Team which 'own' the structures and are responsible for their maintenance regionally.

3.2 Previous and Current Relevant Work

3.2.1 Previous

The Environment Agency's Non Invasive Techniques for River Flow Measurement (SC030230/SR-2005)http://www.envirobase.info/search/DatabaseSearchBin.aspx?outputid=444408&type=pdf reported that the alternative gauging methods being used by the Environment Agency in 2005 included open-channel rated sections, transit time acoustics and electromagnetic flow meters. There did not appear to be any non-invasive flow measurement technologies which were developed and widely used elsewhere that were as yet unknown to the Environment Agency. Doppler acoustics were being mainly used in the USA where experience of transit time acoustic methods was more widespread.

The report considered the resource requirement, practical implications and principles of operation for different non-invasive flow gauging methods. The review of these different methods showed that site suitability and adequate calibration were paramount to the success of the non-invasive methods. Accuracy can be ±5% to ±10% of the gauged flows for most techniques. However, accuracy can deteriorate when operating conditions are less than optimal.

It was suggested that hybrid solutions should be considered such as using a transit time ultrasonic, but switching to a side-looking acoustic doppler velocity meter (ADVM) if sediment loads are exceeded. Newer technologies will allow greater flexibility of deployment as they do not require extensive civil engineering works. This is one of the particular attractions of side looking Doppler Acoustics which does not require cables to be routed across the channel. The report also

recommended that new methods such as Rising Air Float Velocimetry (natural particle image velocimetry) and seismic induction should be investigated.

As this report was written seven years ago it would be worthwhile to update to the report, particularly to see if any of the new and innovative techniques identified originally have been developed further.

3.2.2 Current

There are discussions within the Environment Agency about developing a decision making tool for the removal of structures. This is currently subject to wider discussion and clarification by senior managers within the Agency (Pers: Comm: Richard Iredale - Technical Advisor, Field Hydrometry & Telemetry Monitoring - National Monitoring Service - Head Office Operations). In addition, Southampton University (Paul Kemp) is looking at gauging structures in terms of fish passage http://www.southampton.ac.uk/engineering/about/staff/pk2.page, there is a hydrometric review currently being undertaken by the Adur/Ouse pilot project, and the Midlands Fish Passage Project.

3.3 Accuracy of Alternative Methods

With any kind of measurement of river flows there is uncertainty or error associated with each of the methods. Table 2.1 summarises the uncertainties associated with the different methods of gauging river flows (from Hydrometric Uncertainty Guidance ISO/TS 25377:2007).

Table 3.1 Gauging Uncertainties

Gauging Method	**Uncertainty**
Structure	
Larinier fish pass	3%
Crump and flat v weir	3-6%
V Notch thin plate weir	6%
Non-invasive techniques	
Multi path time of flight ultrasonic gauges	7%-10%
Doppler flow gauges	10%
Electromagnetic flow gauges	10 to15%
Open channel	10% plus.

From Table 3.1 it is clear that the most accurate way of measuring flows in rivers is to use a structure. The Environment Agency's H & T DIAP database holds information on the accuracy of each gauging station and the site's operational or strategic importance. This information can be cross referenced against the needs of fisheries/biodiversity/hydromorphology of rivers to highlight gauges which are most suitable to be removed or replaced with a non-invasive flow measurement system.

Recommendations for non-invasive techniques for differing site and flow conditions is summarised in Table 3.2. This table is very much an overview and each site need to be assessed individually to determine the best option for that site.

Table 3.2 Suitability of methods under differing site and flow conditions

	Acoustic transit time		Acoustic Doppler		Electromgnetic		Doppler Radar	Natural Light PIV	Seismic Induction
Site of Flow Condition	**Single Path**	**Multipath**	**Up looking**	**Side looking**	**Buried Coil**	**Slab**			
Low velocity (< 20mm/s)*	✓	✓	x	x	✓	✓	Repeatable at 10-20 mm/s	✓	x
High velocity (> 1000mm/s)*	✓	✓	✓	✓	✓	✓	✓	✓	✓
Shallow water (< 100mm)*	x	x	x (1)	x	✓ (11)	✓	✓	✓	x
Deep water (> 2m)*	✓ (2)	✓	✓(2)	✓(2)	✓	✓	✓(2)	✓(2)	✓
Wide channel (~ 50-100m)*	✓	✓	x (12)	✓	x	x	✓(12)	?	?
Wide stage range	x	✓	✓	x	x	x	✓	✓	✓
Clear water (< 3mg/l suspended solids)*	✓	✓	x	x	✓	✓	✓	(3)	✓
High aeration	x	x	✓(4)	✓(4)	✓	✓	✓	✓	✓
High sediment load (1-10 x10$_3$mg/l)*	x	x	✓(4)	✓(4)	✓	x (9)	✓	✓	✓
Very high sediment (>10 x10$_3$mg/l)*	x	x	x	x	✓	x (9)	✓	(5)	✓
Variable backwater	✓	✓	✓	✓	✓	✓	✓	✓	N/A
Reverse flow	✓	✓	(6)	x	✓	✓	✓	✓	N/A
Stratified flow (salinity/ thermal)	x	x	✓(10)	✓(10)	x	x	x	x	N/A
Densely vegetated channel or banks	x	x	x	x	✓	✓	x	x	✓

	Acoustic transit time		Acoustic Doppler		Electromagnetic		Doppler Radar	Natural Light PIV	Seismic Induction
Site of Flow Condition	**Single Path**	**Multipath**	**Up looking**	**Side looking**	**Buried Coil**	**Slab**			
Compound channel/ floodplain flows	Depends on configuration		✓(12)	✓(12)	X	X	✓(12)	X	X
Skewed or irregular approach channel	✓(8)	✓(8)	✓(7)	✓(7)	✓	✓	✓	✓	✓
Bed irregularities	✓(2)	Calibration for lowest panel	✓	✓	✓	X	✓	✓	✓

Notes:
* Indicative figures
1 Continuous wave ~100-200 mm, pulsed ~500 mm.
2 Provided suitable index velocity or other calibration exists
3 System requires artificial seeding or bubbler
4 Potential for range bias error
5 For surface seeding only
6 Increased potential for sediment blockage
7 Secondary circulation can reduce accuracy - requires calibration.
8 Preferably cross path configuration
9 Sediment accretion breaks contact between electrodes and water
10 Range-gated device best suited
11 Accuracy reported to decrease
12 May be possible using an array of transducers

****From Non Invasive Techniques for River Flow Measurement - Environment Agency Science Report SC030230/SR**

3.4 Hydrometric and Telemetry Data and Information Acquisition Plan

The Environment Agency national hydrometric team has developed a sophisticated access database which holds information about each of its flow and level gauging stations. The H & T DIAP database is an access database; Table 3.3 shows the main information which is available in the database and Figures 3.1 and 3.2 show snapshots of the database to illustrate the sort of information that this database holds.

The database, of which each area hydrometric team has a copy, holds information about each individual site in terms of site details and the benefits (both potential and actual) of the recorded flow data for different Environment Agency functions (for example flood risk management, water resources and environmental management), also if they are strategic gauging stations with long records and are part of the National River Flow Archive help by the Centre for Ecology and Hydrology (CEH).

Table 3.3 Information and options in the H & T DIAP

Field Name	Input Types	Example
Main Site Details		
Site number	Text Box	012345
Site status	Drop-down list	open
Site type	Text Box	Surface water sites
Region	Text Box	North East
Catchment ID	Drop-down list	01/02
River name	Text Box	River Bec
Site structure type	Drop-down list	Double crump
Site structure type high flows	Drop-down list	Crump
Duplicate of site	Drop-down list	
Site name	Text Box	Bury Grove
NGR	Text Box	NT1234567891
Site subtype	Drop-down list	
Area	Text Box	Colne
Catchment size (km2)	Text Box	54
Site visit frequency	Drop-down list	Site visited every 2 months
Flow derivation method low	Drop-down list	Stage Discharge Rated System
Flow derivation method high	Drop-down list	Stage Discharge Rated System
Component site	Check box	
Composite site	Check box	
ID correct?	Check box	
Non-WISKI site	Check box	No
Expired WISKI site	Check box	No

Field Name	Input Types	Example
NFFS	Check box	Yes
MARS import	Check box	No
Secondary Site Details		
Agency maintained	Check box	Yes
Agency owned	Check box	Yes
Agency read	Check box	Yes
Environmental impacts – migratory fish	Check box	
Access difficulties	Check box	
Telemetry	Check box	
Asset condition indicator	Drop-down list	Fair
Asset Owner	Text Box	EA
Comments	Text Box	
Parameter history		
Start period	Date range	1945
End Period	Date range	Present
Comments	Free Text	
Filter Options		
Filter by	Selection box	Site no.

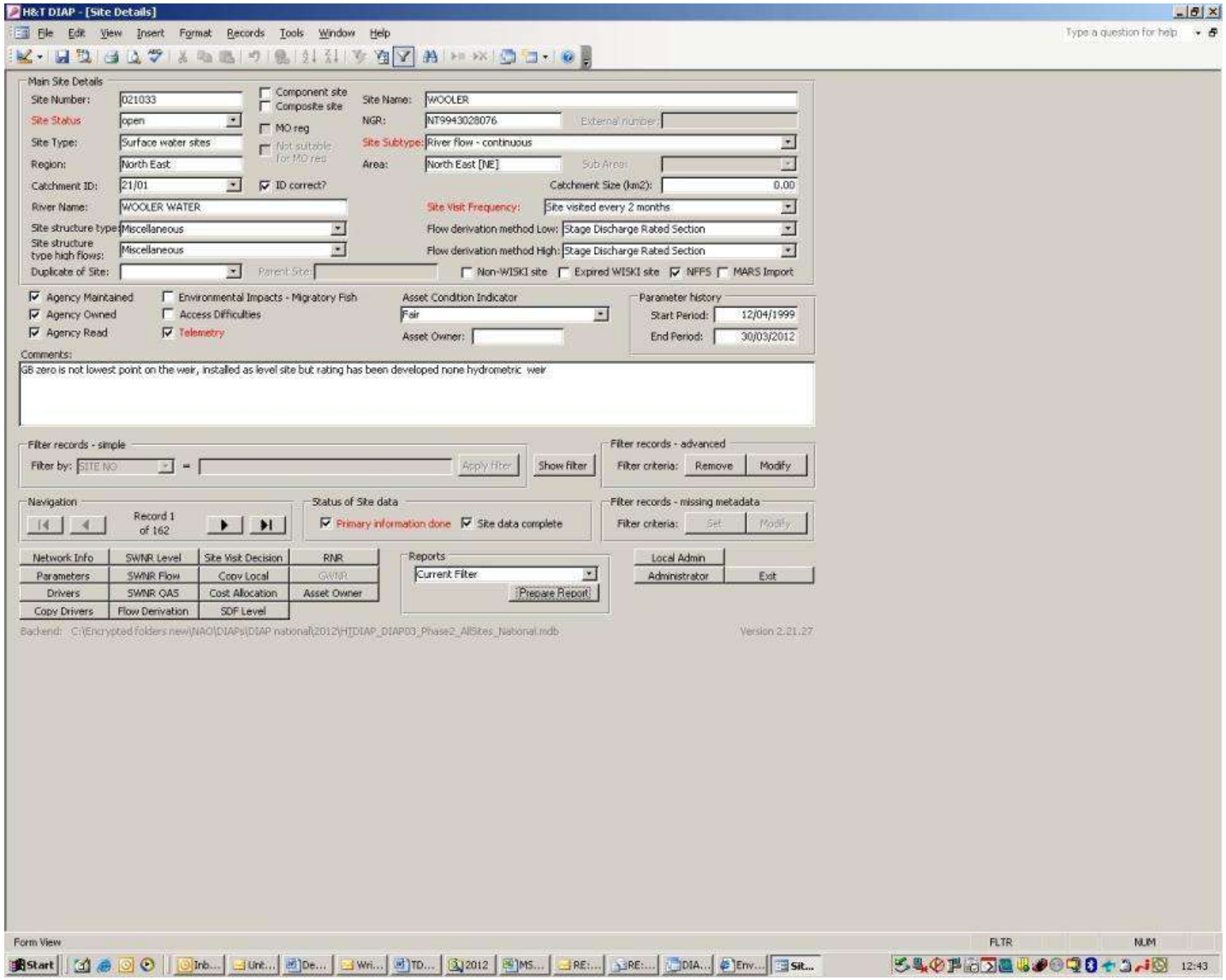

Figure 3.1 Screenshot of H & T DIAP main site details

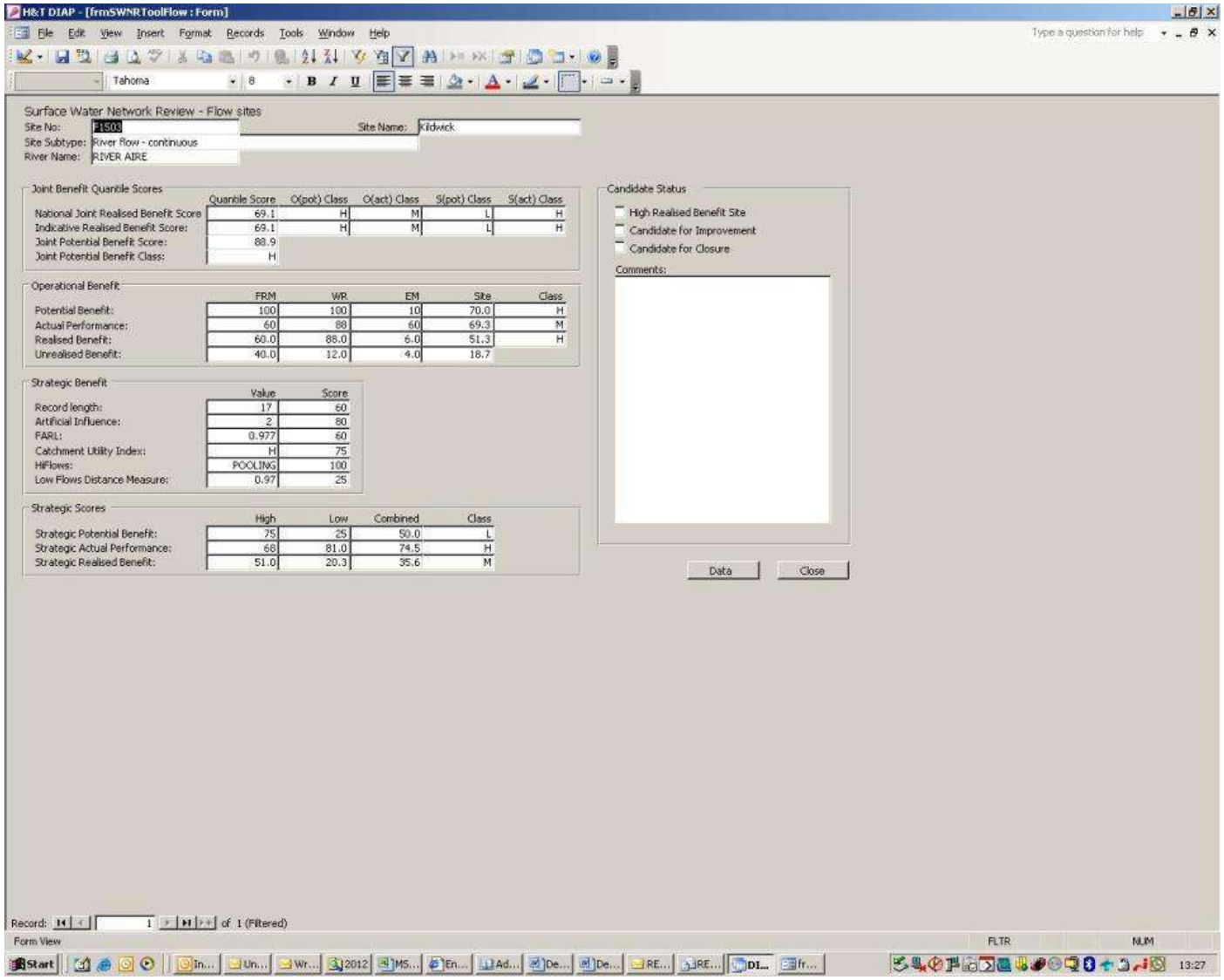

Figure 3.2 Screenshot of H & T DIAP gauging station benefits information

4. Gauging Station Initial Assessment

The assessment of gauging stations requires consideration of a number of elements which can broadly be split into hydrometric and ecological/morphological requirements. The Environment Agency's H & T DIAP database is already set up to assess hydrometric requirements and the database can give a score for the strategic and operational benefits if the gauge site. However, in addition the ecological and morphological requirements of the river and hydrometric requirements also need to be assessed.

4.1 Initial Assessment

Prior to determining if a gauging structure should be removed, replaced or bypassed; the extent of the existing effect on fish passage, morphology and biodiversity should be determined. In addition to assessing the current impact of the structure, the effects of removing, replacing or modifying them need to be considered.

The purpose of looking at current and potential impacts are to;

- Establish a justification for retaining the structure in place for example for abstraction purposes or that it provides a vital part of the hydrometric network or;
- Establish a justification for removing/replacing/modifying the structure for example to re-establish biological and ecological connectivity or ease fish passage.

Different groups within the Environment Agency will have varying perspectives on the gauging structure and any changes to be made. These perspectives should be captured in the initial assessment.

Flood and Coastal Erosion Risk Management (FCERM) would be interested in;

- Range at which the gauge operates (especially if it was bypassed at flood flows);
- The importance of the gauge to the flood warning network;
- any associated flood risk changes;
- The condition and age of the structure and maintenance costs;
- Any erosion or deposition risks upstream and downstream.

Fisheries and biodiversity (F&B) would be concerned with the geomorphological, ecological and biological processes and fish and invertebrate passage. The key issues for F&B would be the number, diversity and distribution of species and habitats including fish, invertebrates, vegetation and protected species.

Water Resources would be concerned with;

- The use of the gauge for monitoring low flows;
- If it was an abstraction or discharge point (any intakes or licenses);
- Is it being used as a strategic and/or operational record.

Once the different perspectives in the initial assessment have been collated the information can be used to make a judgement on whether the structure could be removed/replaced/modified.

During the initial assessment, a number of factors need to be established regarding the ***current impact of the structure*** including:

- Is the structure significantly affecting geomorphological processes, if so what are these effects?
- Is the structure significantly adversely affecting biodiversity, if so what are these effects?
- Is the structure a barrier to fish and invertebrates?

Equally what will be ***the impact of removal/replacement/modification of the structure*** including impacts on;

- Hydraulics and hydrology;
- Water resources;
- Geomorphology;
- Biology/ecology;
- Socio-economic value;
- Water quality and temperature;
- Archaeology.

The sections below look at these impacts of the existing structure and proposed changes to the structure from the different perspectives.

4.1.1 Potential effects on flow and sediment processes

Existing gauging structures and potential removal or modification can alter the sediment and flow regime, which can affect a wide range of stakeholders including Department of Environment, Food and Rural Affairs (DEFRA), Natural England, Environment Agency, local authorities, land owners, property owners, angling societies, water companies, local conservation trusts etc. Any actions which effect sediments should maximise the benefits to habitats and ecosystems, and need to be considered over multiple timescales i.e. short and long term.

The Environment Agency outlines six guiding principles of sediment management as;

- Actions should be reasonable and justified; what is in the Catchment Flood Management Policy relevant to the location? What could the problems be of structure removal?
- Understand the wider problem and identify causes; need to identify potential sediment related problems when considering structure removal and catchment issues with sediment management (i.e. understanding the whole fluvial system);
- Identify and prioritise function of watercourse. Is the priority 1) ecosystem services or 2) societal roles (flood risk management, navigation, land drainage). For ecosystems services constraints may be imposed on maintenance. A HMWB (Heavily Modified Water Body) designation may suggest structure removal/replacement is not required. This would need to be assessed in considering appropriate mitigation measures to achieve Good Ecological Potential. The need to achieve favourable conservation status on SAC rivers would override this consideration for HMWB;
- Identify and appraise management options based on risk analysis; what are the positive and negative impacts of removal/replacement?
- Balance multiple goals of channel management; can encompass both ecological/fisheries and hydrometrics priorities for the watercourse.

- Appraise maintenance outcomes; what targets have been met with reference to the specific functions outlined? Is any adaptive maintenance needed?

4.1.2 Establishing the likely morphological effect of the structure

The morphological effect of structures include raised water levels upstream of the wear, reduced water velocities and resulting deposition upstream of the structure, changes to sediment transport and potential increase erosion and scour downstream of the structure.

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Figure 4.1 Widened channel with slow flows upstream of substantial gauging structure

Figure 4.2 Large gauging structure over 2m high

Figure 4.3 narrower channel with fast flowing water downstream of gauging structure

Figure 4.1 shows the channel upstream of the large gauging structure shown in Figure 4.2. The channel is wide with slow flowing water and no in-stream morphological features such as gravel bars or islands. Any sediment being transported downstream in flood events will start to fall out of suspension as the water velocities slow on the approach to the structure. The structure itself is over 2m high and represents a significant barrier to fish. The structure fixes the channel width being twice the natural width of the river (see Figure 4.3). This river is a medium energy gravel river type and the structure will impede the movement of gravels as well as finer sediment down this reach. These geomorphological changes may have 'knock on' effects in terms of water quality and habitat type

Fluvial geomorphological issues related to existing structures and their potential removal or modification may include;

- Decrease in slope of the water surface behind structures, causing sediment accumulation;
- Release of trapped sediment from upstream of structures, which has the capacity to smother spawning gravels downstream. However, in the long term it may still increase the range of habitats, as well as allowing access to new areas upstream;
- Bank and bed adjustment following replacement/removal of structure i.e. changes in slope which may impact on flow velocity and associated sediment transport capacity. This could lead to head or down cutting within the vicinity of the structure or slumping of the banks. Any potential positive and negative impacts of this need to be considered. It should be noted that the tail level of the gauging weir is not always recorded, so it may be beneficial if monthly tail readings were regularly taken at all gauging weirs, this could be part of the regular gauging weir inspections/visits;
- Design of new channel at replaced gauging site in terms of ability to be "in regime" i.e. no net sediment deposition/erosion. Issues downstream of the structure could be a localised increase in turbulence and flow velocity, which has the potential to cause erosion of the river bed and banks, and may result in the creation of a scour deep pool downstream of the structure, and deposition in the form of a shoal further downstream.

4.1.3 Establishing the likely biodiversity effects of the structure

The effects of in channel structure on biodiversity includes loss of submerged, emergent and bank-side vegetation, and loss of associated animal and invertebrate communities. In some instances structures may maintain high water levels keeping wetland areas inundated. However, fauna and flora favoured by ponded conditions and fine sediment predominate. The overall impact may be lower diversity of habitat, prevalence of lotic conditions, poor water quality in low flow conditions, and water temperature increases. Increased depth of water upstream may drown fish spawning and juvenile areas and increased siltation upstream of the structure may bury potential spawning areas.

4.1.4 Fish and eel passage

One of the first things to determine is whether the structure is a barrier to fish or eels. The Environment Agency Fish Pass Manual has a section on swimming performance which will help with assessing whether or not the structure is passable. There is also an R & D project Swimming Speeds in Fish: phase 2 (Environment Agency 2004) http://cdn.environment-agency.gov.uk/scho0404bipv-e-e.pdf. Another alternative is to consult the Environment Agency's SWIMIT Microsoft Excel spreadsheet. There is also a very comprehensive document produced by SNIFFER on barriers to fish migration surveys (assessment criteria and procedure) which can be found at

http://www.sniffer.or.uk/files/1113/4183/7995/SEPA_WFD111_Phase1_Appendices.pdf

All of these assessment methods, along with details of the structure itself, such as the height and stage-discharge relationship of the structure, should help in determining whether the structure is passable to a range of fish species.

4.1.5 Establishing upstream reach suitability for natural populations

Having established whether the structure is passable or not, it then needs to be established if the various fish species and eels would naturally be found in the reaches upstream of the structure. If the structure is a barrier to fish and or eels and it is expected that naturally a population would be found upstream of the structure, then it is reasonable to start investigations as to the possibility of removing, replacing or altering the structure such that fish are able to negotiate it.

4.1.6 Establishing the socio-economic value of the structure

The removal of structures which form part of a river crossing used by the public or in a public area may have an impact on the local community. However, most gauging stations are purpose built and are unlikely to have any real intrinsic value as far as the public are concerned. The removal of a structure may change the soil moisture of surrounding land leading to alterations in land-use practices but investigations into this would be part of the more detailed assessment done at a later stage as part of the stakeholder engagement.

4.1.7 Establishing the archaeological importance of the structure

The removal or modification of existing structures may have direct impacts on the historic environment, or indirect effects such as lowered water levels exposing drowned or buried artefacts. However, unless the structure is part of a commonly known archaeological interest then it should at least be considered for removal, replacement or alteration if other factors favour such changes. The following principles should be applied when considering the historic environment;

- The significance of designated and non-designated assets and landscapes should be assessed and if required, appropriate mitigation agreed with local authority archaeologists;
- Mitigation options will include design modification to minimise impacts, consolidation/ enhancement of surviving heritage features, or archaeological recording in advance of or during removal/modification of a structure.

A Heritage Assessment protocol has been developed by the Environment Agency's National Environment Appraisal Service (NEAS), and is also briefly outlined in a Natural England "Help Note" which is available from Jenny Wheeldon at Natural England.

4.1.8 Water quality and temperature effects of the structure

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

4.1.9 Hydrometric considerations

Having collated as much information about the effects of the structures from an ecological, morphological and fisheries point of view it is then time to assess those that are gauging structures from a hydrometric view point.

There are a number of considerations which will help with the initial assessment of gauging structure removal, and aid the communication between hydrometric or Asset Team (where applicable) and ecology/fisheries teams, both of which are key stakeholders in the process of gauging structure removal. Once it has been established that changes to the structure are possible then the asset management team need to be approached. Motivations for gauging structure removal include the Habitats Directive, WFD and SSSI condition objectives to improve habitat, longitudinal connectivity, and geomorphology.

These drivers present an opportunity to replace inaccurate or out of date gauging technology with new non-invasive techniques (see Table 3.2). The replacement of the more inaccurate gauging structures with non-invasive gauging methods may increase the accuracy of the network which

would have multiple benefits for flood risk/water resource management, as well as increasing the accuracy of climate change models. Relocating gauging stations gives the opportunity to move the gauging assessment point to a more appropriate location in some instances, which could improve the gauging network overall. Gauging structure removal therefore presents a wealth of opportunities as well as constraints. An identification of these on a site specific basis is critical to a thorough assessment of proposed structure removal. The Environment Agency H & T DIAP database is a key information source to inform the Hydrometric Team/Asset Team and end user perspective on the following issues.

Current purpose of the gauging structure

Essentially flows recorded at gauging stations have two main purposes, strategic and operational;

- Strategic – Strategic gauging structures may be part of the National River Flow Archive supported by the Centre for Ecology and Hydrology (CEH). At strategic sites, flows and levels have been recorded for a long historic period and are used to identify and assess hydrological trends, which contribute to assessments such as climatic change or drought modelling. Loss of strategic gauges could negatively impact these important data sets and therefore must be carefully considered. In some cases the motives behind removal/replacement may still override this consideration.
- Operational – for operation purposes the flows and levels recorded at a site may have a range of specific uses within water resources management or flood defence, specifically in terms of informing flood warning and defence, and abstraction licenses including low and HoFs (Hands off Flows).

Identifying the purpose of the gauging structure helps to define the importance of the gauge at national, regional and catchment scales. This also allows for an assessment of whether it is fit for purpose, further to the information listed on the H & T DIAP database. Establishing the current purpose of a gauge helps to inform the identification of sites which would be most suitable options for removal or replacement/removal.

If removal/replacement of the structure allows it to become more "fit for purpose" or reduces the cost of maintenance or decommissioning, then hydrometric teams will also benefit from changes.

Length of the gauging record

Length of flow record is key when considering removal/replacement of a gauging structure, as gauges with a longer record can be seen as more strategically important, and therefore removal at these locations may be less desirable. In the case of a strategic or vital operational record, alternatives to removal may need to be considered (see Section 4.4.2).

It should be noted that a long record does not discount considering changes at a site, as changes which would allow for increases in the quality of the gauged data could be an advantage for hydrometric teams.

Range of flows currently being recorded

Gauges which were not designed to record the full range of flows are potentially less valuable to the gauging network, and could therefore be a priority for removal/replacement. Key considerations are:

- What accuracy does the station record at?
- Are there any calibration issues with the gauge?

Structures constructed with the sole purpose of flow gauging are often aimed at monitoring a specific range of flow conditions and may be less accurate outside of this flow range. If accuracy of gauging is low, then data becomes less reliable and therefore a less valuable part of the hydrometric network. This is especially the case where information is used to inform climate models, as trends can easily be incorrectly extrapolated. Inaccurate gauging sites could therefore be a priority for removal, as they would not be fit for purpose.

If the gauge needs to be regularly re-calibrated, it may suggest that it is performing below the required accuracy standard. In some cases this could highlight it as a potential for removal/replacement, which could also benefit hydrometric teams.

Performance at high flows

A gauging structure becomes drowned when the water level on the downstream side of the structure (tail) is too high for super-critical flow to be achieved on the structure face. When a structure is "drowned out" gauging accuracy is negatively affected, unless a pressure tapping on the crest or a tail level is available to allow for adjustment of the data recorded. If a gauging structure is regularly being drowned out, then it is not meeting the required standards of hydraulic performance at a full range of flow conditions, and will not produce an accurate flow record.

At high flows the structure may be bypassed as water flows out of banks and around the structure. Many structures have been constructed with the aim of specifically monitoring low flow levels. Therefore, at high flows many gauges become inaccurate. Generally speaking, structures which gauge at a range of flow levels are the most important to be retained within the hydrometric network but this is site specific (i.e. dependent on the gauging range required at a specific location which would be defined by the purpose of gauging).

If a structure is being bypassed or drowns out the assessment should determine if replacement with a non-invasive gauge gives better accuracy at high flows.

Performance at low flows

For water resource management purposes in particular, it is important to be able to accurately measure low flows during drought periods. Some gauging stations have been purpose built to record low flows and these are likely to have less error in recording drought flows than those where a non-standard gauge is being used to calculate flows.

Location of the gauge within the catchment

It is important to consider all other gauging sites locally to the structure and within the wider catchment. Gauging locations on the National River Flow Archive (NRFA) should be noted. By considering how a specific gauging structure site fits into the wider hydrometric network, a better estimation of its significance can be made. This consideration also aims to consider how the specific removal/replacement of a structure could impact on the wider catchment i.e. if a structure is removed what are the overall benefits for that section of river? Are other structures in the vicinity still going to cause a problem for habitats or geomorphology depending on the rationale behind the planned removal/replacement? (Is the impetus for removal focused on geomorphological or ecological connectivity?)

The Environment Agency's asset management teams National Flood and Coastal Defence Database (NFCDD) is a key source of information to answer this question, as it lists all Environment Agency owned gauging stations. All known structures (not owned by the Environment Agency) are listed in a separate GIS layer; however this may not be a complete record. This also enables identification of other structures which interrupt the longitudinal connectivity of river channels, which could influence the effectiveness of structure removal/replacement in terms of re-gaining this connectivity.

Maintenance requirements of the gauging structure

Ponding of water upstream of gauging structures can lead to sediment accumulation and associated increase in weed growth which can require an on-going and expensive maintenance regime. This can involve sediment removal, vegetation removal and structural repairs. Structures which have a significant maintenance requirement would be a priority for replacement/removal, especially where the financial costs outweigh the potential gains of retaining the unaltered structure. However, high maintenance costs do not automatically qualify a site for removal/replacement.

Should replacement be highlighted as an option, consideration needs to be made of any likely maintenance requirements of the alternative gauging options. This is especially important when considering non-invasive techniques (outlined in Table 3.2) in low energy environments, as sedimentation and weed growth can interrupt gauging signals.

Third Party Investment

In some instances the structure may have investment from a third party such as a water company if it is used to regulate and manage one of their abstraction points. The gauging station may be part of the abstraction licence provisions. If this is the case the decommissioning or alteration of the gauge may be subject to compensation.

Age and Condition of the Structure

Old structures which are reaching the end of their working life, or structures in a poor state of repair will require more maintenance, therefore their removal or replacement with a non-invasive gauge is a more likely option.

4.1.10 Ranking structures within a catchment or area

If a single structure is being considered this process is useful in informing the relative importance of the structure in the catchment and establishing a catchment perspective. If a number of structures are being considered for removal, replacement or modification it may be useful to consider ranking those structures to establish a priority list for action.

As well as collating as much information as possible on the gauges themselves as explained previously in this chapter, it is recommended that an understanding of where the gauging stations are in relation to each other and other structure structures need to be gained. In addition the general issues in the catchment need to be fully understood. Catchment issues might include;

- Water quality
- Flood risk
- Protected species
- WFD mitigation measures
- Urbanisation
- Invasive species
- Agricultural runoff and associated sediment loading
- Low flows related to abstraction
- Effluent discharges
- Water transfer discharges
- Naturalness of the channel upstream and downstream of the structures

It is suggested that as much information as possible should be collated about each gauging structure. Basic information about many gauging structures can be collated from the CEH web site http://www.ceh.ac.uk/data/nrfa/data/search.html. Figures 4.4 and 4.5 show examples of information which can be collated from the CEH website. This can be used in conjunction with the H & T DIAP information.

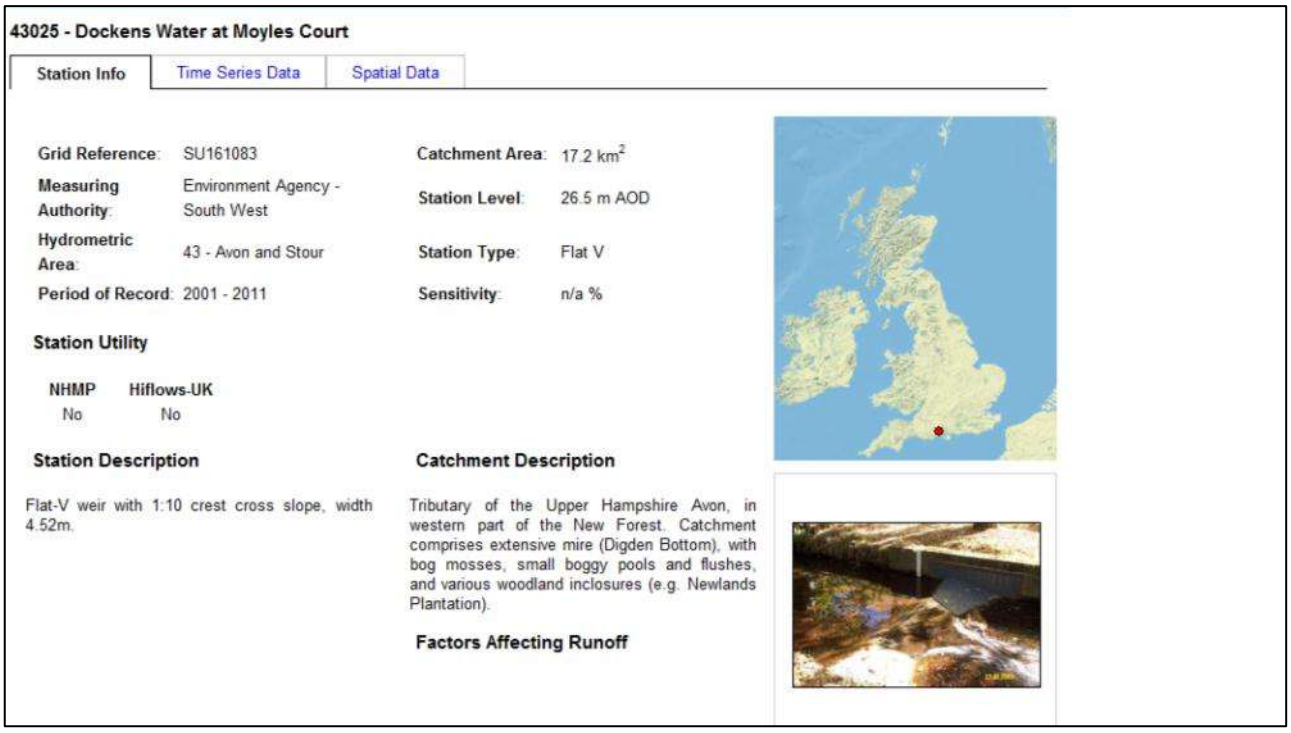

Figure 4.4 CEH website station information for Moyles Court gauging station on Dockens Water

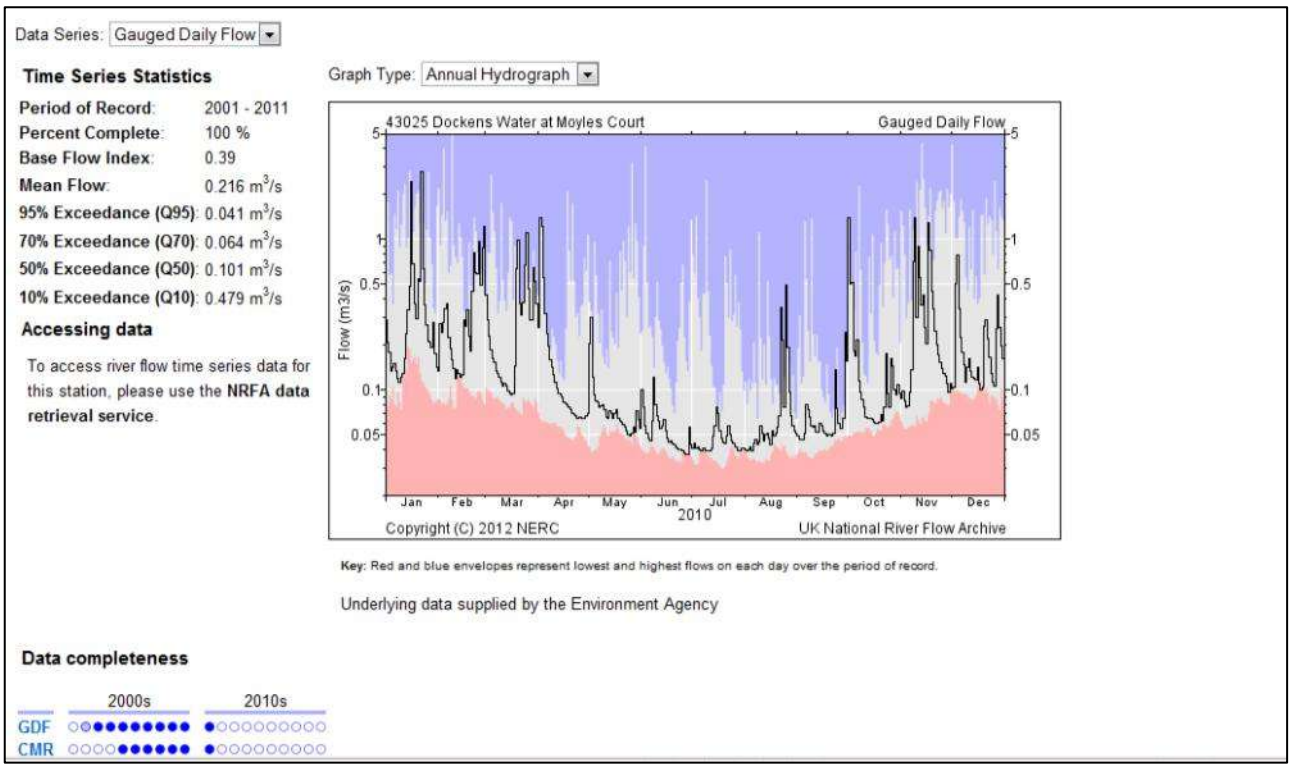

Figure 4.5 Annual hydrograph and percentile flow summary for Moyles Court Gauging station on Dockens Water

The CEH and H & T DIAP information, combined with the assessments of the effect on morphology, biodiversity and fish passage can then be used to rank the structures in terms of their

importance within a catchment or within and Environment Agency Area or Region as a whole both to the Hydrometric or Asset Team (where appropriate) and their 'customers', and the significance of the detrimental effect the structure is having on ecology, morphology and fisheries.

For example, Yorkshire and North East Region commissioned Black & Veatch in 2011 to appraise 61 sites where structures across the Region, principally structures or sluices, posed a barrier to fish passage (internal Environment Agency document – contact Steve Chambers - Leeds for information). This method took into account several factors including the following:

- The ecological value of the watercourse upstream and downstream of the barrier.
- Barrier passability to different species / life stages under different flow regimes.
- Likely ecological gains from implementing a solution.
- Restoration of connectivity (length of river opened up if barrier is passable).
- Presence of additional barriers upstream and downstream.
- Other benefits of mitigation; including hydromorphological enhancement and potential impacts on recreational use (each of which can be either positive or negative).

Indicative costs associated with proposed mitigation measures, which will indicate those schemes that offer best value.

5. Pre Technical and Technical Assessment

Once the different perspectives in the initial assessment have been collated the information can be used to make a judgement on whether the structure could be removed/replaced/modified. If the answer at this high level step is a "yes" then the more technical assessments can be undertaken as to which option of removal, replacement, or modification is preferable. The sections below detail the processes of pre-technical, technical assessment and options appraisal.

The detailed assessment of structure removal/replacement/modification should include the potential effects on the following;

- Delivery of hydrometric requirements
- Structures upstream of the gauging structure
- Structures downstream of the gauging structure
- Flooding
- Morphology
- Ecology
- Archaeology
- Water quality
- Abstractions and discharges

Having established if there is potential to take action in initial assessment described in the sections above, this section outlines the process for more technical and detailed assessment of the possible options.

5.1 Pre-technical Assessment

The pre-technical assessment should be carried out before the technical assessment and should include basic considerations before getting into more detailed design. The pre-technical assessment will use information from the initial assessment in addition to the following;

- Access: - getting to and from site;
- Services: - are there any services (gas, water, sewer pipes, and electricity pylons) which the proposed changes will affect? Consider the gauging station and access routes;
- Health and safety regulations: - during works and in the long term would health and safety be compromised? for example provision of hand rails;
- Landowner information: - within 500m of the site and along any access routes, may include councils, network rail, private landowners, private businesses, fishing tenants etc;
- Identification of external stakeholders: - including recreational uses for example local angling and canoe clubs, local wildlife trusts, British Waterways and English Heritage;
- Identification of internal stakeholders: - which might include the asset management team, water resources, FCERM and water quality.

- Planning permission/permissions and permits to carry out work (especially in the case of presence of protected species): - are these restrictive to planned removal?
- Identification of listed or historic structures and areas of archaeological or heritage importance: - may also include the structure itself. Identification of heritage interests may mean that pre-investigations must be carried out;
- Is the gauging structure located on a main river?
- Identification of areas of contaminated land from the Environment Agency and local authority information;
- What is the likely costs of the removal/replacement (this should include the cost or parallel running of replacement gauging station;
- Benefit analysis of proposed changes- an appreciation of the benefit of works versus the cost of carrying out the proposed changes (also consider the cost of a "do nothing" scenario which could be a motivation for removal);
- What improvement to amenity and aesthetics will there be?
- Will changes to the structure affect any angling clubs or other third party users?
- Protected species, adjacent habitats and designated sites – for example water voles – need to plan for and design around;
- Ecology: - nearby sites of ecological importance and nearby designated sites for example SSSI/SAC;
- Connectivity: - how many kilometres of river will be reconnected by removing the structure?

5.2 Technical Assessment

Having got the basic information together from the initial assessment and pre-technical assessment then the more detailed technical assessment can begin, which assesses the options and their feasibility. The technical assessment is to establish the reach and catchment characteristics and should include the assessment of;

- Hydrometry data
    - Hydrological character used to inform flood risk and ecological assessment and geomorphology - flow and water levels recorded at gauge
- Flood risk and flood information –
    - How is flood risk going to be impacted – frequency, location, extent (vertically and laterally) - how is this going to be done – flood risk assessment (FRA) at what level?– risk based approach,
- Water Resources data
    - Abstraction and discharges information licensed or not, Hands off Flow (HoF) triggers? What are the implications of changing the gauging station related to HoFs and abstractions?
- Geomorphology data

- Topographic surveys (upstream and downstream cross sections, long profile),
- Geomorphological surveys,
- Catchment information

- Species/habitat diversity number and distribution data
  - Fisheries - assessment of possibility of passage of species including salmonids, cyprinids and eels and species records (fish species records), invertebrates – impact?
  - Protected species – location/mitigation – how are we going to deal with this
  - Impact on instream vegetation – for example growth, quality and diversity – what are conditions we are creating and how will veg abundance, diversity/type/biomass change?
  - Impacts on adjacent floodplain habitats

- Structures
  - Structural integrity of structure itself and any nearby structures - use as built drawings if available
  - Maintenance requirements in light of planned removal/replacement
  - Impacts on structures up and down stream:
    - Structure removal can particularly potentially affect any structures in, or on the bank within the backwater effect. The extent of the backwater upstream of a structure can be estimated using the following equation **(0.7xdepth)/slope**. To this effect the extent of potential issues can be assessed within this calculated reach length. The Environment Agency have also produced a best practice guidance document on structure removal (see references).
  - Is a temporary diversion necessary?
  - Change in level between the head and tail water at the structure,

5.2.1 Data acquisition

Useful sources of information to inform this assessment are shown in Table 4.1

- Base Maps
- LiDAR
- Water temperature
- Flow
- Stage/discharge table
- Water level
- Model info (hydraulic/flood risk)
- Land registry
- Abstraction licences

- Fish surveys
- River Habitat survey (RHS)
- River corridor survey (RCS)
- Fluvial audits including SSS plans
- Contaminated land
- Historic flood maps
- Detailed river network (DRN)
- WINFAP-FEH (flow model) catchment characteristics
- Rating curves

Table 5.1 Summary of information to inform the hydromorphological, hydrometric and ecological assessment

	Hydrometrics	Fish Passage	Catchment Characteristics and Connectivity	Flooding	Geomorphology	Ecology	Structural integrity	Maintenance
Base Maps	✓		✓	✓	✓			
LiDAR			✓	✓	✓			
Water temperature		✓	✓			✓		✓
Flow	✓	✓	✓	✓				✓
Stage/discharge table	✓							
Water level	✓	✓	✓	✓		✓	✓	✓
Model info (hydraulic/flood risk)	✓	✓	✓	✓	✓		✓	✓
Land registry			✓					
Abstraction licences	✓		✓			✓		
Fish surveys		✓	✓			✓		
River Habitat survey (RHS)			✓		✓	✓		
River corridor survey (RCS)			✓		✓	✓		
Fluvial audits			✓		✓			
Contaminated land			✓			✓		
Historic flood maps	✓	✓		✓	✓	✓		
Detailed river network (DRN)	✓	✓	✓	✓	✓	✓	✓	✓
WINFAP-FEH catchment characteristics			✓	✓	✓	✓	✓	✓

	Hydrometrics	Fish Passage	Catchment Characteristics and Connectivity	Flooding	Geomorphology	Ecology	Structural integrity	Maintenance
Rating curves	✓							
Fluvial audit data (including form SSSI river restoration plans			✓		✓	✓		
WFD mitigation measures		✓	✓		✓	✓		
Services searches			✓					
As built drawings			✓					
Planning permission							✓	✓
SSSI River Restoration Plans	✓	✓			✓	✓		

5.3 Further Non-technical Considerations

Further considerations relevant to removal/replacement including installation of a bypass channel, notching/lowering of structure and fish pass installation would include;

- Ownership of the structure;
- Land ownership - are the land and fishing right owners open to the possibility of changes for example associated channel change and potential loss of land?
- Access consent - will land owners allow access for works to take place? This may involve multiple parties;
- Access for waste/sediment removal/disposal of spoil;
- Timing of works – for example consideration of fish spawning, risk of adverse conditions, flooding etc;
- Existing associated consents and offtake channels associated with the impounding effect of the structure i.e. hydropower, fish stew ponds, secondary channels through gardens etc;
- Legislation/Consents- What consents are necessary to carry out work? i.e. planning permission from councils, EA (flood risk consents, WFD compliance, waste), protected species licences, Natural England consent or assent for SSSIs etc ;
- Health and safety- of the proposed changes for whilst works are being carried out and in the longer term (for public access and maintenance);
- Collate further archaeological information for example by contacting the County Archaeologist, local authority, local historical groups or collate information from the internet

6. Options Appraisal

Options appraisal would be undertaken after the pre-technical and technical assessment to determine which option would be the best in the circumstances identified. If changes to the structure could be made, the preference from the biological/ecological viewpoint would be to remove, then to replace with something more suitable or to modify the structure. If changes cannot be made to the structure then mitigation measures should be considered, with a bypass channel, pre-barrage or baffles and then technical fish pass installation, being the order of preference for biological/ecological perspectives.

6.1 Changes to the Structure: Considerations

6.1.1 Removal

If the structure is no-longer required for gauging purposes it can be removed, providing its removal does not cause any detrimental effects to nearby properties or structures (see Section 5.6.4). Structure removal is preferable for ecology/habitats and meeting the requirements of WFD including the restoration of natural river processes and the free passage of migratory and other fish both upstream and downstream. This is particularly a consideration at SSSI sites, where restoration of natural river processes and biological connectivity is a priority.

Possible negative impacts from an ecological/habitats perspective should also be considered, such as sites where gauging structures control the migration of invasive species or where contaminated sediment could be released, which might have an impact on downstream reaches in the short term and create maintenance requirements post-removal. This does not mean the structure cannot be removed, but these elements would need to be evaluated prior to any work being carried out.

Geomorphological effects of structure removal which should be considered include: Changes in sediment dynamics (specifically changes in sediment load) and deposition and erosion both up and downstream. Release of sediments in the short term might smother important spawning habitats downstream for example (so would need to be controlled), but long term may increase the suitable habitats upstream, and access to them. Head or down-cutting may occur within the vicinity of the structure, and slumping of banks as a result of their drying out. The potential positive and negative impacts will need to be considered.

6.1.2 Replacement with a structureless gauge

If discharge measurement is still required at the location of the existing gauging structure, but the site is suitable for a structureless gauge such as an ultrasonic or ADCP, and reduced gauging accuracy will not be an issue, then the gauging station can be replaced, providing its replacement does not cause any detrimental effects to nearby properties or structures (see Section 5.6.4). The new measuring station would usually need to be run in parallel to the old site for a number of years partly to help calibrate the new gauge and to ensure that the two sets of data could be merged together to create a continuous record.

Considerations for a structureless gauge are similar to those of structure removal, though in some instances the new gauge may require some hard engineered infrastructure such as concrete revetments and channel narrowing.

6.1.3 Modification - Notching or lowering of structures

If the structure cannot be removed or replaced with a structureless gauge, there may be the option to notch the structure to allow fish to pass up and down the structure. Notching will not remediate for morphological effects of the structure. Considerations for this option should include;

- What are the target species and will notching/lowering allow them move up and down the structure?
- What are the proposed benefits, specifically for fish target species?
- Will the structural integrity of the structure remain intact if it is notched/lowered?
- Will the gauge still be able to record flows accurately enough?
- What work will be required to recalibrate the gauging station?
- Will other ecological and morphological issues be resolved by the notching/lowering of the structure

Structural design considerations are likely to be site specific. Case studies could be used as a guide to options as they illustrate what has been done successfully in similar situations. It is generally considered that any structure greater than 0.3 m high is a barrier to some fish. The assessment of whether fish can pass up and down the structure would require structure dimensions, flow/levels, swim requirements for fish (see Environment Agency Fish Pass Manual section on fish swimming performance).

Changes to the gauging structure would require re-calibration of the stage discharge table. The cost in time and money for doing this needs to be considered and added to the overall cost of the project.

6.2 Mitigation

6.2.1 Is there room for a natural bypass channel?

If structure removal/replacement or notching/lowering is not an option, then the next thing to consider is a natural fish bypass channel. It should be noted that a bypass channel could provide additional habitat but conversely splitting the flow could have a detrimental effect especially in drought periods. Notching will often be a cheaper and more practical alternative to creating a bypass channel and the structure can still be used to measure flow. Considerations for this option would include;

- Is there room for a bypass channel?
- Assessment of the drop in height required and resulting average slope of the bypass channel is required
- The target species and swim rates need to be considered;
- Identify potential impact areas should channel adjustment occur;
- Are there any existing or historic channels which already bypass the structure?
- How will flow be gauged in the bypass channel?
- Initial design needs to anticipate the start and finish locations of the new channel and channel slope (case studies could be used as a basis for discussing design options) see also Environment Agency Fish Pass Manual;
- Is there any opportunity to benefit other wildlife for example creation of otter holt or water vole habitat?
- Management of levels of water going over the structure and how the flow will be split between the main channel and the side channel;

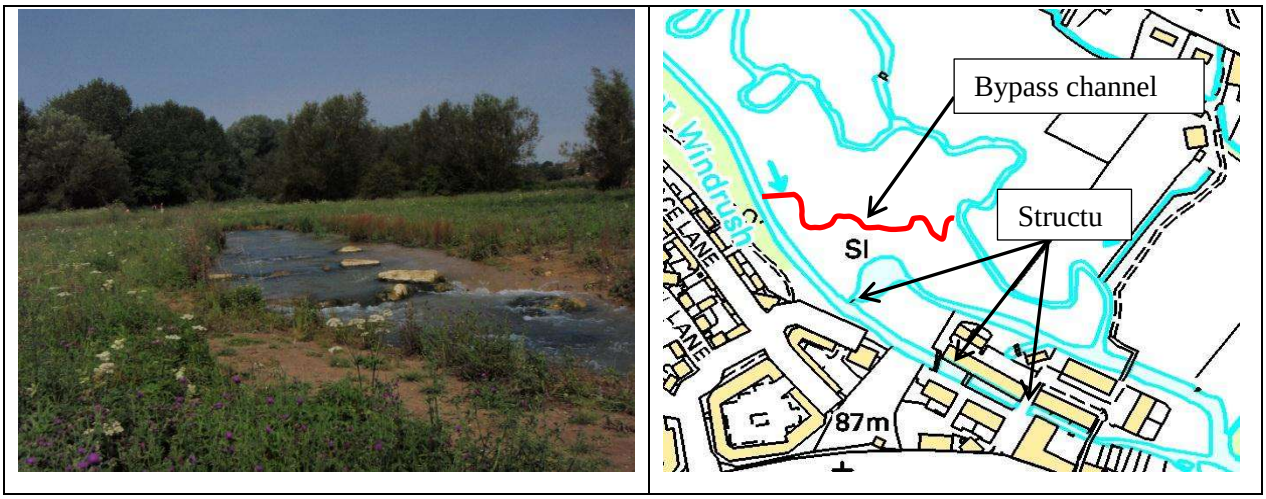

Figure 6.1 Example of natural bypass channel around structures

6.2.2 Installation of rock ramp or baffles

If the structure cannot be removed or replaced and lowering is not suitable, in some instances installing a pre-barrage or rock ramp (see Figures 6.2 and 6.3) can be a suitable option. Dibley *et al* (2012) looked at the effects of retrofitting on Brimpton gauging station on the River Enborne. Their conclusions were that the baffles had limited impact on the upstream head and therefore was not thought to have a significant impact on the accuracy of the gauging structure. Another alternative is to install pre-barrages to provide resting pools downstream of the structures which would allow salmonids to negotiate the structures, but would not be suitable for cyprinids or eels.

Figure 6.2 Bontnewydd gauging station rock ramp

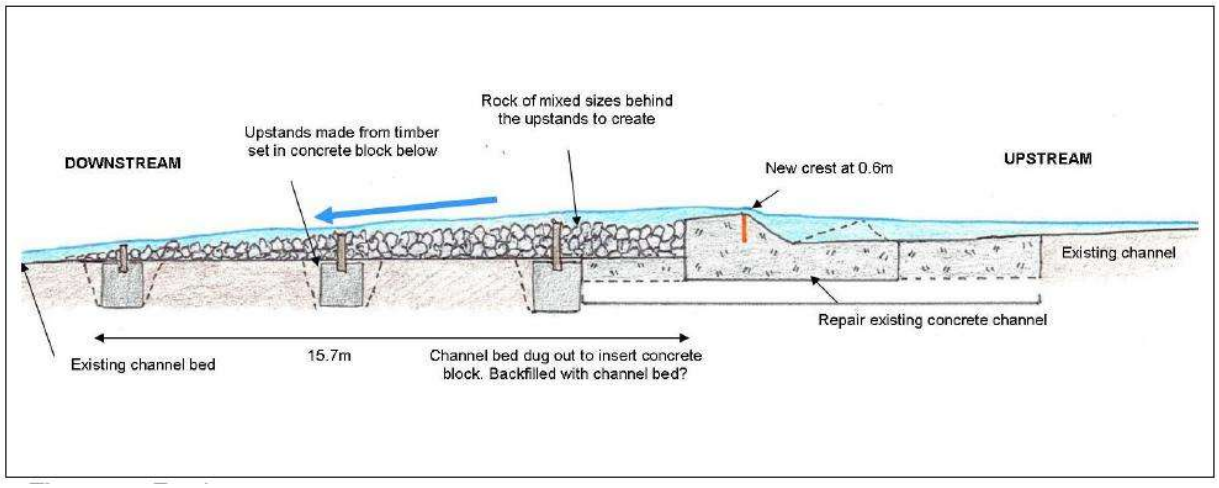

Figure 6.3 Rock ramp design from *EA Bontnewydd Gauging Station Environmental Report 2009*

6.2.3 Can a fish pass be installed?

If there is no space available to put in a natural bypass channel then the next option is to consider a fish pass for example a Larinier or Denil fish pass.

Consideration include;

- Need to initially define specific requirements of the ladder/bypass to guide the best design.
- What effect will the installation of a fish pass have on gauging accuracy? And what may need to be done to mitigate this?
- Is the fish pass important seasonally, or at specific flow ranges and if so when/which?
- Is the fish pass targeted at allowing passage at specific reproductive stage?

The design must be appropriate for both the existing structure and target fish species for example salmonids, coarse fish and eels. This may involve the installation of multiple designs. Most of these requirements are covered in the Environment Agency Fish Pass Manual. http://www.environment-agency.gov.uk/business/sectors/37580.aspx .

Figure 6.4 Fish Ladder on Focherbers Burn

7. Case Studies

Two case studies are included here. These case studies are a mixture of structures which have actually been removed to give an understanding of the issues experienced with gauging structure removal and examples of structures which have been recommended for removal. This allows us to gain understanding of the difficulties which may arise from the removal, and the different opinions and issues from both a hydrometric and ecological (fisheries/biodiversity/ hydromorphology) perspective

The Castle Rising site was selected as a structure which currently prevents fish movement in the lower reaches of Babingly Brook in Norfolk. To date no assessment has been made in any detail for the potential for removing, replacing or altering the gauge structure.

The second case study is for Shaw gauging station on the River Lambourn which was also highlighted as a structure which was a barrier to fish passage. In addition the gauge was being bypassed. Atkins were commissioned by the Environment Agency to investigate the options for removing, replacing or bypassing the gauge. The case study is based on their feasibility report

7.1 Castle Rising Gauging Station

7.1.1 Location

The Castle Rising Gauging Station is located on the River Babingley, near the village of Castle Rising in North West Norfolk - Grid Ref: TF68152525. The catchment area upstream of the gauging station is 47.7km2 and the catchment is a chalk catchment, with predominantly arable land use. The map below in Figure 1 shows the location of the gauging station.

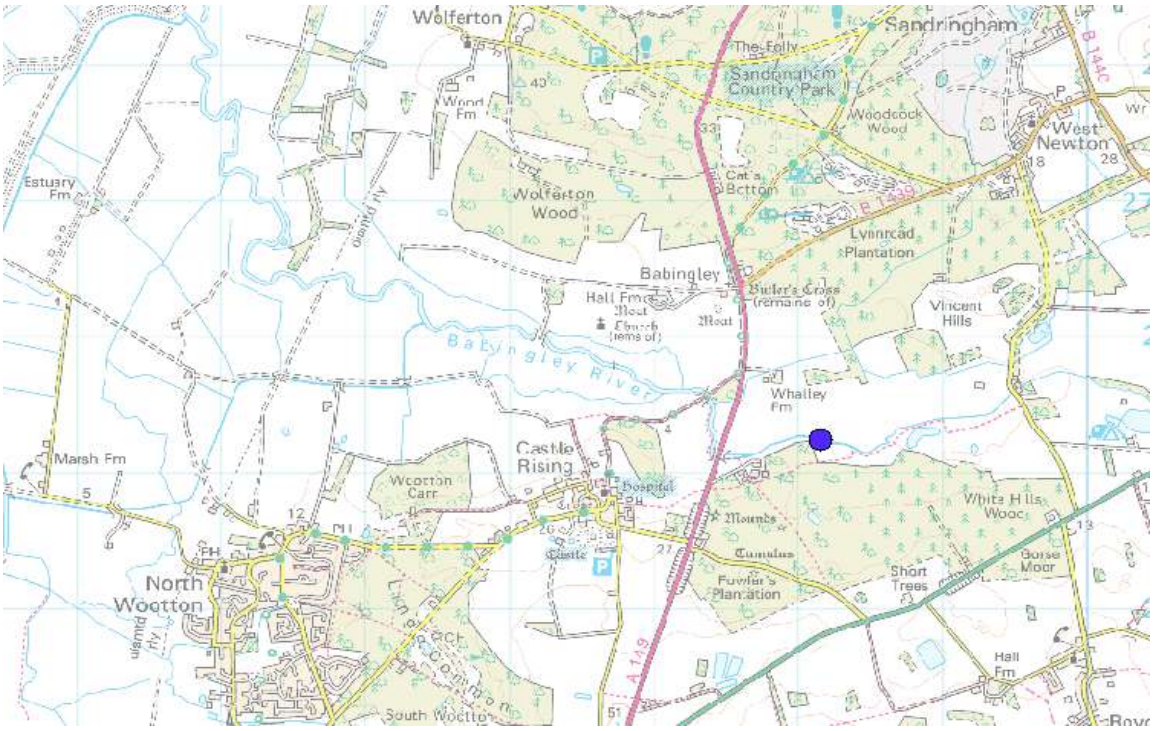

Figure 7.1Location of Castle Rising Gauging Station

7.1.2 Initial assessment

The Gauging Station is part of the CEH national network – station 33054 and the record extends from 1976. It is part of the HI-Flows pooling network. The structure is a triangular profile Flat V crump

structure with a width of 4.5m and the wing walls are 1.2m above crest. The level of the crest is 4.5m AOD. The drop across the structure would be of order of 0.90m under normal flow conditions and the structure is subject to drowning under high flows. Figures 7.2 and 7.3 show the gauging station and structure from upstream and downstream.

The gauging structure is located on a main river. It measures the full range of flow and has a sensitivity of 67%. It is both of operational and strategic importance and is used as part of the River Nar catchment assessment of flows.

In this catchment there is significant groundwater abstraction for potable water in addition to abstractions for industry/agriculture. It is considered to be a high baseflow catchment.

Figure 7.2Gauging structure looking downstream

Figure 7.3Gauging structure looking upstream

7.1.3 Geomorphological considerations

The structure prevents some sediments moving down through the river system and restricts morphological connectivity and diversity upstream and downstream. This has been mitigated to some degree by the restoration works already undertaken in April 2012.

7.1.4 Biological and ecological considerations

The structure restricts ecological connectivity from upstream and downstream. Fish passage is restricted upstream of the structure especially for trout and eels

7.1.5 Potential impact of replacement, removal or modification

Improvement to Amenity and aesthetics

Improvement to fish and invertebrate passage - river has already been improved by inclusion of woody debris and the removal of the structure would enable continuity for communities of fauna from upstream to downstream of the gauging station.

Potential impact on sediment movement and morphology

The removal of the structure may cause a movement of sediment which had built up behind the structure. This sediment might be contaminated and so that would need to be checked before any structure removal were to proceed. Sediment could be removed from behind the structure prior to any works. The structure removal would allow sediment movement through the catchment. The structure removal could create more sediment downstream. The woody debris restoration would trap some of the sediment moving through the system.

Potential impact on ecology and biology
By removing/replacing/modifying the gauging structure improved connectivity for fish and invertebrates would be restored or improved. The ecological connectivity for vegetation would also benefit. The upstream reaches have been recently restored so they would provide valuable existing habitat and the upstream and downstream restoration would be linked.

From the data collated and collected in the initial assessment there is a clear reason for removing/replacing/modifying the gauging structure. The main restriction to any changes would be the use of the gauging structure for assessing water resources abstractions which are a key component in the consideration.

7.1.6 Pre-technical and technical assessment

Pre-technical information
The extent of the backwater is not yet known.

There is an access bridge 350m downstream of the gauging station and then a road bridge a further 350m beyond that. Upstream there are some unofficial footbridges and a road bridge 1600m upstream of the gauging station

The downstream access bridge is not very strong but is sufficiently far away (350m) as not to be impacted by changes to the gauging station

There are earth banks upstream and downstream. The angle of banks upstream and downstream are in places quite steep 30 degrees but in other places restoration work has been carried out with woody debris placed in the river and bank laid back. The banks are generally in good condition.

It is not clear if there is a topographic survey through gauging to station to the next hard bed point (e.g. bridge invert) both upstream and downstream.

There is good access from both upstream and downstream along the river bank, although access via bridge downstream would have a limited load.

There are no services affecting any changes.

There are no health and safety concerns.

The private landowner has been happy for restoration works to be undertaken by the EA. There is a no reason to assume that he would object to a structure replacement/removal or bypass channel but this would need to be confirmed.

Technical information

The following information is available for a technical assessment;

- Hydrometry data - Available
- Water Resources data - Available
- Geomorphology data
    - Catchment information
    - LiDAR data

      Hydromorphological walkover report
- Species/habitat diversity number and distribution data
    - Fisheries – some data available
    - WFD walkover report

- Structures
    - Structural integrity of structure itself and any nearby structures - use as built drawings if available
    - Impacts on structures up and down stream

From the pre-technical and technical information there are some data which could need collecting/clarifying before a design could be made on the favoured option. The key information to be collected would be the cross-section/long section information.

7.1.7 Options appraisal

Potential for removal/replacement to gauging structure

As this is a significant gauge any changes or removal of the structure would need to include plans to continue gauging at this site. Alternative gauging options, their suitability and accuracy would need to be considered.

In physical terms the drop across the structure is not too significant to raise concerns over destabilising banks. The bridges upstream and downstream would not be impacted as they are a sufficient distance away.

This option would allow ecological and morphological connectivity to be restored.

The removal of the structure would need to consider the restoration works which have already been undertaken upstream and downstream of the structure and if these could be adapted to continue to enhance the channel without the structure.

Potential for a bypass channel

A bypass channel would be a possibility for this site if the structure needed to be retained. The land is available and the drop is not too significant. A gauging device would be needed on the bypass channel. This may cause a problem with being able gauge accurately with the techniques available. Any of the techniques available may be subject to high maintenance requirements to keep them clear of sediment and vegetation.

Potential for pre-barrage or baffles

This option would be possible downstream of the existing structure. It would allow the existing structure to be retained and the flexibility/necessity to provide water resources information whilst providing a passage for fish. It would not allow an improvement in morphological or ecological connectivity

7.2 Shaw Gauging Station

Figure 7.4 Shaw Gauging station from EA HiFlows Site

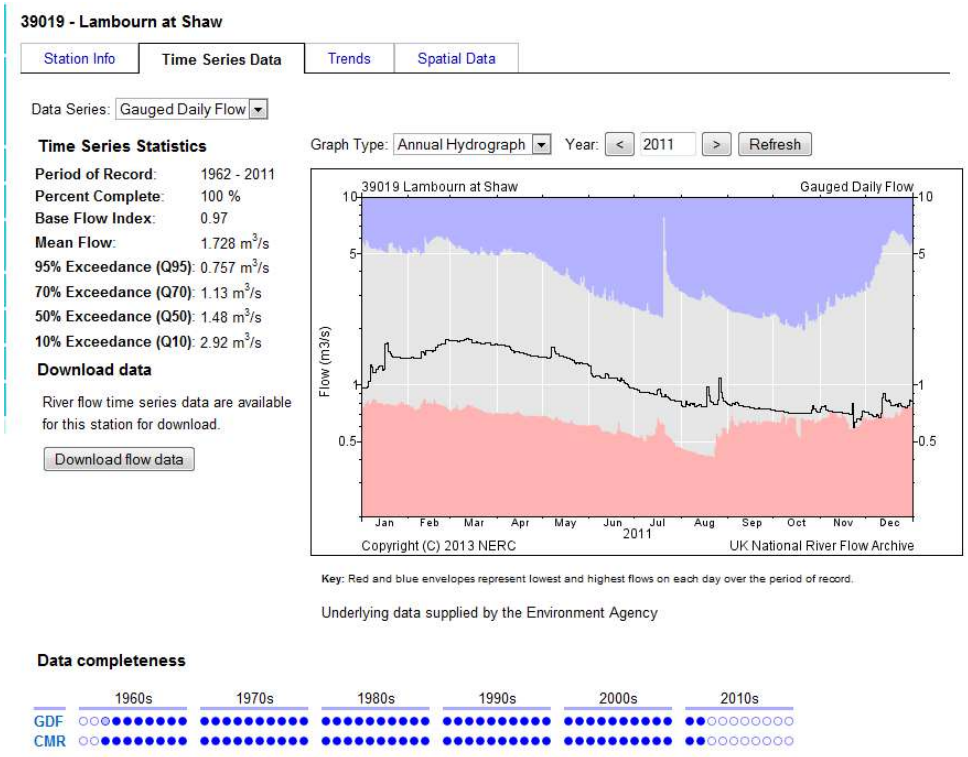

Figure 7.5 Screenshot of Time series information for Shaw gauging station from CEH website

In May 2012 Atkins were asked to assess options for river restoration of the River Lambourn at Shaw between SU4669 6841 to SU 4703 6822. The Shaw gauging station itself is located at SU 47033 68220 upstream of which the river has been straightened and widened. The backwater effect of the gauging structure extends for some 335m upstream. Immediately upstream of the gauging structure the substrate

is clear of silt though siltation is occurring in parts of the upstream reach. The structure itself is a 10.67m wide crump structure. Flow has been recorded at this site since 1962 and it is part of the National River Flow Archive (NRFA) help by the Centre for Ecology and Hydrology (CEH).

7.2.1 Gauging station accuracy

In 2012 it was noted that a significant proportion of flow in the Lambourn bypassed the gauging structure through the lakes at Donnington, eventually flowing into Spout Ditch which re-joins the main river some 900m downstream of the gauging structure.

The wide crump structure means that the gauging station is insensitive to flow changes particularly under low flow conditions. Sensitivity analysis showed that 90% of the flow range is gauged in a 200mm band of head above crest height. The modular limit of flow recording is 4.8 m^3/s

7.2.2 Impacts on habitat

The structure acts as an almost total barrier to fish passage being some 0.62m above bed level. It also impounds the river upstream of the structure where the channel is over-deep and over-wide with resulting poor habitat.

7.2.3 Options appraisal

The assessment looked at three different options, structure removal; structure lowering; and modification or bypass with a fish pass.

Structure removal

The Environment Agency's hydrometric team commented that a properly maintained ultrasonic gauging station would effectively record both high and low flows at this site. Recording at low flows accurately would however be challenging but since the current 10.67m wide structure already poses problems in accurate low flow measurement (see Section 5.2.1) the use of an ultrasonic gauging station was not perceived as being problematic.

Structure lowering

In order to allow fish passage the structure would need to be lowered to less than 0.3m height, i.e. approximately halving the height of the structure. There were a number of issues raised in respect to this option. Firstly as a result of lowering the structure would drown out more easily making high flow recording less accurate. Secondly lowering the structure may put the structural integrity of the structure at risk and thirdly structure lowering would not be as good a technical option compared to structure removal or a fish pass in terms of allowing fish to pass up and down the structure.

Fish pass

A Larinier type fish pass could be installed within the structure itself or in a bypass channel. Using a bypass channel would avoid having to modify the structure (with inherent risks to integrity of the structure), but would require landowner consent, may be more complex to achieve at the installation stage and is likely to require on-going maintenance. The advantages of a Larinier fish pass into the structure itself are associated with its fish passage and gauging performance. Siting the pass on the outside of a very slight left hand bent in the river would better align the pass with upstream flow paths and by installing it on the side of the river would make it less vulnerable to siltation and fish would probably favour this location in terms of approaching the structure. Modelling was carried out to determine the optimum design of a fish pass.

Preferred option

The option for removal was chosen as the preferred option as it met all the requirements of the WFD. An ultrasonic gauging station will be sited downstream of the existing structure which will enable the full range of flows to be measured including the water which currently bypasses the existing gauging structure.

It should be noted that the two gauging stations will need to be run in parallel for at least two years which will allow analysis of the gauged flows from the two sites and any necessary adjustments to the flow records to be made

References

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Environment Agency (2010) – Environment Agency Fish Pass Manual, GEHO 0910 BTBP-E-E http://www.environment-agency.gov.uk/business/sectors/37580.aspx

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Environment Agency, April 2013, Gauging Weir Workshop Output Final

Hydrometric Uncertainty Guidance ISO/TS 25377:2007

River Restoration Centre (RRC), 2012, Possibilities for removing or replacing gauging structures: Workshop output

River Restoration on Designated Sites http://www.therrc.co.uk/rrc_designated.php

SNIFFERhttp://www.sniffer.org.uk/files/1113/4183/7995/SEPA_WFD111_Phase1_Appendices.pdf

Appendix A
Glossary

CEH - Centre for ecology and hydrology (previously IoH Institute of hydrology)

CFMP - Catchment Flood Management Plan

Doppler flow gauges - Measure the Doppler shift resulting from the reflection of an ultrasonic beam off small fluid particles or air bubbles.

EA - Environment Agency

Electromagnetic flow gauges- The flow can be measured by electromagnetic induction (exposure to an electromagnetic field).

Favourable Condition - Favourable or recovering condition, means that the SSSI habitats an species are being conserved by appropriate management

Fish pass/fish ladder - Retro-fitted structure added to the structure to aid fish passage by altering part of the surface of the structure and/or the slope of the structure face.

FCERM - Flood and Coastal Erosion Risk Management

GES - Good ecological status

GEP - Good ecological potential

Hands off Flow (HoF) - Defines the flow condition at which the Environment Agency reduce or stop abstraction from ground or surface sources by third parties. This flow condition is defined by the gauged flow at a gauging structure. The majority of abstraction licenses are restricted by HoF conditions, which are guided by the WFD.

Head level - Level of water upstream of a gauging weir

H&T DIAP database - Developed by the Environment Agency's national hydrometric team this access database holds information on all gauging station sites in the UK. Information available includes; site details, catchment details, length of gauging record, function of station (by percentage relevance), identification of strategic stations, identification of stations which are part of the National River Flow Archive (NRFA), ownership and maintenance responsibilities.

Multi path time of flight ultrasonic gauges - Use acoustic sensors to measure velocity by calculating the time taken for an ultrasonic pulse to be sent in the direction of flow, and then returned opposite to the flow direction. These can be affected by temperature and density.

Natural bypass channel - A channel created with the specific purpose of bypassing a structure for the benefit of fish passage.

Notching or lowering of structure - Structure adjustment which may include changes to the slope or surface of the structure to aid fish passage.

NE - Natural England (previously English Nature)

Open channel gauging - Method of measuring flow in a channel without a structure

Pressure tapping - Flow measurement of the water depth at the top of the structure (crest).

SAC - Special Area of Conservation

SLA - Service Level Agreement

SSSI – Site of Special Scientific Interest

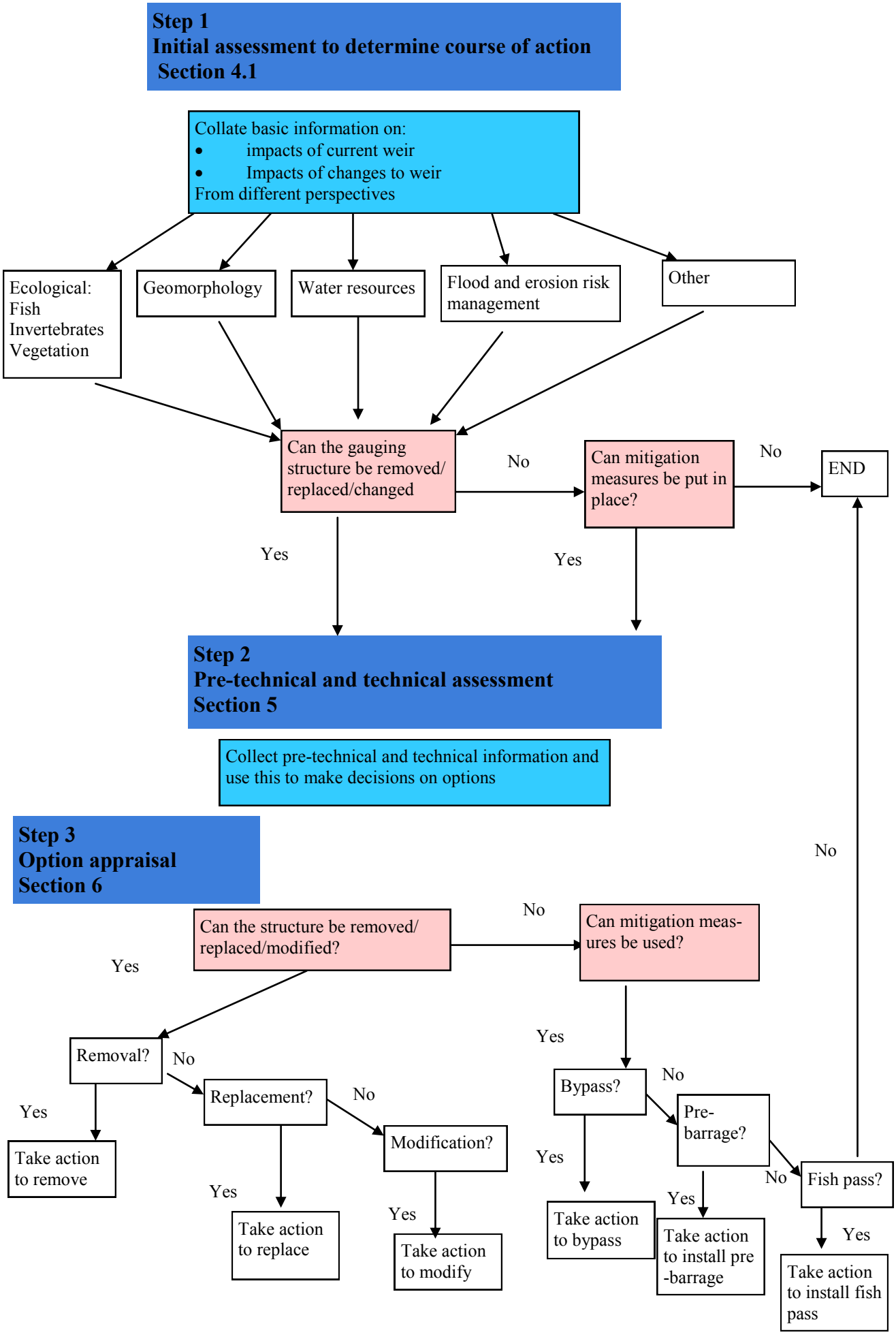
Stilling well - Well connected to the river channel such that the level in the well reflects the water level upstream of the structures. Tail levels can also be measured by installing a stilling well that measures the level of water downstream of the structure.

Tail level – The level of water located downstream of the structure. This can allow for compensation of inaccurate flow measurement at the structure crest.

Structure - An artificial obstruction in any watercourse that results in increased water surface level upstream for some, if not all, conditions. A structure in a river, stream, canal, or drain over which free-surface flow occurs. May be used variously for control of upstream water levels, diversion of flow, and/or measurement of discharge (DEFRA/Environment Agency, 2003).

WFD – Water Framework Directive

Appendix B
Flow Chart


Step 1
Initial assessment to determine course of action
Section 4.1
Collate basic information on:
• impacts of current weir
• Impacts of changes to weir
From different perspectives
Ecological:
Fish
Invertebrates
Vegetation
Geomorphology
Water resources
Flood and erosion risk management
Other
Can the gauging structure be removed/ replaced/changed
No
Can mitigation measures be put in place?
No
END
Yes
Yes
Step 2
Pre-technical and technical assessment
Section 5
Collect pre-technical and technical information and use this to make decisions on options
Step 3
Option appraisal
Section 6
No
Can the structure be removed/ replaced/modified?
No
Can mitigation meas-ures be used?
Yes
Yes
Removal?
No
Yes
Take action to remove
Replacement?
No
Yes
Take action to replace
Modification?
Yes
Take action to modify
Yes
Bypass?
No
Yes
Take action to bypass
Pre-barrage?
Yes
Take action to install pre -barrage
No
Fish pass?
Yes
Take action to install fish pass