

River Kent and Tributaries SSSI and River Kent SAC

Weirs: Audit and Options Baseline Report

Natural England

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Executive summary

Physical modifications, including weirs have been identified in the River Restoration Plan for the River Kent SAC (Jacobs 2010) as key pressures contributing to Unfavourable Condition. More detailed assessment to develop restoration options is now required.

This study considers 14 weirs, identified by Natural England as disrupting the natural flow and sediment regime, and in turn the natural ecological habitat of the River Kent catchment. The main objectives of the study include:

- Provide a baseline audit of 14 impoundment structures situated within the Kent catchment;
- Appraise the options for restoring the river ecosystems in both form and function; and
- Make recommendations and provide outline costs for future work.

This project comprised a high level geomorphology, ecology and engineering assessment to screen the 14 weirs and prioritise actions in the catchment. A Multi-Criteria Analysis (MCA) using agreed indicators and weightings helped prioritise the weirs for removal (or partial removal). The key findings include:

- MI03 Weir at Patton Mill on the River Mint and SP02 Weir upstream of Garnett Bridge on the River Sprint are the highest ranking sites for weir removal options and restoration of the natural river form and function. These are in the upper parts of the SSSI and SAC, but still provide good ecological justification for removal. The geomorphological risks and feasibility have been judged to be low.
- Removal of KE02 Helsington Weir immediately downstream of Kendal is a higher risk site, but would provide a much improved river environment. Detailed assessments would be required to understand and evaluate all the risks at this site.
- KE08 at Barley Bridge at Staveley is surrounded by historic features and listed structures so the impact of removal will need to be thoroughly considered. This site does however fall into SSSI Unit 107 which is currently classified Unfavourable No Change. Weir removal may help to achieve a recovering position as the ecological benefits are deemed high at this site. Flood risk may be an issue at this site in Staveley.
- KE06 Weir at Cowan Head has an abstraction licence which is unlikely to be revoked in the short-term.
- KE04 Weir at Bowston has a moderate ecological benefit from removal and a moderate geomorphological risk. Weir removal at this site may however help to achieve the WFD objectives for the water body by addressing some of the mitigation measures not currently in place (for example regaining natural sediment regime and geomorphological function, refer to). The water body has to reach Good Ecological Potential by 2027.
- KE07 Weir at Staveley has an abstraction licence which may preclude it from further investigation, certainly in the short-term.
- MI02 Weir upstream of Meal Bank on the River Mint has also been prioritised for removal. The ecological benefits are potentially high and the geomorphological risks are considered low. The feasibility of removal at this site is low however and the costs relatively high. There is also another weir upstream (not considered in this study) which may become more of a barrier or be undermined.

Recommendations for future work and priority actions are identified and include i) public consultation, ii) pre and post monitoring, iii) further investigations, iv) linking with other projects and initiatives and v) funding opportunities and delivery mechanisms.

1. Introduction

1.1. Project background

A fluvial audit of the River Kent catchment was undertaken in 2010, which produced targeted site specific reach scale restoration action plans. The resulting restoration vision identified that, despite the largely rural catchment, the river Sites of Special Scientific Interest (SSSI) units are significantly affected by historic modifications to the channel (for agricultural and industrial purposes) which have resulted in changes to the river habitats (Jacobs, 2010). Physical modifications, such as bank reinforcements, weirs and embankments, and their associated impacts have been identified as being key pressures responsible for the Unfavourable Condition of river units.

As a result, the proposed study could initiate projects to yield real benefits towards SSSI units achieving Favourable Condition. This would be achieved by removal or remediation of weir modifications to improve river continuity. This project focuses on 14 weir structures, these are listed in Table 1-1 and shown on Figure 1-1.

Table 1-1 Name and locations of weirs to be surveyed

River	Weir ID and Name	NGR	
River Kent	KE01	Weir at Sedgwick and EA gauging station	SD 50870 87410
	KE02	Helsington Weir, Water Crook	SD 51300 90582
	KE03	Stramongate Weir, Kendal	SD 51924 92953
	KE04	Weir at Bowston and EA gauging station	SD 49733 96826
	KE05	Bowston EA gauging station	SD 49947 96549
	KE06	Weir at Cowan Head	SD 49198 97395
	KE07	Weir at Staveley	SD 47214 98355
	KE08	Weir at Barley Bridge, Staveley	SD 46997 98725
River Mint	MI01	Weir upstream of Mint Bridge and EA gauging station	SD 52433 94452
	MI02	Weir upstream of Meal Bank	SD 54624 95770
	MI03	Weir at Patton Mill	SD 55402 97811
River Sprint	SP01	Weir at Sprint Mill and EA gauging station	SD 51481 96090
	SP02	Weir upstream of Garnet Bridge	SD 52267 99361
River Gowan	GO01	Weir at Staveley	SD 46700 98300

1.2. Project aims and objectives

The overall aim of the project is to appraise and prioritise river restoration options for the 14 sites on the River Kent and Tributaries SSSI which is also designated as a Special Area of Conservation (SAC). This project will focus on full removal and partial removal of the weirs (Table 1-1), but also consider the 'Do Nothing' and fish pass/easement options for comparison. The recommended options should help to support improvement in the condition of the overall SSSI into Favourable Recovering or Favourable Condition. The key objectives include:

1. Provide a baseline audit of 14 impoundment structures (weirs) situated within the Kent catchment;
2. Appraise the options for restoring the river ecosystems in both form and function; and
3. Make recommendations and provide outline costs for future work.

This project will help to prioritise the sites most suitable for weir removal or modification in terms of ecological benefit, likely impacts, risks and technical feasibility. Heritage and stakeholder considerations will also be included in the assessment where the information has been available. Indicative costs for each of the options and future management actions will be provided.

This project is essentially a pre-feasibility or screening exercise to help Natural England and the Environment Agency plan for future river management works in the Kent catchment and restore the natural habitats. Weir removal and regaining the natural flow and sediment regime helps achieve, not only the Habitats Directive objectives, but also promotes the core values behind the Water Framework Directive (WFD).

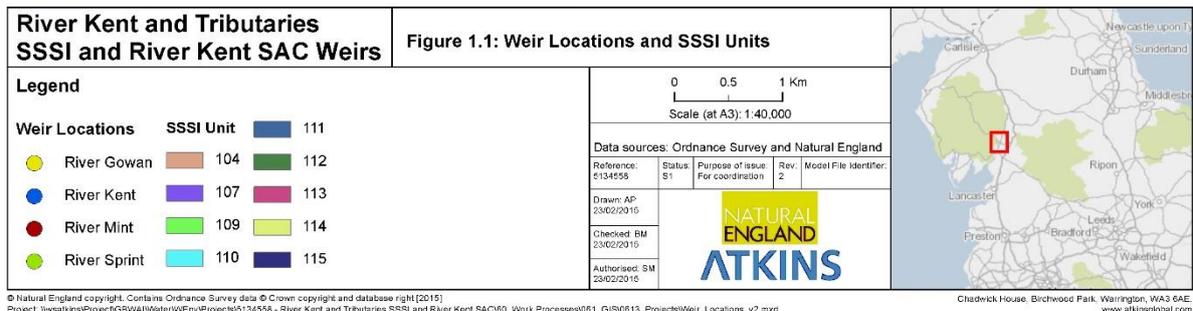
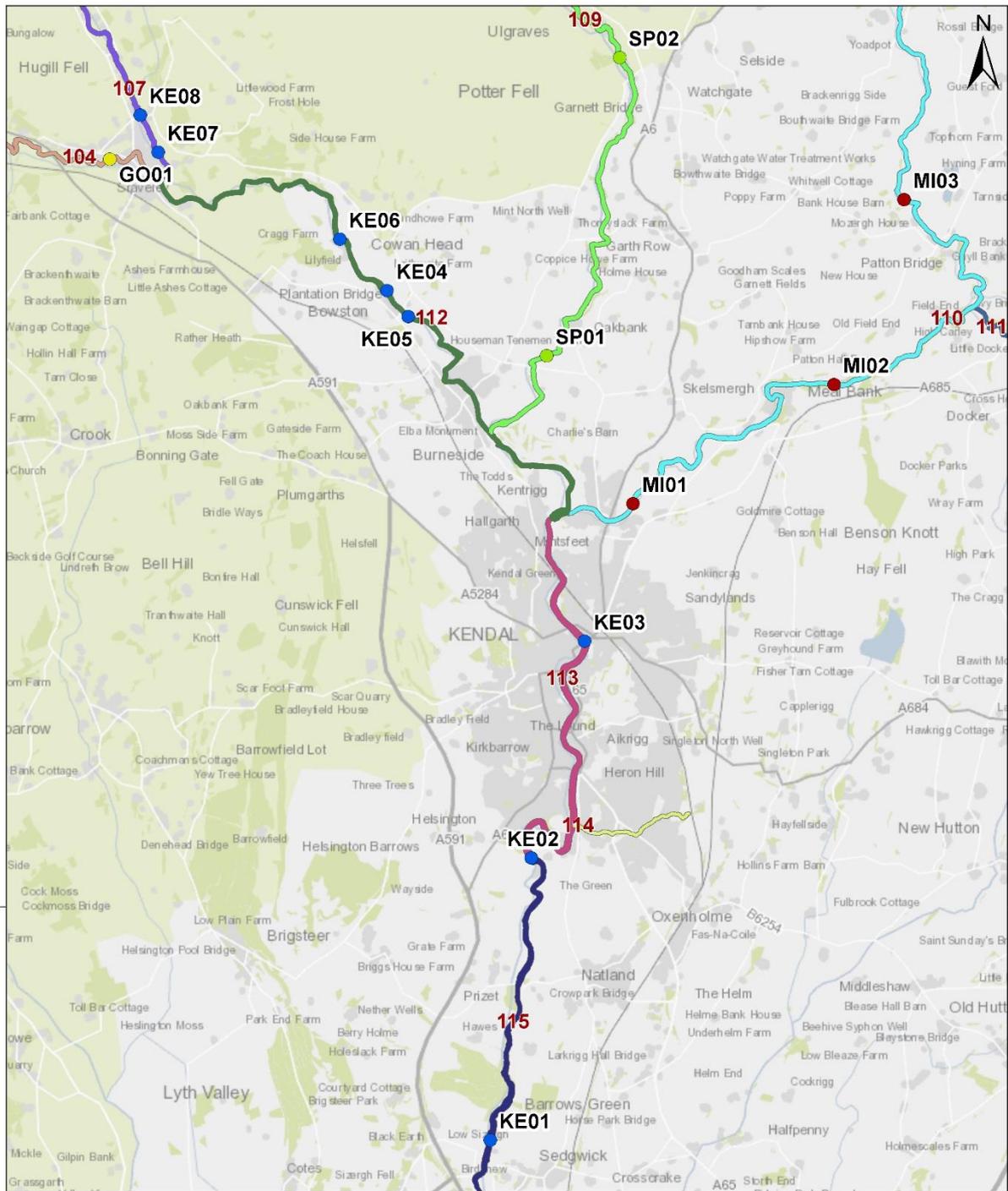


Figure 1-1 Weir Locations and SSSI Units

1.3. Report structure

The structure of the report is described below in Table 1-2.

Table 1-2 Report structure

Section	Content
1	Introduction
2	Methodology
3	Desk study
4	Field study
5	Options assessment
6	Summary and recommendations
7	References

2. Methodology

2.1. Approach

The project will assess how feasible it is to remove (or modify) the weirs at the 14 sites identified in Table 1-1, with the aim to improve the SSSI river habitat and Favourable Condition.

It is therefore important to understand the potential impacts of the structures. There is publically available guidance which discusses the potential risks, constraints and best practice of removing weirs in rivers (for example: Defra/Environment Agency, 2003 and Environment Agency, 2013). Experience and professional judgement is also valuable to identify the site specific risks and uncertainties, and this is supported by a desk study (Section 3) and site visit by an ecologist, engineer and geomorphologist (Section 4). The information collated from the desk and field based surveys helped with the option development and identification of a preferred solution (Section 5). The likely costs of the options have also been estimated (Section 5 and Appendix D).

2.2. Understanding the potential impacts of weirs

There are three primary effects that weirs can have on the physical and ecological characteristics of the river (Natural England, Help Note 4). These are:

- Alterations to the geomorphology and hydraulics of the channel through water impoundment and altering sediment transfer;
- Alterations to flow regime; and
- Interruption of biological connectivity, including the passage of fish and invertebrates.

Natural England and the Environment Agency recognise the impacts of weirs on rivers and the need to remove as many as is practicably possible (Environment Agency, 2013). The importance of restoring natural river processes and connectivity is also heightened by climate change and the need to consider vital adaptation measures. The following flow diagram (Figure 2-1) modified from Defra/Environment Agency (2003) illustrates the potential impacts of removing weirs in rivers and what key elements need to be considered.

The removal of a weir can potentially lead to both positive and negative environmental impacts, although the negative impacts can be mitigated for, or avoided altogether, with good planning and appropriate investigations and monitoring.

Removal or lowering of a weir will have a direct impact on the flow and dominant geomorphological processes. The river regime upstream becomes more naturalised (compared with a slow deep backwater behind an impoundment) which improves the ecological habitat and diversity as well as fish passage. Lower water levels also often lead to better land drainage and a reduced flood risk.

Sediment transport is more effective and the downstream reaches benefit from a more continuous supply of fine and coarse material; in the River Kent catchment, gravel replenishment is especially important to maintain the healthy salmonid population. The faster flows would also help flush the very fine material downstream, cleaning and oxygenating the river bed. It is important however to ensure that the sediment accumulated behind the weir is not contaminated, given the Kent catchment's industrial legacy, and its release will not adversely affect the aquatic ecology downstream. It is also crucial to understand the impact of an accelerated sediment loading in the initial phase of removal and ensure that flood risk is not heightened if local downstream bed levels are raised.

Often one of the greatest uncertainties of any weir removal is the degree of channel adjustment and spatial and temporal scale over which this may occur. Morphological adjustment may take several decades and depends on the river type, bedload material and size of the in-channel structure. Those sites with bedrock outcrops upstream are often more predictable as the local geology provides a natural bed check and reduces the risk of a knickpoint or headcut working upstream. Those with less consolidated bed and banks are more vulnerable to erosion. Those sites in a more urban environment may also have nearby infrastructure or properties that could be within the geomorphological impact zone. With thorough investigation and monitoring prior to removal these risks can be mitigated for and the adjustment managed.

A phased removal with a monitoring programme is recommended if the morphological adjustment risks are high and the impacts are uncertain.

In many cases, the improved morphology, and in turn, the ecology and fish passage is welcomed by the community and river users. However, sometimes removal of a weir is seen as a loss of the historic environment and landscape feature, even if the structure is currently redundant. The heritage value of the structure and surroundings can be evaluated, and if there are no restrictions then a good public consultation programme is important to gain local buy in and to the ultimate success of the project.

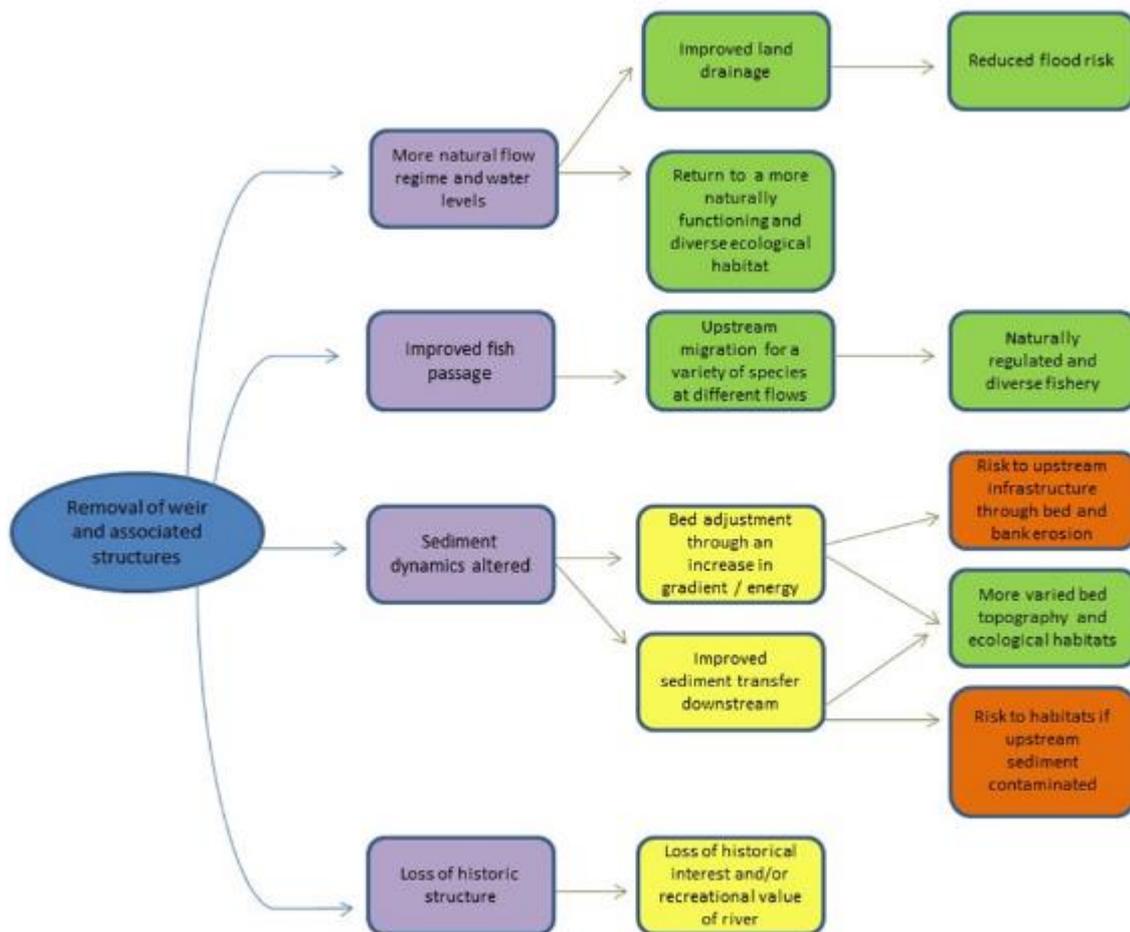


Figure 2-1 Potential impacts and consequences of removing a weir (adapted from Defra/Environment Agency, 2003)

2.3. Desk study analysis

A desk study was undertaken to collate information on the weir sites. This involved both a review of previous reports and collation of new data including:

- **Existing reports** - River Restoration Plan for the River Kent SAC (Jacobs, 2010) and two fluvial audits (see Section 3.3).
- **OS maps**– review and analysis of the current OS maps.
- **SSSI/SAC information** – review of SSSI and SAC citations and identification of which SSSI units the weirs are located in and their condition.
- **WFD** – review of WFD information for the water bodies that the weirs are located in.
- **Infrastructure and properties** – review of aerial photography and mapping to assess site location and context.
- **Heritage** – information on the historic environment from national and regional repositories.

- **Ecology data** – liaison with the Environment Agency and Natural England throughout the project yielded aquatic and terrestrial ecological information and interpretation.
- **Flow data** – from the Environment Agency and Centre for Ecology and Hydrology (CEH) (online). **Weir use** - information from Natural England, Environment Agency and South Cumbrian Rivers Trust (SCRT) on the use (e.g. current gauging station) and abstraction licences associated with the individual weirs.

The information collected as part of the desk study is presented within the site summary sheets where relevant. No topographic data or bathymetric surveys were examined as part of this project.

2.4. Contemporary field survey

Site visits were conducted between 13th and 16th October 2014 by a fluvial geomorphologist, aquatic ecologist and civil engineer. The weather at the time of the site visits was dry and cold, and the flow was moderate. Each weir structure was inspected (visual survey only) for stability and the impact zone and surrounding area upstream and downstream surveyed to understand the baseline character of the channel and habitats, and identify constraints and opportunities where possible. The field surveys were completed with the four main options in mind:

1. Do Nothing;
2. Full weir removal;
3. Partial weir removal; and
4. Installation of fish pass or easement.

2.4.1. Geomorphology assessment

A significant amount of geomorphological baseline data was collected as part of the restoration vision by Jacobs (2010) which provided useful context for this study. The following information was captured during this site visit to specifically help understand the likely adjustment with weir removal or modification works:

- Valley side and landscape character;
- Channel morphology and primary processes;
- Riparian habitat and floodplain connectivity;
- Existing infrastructure or properties at risk from erosion and/or flooding;
- Upstream features and habitats at risk from erosion; and
- Downstream features and habitats at risk from excessive sediment deposition.

The site immediately in the vicinity of the weir was observed, as was the zone of impact upstream and downstream. This is the zone by which the hydraulic and geomorphological processes are directly affected by the impoundment (or backwater). A rapid assessment was completed at each site based broadly on the approach outlined in Shaw *et al.* (2011), although this study was undertaken at a relatively high level and essentially provides a screening or pre-feasibility assessment for weir removal.

2.4.2. Engineering assessment

An assessment of the four options at each of the weirs was undertaken to assess technical feasibility and buildability issues. During the site visit the following information was captured to inform these assessments:

- Potential construction access to and across the site;
- Potential areas for site compounds and working areas;
- Overhead cables and services;
- Type of structure and rough dimensions;
- Condition of the weir (visual assessment only);
- Purpose of the weir and whether it is still in use;
- Channel and bank modifications up and downstream;
- Evidence of scour at the structure or within the channel and banks upstream and downstream;
- Structures, buildings and vegetation on the banks around the weir;
- Likely stakeholders affected by each option; and
- Any other site specific issues with each option.

2.4.3. Ecology assessment

The ecological assessment at each structure characterised three core elements:

- The extent of backwater upstream of the weir (the zone of impact on functional habitat provision as a result of the structure);
- The likely barrier effect of the structure on fish local and spawning migrations (migratory salmonids, resident trout and coarse fish were considered separately, with reference to published guidance (Environment Agency, 2010)); and
- Physical riverine habitat provision 100m upstream and downstream of the weir (including an assessment of substrate, flow, and channel vegetation composition; fish spawning and in-channel refuge availability; presence of invasive riparian and aquatic flora; extent of shading and other habitat features of note).

Physical habitat characterisation was also used to assess the impact of the structure on habitat suitability for SAC qualifying features. There is no published standard methodology for assessing habitat suitability for SAC qualifying features at a scale relevant to this high-level assessment. Assessing Favourable conservation status of SAC features (at a site level) requires bespoke species survey. Bullhead, for example, must be characterised in terms of both their abundance and population demographic structure. Similarly, SSSI Common Standards Monitoring (CSM) guidance is appropriate only at (larger) SSSI unit level and requires the use of biological monitoring data, River Habitat Survey (RHS) data and numerous other factors. Physical habitat characterisation was therefore used to categorise habitat suitability for SAC features (upstream and downstream of each structure) using a basic two-tiered measure of suitability:

- Optimal suitability: **no obvious limitations** in physical habitat provision within the reach characterised, with reference to the accepted life history requirements of the qualifying feature; and
- Sub-optimal suitability: **obvious limitations** in physical habitat provision within the reach characterised, with reference to the accepted life history requirements of the qualifying feature.

Life history requirements for qualifying species made reference to, in particular, the Conserving Natura 2000 Rivers Ecology Series (Holdich, 2003; Skinner *et al.*, 2003; Tomlinson and Perrow, 2003; and Hatton-Ellis and Grieve, 2003).

2.5. Heritage assessment

A high level, preliminary assessment was made to identify any potential licencing requirements and design considerations in relation to the historic environment. The historic environment encompasses designated and undesignated heritage assets, including Scheduled Monuments, Listed Buildings (statutorily listed), World Heritage Sites, Registered Parks and Gardens, Conservation Areas, historic buildings (locally listed and unlisted), known archaeological sites and areas of archaeological potential, as well as the character of the historic landscape. The county archaeologist should be engaged in project development at an early stage to ensure historic environment can be taken into account fully (including agreeing mitigation where required, such as the appropriate recording of assets).

Online resources included:

- National Heritage list for England (NHLE) maintained by English Heritage (english-heritage.org.uk);
- MAGIC interactive mapping (magic.gov.uk);
- Cumbria Historic Environment Record (HER) online (cumbria.gov.uk);
- Lake District HER data available via English Heritage's Heritage Gateway (heritagegateway.org.uk); and
- Information on Kendal Conservation Area available online (southlakeland.gov.uk).

This search was focussed on identifying any designated or undesignated heritage assets present within an approximate 500m study area around each weir site, most significantly those likely to be physically affected by the scheme. During this process the wider archaeological and historic context was also characterised, based on a rapid overview of local HER data.

In general terms, development can affect the historic environment in two ways: construction activities can disturb or destroy material remains (such as built heritage, earthworks or buried remains) or affect their preservation (for example hydrological changes resultant from the scheme), while the sights, sounds and

smells altered through the impacts of the scheme may impair or improve the experience of designated heritage assets whose setting forms part of their significance, or the wider historic landscape character.

In licensing terms, appropriate consents are required for the physical alteration of listed buildings, Conservation Areas and Scheduled Monuments, including buried sites. It should be noted that there are statutory provisions relating to the conservation of listed buildings and their settings, and separate provisions relating conservation areas and scheduled monuments which decision makers are required to give considerable weight to. In addition, planning permission may be required for works and as such policies in the Local Plan and National Planning Policy Framework relating to the conservation of designated and non-designated assets and their settings may need to be addressed. In this context agreement with English Heritage and the Local Planning Authorities (LPAs) may be required where a change to a designated asset or its setting is anticipated that would affect its significance.

3. Desk study

3.1. Study area

The study is focused on the River Kent and tributaries SSSI, which is also designated as a SAC, and is situated in south Cumbria within the Lake District National Park, east of Lake Windermere. The area is divided into several SSSI management units, a number of which have been subject to physical modifications (morphological pressures) which have resulted in them being classed as Unfavourable Condition. The study area covers the Rivers Kent, Mint, Sprint and Gowan.

3.2. River Kent catchment characteristics

3.2.1. Geology and topography

The bedrock of the study area is predominantly undifferentiated Silurian Rocks, sedimentary rocks comprising mudstone, siltstone and sandstone north of Kendal and undifferentiated Dinantian Rocks, sedimentary bedrock of sandstone, limestone and argillaceous rocks to the south (British Geological Survey, 2014). Where present, the drift geology underlying the rivers to the north of Kendal is glacial sand and gravel deposits and to the south of Kendal it is glacial sand and gravel deposits and till diamicton.

The sources of the Rivers Kent, Sprint, Mint and Gowan are in the fells to the north and northwest of Kendal. Within the upper reaches, the rivers flow within steep sided narrow valleys. In the lower reaches the valleys are much wider, before all tributaries eventually join the River Kent.

3.2.2. Physical modification

The River Kent catchment has been historically heavily modified which has resulted in a detrimental impact on both the geomorphological processes and ecological habitats within the river. This is reflected in the current status of the SSSI units within the catchment (see Section 3.2.4). Historical physical modifications within the catchment relate to: historical mining within the upper reaches of the catchment, and the associated infrastructure and mine tailings; mills within the middle and lower reaches of the catchment and the associated weirs and other mill structures; and channelisation. This has resulted with in-channel structures and obstructions, channel straightening and bank protection present within the catchment.

3.2.3. Ecological habitats and key species

The ecological habitats and key species of the River Kent are summarised in the SSSI and SAC citation, reproduced (in part) below. In addition, and of particular relevance to this study, an assessment of salmonid stock performance (Environment Agency, 2012) confirms that migratory sea-trout and salmon reach the headwaters of the catchment (the Kent, Sprint and Mint) in order to spawn. This is evidenced by fry and parr catches from Environment Agency electro-fishing surveys throughout the catchment headwaters.

The River Kent's main tributaries are situated in the south eastern Lake District fells. Natural mineral enrichment provides the calcium necessary for growth of crayfish. Downstream from Kendal, the main channel of the Kent flows through a series of gorges, influenced by calcium-rich limestone springs. White-clawed crayfish are found throughout the river system, from the headwaters of the Rivers Kent, Gowan, Mint and Sprint downstream to the lower reaches of the main Kent channel near Sedgwick.

The Kent system presents a variety of habitats for crayfish. This includes extensive areas with a loosely structured, but stable stream bed of cobbles and stones. Crayfish are also found in the more unstable, turbulent reaches of the upper Kent and Sprint wherever there are small areas of cobbles and stones at the edge of channels. Two small disused reservoirs at the head of the River Gowan provide important refuge populations of crayfish, which are the most likely to survive in the event of an outbreak of crayfish plague in the Kent system.

In the lower reaches, and particularly through Kendal, there are extensive beds of water crowfoot *Ranunculus* spp. and alternate-flowered water-milfoil *Myriophyllum alterniflorum* providing further habitat and a food source for crayfish. The main channel of the River Kent has extensive reaches with undisturbed riparian habitats of woodland and tall riparian vegetation. Much of the river system is lined with tall, marginal vegetation of reed canary grass *Phalaris arundinacea*, hemlock water-dropwort *Oenanthe crocata* and

associated tall herbs and grasses. The submerged roots of these plants, and the diversity of habitats created by the riparian vegetation, provide excellent refuges for crayfish.

The Kent and its tributaries have generally high water quality. With a short distance from the headwaters to the mouth of the river, and heavy rainfall on the catchment fells, the river has a high degree of flushing. This maintains the river bed relatively free of silt and algal growth. These conditions also provide suitable habitat for populations of bullhead.

White-clawed crayfish and freshwater pearl mussels are found together in one of the upper tributaries. In addition to good water quality, this headwater also provides the moderate to fast flow regime, cool temperatures and suitable areas of stable river channel, required by freshwater pearl mussels. Freshwater pearl mussels can live for over 100 years. Their life cycle is however complex and in part dependent upon the maintenance of a healthy salmonid population. The mussels do not mature until 15 years, when the females produce eggs. After initially remaining within the mother's shell the larvae (0.2 mm) attach themselves for a short period to young salmon and trout. After dropping off, they remain buried within clean sand and gravel in the stream bed for a further five to ten years. This buried stage within the life cycle is particularly susceptible to changes in the flow regime, siltation and algal deposition.

3.2.4. SSSI status

The River Kent and Tributaries SSSI habitats are designated due to supporting a nationally important population of white-clawed crayfish *Austroptamobius pallipes* and one of the largest population of freshwater pearl mussels *Margaritifera margaritifera* in one of the headwaters.

The SSSI comprises 15 units. The latest SSSI condition assessment, summarised in August 2014 and in Table 3-1, indicates that one of the units is in Favourable condition, nine units are Unfavourable Recovering and five units are Unfavourable No Change. The Favourable unit is considered to be 'at risk' due to a pond requiring regular de-silting to maintain habitat for the white-clawed crayfish. The Unfavourable assessment relates to factors including water abstraction, grazing pressure, invasive species, diffuse pollution and channel modifications.

Table 3-1 SSSI condition summary (August 2014)

% Area meeting PSA target	% Area favourable	% Area unfavourable recovering	% Area unfavourable no change	% Area unfavourable declining	% Area destroyed / part destroyed
83.73%	0.37%	83.36%	16.27%	0.00%	0.00%

<http://www.sssi.naturalengland.org.uk/Special/sssi/reportAction.cfm?report=sdr118&category=S&reference=2000335>

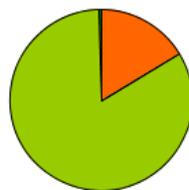
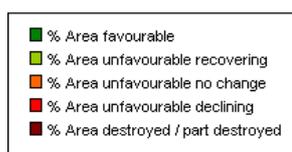


Table 3-2 below indicates which SSSI unit each of the weirs are in, and the current condition of the units. It should be noted that not all condition assessments have used Common Standards Monitoring guidance. In addition, the Common Standards Monitoring guidance for SSSI rivers has been revised since the condition assessments were undertaken.

Where there is a whole river restoration strategy in place, work underway on the ground and a commitment to ongoing resourcing to the delivery of projects, then the remedy is judged to be underway. Where other remedies attached to a unit are also underway, the unit can be judged to be in Unfavourable recovering condition. However, if ongoing delivery ceases the remedy may be judged not to be underway, which would turn the units back to unfavourable condition.

Table 3-2 Location of weirs within SSSI units and unit condition (compiled August 2014)

Unit	Weirs	Current Condition
104	GO01- Weir at Staveley	Unfavourable – Recovering
107	KE07 – Weir at Staveley KE08 – Weir at Barley Bridge, Staveley	Unfavourable – No change
109	SP01- Weir at Sprint Mill and EA gauging station SP02 – Weir upstream of Garnet Bridge	Unfavourable – Recovering
110	MI01 – Weir upstream of Mint Bridge and EA gauging station MI02 – Weir upstream of Meal Bank MI03 – Weir at Patton Mill	Unfavourable – Recovering
112	KE04 – Weir at Bowston and EA gauging station KE05 – Bowston EA gauging station KE06 – Weir at Cowan Head	Unfavourable – Recovering
113	KE02 – Helsington Weir, Water Crook (weir is boundary between unit 113 and 115) KE03 – Stramongate Weir, Kendal	Unfavourable – Recovering
115	KE02 – Helsington Weir, Water Crook (weir is boundary between unit 113 and 115) KE01 – Weir at Sedgwick and EA gauging station	Unfavourable – Recovering

3.2.5. SAC status

The boundaries of the River Kent SAC coincide with the boundaries of the River Kent SSSI. The SAC is designated due to high densities of white-clawed crayfish for which the Kent is considered to be one of the best areas in the UK.

The following SAC qualifying features are also present within the SAC designation, but are not the primary reason for the designation of the site:

- Watercourses of plain to montane levels with *Ranunculion fluitantis* and *Callitriche-Batrachion* vegetation;
- Freshwater pearl mussel *Margaritifera margaritifera*; and
- Bullhead *Cottus gobio*.

Vulnerabilities to the SAC are summarised in the Natura 2000 form (JNCC); “Some areas of the site suffer from poor habitat quality, upon which the species within the SAC depend for breeding and nursery areas, although this is intended to be addressed through habitat creation schemes. The impact of point-source discharges is being reviewed. The white-clawed crayfish are being affected by pyrethroid sheep-dip pollution within the river, which are being investigated. The freshwater pearl mussel population is dwindling and factors affecting recruitment and structure are being investigated”.

3.2.6. Eel and fish passes

Fish passes are known to only deal with connectivity problems for certain fish species, mainly of commercial importance, e.g. salmon or eels and they do not address the habitat and connectivity needs of the diverse biological community as a whole.

In cases where a structure is judged to be immovable in the medium term, fish pass improvements may be proposed as a mitigation measure. The longer term restoration plan action should however be to remove or modify the structure. Where a structure is permanently immovable, a fish pass may be the only mitigation option. In either case, pass design should consider the needs of the characteristic biological community as a whole, including priority species such as lampreys, bullhead and non-fish species.

South Cumbria Rivers Trust (SCRT) have undertaken an assessment of structures within their area, which includes the River Kent catchment, for eel passage as well as noting the presence of fish passes at structures. Information relevant to the weirs included within this study is provided below in Table 3-3.

Table 3-3 Summary of fish passes and eel passages as surveyed by South Cumbria Rivers Trust

Table 3-3 is not a comprehensive list of all the weirs in the Atkins project.

Weir	Weir ID	Assessment date	Information on fish pass	Information on eel migration	2014 update – eel pass installed?
Sedgwick weir	KE01	2010		Partial barrier to eel migration	Yes
Stramongate Fish Pass	KE03	2010	Fish pass in centre	Partial barrier to eel migration	Yes
Bowston Fish Pass	KE04	2010	Fish pass on right bank	Partial barrier to eel migration	
Bowston 730120	KE05	2010		No barrier to eel migration	
Cowan Head Fish Pass	KE06	2010	Fish pass on left hand bank	No barrier to eel migration	
Staveley Wood Turning Fish Pass	KE07	2010	Fish pass on left bank	No barrier to eel migration	
Barley Bridge Fish Pass	KE08	2010	Fish Pass on left hand bank	No barrier to eel migration	
Mint Bridge 730404	MI01	2010		No barrier to eel migration	
Meal Bank Fish Pass	MI02	2010	Fish pass in centre	Partial barrier to eel migration	
Sprint Mill	SP01	2010		No barrier to eel migration	

3.2.7. Water Framework Directive

The River Kent and Tributaries SSSI are covered by seven WFD water bodies: three on the River Kent, two on the River Mint, and one on each of the River Sprint and River Gowan. A summary of these water bodies, and the location of the weirs within these water bodies, is provided below in Table 3-4. Four of the water bodies are currently achieving Good overall and ecological status or potential. Two of the water bodies on the River Kent, from Staveley down to the Kent Estuary, are designated as heavily modified water bodies due to power generation, water storage, flood protection and urbanisation. Further details on the WFD water bodies is provided in Appendix A.

Table 3-4 Summary of the current status of the WFD water bodies (Environment Agency, 2009)

Water body name and ID	Current Overall Status (and Predicted Status)	Current Ecological Status (and Predicted Status)	Hydromorphological Designation	Weirs
River Kent (GB112073071390)	Good (Good by 2015)	Good (Good by 2015)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	KE07 KE08
River Kent (GB112073071380)	Moderate (Good by 2027)	Moderate (Good by 2027)	Heavily Modified Water Body (HMWB) (due to Power Generation; Water Storage – non-specific)	KE04 KE05 KE06
River Kent (GB112073071460)	Good (Good by 2015)	Good (Good by 2015)	Heavily Modified Water Body (HMWB) (due to Flood Protection; Urbanisation)	KE01 KE02 KE03
River Mint (GB112073074640)	Moderate (Good by 2015)	Moderate (Good by 2015)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	MI03

River Mint (GB112073071370)	Good (Good by 2015)	Good (Good by 2015)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	MI01 MI02
River Sprint (GB112073071430)	Moderate (Good by 2015)	Moderate (Good by 2015)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	SP01 SP02
River Gowan (GB112073071410)	Good (Good by 2015)	Good (Good by 2015)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	GO01

3.2.8. Potential pressures

Rivers within the Kent catchment are under pressure from modifications from industry and urban development and the historical legacy such as mining, as summarised further in previous studies (see Section 3.3). There are also pressures from water abstraction, with data received from the Environment Agency indicating that abstraction licences are present at two of the weirs:

- KE06 Weir at Cowan Head – Lake and pond throughflow.
- KE07 Weir at Staveley – Two licences for hydroelectric power generation and industrial, commercial and public services.

These abstraction licences have recently been reviewed as part of the Review of Consents and will be ongoing for as long as the licensee wishes and assuming there are no changes to the abstraction flow. If an alteration to the abstraction intake is possible, this would need to be investigated so that the licence can be fulfilled.

3.2.9. Flow data and flooding

Information on flow within the River Kent catchment was obtained from the National River Flow Archive (Centre for Ecology and Hydrology, 2014). This is summarised in Table 3-5.

Table 3-5 Summary of flow data within the River Kent catchment

River	Station Name	Station Number	Catchment Area (km ²)	Period of Record	Mean Flow (cumecs)	Q95 Flow (cumecs)
Kent	Burneside	73003	73.6	1981-1999	3.735	0.274
Kent	Sedgwick	73005	209	1968 - 2013	9.249	1.173
Sprint	Sprint Mill	73009	34.6	1976 - 2013	1.98	0.175
Mint	Mint Bridge	73011	65.8	1970 - 2013	2.511	0.201

The River Kent drains a large steep catchment which is very responsive to rainfall events, leading to a very flashy hydrograph. Flooding has therefore been a recurring issue in Kendal and the surrounding towns. The main flood alleviation works were constructed in 1978 and have largely reduced the areas affected by flood waters. However, severe events such as that experienced in 2009 have caused serious damage and there is still a need to reduce urban flooding in Kendal (CFMP, 2009). As most of the floodplain around Kendal has been developed for industry, upland catchment management measures to slow the flood waters are likely to be the most effective and sustainable options, together with improved flood warning systems. Climate change and the likely scenario of increased magnitude and frequency of heavy rainfall events only exacerbates the need to consider managing flood risk sustainably on the River Kent and better 'Working With Natural Processes'. In addition to removal of weirs (to increase the water depth upstream and therefore storage), other sustainable measures that may be considered in the Kent catchment include moorland restoration, targeted woodland creation, increasing riparian vegetation, sediment management, floodplain storage and land use management (reducing stock densities for example).

3.2.10. Heritage assessment

A summary of all anticipated heritage constraints for each weir site is tabulated in Appendix B, including recommendations with regards to further assessments needed (detailed/basic). No World Heritage Sites, Registered Park and Gardens, or Historic Battlefields are situated in the proximity of any of the weir sites examined. It is however noted that the Lake District is a candidate World Heritage Site. One weir site forms

part of a Scheduled Monument and is therefore of high (national) importance, while another is within a Conservation Area and can be also considered of high importance. A number of weir sites are also situated in the vicinity of Listed Buildings.

With the exception of these sites, the historic environment around the majority of the weirs within this study is predominantly of a historic character (medieval and later), and characterised by rural settlement evidence and early riverine industries, overall considered to be most likely of a low (local) to medium (regional) value. Prehistoric and Roman sites have been noted around a few of the weir sites in this assessment, around the majority of sites there is a lack of known assets; this may be due to a lack of modern development and associated structured investigations around most of the weir locations.

All sites require further assessment to the level indicated in Appendix C. Data collection will require consultation with either the Cumbria HER, Lake District HER, or both, as set out in the table.

The results are summarised in relation to each river below.

River Kent (KE01-KE08)

- Scheduled Monument Consent would be required for physical alterations within the area at Helsington (KE02). The Scheduled Monument is a Roman fort, and archaeological settlement and ritual remains of that date are frequent in the wider surrounds of the weir site.
- Planning permission will be required for physical alterations within the Kendal Conservation Area at Stramongate Weir (KE03). The site lies embedded within a historic settlement, with considerable survival of above and below ground remains of multiple periods. The development may also affect the setting of listed buildings within the Conservation Area.
- Liaison with the LPA and English Heritage may be required with regard to potential alterations to the setting of designated assets near Sedgwick Weir and EA gauging station (KE01); Helsington Weir (KE02); Stramongate Weir (KE03); and Barley Bridge Weir (KE08).
- No designated heritage assets are anticipated to be affected at the remaining weir sites (KE04-KE07), although a county archaeologist should be consulted.

River Mint (MI01-MI03)

- There are no designated sites where a need for licencing is anticipated at these weirs although a county archaeologist should confirm.

River Sprint (SP01-SP02)

- There are no designated sites where a need for licencing is anticipated at these weirs although a county archaeologist should confirm.

River Gowan (GO01)

- There are no designated sites where a need for licencing is anticipated at these weirs although a county archaeologist should confirm.

To conclude, a high level preliminary assessment of historic environment constraints indicates that licensing may be required for works at Helsington Weir, KE02. Additionally works at the Stramongate Weir, KE03, may require planning permission in relation to the Kendal Conservation Area. Liaison with the relevant regulatory authority (English Heritage/the LPA) may also be required where works will alter the setting of a number of designated heritage assets at weirs KE01-KE03, and KE08 along the River Kent. No licences are expected to be needed for weirs along the Rivers Mint, Sprint and Gowan.

The historic environment potential for the scheme overall requires a programme of detailed assessment which would confirm the need for any licensing and inform a subsequent mitigation strategy to be agreed with the LPA and English Heritage. The assessment should consider all demolition and all other significant works, such as repairs and the construction of ancillary structures, but also the proposed sites for temporary compounds and haul routes. The assessment should also evaluate the potential physical and setting impacts on all possible historic environment receptors from these works, including on the historic landscape/townscape character of each weir site.

3.3. Previous studies

Three previous studies have been undertaken within the River Kent catchment, these are:

- Kent Catchment Geomorphological Assessment. Orr, Block and Newson (2000) (for the Environment Agency);
- PSA3 Riverine SSSI Restoration Visions, River Kent Catchment – Restoration Vision, Jacobs (2010) (for the Environment Agency and Natural England); and
- River Kent Geomorphological Assessment, CBEC (2014) (for SCRT).

For the 2000 Geomorphological Assessment a fluvial audit of the River Kent catchment was undertaken. This identified that natural processes were restricted within the catchment, with channel change related to factors including milling activity and channelisation, and sediment deposition occurring behind impoundments. The collapse of weirs and the large slugs of sediment which are still working down the system are among the issues identified within the catchment.

The Jacobs Report provided a restoration vision for the SSSI as a target to work towards achieving Favourable Condition, with channel modifications affecting functioning habitats within the river. One of the key modifications identified within the SSSI units during site walkovers was the installation of structures (including weirs) which were preventing natural channel adjustment and altering sediment storage. The channel modifications were identified as having an impact upon the ecology within the catchment, including weirs causing a barrier to migration.

The geomorphological assessment undertaken by CBEC focused on the upper River Kent, in particular the reach alongside the Jumb Quarry site, and specifically the breach of the dam and erosion of mine tailings in 1997 during high flows. Sediment from the mine tailings has had limited impact downstream and there was little evidence of sediments derived from the mine tailing having a chronic effect upon fish habitat. However, if a similar high flow event like that in 1997 occurred again it would result in considerable sediment transport and channel adjustment in the reach downstream of the mine tailings.

A more detailed summary of these three reports is provided in Appendix C.

4. Field survey and analysis

4.1. Site access and limitations

All of the weirs were largely accessible from public footpaths and roads and were observed for this high level assessment. There was some difficulty viewing GO01 (Weir at Staveley on the River Gowan) directly alongside the weir, and there was limited access upstream of MI02 (Weir upstream of Meal Bank on the River Mint) and downstream of SP02 (Weir upstream of Garnet Bridge on the River Sprint).

At the time of survey flow conditions were moderate so visual inspection of all of the weirs was possible, however a detailed topographic and structural survey of the weir and surrounding structures will have to be conducted if any of these sites are progressed to the feasibility stage. Likewise, a more detailed geomorphological survey would need to be carried out. Bed and bank characteristics were recorded as accurately as possible from bank top observations to assess the potential adjustment, but no in-channel work was completed. Whilst the level of geomorphological risk has been assessed for this study based on the site observations, a topographic survey of the upstream and downstream bed and bank levels will be necessary to fully evaluate the impact of weir removal. A more detailed walkover of the individual areas and the wider catchment (beyond the impact zones) will also aid the understanding of the flow and sediment regime and inform any modelling inputs and hydraulic and geomorphological change.

The ecological assessment is also based on observations of the current habitats on the day of survey, rather than through analysis of any monitoring data for the specific areas. No terrestrial ecological surveys were completed for this assessment. The estimate of habitat connectivity is based on other known structures from this survey. It was clear from the field survey that other small weirs were evident (e.g. upstream of GO01 and MI03) but for consistency these have not been included in the potential connectivity benefits. Waterfalls are not considered in the potential upstream connectivity estimates as these are natural features and the lengths provided are for natural connectivity, whether it include bedrock cascades or falls or not. The only waterfall likely to have a bearing on river connectivity in relation to weir removal or modification are the falls below SP02, the weir at Garnett Bridge.

No stakeholder consultation was conducted during the field surveys or for this assessment as a whole beyond the project steering group. Key information such as whether the weirs are gauging stations, have associated abstraction licences or have recently had an eel or fish pass installed has been collected to help with the assessment and prioritisation. It is believed that public consultation will form an early part of the next phase when decisions have been made which sites to progress to feasibility.

4.2. Survey overview

Sites included in the investigation were widely distributed within the River Kent and its tributaries (see Figure 1-1).

There are four gauging stations, KE01 at Sedgwick, KE05 at Bowston, M101 at Mint Bridge and SP01 at Sprint Mill. At the current time, there are no suitable alternatives for gauging at these sites (pers. comm Environment Agency) and the weirs will need to be retained for flood warning. Weir removal or modification can be considered at these sites when an alternative accurate high flow end approach can be designed.

The other structures are situated in a range of rural and urban settings, and varied extensively in size, age, construction and condition. KE03 for example, spans the River Kent through the centre of Kendal, at a width of approximately 60m. Through this reach, the River Kent is wide and shallow, with a realigned channel and extensively reinforced banks. Similarly, GO01 spans the River Gowan, through the town of Staveley, in a realigned and reinforced channel, but over a width of only 10m. Other weirs such as MI03 were located in predominantly rural settings, with relatively little channel and bank modifications other than those associated with the structure itself.

The location and setting of the weirs within the catchment not only affects the feasibility of their removal, but also determines the likely magnitude of the ecological and geomorphological response following removal. Channel migration is unlikely to occur through areas of reinforced banks, but could undermine the buildings and infrastructure it supports through vertical erosion (incision). Conversely, channel migration in more naturalised reaches may occur but the risks, if understood and mitigated/managed, would be relatively low. The size and construction of the weir itself is also not necessarily proportional to the impact the structure has

on river form and function, or the barrier the structure might present to migratory species. The impacts associated with each weir was therefore site-specific, varying widely between structures during survey.

4.3. Multi-Criteria Analysis (MCA)

This section describes how the options appraisal was undertaken using a Multi Criteria Analysis (MCA) approach. The criteria, weightings and scores were discussed and agreed by consensus by representatives from Atkins, Natural England and Environment Agency. This method reduces the subjectivity to some degree, and allows for the benefits and technical difficulties to be scored and prioritised for each option and between sites. This then helps plan future work by short-listing those weirs for removal where the ecological benefits are high and the technical feasibility and practicality is acceptable.

The four steps in the MCA approach are described below.

1. The first step involves defining a series of criteria against which the four proposed options can be assessed. Features including ecology, morphological diversity, landscape, stakeholders and engineering were chosen and broken down into separate indicators. Weightings, between 1 and 0 were given to these indicators based on the main drivers for the project (**Error! Reference source not found.**). A weighting of 1 had the highest priority or influence.
2. A score of between -2 and +2 was then applied to each option at each site depending on the degree to which the option complies with the criteria, defined as relevance and/or benefit and detriment:
 - 'Relevance and/or benefit' - option complies with the criteria or brings about improvement of features relating to that criteria; and
 - 'Detriment' - option does not comply with the criteria or brings about adverse change to features relating to that criteria.
3. The score applied to each criteria was then multiplied by the individual weighting factor to produce a weighted score. The weighted scores for each option were then summed up to produce the total weighted score.
4. Each site and option were ranked by ecological benefit, technical feasibility and total weighted score with and without cost.

4.4. MCA criteria

The features and indicators chosen are described below in Table 4-1. It was intended to keep this process simple and only include those criteria that are meaningful to the options and are distinctive between options and sites. It was agreed that the scoring for criteria such as climate change and sustainability would be the same across all sites so would not be included. This was also thought true of flood risk, although individual assessments will need to be conducted if any of the options are progressed. Compliance with WFD and SSSI objectives are partly covered in the ecological and morphological diversity features. In addition, all except one SSSI unit is recovering, albeit Unfavourable and none of respective water bodies are failing under the WFD for fish passage (Sections 3.2.4 and 3.2.7, respectively).

Table 4-1 Criteria used for MCA with weighting and description

Feature	Indicator	Weighting	Description
Ecology	Habitat connectivity	1	The length of habitat change through linking good existing habitat, upstream and downstream
	Fish passage	1	The magnitude of change in fish migration potential (both local and spawning migrations)
	Length of impact	0.9	The length of backwater effect upstream of the weir and therefore potential length for habitat for target ecological communities
Morphological diversity	Flow	0.9	The number of flow types that could exist compared to those evident at the time of survey
	Sediment	0.9	The change in sediment patterns and calibre compared to those evident at the time of survey
Landscape	Heritage value	0.8	The historical context, with specific reference to heritage designations

Stakeholders	Statutory	0.9	Compliance with statutory stakeholders aims and objectives
	Non statutory	0.9	Consideration of the non-statutory stakeholder interests or conflicts, such as hydropower, recreational activities, recent fish/eel pass upgrades etc.
Engineering	Condition of weir	0.9	The use, potential maintenance, size, structure type and stability
	Technical feasibility	0.9	The land use, infrastructure and practicality of undertaking modifications or removals
	Cost	0.8	The capital cost associated with the option with consideration of further assessments and site investigations required to undertake the works

There is a degree of subjectivity scoring indicators like these. In order to reduce this subjectivity as much as possible, some thresholds were applied. This worked well for the ecology, morphological diversity and landscape features in particular. The following sections describe these thresholds or scoring patterns in more detail.

4.4.1. Ecology

Habitat Connectivity – The extent of continuous riverine connectivity restored (including major tributaries). This is calculated with reference to the next known upstream and downstream structure.

	< 5km	≥ 5km	≥ 10km
Do Nothing	0	0	0
Full Removal	0	1	2
Partial Removal	0	0	1
Fish Pass	0	0	0

Fish Passage - Scale of potential improvement from baseline barrier effect of structure on fish migration. Priority is given for migratory salmonids. Although some coarse fish are migratory, bullheads are not.

Baseline							
Migratory Salmonids	✓	✓	✓	✓	✗	✗	✗
Resident Trout	✓	✓	✗	✗	✗	✗	✗
Coarse Fish	✓	✗	✗	✗	✗	✗	✗
↓							
Outcome							
Migratory Salmonids	✓	✓	✓	✓	✓	✓	✓
Resident Trout	✓	✓	✓	✓	✗	✓	✓
Coarse Fish	✓	✓	✓	✗	✗	✗	✓
MCA Score	0	1	1	1	2	2	2

✓ = passable under most flow conditions
✗ = barrier under most flow conditions

Length of Impact - Extent of removal of backwater upstream of the weir (the direct improvement in functional habitat provision as a result of structure removal).

	<25m	≥ 25m	≥ 100m
Do Nothing	0	0	0
Full Removal	0	1	2
Partial Removal	0	0	1
Fish Pass	0	0	0

4.4.2. Morphological Diversity

Flow - The flow variety that could exist if the weir was fully removed. Existing reference conditions upstream and downstream were used to support this scoring. The scoring for partial removal is more subjective, and is based broadly on reducing the height (and benefits) by half. In reality, the increase in flow diversity would depend on how the weir was modified and what height the bed levels upstream are lowered by.

Full removal	<25m	≥ 25m	≥ 100m
No change	0	0	0
Increase of 1 flow type	0	1	2
Increase of 2 or more flow types	1	2	2

Sediment - The change in variety of bed topography, sediment patterns and calibre of sediment if the weir was fully removed. Existing reference conditions upstream and downstream were used to support this scoring. The scoring for partial removal is as above.

Full removal	<25m	≥ 25m	≥ 100m
No change	0	0	0
Low increase	0	1	1
Moderate increase	1	2	2
High increase	2	2	2

4.4.3. Landscape

Heritage - The historical context of the weir site and surroundings with specific reference to heritage designations (see Section 3.2.10 and Appendix B for recommendations for basic or detailed assessment). A low score has been attributed to those sites where the heritage value may be of significance and where weir removal or modification may require a more stringent planning process.

	Basic assessment	Detailed assessment
Low risk (no designations or listed buildings in immediate area)	0	0
Moderate risk (some historic interest but no designations or listed buildings in immediate area)	-1	-2
High risk (designations or listed buildings in immediate area)	N/A	-2

4.4.4. Stakeholders

Statutory - The use of the weir (for example a gauging station). Data from these gauging stations is critical for the current flood forecasts. They are essential assets until more accurate alternatives can be designed and installed. Therefore the do nothing option scores 2 for weirs that are gauging stations.

	Gauging station	Redundant use
Do Nothing	2	-2
Full Removal	-1	2
Partial Removal	-1	1
Fish Pass	-1	1

Non-statutory - Considerations of gauging stations, abstraction licences and newly installed eel or fish passes (SCRT). Again a reliable flood forecast is critical to the residents and the do nothing option scores 2. Where there is an abstraction licence, full weir removal would not be acceptable (-2) and it would be a sensitive issue to remove or modify a weir that has had a newly installed fish or eel pass.

	Gauging station	Abstraction licence	New fish or eel pass
Do Nothing	2	0	0
Full Removal	0	-2	-1
Partial Removal	0	-1	-1
Fish Pass	0	0	0

4.4.5. Engineering

Condition of Weir - Considerations of use (gauging station), size, structure type and stability. This varies markedly between sites and between options but in very broad terms:

	Gauging station	Formal, good condition	Less formal, or poor condition
Do Nothing	2	0	-2
Full Removal	-2	-2	2
Partial Removal	-2	-1	1
Fish Pass	0	0	0

Technical feasibility and practicality - Access for plant and works compound, overhead and underground services, risk to infrastructure and properties and type of weir. This varies between sites and between options but in broad terms at the extremes:

	Gauging station	Formal, good condition	Less formal, or poor condition
Do Nothing	2	0	-2
Full Removal	-2	-2	2
Partial Removal	-2	-1	1
Fish Pass	0	0	0

Cost - The costs directly relate to the feasibility of the option and the level of risk, and therefore the level of detail for further investigations. Also, abstraction licences for the site are considered. These will need to be bought out for removal or modification (and would therefore score -2).

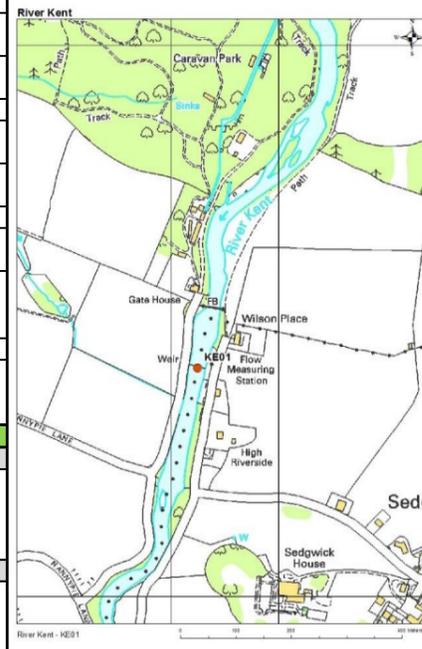
Indicative costs are provided in more detail in Appendix D.

4.5. Summary sheets

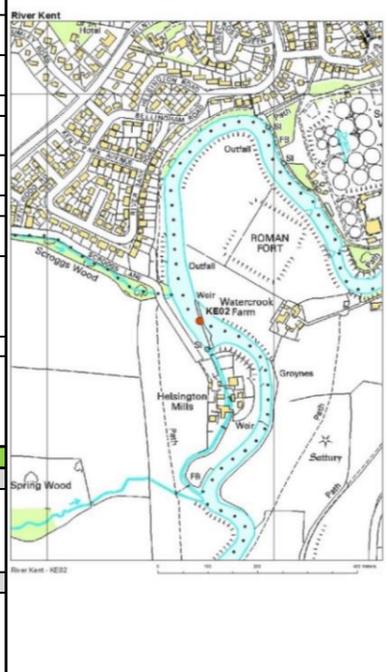
The findings of the ecology, geomorphology and engineering survey together with the relevant desk based information is provided on the accompanying summary sheets. There is one sheet for each of the 14 weirs and it is hoped that these could form a standalone hand out for use as part of the early public consultation as the projects progress. The low, medium and high values associated with the ecological benefits and the technical feasibility have been derived from the Multi-Criteria Analysis (MCA) and the indicative costs (see Section 5).

The summary sheets are presented over the following 14 pages.

Date of Survey:	15/10/2014	Weir Name:	Weir at Sedgwick and EA gauging station	BACKGROUND INFORMATION:	
Weir ID:	KE01	NGR:	SD 50870 87410	A tree-lined channel in a wide valley. This weir is currently used as an Environment Agency flow gauging station (Sedgwick) which is currently used for flood warning and drought planning, with a newly installed eel pass (South Cumbria Rivers Trust) on the left hand bank. There is a low flow channel in the centre of the weir. The river is predominantly surrounded by agricultural fields, with some residential properties along the left hand bank, access roads on both banks and a footbridge approximately 100m upstream.	
Watercourse:	River Kent				
HISTORICAL VALUE:					
Neither the weir nor the gauging station is designated, and no licensing requirements are anticipated. However, designations are present within a 300m radius and may require assessment with regard to setting impacts and liaison with English Heritage. High level data searches indicate numerous post-medieval industrial sites (mills, quarries, kilns etc.); their relationship with Sedgwick gunpowder works Scheduled Monument requires further assessment.					
GEOMORPHOLOGICAL CHARACTER					
Upstream					
Average bankfull width (m):	31.0	Normal low flow width (m):	30.0	Flow diversity:	Uniform within impact zone.
Average bankfull depth (m)	2.0	Normal low flow depth (m):	0.4		
Bank substrate:	Earth and fine gravels.		Bed substrate:	Predominantly cobbles and pebbles, with a fine layer of silt.	
Downstream					
Average bankfull width (m):	32.0	Normal low flow width (m):	31.0	Flow diversity:	Varied - riffles predominate.
Average bankfull depth (m)	2.0	Normal low flow depth (m):	0.5		
Bank substrate:	Partially visible as highly vegetated - earth and artificial.		Bed substrate:	Predominantly cobbles, pebbles and gravels.	
Gradient:	Low		Flow:	Low	
Evidence of modification and instability:	Stone bank protection on both banks around weir. Concrete bed for approximately 5m downstream of weir. No evidence of scour along the banks. Small area of poaching visible upstream of the footbridge on left hand bank.				
Notes:	Water flowing over the full width of the weir at the time of the survey. Water ponded for approximately 20m behind weir. Channel very similar in character immediately upstream and downstream of the weir, with greater silt deposits upstream. Mid-channel vegetated islands present upstream and downstream of weir, as well as gravel bar deposits on left hand bank. Assumed some management of channel within vicinity of the gauging station.				
Geomorphological risk of removal:	low				
Potential tree loss upstream with drop in water level. Residential properties are located downstream of the weir, so flood risk may be an issue. Agricultural land predominately surrounds the weir which reduces the impact of adjustment. The footbridge upstream doesn't have pillars in the channel so is not at risk of failing through bed adjustment although there may be some bank instability. Sediment upstream is predominantly cobbles and pebbles which will be reworked downstream but zone of impact 25m.					
ECOLOGICAL ASSESSMENT					
Extent of Backwater Effect (m)	25.0	SAC Qualifying feature habitat suitability			
Alternative Passage Available	Yes	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>	Sub-optimal habitat suitability upstream and downstream structure. Good substrate diversity, but lack of riparian corridor on left bank (and associated features e.g. exposed bankside roots), as well as some reinforcement of banks which limits overall suitability.		
Structure Passable					
<i>Migratory Salmonids</i>	✓				
<i>Resident Trout</i>	✓/✗				
<i>Coarse Fish</i>	✗				
SAC Qualifying feature (not primary reason for site selection) habitat suitability					
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>	Sub-optimal habitat suitability upstream and downstream structure. Good substrate diversity, but lack of riparian corridor on left bank (and associated features e.g. exposed bankside roots). Reinforcement of banks limits overall suitability. Flow diversity is good outside of backwater reach.	
Lithophilic Fish	Good	Moderate			
Phytophilic Fish	Good	Moderate			
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranunculus fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation	<i>Ranunculus</i> sp. observed upstream and downstream weir- larger densities upstream. Habitat suitability may be optimal (downstream weir in particular), but re-colonisation following historical management may be limiting factor.	
Liverwort/Moss/Lichen	10	15			
Emergent Broad-Leaved			1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>	Sub-optimal habitat suitability through substrate composition upstream and downstream of weir (clean rocky substrates with interstitial sand/gravels) and flushing flows downstream of weir, but channel shading is limited.	
Emergent Reeds/Sedges	<1	<1			
Floating Leaved (Rooted)					
Free Floating					
Submerged Broad-Leaved					
Submerged Linear-Leaved					
Submerged Fine-Leaved	15	5			
Filamentous Algae	10				
Additional Notes:					
The weir crest had a central depression; the head difference will be passable to migratory salmonids and resident trout at most flows, but is likely impassable to many coarse fish at most flows. Newly installed eel pass will also facilitate eel passage.					
STRUCTURAL ASSESSMENT					
Approx. height of weir (m):	1	Approx. length of weir (m):	0.5m		
Approx. width of weir (m):	30	Stability:	Very good condition		
Notes:					
Concrete weir structure with a low flow channel and fish pass in centre of the structure. It was also noted that an Eel Pass has been newly installed on the left bank. In the immediate vicinity of the structure, the banks are lined with masonry walls. Upstream and downstream of this the banks are natural and tree lined. No obvious signs of scour upstream or downstream.					
OPTIONS					
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost
Do-nothing		Weir is currently in a very good condition. Maintenance of the weir will be carried out by the Environment Agency. An eel pass has recently been installed.		Maintenance of current conditions - impassable to certain fish species, especially at lower flows, impact on flow regime upstream and impact on sediment transfer, with dominance of finer sediments upstream.	low
PREFERRED OPTION	no	high			
Full removal	mod	mod		Loss of Environment Agency gauging station which is currently used for flood warning and residents downstream at risk of flooding will lose flood warning service. The very recently installed eel pass may become redundant. A Flood Risk Assessment would be required for downstream properties. Movement of sediment downstream. Potential localised tree loss on banks immediately surrounding structure upstream. May require assessment with regard to setting impacts and liaison English Heritage.	high
Partial removal	low	mod		There will be loss of the gauging station, without reaping the full benefits of full removal. Not restoring full natural flow and sediment processes. May require assessment with regard to setting impacts and liaison with English Heritage.	high
Formal/ informal/ easement type fish pass	low	high		Possible reduction in accuracy of gauging station. The existing structure already allows passage for migratory salmonids and resident trout at most flows, along with eels due to eel pass. May require assessment with regard to setting impacts and liaison with English Heritage.	low



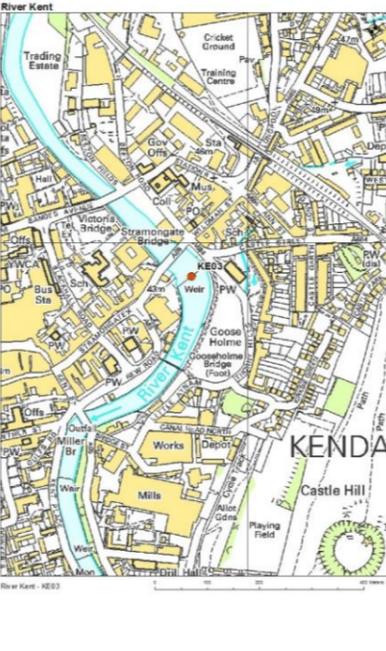
Date of Survey:	15/10/2014	Weir Name:	Helsington Weir, Water Crook	BACKGROUND INFORMATION:	
Weir ID:	KE02	NGR:	SD 51300 90582	The weir is amongst a partially tree-lined channel within a wide valley. It is surrounded by agricultural fields on the left hand bank and an old mill (Helsington Mills), agricultural fields, woodland and residential properties (part of Kendal) on the right hand bank. Right hand bank upstream of weir within woodland is steep and also immediately downstream on both banks. Leat to mill from right hand bank immediately upstream of weir. Small tributary flows in on right hand bank approximately 100m upstream. Small informal fish pass on left hand bank side of weir.	
Watercourse:	River Kent			Water Framework Directive	SSSI
HISTORICAL VALUE:				Water body ID:	Unit:
The weir falls within or close to the Watercrook Roman fort and settlement Scheduled Monument; for works within the Scheduled area Scheduled Monument Consent will be required. The area overall appears to be rich in archaeological remains from multiple periods, which could be of low to high value, and proposals needs detailed assessment in this respect.				Current status:	Current condition:
				GB112073071460	113/115
				Good Ecological Potential	Unfavourable - Recovering
GEOMORPHOLOGICAL CHARACTER					
Upstream					
Average bankfull width (m):	35.0	Normal low flow width (m):	30.0	Flow diversity:	Uniform within impact zone.
Average bankfull depth (m):	3.0	Normal low flow depth (m):	0.3		
Bank substrate:	Partially visible - earth.		Bed substrate:	Partially visible - mix of sands to boulders covered in silt.	
Downstream					
Average bankfull width (m):	45.0	Normal low flow width (m):	43.0	Flow diversity:	Varied - riffles predominant.
Average bankfull depth (m):	1.3	Normal low flow depth (m):	0.8		
Bank substrate:	Partially visible - earth and cobbles.		Bed substrate:	Predominantly cobbles, gravels and boulders.	
Gradient:	Low		Flow:	Low	
Evidence of modification and instability:	Bank protection - placed stone on both banks downstream of weir. Over-widened channel immediately upstream of weir, with weir on meander. Bank slumping and poaching evident on left hand bank both upstream and downstream of weir - some fencing along bank downstream of weir.				
Notes:	Water flowing over full width of weir at time of survey, apart from where blocked by large fallen tree on the weir crest. Extensive ponding for 550m upstream of weir. Upstream of weir, bed substrate composition difficult to view, however there was more silt than downstream of the weir. Gravel deposits upstream of weir where small tributary flows in and downstream of weir vegetated mid-channel bar and gravel bar on right hand bank. Significant difference in flow types between upstream (uniform) and downstream (varied) of the weir. Extensive poaching and bank slumping evident.				
Geomorphological risk of removal:	high				
Potential loss of trees from right hand bank upstream which is quite steeply banked with residential properties at the top with drop in water level. Agricultural land use on left hand bank and downstream which reduces the impact of downstream adjustment by accommodating the change in sediment transport. However, the town of Kendal is immediately upstream and located on a bend in the river. The large weir is causing a significant backwater (over 500m) and adjustment is likely to be extensive and fairly rapid which is likely to require river training and scour protection works.					
ECOLOGICAL ASSESSMENT					
Extent of Backwater Effect (m)	550.0				
Alternative Passage Available	Yes				
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>				
<i>Migratory Salmonids</i>	✓				
<i>Resident Trout</i>	✓				
<i>Coarse Fish</i>	✓/x				
SAC Qualifying feature habitat suitability					
Sub-optimal habitat suitability upstream and downstream structure. No riparian corridor (lack of associated features e.g. exposed bankside roots). Reinforced banks downstream and siltation issues upstream (poaching). Good underlying substrate diversity but overall sub-optimal suitability.					
SAC Qualifying feature (not primary reason for site selection) habitat suitability					
Sub-optimal habitat suitability upstream and downstream structure. No riparian corridor (lack of associated features e.g. exposed bankside roots). Reinforced banks downstream and siltation issues upstream (poaching). Good underlying substrate diversity but overall sub-optimal habitat.					
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>		
Lithophilic Fish	Poor	Moderate	Sub-optimal habitat suitability upstream and downstream structure. No riparian corridor (lack of associated features e.g. exposed bankside roots). Reinforced banks downstream and siltation issues upstream (poaching). Good underlying substrate diversity but overall sub-optimal habitat.		
Phytophilic Fish	Poor	Poor	3260 Water courses with <i>Ranunculus</i> sp. observed downstream weir due to increased flow heterogeneity. Habitat suitability sub-optimal upstream of structure due to impounded flows and siltation.		
Channel veg. ass. (%)	Upstream	Downstream	1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>		
Liverwort/Moss/Lichen		10	Sub-optimal habitat suitability due to absence of channel shading (important in maintaining water temperature and inhibiting algal growth for freshwater pearl mussel), and siltation issues upstream of structure.		
Emergent Broad-Leaved			Additional Notes:		
Emergent Reeds/Sedges	<1	5	The structure was passable to most fish species (including eel) due to the presence of an informal fish easement (rock ramp).		
Floating Leaved (Rooted)					
Free Floating					
Submerged Broad-Leaved	20				
Submerged Linear-Leaved					
Submerged Fine-Leaved		5			
Filamentous Algae	30				
STRUCTURAL ASSESSMENT					
Approx. height of weir (m):	2	Approx. length of weir (m):	6		
Approx. width of weir (m):	100	Stability:	Poor condition		
Notes:					
The condition of the weir is poor, with major defects identified. There is a build up of debris across the crest including a tree. The concrete slab is broken and has lifted in the centre of the channel. An informal fish easement has been constructed on the left bank by breaking out part of the structure. There is a mill race to the site of a former mill on the right bank.					
OPTIONS					
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost
Do-nothing	no	low		Likely that further defects will form and there may be a partial or total collapse of the structure and there will be no management of channel migration should total collapse occur. Further build up of debris behind weir. Maintenance of current conditions - impassable to certain fish, impact on flow regime upstream and impact on sediment transfer.	mod
Full removal PREFERRED OPTION	high	mod		Likely increased scour upstream, potential loss of trees on right hand bank upstream and movement of channel. Movement of sediment, including silt, downstream. Loss of mill leat on right hand bank. Cattle grazing upstream of weir - need to manage banks. In channel works would be required. Proximity to Scheduled Monument - consent may be required.	high
Partial removal	low	high		Likely increased scour upstream, potential loss of trees on right hand bank upstream and movement of channel. Movement of sediment, including silt, downstream. Not restoring full natural flow and sediment processes. Potential impact on mill leat on right hand bank. In channel works would be required. Potential undermining of section of weir left and preferential flow pathways increasing downstream scour. Proximity to Scheduled Monument - consent may be required.	mod
Formal/informal/easement type fish pass	no	mod		Poor condition of weir indicates partial or total collapse is considered likely, which could lead to redundancy of any fish pass installed. Proximity to Scheduled Monument - consent may be required.	mod



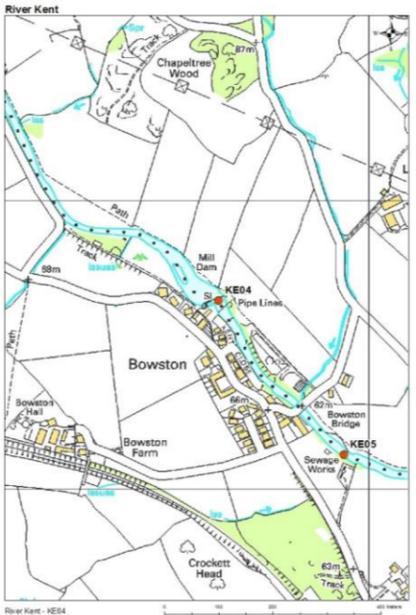
View upstream of weir from left hand bank. (SD 51391 90522)



View of fish pass on left hand bank side of weir (SD 51309 90574)

Date of Survey:	15/10/2014	Weir Name:	Stramongate Weir, Kendal	BACKGROUND INFORMATION: This weir is located within Kendal town centre surrounded by urban residential and commercial properties on both banks with a small park area downstream on the left hand bank. A road bridge, with piers in the channel, is approximately 50m upstream and a footbridge approximately 180m downstream. Footpaths run along both banks. A fish pass is present in the central section of the weir and an eel pass has been installed (South Cumbria Rivers Trust).	
Weir ID:	KE03	NGR:	SD 5192492953		
Watercourse:	River Kent				
HISTORICAL VALUE: The weir lies within a conservation area and works are likely to require consent from the LPA (Local Planning Authority). Impacts on the setting of designated assets require detailed assessment. Numerous known non-designated sites are recorded around the site, and also require detailed assessment. Any such remains are likely to be of a low to medium value.					
GEOMORPHOLOGICAL CHARACTER					
Upstream					
Average bankfull width (m):	55.0	Normal low flow width (m):	54.0	Flow diversity:	Uniform
Average bankfull depth (m)	2.0	Normal low flow depth (m):	0.3		
Bank substrate:	Partially visible - artificial bank protection		Bed substrate:	Predominantly cobbles and pebbles with some sand and gravels.	
Downstream					
Average bankfull width (m):	66.0	Normal low flow width (m):	60.0	Flow diversity:	Varied for a short distance and then uniform
Average bankfull depth (m)	3.0	Normal low flow depth (m):	0.4		
Bank substrate:	Partially visible - artificial bank protection		Bed substrate:	Partially visible - predominantly cobbles and pebbles. Small strip of concrete bed across width of channel.	
Gradient:	Low		Flow:	Low	
Evidence of modification and instability:	Re-sectioned, re-aligned and over-widened channel. Full bank protection along both banks both upstream and downstream of weir. Outfall on left hand bank immediately downstream of weir and presumed pipe crossing in concrete bed immediately upstream of weir.				
Notes:	Water flowing over full width of weir at time of survey. Water ponded extensively (300m) behind weir and further uniform flow evident downstream. Only variability in flow seen immediately downstream of weir in slightly higher gradient section where riffles predominate. Downstream of weir vegetated mid-channel islands and gravel side bars. Upstream of weir, no deposition until beyond road bridge. Some evidence of channel narrowing with vegetation along edge of channel. Bed sediment finer upstream of weir.				
Geomorphological risk of removal:	high Lots of infrastructure along, and within the channel, as river is within Kendal town centre. Road bridge upstream with piers in the channel, which are at risk of failing through bed adjustment. Pipe crossing in river bed upstream of weir which is at risk of erosion through bed adjustment. Buildings form part of the river bank upstream of the weir, which are at risk of being undermined and needing additional structural support from drop in water level. Full bank protection along the channel which is likely to need additional works from drop in water level. Sediment upstream is predominantly cobbles and pebbles which will be reworked downstream.				
ECOLOGICAL ASSESSMENT					
Extent of Backwater Effect (m)	300.0				SAC Qualifying feature habitat suitability Sub-optimal habitat suitability upstream and downstream of structure. No shading, no riparian corridor (and lack of associated features e.g. exposed bankside roots), and reinforced banks. Good substrate diversity but overall sub-optimal habitat.
Alternative Passage Available	Yes				
Structure Passable	✓				
Migratory Salmonids	✓				
Resident Trout	x				
Coarse Fish	x				
SAC Qualifying feature (not primary reason for site selection) habitat suitability					
Spawning habitat ass.	Upstream	Downstream			1163 Bullhead <i>Cottus gobio</i> Sub-optimal habitat suitability upstream; slightly improved (but still sub-optimal) habitat suitability downstream structure. No shading, no riparian corridor (and lack of associated features e.g. exposed bankside roots), and reinforced banks, but good substrate and flow diversity downstream.
Lithophilic Fish	Moderate	Moderate			
Phytophilic Fish	Poor	Poor			
Channel veg. ass. (%)	Upstream	Downstream		3260 Water courses with <i>Ranunculus fluitans</i> and <i>Callitriche-Batrachion</i> vegetation <i>Ranunculus</i> sp. observed downstream weir due to flow heterogeneity; in contrast, none observed upstream weir as reach impounded and dominated by laminar flow - sub-optimal habitat suitability upstream weir.	
Liverwort/Moss/Lichen	20	5			
Emergent Broad-Leaved				1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i> Sub-optimal habitat suitability upstream and downstream structure due to total absence of channel shading, which is important in maintaining water temperature and inhibiting algal growth for freshwater pearl mussel. Additional Notes: Head difference will be passable to migratory salmonids via fish pass at most flows. Resident brown trout and many coarse fish will be unlikely to pass the structure (moving upstream) at most flows. Eel passage is facilitated by an existing eel pass.	
Emergent Reeds/Sedges	<1	<1			
Floating Leaved (Rooted)					
Free Floating					
Submerged Broad-Leaved					
Submerged Linear-Leaved					
Submerged Fine-Leaved		10			
Filamentous Algae	<1	10			
STRUCTURAL ASSESSMENT				Notes: Round nosed concrete weir with fish pass in centre. The weir is in very good condition. The purpose of the weir is unclear. The upstream road bridge has three piers in the channel. There appears to be a pipe crossing with concrete cover around 20m upstream of the structure. Downstream there are several vegetated islands and an outfall from a culverted watercourse. The levels here are controlled by the weir.	
Approx. height of weir (m):	1.5	Approx. length of weir (m):			
Approx. width of weir (m):	60	Stability:	Very good condition		
OPTIONS					
Options	Benefits	Technical Feasibility	Risks and Considerations	Cost	
Do-nothing	no No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in flow types or sediment patterns.	high The weir is well maintained, and part of an established series of weirs through Kendal.	Maintenance of current conditions - impassable to certain fish, impact on flow regime upstream and impact on sediment transfer.	low	
Full removal PREFERRED OPTION	mod Approximately 14 km of improved connectivity; Improved migratory potential for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish); Direct improvement of 300 m of impounded habitat. Large 300m impacted reach in low gradient channel. Channel migration/modification will be constrained by full bank protection as within urban area. Only variability in flow seen immediately downstream of weir (predominantly riffles) in higher gradient section, with some vegetated gravel islands beyond, features which will return to the impacted reach. Finer sand and gravel deposits currently deposited within the impounded reach will be transported downstream and further bed features develop as seen outside of impounded reach.	low Access is excellent from A roads and footpaths on both banks and park area on left hand bank suitable for site compound. Several trees on the right bank, but no overhead cables were identified. Structural assessment of surrounding buildings and structures required. High structure with significant silt deposits likely behind it. Heritage assessment required.	Potential scour of road bridge and buildings upstream, as well as at the pipe crossing on the channel bed. Structural stability of these structures would require assessment. Water level increases may increase flood risk from the watercourse outfalling downstream. Vegetated mid-channel island would likely be lost and movement of sediment downstream. May get limited improvement in habitat due to highly protected banks. Works would require in channel working. Likely to require consent from the Local Planning Authority as in conservation area.	high	
Partial removal	mod Approximately 14 km of partly improved connectivity. Partly improved migratory routes for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish). Part improvement of 300 m of impounded habitat. Large 300m impacted reach in low gradient channel. Only variability in flow seen immediately downstream of weir (riffles predominate) in higher gradient section, with some vegetated gravel islands beyond, which should partially return to the impacted reach, although not as extensive as for full	low Access is excellent from A roads and footpaths on both banks and park area on left hand bank suitable for site compound. Several trees on the right bank, but no overhead cables were identified. Structural assessment of surrounding buildings and structures required. High structure with significant silt deposits likely behind it. Heritage assessment required.	Existing fish pass and eel pass would become redundant and improvements would be required. Potential scour of road bridge and buildings upstream, as well as at the pipe crossing on the channel bed. Structural stability of these structures would require assessment. Movement of sediment downstream. In channel working would be required. Likely to require consent from the Local Planning Authority as in	high	
Formal/ informal/ easement type fish pass	low No direct improvement in habitat connectivity; Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design). No improvement of 300 m of impounded habitat; no change to morphology.	high Access is excellent from A roads and footpaths on both banks and park area on left hand bank suitable for site compound. Several trees on the right bank, but no overhead cables were identified. Minor improvements to existing pass structure possible.	This option would be to improve or replace the existing fish pass and eel pass. It seems unlikely major improvements could be achieved on the existing structure. Likely to require consent from the Local Planning Authority as in conservation area.	low	

Date of Survey:	14/10/2014	Weir Name:	Weir at Bowston	BACKGROUND INFORMATION:		
Weir ID:	KE04	NGR:	SD 49733 96826	A tree-lined channel surrounded by agricultural fields on the left hand bank and residential properties and gardens (part of Bowston) on the right hand bank. Two structures thought to be fish passes are present on right hand bank and just in-channel from the left hand bank. Weirs KE06 approximately 750m upstream and KE05 approximately 300m downstream; additionally small weir approximately 50m downstream. Pipeline crossing approximately 15m downstream, above channel but with piers in river.		
Watercourse:	River Kent			Water Framework Directive	SSSI	
HISTORICAL VALUE:				Water body ID:	Unit:	
The weir is not designated, and does not lie close to any national designations. Therefore no licensing in this respect is anticipated. High level data searches indicate numerous post-medieval industrial sites (mills, quarries, kilns etc.), but these are likely to be of a low value, and the overall archaeological potential is rated low at this preliminary stage of assessment.				Current status:	Current condition:	
				GB112073071380	112	
				Moderate Ecological Potential	Unfavourable - Recovering	
GEOMORPHOLOGICAL CHARACTER						
Upstream						
Average bankfull width (m):	46.0	Normal low flow width (m):	40.0	Flow diversity:	Uniform in impact zone	
Average bankfull depth (m)	1.5	Normal low flow depth (m):	1.0			
Bank substrate:	Not visible - assumed to be bedrock		Bed substrate:	Predominantly cobbles and pebbles with some silt and leaf litter		
Downstream						
Average bankfull width (m):	25.0	Normal low flow width (m):	20.0	Flow diversity:	Varied	
Average bankfull depth (m)	5.0	Normal low flow depth (m):	0.5			
Bank substrate:	Partially visible - bedrock and bank protection		Bed substrate:	Predominantly cobbles and pebbles, with bedrock and boulders.		
Gradient:	Medium		Flow:	Moderate		
Evidence of modification and instability:	Bank protection (gabion baskets), particularly along right hand bank at the back of residential properties. Piers of pipeline crossing in channel immediately downstream of weir. Over-widened channel behind weir. No evidence of instability.					
Notes:	Water flowing over full width of weir at time of survey. Water ponded for approximately 105m behind weir. Upstream of weir, bed sediment siltier than downstream, with bedrock visible downstream creating greater variation in flow. Vegetated mid-channel island upstream of weir.					
Geomorphological risk of removal:	Moderate					
Potential loss of trees on both banks upstream from drop in water level. Residential properties and gardens on right hand bank at risk from water level drop and erosion and may require bank stabilisation. Bedrock visible within the channel downstream of weir indicating adjustment and movement of channel may be low and therefore pipeline crossing with piers in the channel just downstream of weir may be at low risk from bed adjustment.						
ECOLOGICAL ASSESSMENT						
Extent of Backwater Effect (m)	105.0					
Alternative Passage Available	Yes					
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>					
<i>Migratory Salmonids</i>	✓					
<i>Resident Trout</i>	x					
<i>Coarse Fish</i>	x					
SAC Qualifying feature (not primary reason for site selection) habitat suitability						
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>			
<i>Lithophilic Fish</i>	Moderate	Moderate	Sub-optimal habitat suitability upstream - heavy siltation and lack of shading. Slightly improved (but sub-optimal) suitability downstream; reinforced bank/ low shading, but good substrate and flow diversity, areas of established riparian corridor on left bank, and exposed bankside roots.			
<i>Phytophilic Fish</i>	Moderate	Poor				
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranuncion fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation			
<i>Liverwort/Moss/Lichen</i>	<1	10	No <i>Ranunculus</i> sp. observed upstream or downstream weir. Sub-optimal habitat suitability upstream weir, limited by siltation and lack of flow diversity through impounded reach. Optimal habitat downstream but re-colonisation following historical management may be a limiting factor.			
<i>Emergent Broad-Leaved</i>	<1					
<i>Emergent Reeds/Sedges</i>	10	<1	1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>			
<i>Floating Leaved (Rooted)</i>			Sub-optimal habitat suitability through entire reach. Absence of discrete sand deposits downstream of weir (along with high velocity, turbulent flows), and siltation issues upstream of weir.			
<i>Free Floating</i>	<1					
<i>Submerged Broad-Leaved</i>						
<i>Submerged Linear-Leaved</i>						
<i>Submerged Fine-Leaved</i>			Additional Notes:			
<i>Filamentous Algae</i>	<1		Historical fish pass structure likely still passable to migratory salmonids. As the structure is a step-pool passage with head jumps, it may not be suitable for upstream migration of eel. Many coarse fish will also be unlikely to move upstream over the structure.			
STRUCTURAL ASSESSMENT						
Approx. height of weir (m):	3	Approx. length of weir (m):				
Approx. width of weir (m):	30	Stability:	Generally good condition			
Notes:						
This is a large stone weir. There is a low flow structure in the centre of the channel and there appears to be a dilapidated fish pass on the right hand bank. In addition, there is an old sluice gate on the right hand side with a mill race. The mill no longer exists with residential properties downstream of the structure on the right bank. There is debris including a tree on the weir crest. The weir generally appears to be in good condition although there is a lot of vegetation growth across the structure.						
OPTIONS						
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost	
Do-nothing	no	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in flow types or sediment patterns.		Weir considered to be in good condition.	low	
Full removal	mod	Approximately 2 km of improved connectivity; Improved migratory potential for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish); Direct improvement of 105 m of impounded habitat. Medium sized 105m impounded reach within moderate gradient channel. Any channel migration/modification will be constrained on the right hand bank by bank protection/properties, however agricultural fields on left hand bank will allow for channel adjustment. The greater variety of flow in terms of riffles, glides and turbulent flow within a channel that is predominantly bedrock and boulders, as seen downstream of the weir, would likely return to the impacted reach with the transport and reworking of finer sediments downstream which are currently present in the impacted zone.		Not considered any flood risk issues would arise from a full removal given the high bank levels at the properties. Good access from the field on the left hand bank and space here for a site compound. There is a pipe crossing on the channel and overhead power cables in close proximity. Structural assessment of surrounding buildings and structures required. Flood risk assessment required.	Downstream movement of sediment. Potential scour upstream putting properties and gardens on right hand bank and trees on both banks at risk. Scour protection measures downstream may need to be reviewed and increased appropriately. Would be in-channel working.	high
Partial removal	low	Approximately 2 km of partly improved connectivity; Partly improved migratory routes for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish); Part improvement of 105 m of impounded habitat. The greater variety of flow in terms of riffles, glides and turbulent flow within a channel that is predominantly bedrock and boulders, as seen downstream of the weir, would partially return to the impacted reach with the transport and reworking of finer sediments downstream which are currently present in the impacted zone, although not to the extent as with full removal.		Not considered to be a realistic option as it would provide less benefits than full removal without reducing the risks significantly.	Not restoring full natural flow and sediment processes. Would be in-channel working. Scour protection measures downstream may need to be reviewed and increased appropriately.	high
Formal/ informal/ easement type fish pass	low	No direct improvement in habitat connectivity; Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design). No improvement of 105 m of impounded habitat; no change to morphology.		Access is difficult to the fish pass structure on the right bank. Fish pass structure likely to be large to overcome the existing structure. Additional eel pass may be required.	This option would be to improve or replace part of the existing fish pass structure on the right hand bank. Would be in-channel working.	mod

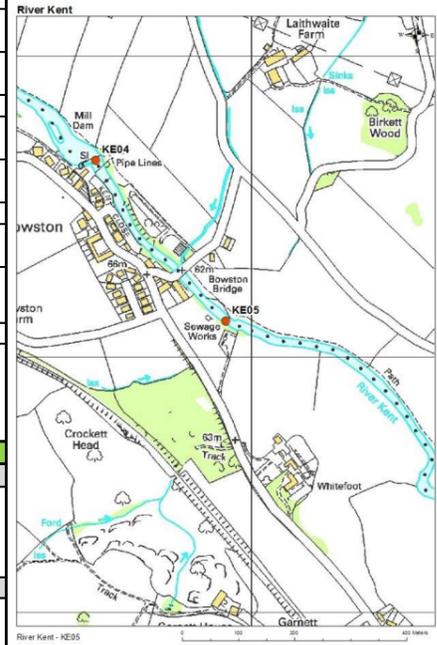


View of weir from left hand bank. (SD 49733 96826)



View upstream of weir from left hand bank. (SD 49733 96826)

Date of Survey:	14/10/2014	Weir Name:	Bowston EA gauging station	BACKGROUND INFORMATION:		
Weir ID:	KE05	NGR:	SD 49947 96549	This weir is part of an Environment Agency gauging station. A tree-lined channel which is surrounded on both banks by agricultural fields. Small water treatment works present on right hand bank approximately 30m downstream. Road bridge crosses approximately 90m upstream and properties associated with Bowston are present by the bridge. Weir KE04 is present approximately 300m upstream.		
Watercourse:	River Kent					
HISTORICAL VALUE:						
The weir is not designated, and does not lie close to any national designations. Therefore no licensing in this respect is anticipated. High level data searches indicate numerous post-medieval industrial sites (mills, quarries, kilns etc.), but these are likely to be of a low value, and the overall archaeological potential is rated low at this preliminary stage of assessment.						
GEOMORPHOLOGICAL CHARACTER						
Upstream						
Average bankfull width (m):	20.0	Normal low flow width (m):	15.0	Flow diversity:	Uniform in impact zone	
Average bankfull depth (m):	3.0	Normal low flow depth (m):	0.8			
Bank substrate:	Earth		Bed substrate:	Predominantly cobbles, pebbles and gravels with some sand		
Downstream						
Average bankfull width (m):	22.0	Normal low flow width (m):	20.0	Flow diversity:	Varied - riffles predominate	
Average bankfull depth (m):	2.0	Normal low flow depth (m):	0.5			
Bank substrate:	Earth with some bedrock outcrops visible		Bed substrate:	Predominantly cobbles, pebbles and gravels with some sand		
Gradient:	Medium		Flow:	Moderate		
Evidence of modification and instability:	Bank protection around the weir. Small areas of bank slumping evident, however appear stable.					
Notes:	Water flowing over full width of weir at time of survey. Small length of ponding (40m) behind the weir. Minimal differences in bed sediment composition and flow types between upstream and downstream. Overall, weir appearing to have minimal impact within the channel. Assumed some management of channel within the vicinity of the gauging station.					
Geomorphological risk of removal:	Low					
No infrastructure or trees considered to be at risk near the weir as water level drop and erosion will be minimal from weir removal. Upstream bed material will be reworked downstream, however this is of similar composition to bed sediments currently downstream.						
ECOLOGICAL ASSESSMENT						
Extent of Backwater Effect (m)	40.0					
Alternative Passage Available	No					
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>					
<i>Migratory Salmonids</i>	✓					
<i>Resident Trout</i>	✓					
<i>Coarse Fish</i>	✓					
SAC Qualifying feature habitat suitability						
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>			
Lithophilic Fish	Good	Good	Optimal downstream suitability; sub-optimal upstream suitability (limited by reinforced banks and less established riparian corridor). Good substrate and flow diversity throughout, some exposed bankside roots; shading could be higher throughout channel, but is not considered to be limiting.			
Phytophilic Fish	Poor	Poor	SAC Qualifying feature (not primary reason for site selection) habitat suitability			
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranunculus fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation			
Liverwort/Moss/Lichen	10	20	No <i>Ranunculus</i> sp. observed upstream or downstream weir. Optimal habitat suitability exists (downstream weir in particular), but re-colonisation following historical management may be limiting factor.			
Emergent Broad-Leaved			1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>			
Emergent Reeds/Sedges		5	Sub-optimal habitat suitability through substrate composition (clean rocky substrates with interstitial sand/gravels), but low channel shading, which is important in maintaining water temperature and inhibiting algal growth for freshwater pearl mussel.			
Floating Leaved (Rooted)			Additional Notes:			
Free Floating			Structure passable to all fish species at most flows due to the very small head difference. Upstream migration of eel should also be possible, as the structure will drown out at many flows, removing the head-jump.			
Submerged Broad-Leaved		<1				
Submerged Linear-Leaved						
Submerged Fine-Leaved						
Filamentous Algae						
STRUCTURAL ASSESSMENT						
Approx. height of weir (m):	0.5	Approx. length of weir (m):				
Approx. width of weir (m):	12	Stability:	Good condition			
Notes:						
The weir is of concrete construction and is in good condition. The associated kiosk is situated on the right hand bank. There are no structures upstream or downstream within a reach affected by the structure.						
OPTIONS						
Options	Benefits		Technical Feasibility		Risks and Considerations	Cost
Do-nothing	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision.		Weir is considered to be in good condition. The weir is likely to drown out at fairly low flows allowing passage of all fish species.		Maintenance of current conditions - impact on flow regime upstream and impact on sediment transfer.	low
PREFERRED OPTION	no		high			
Full removal	low		mod		Loss of the Environment Agency gauging station. The benefits from removal would be small for a short reach of channel. Potential in channel working required.	mod
Partial removal	low		low		The structure is too small to justify a partial removal. Loss of the Environment Agency gauging station. Potential in channel working required.	mod
Formal/informal/easement type fish pass	no		mod		The structure is too small to justify a fish pass. Loss in accuracy of the Environment Agency gauging station.	low

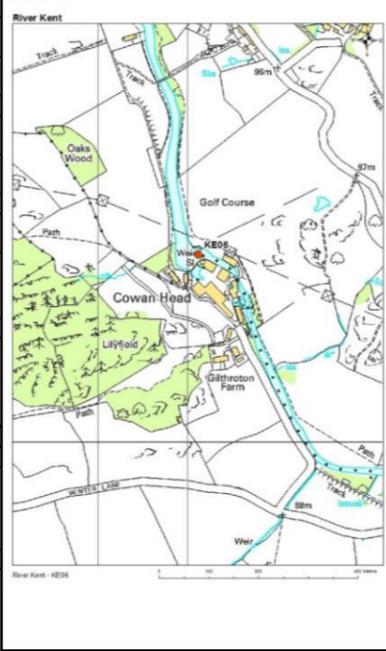


View upstream of weir from right hand bank. (SD 49947 96549)



View of weir from left hand bank. (SD 49947 96549)

Date of Survey:	14/10/2014	Weir Name:	Weir at Cowan Head	BACKGROUND INFORMATION:			
Weir ID:	KE06	NGR:	SD 4919897395	A tree-lined channel surrounded by a golf course and agricultural land on the left hand bank, and residential properties (part of Cowan Head) on the right hand bank and left hand bank. A fish pass (Cowan Head Fish Pass) is present on the left hand bank. An abstraction licence is recorded for the weir for a lake and pond throughflow, thought to be on the right hand bank. A public footpath follows the left hand bank and a footbridge crosses the channel approximately 80m downstream.			
Watercourse:	River Kent			Water Framework Directive	SSSI		
HISTORICAL VALUE:				Water body ID:	GB112073071380		
The weir is not designated, and does not lie close to any national designations. Therefore no licensing in this respect is anticipated. High level data searches indicate numerous post-medieval industrial sites (mills, quarries, kilns etc.), but these are likely to be of a low value, and the overall archaeological potential is rated low at this preliminary stage of assessment.				Current status:	Moderate Ecological Potential		
GEMORPHOLOGICAL CHARACTER				Unit:	112		
Upstream				Current condition: Unfavourable - Recovering			
Average bankfull width (m):	35.0	Normal low flow width (m):	28.0	Flow diversity: Uniform in impact zone			
Average bankfull depth (m):	1.5	Normal low flow depth (m):	1.0				
Bank substrate:	Partially visible - bedrock	Bed substrate:	Predominantly pebbles with silt and gravels.				
Downstream							
Average bankfull width (m):	25.0	Normal low flow width (m):	15.0	Flow diversity: Varied - gorge area with steps and pools.			
Average bankfull depth (m):	10.0	Normal low flow depth (m):	1 (difficult to see)				
Bank substrate:	Partially visible - bedrock	Bed substrate:	Partially visible - bedrock.				
Gradient:	High	Flow:	Moderate				
Evidence of modification and instability:	Bank protection around weir and along residential properties. Downstream footbridge piers in channel. Over-widened upstream of weir. No evidence of instability.						
Notes:	Water flowing over full width of weir at time of survey. Water ponded for approximately 120m behind weir. Immediately downstream of weir, channel is very steep and constrained within a gorge-like bedrock channel with steps and pools causing great variability in flow. In comparison, flow is uniform in ponded area behind the weir. Bed sediments more variable and finer upstream of the weir.						
Geomorphological risk of removal:	Moderate						
Residential properties are built into the bank with full bank protection and may be at risk from erosion and changes in water levels and need further reinforcement. Residential gardens are also present on the right hand bank upstream of the weir which may be at risk from water level drop and erosion and require bank stabilisation works. Agricultural land/golf course land use elsewhere which will allow channel adjustment. Vegetated island upstream of weir is at risk from water level drop and erosion and may cause significant sediment redistribution downstream. Bedrock outcrops are visible downstream which may mean that channel adjustment will be fairly low and predictable, although a topographic survey will have to verify this.							
ECOLOGICAL ASSESSMENT							
Extent of Backwater Effect (m)	120.0	SAC Qualifying feature habitat suitability					
Alternative Passage Available	Yes	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>					
Structure Passable		Sub-optimal habitat suitability overall. Heavy siltation upstream of weir and lack of established riparian corridors and associated features. Reinforced banks downstream of weir, and high gradient, high velocity, turbulent flows.					
Migratory Salmonids	✓						
Resident Trout	✓						
Coarse Fish	✓/x	SAC Qualifying feature (not primary reason for site selection) habitat suitability					
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>				
Lithophilic Fish	Poor	Poor	Sub-optimal habitat suitability overall. Heavy siltation upstream of weir and lack of established riparian corridors and associated features. Reinforced banks downstream of weir, and high gradient, high velocity, turbulent flows.				
Phytophilic Fish	Poor	Poor					
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranuncion fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation				
Liverwort/Moss/Lichen	<1	40	No <i>Ranunculus</i> sp. observed upstream or downstream weir. Habitat suitability is sub-optimal throughout reach. Heavy siltation and uniform, laminar flows upstream of the structure; reinforced banks and high gradient, high velocity and turbulent flows.				
Emergent Broad-Leaved	<1						
Emergent Reeds/Sedges	5		1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>				
Floating Leaved (Rooted)			Sub-optimal habitat suitability throughout. Absence of discrete sand deposits downstream of weir (along with high velocity, turbulent flows), and siltation issues upstream of weir.				
Free Floating							
Submerged Broad-Leaved	<1						
Submerged Linear-Leaved			Additional Notes:				
Submerged Fine-Leaved			Structure passable to most fish species due to the presence of fish pass. Water levels within the fish pass were noted as low at the time of survey; some maintenance may be required to reduce sediment in the steps and clear inlet/outlet. As the structure is a step-pool passage with head jumps, it may not be suitable for upstream migration of eel.				
Filamentous Algae							
STRUCTURAL ASSESSMENT							
Approx. height of weir (m):	3	Approx. length of weir (m):	2				
Approx. width of weir (m):	20	Stability:	Fair condition				
Notes:							
The structure is adjacent to an old paper mill (now residential apartments), with a sluice gate and fixings evident on the right bank. The sluice gate is in poor condition and is collecting debris. It has previously been noted the sluice requires replacement or removal. There are some defects evident but overall the structure is in a fair condition. The mill on the right bank is immediately adjacent the structure and channel. Properties upstream on the right bank are set back from the channel and pond. No more buildings or structures are considered to be impacted for a significant distance upstream. A large access bridge downstream is not impacted by the channel.							
OPTIONS							
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost		
Do-nothing	no	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in flow types or sediment patterns.		high	Weir is considered to be in fair condition. A full condition assessment may be required.	Maintenance of current conditions - potential impact on eel migration, flow regime upstream and impact on sediment transfer. Works will still be required to the sluice gate on the right hand side of the structure due to the poor condition. There will be ongoing maintenance associated with the sluice and fish pass.	low
Full removal	high	Approximately 5 km of improved connectivity; Improved migratory potential for all species (removal of barrier to some coarse fish); Direct improvement of 120 m of impounded habitat. Moderate size 120m impounded reach in high gradient channel with 3 m high weir. Bedrock gorge area with steps, pools and turbulent flow immediately downstream of weir and pool riffles beyond would likely return to impacted area with finer deposits being reworked downstream. Channel migration/modification limited particularly on right hand bank with bank protection around residential properties, greater mobility on left hand bank with golf course and agricultural fields.		mod	Good access through residential car park on right hand bank or through golf course on left hand bank, with site compound located on the edge of the golf course or within the residential development grounds. There are overhead power lines on the left hand bank. There is no access from downstream of the weir. There is a lot of tree cover on the left hand bank. Heritage assessment required. May require additional works to address loss of abstraction to residents ponds.	Downstream movement of fine sediment. Would need to investigate if alteration to abstraction intake possible so licence can be fulfilled. Alterations to channel upstream are likely to be significant - which will have an impact on habitat and the existing ponded zone, which is of concern to the local residents. Existing fish pass will become redundant. May be structural implications at the foundations of the old paper mill (now residential properties) on the right hand bank. May require in-channel works.	high
Partial removal	mod	Approximately 5 km of partly improved connectivity; Partly improved migratory potential for all species (removal of barrier to some coarse fish); Part improvement of 120 m of impounded habitat. Moderate size 120 m impounded reach in high gradient channel with 3m high weir. Bedrock gorge area with steps, pools and turbulent flow immediately downstream of weir and pool riffles beyond would likely partially return to impacted area, although not to such an extent as with the full removal.		mod	Good access through residential car park on right hand bank or through golf course on left hand bank, with site compound located on the edge of the golf course or within the residential development grounds. There are overhead power lines on the left hand bank. There is no access from downstream of the weir. There is a lot of tree cover on the left hand bank. Heritage assessment required. May require additional works to address loss of abstraction to residents ponds. A full condition assessment and additional works at the sluice gate may be required.	Potentially affect attraction flows at the existing fish pass and associated works would be required. Assessment of the structural stability of the paper mill would be required.	high
Formal/informal/easement type fish pass	no	No direct improvement in habitat connectivity. Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design). No improvement of 120m of impounded habitat; no change to morphology.		mod	The existing fish pass is in good condition with some minor maintenance requirements to reduce vegetation at the inlet and sediment in the pools. Good access through residential car park on right hand bank or through golf course on left hand bank, with site compound located on the edge of the golf course or within the residential development grounds. There are overhead power lines on the left hand bank. There is no access from downstream of the weir. There is a lot of tree cover on the left hand bank. A full condition assessment and additional works at the sluice gate may be required.	Any option would be for improvements or replacement to the existing fish pass.	low

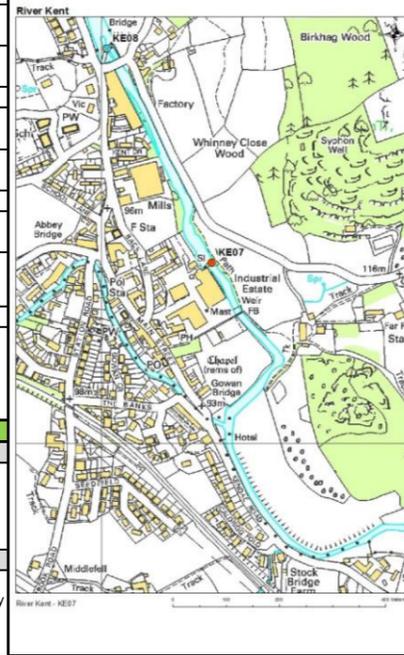


View upstream of weir from left hand bank. (SD 4919897395)



View upstream of weir from footbridge (SD 4928497334)

Date of Survey:	13/10/2014	Weir Name:	Weir at Staveley	BACKGROUND INFORMATION:		
Weir ID:	KE07	NGR:	SD 47214 98355	A tree-lined channel in a deep valley. This weir currently has a fish pass (Staveley Wood Turning Weir fish pass) on the left hand bank. The river is predominantly surrounded by rough pasture fields on the left hand bank, with residential properties and an old mill (now an industrial estate) within Staveley on the right hand bank. Weir (KE08) approximately 430m upstream. Footbridge over river approximately 90 metres downstream with footpath along left hand bank. Two abstraction licences recorded for this weir: for hydroelectric power generation and industrial, commercial and public services general		
Watercourse:	River Kent			Water Framework Directive	SSSI	
HISTORICAL VALUE:				Water body ID:	Unit:	
The weir is not designated, and does not lie close to any national designations. Therefore no licensing in this respect is anticipated. High level data searches indicate numerous post-medieval industrial sites (mills, quarries, kilns etc.), but these are likely to be of a low value, and the overall archaeological potential is rated low at this preliminary stage of assessment.				Current status:	Current condition:	
				GB112073071390	107	
				Good Ecological Status	Unfavourable - No change	
GEMORPHOLOGICAL CHARACTER						
Upstream						
Average bankfull width (m):	31.0	Normal low flow width (m):	30.0	Flow diversity:	Uniform within impact zone.	
Average bankfull depth (m)	2.0	Normal low flow depth (m):	0.4			
Bank substrate:	Earth and fine gravels.		Bed substrate:	Predominantly cobbles and pebbles, with a fine layer of silt.		
Downstream						
Average bankfull width (m):	21.0	Normal low flow width (m):	15.0	Flow diversity:	Varied and complex - riffle/glide sequence predominate.	
Average bankfull depth (m)	2.0	Normal low flow depth (m):	0.4			
Bank substrate:	Not visible - assumed to be predominantly earth with bedrock outcrops.		Bed substrate:	Predominantly cobbles, with pebbles, gravels and boulders. Some sand. Not as much leaf litter as upstream bed.		
Gradient:	Medium		Flow:	Moderate		
Evidence of modification and instability:	Bank protection, particularly downstream on right hand bank. Re-sectioned and straightened channel. Exposed bank toe upstream of weir, but appears stable.					
Notes:	Water flowing over the full width of the weir at time of survey. Water ponded for approximately 230m behind weir. Bed substrate behind weir more gravelly than downstream, and flow exhibiting greater variability downstream from gravel riffles. Water flowing down fish pass at time of survey. Coarse gravel riffles in channel downstream of weir.					
Geomorphological risk of removal:	Moderate					
Industrial buildings (old mill) form part of the right hand river bank alongside, and downstream of, the weir which are at risk from erosion and water level drop which may require further underpinning and maintenance. Residential building and gardens are also present on the right hand bank, upstream of the weir, which again may require additional works to stabilise the bank to prevent erosion. There is a footpath and road on the left hand bank which may be at risk if there is bank erosion. The sediment upstream is predominantly cobbles and pebbles, with some silts, which will be reworked downstream.						
ECOLOGICAL ASSESSMENT						
Extent of Backwater Effect (m)	230.0					
Alternative Passage Available	Yes					
Structure Passable						
<i>Migratory Salmonids</i>	✓					
<i>Resident Trout</i>	✓					
<i>Coarse Fish</i>	✓/x					
Spawning habitat ass.		SAC Qualifying feature habitat suitability				
	Upstream	Downstream	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>			
Lithophilic Fish	Good	Good	Optimal habitat suitability upstream and downstream. Good substrate diversity, extensive undercutting, exposed bankside roots, shading and detritus. No sedimentation issues. Slightly reduced suitability downstream (lack of riparian corridor on right bank), but not considered limiting.			
Phytophilic Fish	Poor	Poor				
		SAC Qualifying feature (not primary reason for site selection) habitat suitability				
	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>			
Lithophilic Fish	Good	Good	Optimal habitat suitability downstream; sub-optimal upstream. Good substrate diversity, extensive undercutting, exposed bankside roots, shading and detritus (upstream of weir in particular). Flow heterogeneity downstream of structure; uniform upstream. Good refuge throughout.			
Phytophilic Fish	Poor	Poor				
Channel veg. ass. (%)		3260 Water courses with <i>Ranunculus fluitans</i> and <i>Callitriche-Batrachion</i> vegetation				
Liverwort/Moss/Lichen	10	10	None observed. Optimal suitability exists - flow/substrate composition (downstream of weir), although extensive shading may be an issue, as well as lack of re-colonisation following historical management.			
Emergent Broad-Leaved	<1					
Emergent Reeds/Sedges			1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>			
Floating Leaved (Rooted)			Optimal suitability downstream structure (discrete sand deposits in gravel/pebble substrates, with flow heterogeneity and riparian shading). Sub-optimal upstream due to lack of flow diversity.			
Free Floating						
Submerged Broad-Leaved			Additional Notes:			
Submerged Linear-Leaved			Structure passable to most fish species due to formal fish pass on left bank. As the structure is a step-pool passage with head jumps, it may not be suitable for upstream migration of eel.			
Submerged Fine-Leaved						
Filamentous Algae						
STRUCTURAL ASSESSMENT						
Approx. height of weir (m):	3	Approx. length of weir (m):	5			
Approx. width of weir (m):	15	Stability:	poor			
Notes:						
The weir is a stone construction, with an existing fish pass having been constructed on the left bank. There is evidence of a partial collapse in the centre of the weir. Mill race, sluice and pipework is still evident on site. Downstream, there is a footbridge around 100m remote from the weir; no part of the structure is within the channel and it will not be impacted. There are some exposed tree roots on the banks upstream but generally the channel appears stable with little evidence of scour.						
OPTIONS						
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost	
Do-nothing	no	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in flow types or sediment patterns.		The channel seems stable; there is limited risk of bank and bed scour with the weir in place. A fish pass is already present which is maintained by the Environment Agency. Condition assessment required as partial collapse of the weir has occurred.	Maintenance of current conditions - potential impact on eel migration, impact on flow regime upstream and impact on sediment transfer. Unmanaged, maintenance of current conditions could lead to upstream scour, and structural stability issues at the buildings. Given the condition of the weir, there is a risk of total collapse.	low
Full removal	mod	Approximately 3 km of improved connectivity; Improved migratory potential for all species (removal of barrier to spawning and local migrations for some coarse fish); Direct improvement of 230 m of impounded habitat. Large size 230m impounded reach in moderate gradient channel with 3m high weir. Channel migration/modification will be constrained by some bank protection along the right hand bank and may have to be constrained along the left hand bank due to a public footpath and road. Predominantly riffle flow observed downstream of the weir is likely to return to impacted reach with full weir removal, along with downstream reworking of sediments, including fines, from the impacted reach.		Industrial site off road with potential areas for site compound on right hand bank. However, access is tight between buildings (approx. 5m width) and with overhead cables. Access from the left hand bank would require temporary removal of a wall and closure of a footpath. High structure is likely to have significant sediment deposits behind it.	May impact upon the structural stability of the buildings on the right hand bank. Downstream sediment movement. The existing fish pass would become redundant. In the context of the river, works here would have negligible benefit without additional works at the weir upstream. Potential loss of abstraction licence; would need to investigate if alteration to abstraction intake is possible. In channel working likely required.	high
Partial removal	mod	Approximately 3 km of partly improved connectivity; Partly improved migratory potential for all species (removal of barrier to spawning and local migrations for some coarse fish); Part improvement of 230 m of impounded habitat. Large size 230m impounded reach in moderate gradient channel with 3m high weir. Predominantly riffle flow observed downstream of the weir is likely to partially return to impacted reach, along with partial downstream reworking of sediments, including fines, from the impacted reach, although not to the extent as with full weir removal.		Partial removal already been undertaken for instalment of the fish pass, so is considered feasible. Industrial site off road with potential areas for site compound on right hand bank. However, access is tight between buildings (approx. 5m width) and with overhead cables. Access from the left hand bank would require temporary removal of a wall and closure of a footpath. High structure is likely to have significant sediment deposits behind it.	Any additional partial removal is unlikely to improve upon the existing fish pass and may impact upon the attraction flows reaching the fish pass inlet. Loss of abstraction licences.	mod
Formal/ informal/ easement type fish pass	no	No direct improvement in habitat connectivity; Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design). No improvement of 230 m of impounded habitat; no change to morphology.		Minor improvements possible; there is a good amount of space available on the left hand bank for an improved fish pass. Good attraction flows. Industrial site off road with potential areas for site compound on right hand bank. However, access is tight between buildings (approx. 5m width) and with overhead cables. Access from the left hand bank would require temporary removal of a wall and closure of a	Fish pass already present.	low

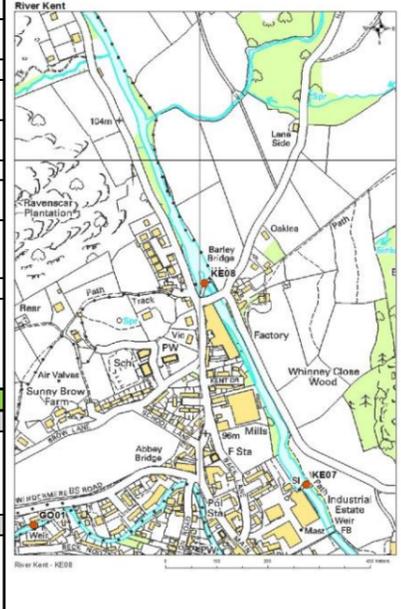


View upstream of weir from left hand bank. (SD 47214 98355)



View of weir and fish pass from left hand bank. (SD 47214 98355)

Date of Survey:	13/10/2014	Weir Name:	Weir at Barley Bridge, Staveley		BACKGROUND INFORMATION: A partially tree-lined channel in a deep valley. This weir currently has a fish pass (Barley Bridge fish pass) on the left hand bank. The river is predominantly surrounded by rough pasture fields, with residential properties (part of Staveley) and a factory on right hand bank. Road bridge approx. 30m downstream, with pier in the channel, and road runs along the right hand bank. Next weir is approx. 430m downstream (KE07).		
Weir ID:	KE08	NGR:	SD4699798725				
Watercourse:	River Kent						
HISTORICAL VALUE: A LBI (Listed Building Grade II, Barley Bridge) is close to the weir and changes to its setting may require liaison with the LPA (Local Planning Authority). High level data searches indicate numerous post-medieval industrial sites (mills, quarries, kilns etc.), but these are likely to be of a low value, and the overall archaeological potential is rated low at this preliminary stage of assessment.							
GEOMORPHOLOGICAL CHARACTER							
Upstream							
Average bankfull width (m):	35.0	Normal low flow width (m):	25.0	Flow diversity:	Uniform in impact zone.		
Average bankfull depth (m):	1.5	Normal low flow depth (m):	0.3				
Bank substrate:	Partially visible as heavily vegetated banks - bare earth and some walling visible.		Bed substrate:	Partially visible - gravels and sands.			
Downstream							
Average bankfull width (m):	20.0	Normal low flow width (m):	15.0	Flow diversity:	Varied - riffles predominate from cobbles and bedrock.		
Average bankfull depth (m):	2.0	Normal low flow depth (m):	0.8				
Bank substrate:	Partially visible - predominantly earth with some bedrock visible.		Bed substrate:	Predominantly bedrock, boulders and cobbles, with some finer gravels and sands.			
Gradient:	Medium		Flow:	Moderate			
Evidence of modification and instability:	Road bridge approximately 30m downstream of weir. Bank protection - placed stones - downstream of weir on both banks. Channel over-widened immediately behind weir. No active bank erosion visible. Some bare toe banks visible downstream, but appear stable.						
Notes:	Water flowing over the full width of the weir at the time of the survey. Water ponded for approximately 300m behind weir, just downstream of small tributary flowing in on left hand bank. Behind weir, water shallow and sediment nearly up to top of weir. Vegetated island upstream of weir in centre of channel. Difficult to view bed substrate upstream of weir, however appears finer sediments are present upstream than downstream. Immediately downstream of weir channel is steeper.						
Geomorphological risk of removal:	Moderate						
Roadbridge with piers in the channel immediately downstream which may be at risk from bed adjustment. Industrial building on right hand bank and residential building and garden on left hand bank immediately downstream of weir which may be at risk from channel adjustment and banks may need further reinforcement here. Potential loss of trees on both banks upstream from water level drop and scour of vegetated island upstream leading to sediment mobilisation and reworking downstream. Bedrock visible in channel downstream of weir, suggesting channel movement will be reduced and not rapid. Road along right hand bank upstream of weir may be at risk from erosion of bank and may need additional bank protection.							
ECOLOGICAL ASSESSMENT							
Extent of Backwater Effect (m)	300.0						
Alternative Passage Available	Yes						
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>						
Migratory Salmonids	✓						
Resident Trout	✓						
Coarse Fish	✓/✗						
SAC Qualifying feature (not primary reason for site selection) habitat suitability							
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>				
Lithophilic Fish	Good	Good	Optimal habitat suitability downstream structure. Clean gravels, flow heterogeneity, and good refuge upstream and downstream of weir. Flow diversity is limited upstream meaning habitat is sub-optimal for bullhead.				
Phytophilic Fish	Moderate	Moderate					
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranunculus fluitans</i> and <i>Callitriche-Batrachion</i> vegetation				
Liverwort/Moss/Lichen		10	Optimal habitat suitability exists (downstream of weir in particular) - flow and substrate suitable in places; re-colonisation following historical management could be an issue.				
Emergent Broad-Leaved							
Emergent Reeds/Sedges			1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>				
Floating Leaved (Rooted)			None observed. Sub-optimal habitat suitability; discrete sand deposits in gravel/pebble substrates, but shading is limited, which is important in maintaining water temperature and inhibiting algal growth for freshwater pearl mussel.				
Free Floating							
Submerged Broad-Leaved							
Submerged Linear-Leaved			Additional Notes:				
Submerged Fine-Leaved	5		Existing fish pass will be passable to most fish species at a range of flow conditions. As the structure is a step-pool passage with head jumps, it may not be suitable for upstream migration of eel.				
Filamentous Algae							
STRUCTURAL ASSESSMENT							
Approx. height of weir (m):	3 - 4	Approx. length of weir (m):	2 - 3				
Approx. width of weir (m):	30	Stability:	Good condition.				
Notes:							
The weir is of stone construction and is generally in a good condition. There are some minor defects where stones are missing. The structure is for an old Mill Race, still evident on the right hand bank with associated fittings (sluice etc.). There is an existing pool and traverse fish pass structure on the left hand bank, which appears in reasonable condition with a few minor defects and leaks noted.							
OPTIONS							
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost		
Do-nothing	no	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in flow types or sediment patterns.		mod	Weir is currently in good condition. Maintenance of the fish pass will be carried out by the Environment Agency.	Maintenance of current conditions - potential impact on eel migration, flow regime upstream and impact on sediment transfer, with dominance of finer sediments upstream.	low
Full removal PREFERRED OPTION	high	Approximately 15 km of improved connectivity; Improved migratory potential for all species (removal of barrier to spawning and local migrations for some coarse fish); Direct improvement of 300 m of impounded habitat. Large 300m impounded reach in moderate gradient channel with 3-4m high weir. Riffles and turbulent flow predominate in bedrock and boulder channel downstream of weir, which is likely to return to impacted reach with removal of the weir. Channel migration/modification will be possible on left hand bank which is predominantly agricultural land.		mod	Access good on left hand bank from the fields, including space for a compound, and access good on right hand bank with road. Environment Agency have access for maintenance of the fish pass on left hand bank. Heritage and structural assessments at bridge and buildings downstream required. Flood risk assessment required. High structure with likely significant deposits of sediment behind it.	Scour of downstream bridge may put it at risk of collapse. Scour upstream and risk to road on right hand bank, potential loss of trees on both banks and scour of vegetated island. Existing fish pass would become redundant. Release of large volumes of sediment. Proximity to listed building, may require liaison with Local Planning Authority.	high
Partial removal	mod	Approximately 15 km of partly improved connectivity; Partly improved migratory routes for all species (removal of barrier to spawning and local migrations for some coarse fish); Part improvement of 300 m of impounded habitat. Large 300m impounded reach in moderate gradient channel with 3-4m high weir. Riffles and turbulent flow predominate in bedrock and boulder channel downstream of weir, which is likely to partially return to		mod	Access good on left hand bank from the fields, including space for a compound, and access good on right hand bank with road. Environment Agency have access for maintenance of the fish pass on left hand bank. Heritage and structural assessments at bridge and buildings downstream required. Flood risk assessment required. High structure with likely significant deposits of sediment behind it.	Scour upstream and risk to road on right hand bank, potential loss of trees on both banks and scour of vegetated island. Existing fish pass would become redundant without modification works. No benefit over full removal with limited reduction in risks. Proximity to listed building, may require liaison with Local Planning Authority.	high
Formal/ informal/ easement type fish pass	low	No direct improvement in habitat connectivity; Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design); No improvement of 300 m of impounded habitat; no change to morphology.		mod	Improvements and maintenance to existing fish pass is an option. Access good on left hand bank from the fields, including space for a compound, and access good on right hand bank with road. Environment Agency have access for maintenance of the fish pass on left hand bank. Eel pass could be added to the structure.	Current fish pass in place, so would be works to improve or replace existing fish pass. Proximity to listed building, may require liaison with Local Planning Authority.	low

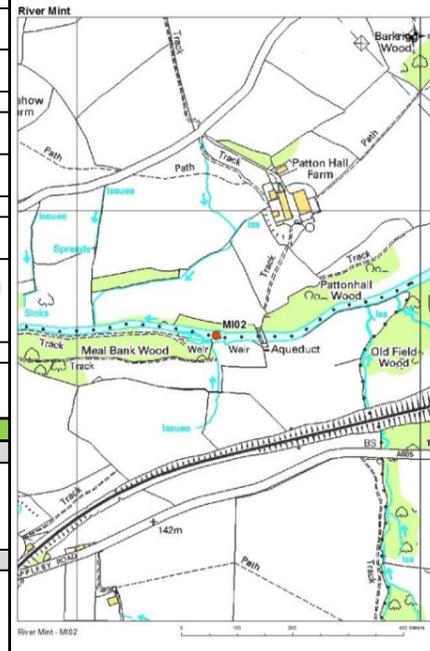


View upstream of weir from right hand bank (SD 47026 98719)



View of Barley Bridge fish pass on left hand bank (SD 47028 98742)

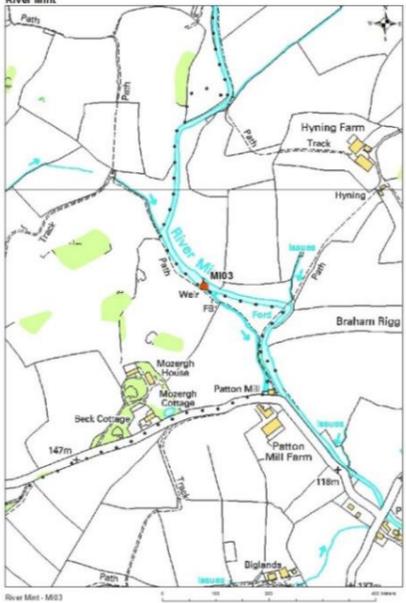
Date of Survey:	14/10/2014	Weir Name:	Weir upstream of Meal Bank	BACKGROUND INFORMATION:	
Weir ID:	MI02	NGR:	SD 5462495770	A tree-lined channel within a steep valley. This weir has a fish pass in the centre of the structure and there is a by-pass structure on the left hand bank, which was dry at the time of the survey. Surrounded by agricultural fields on both banks, with an industrial unit area approximately 600m downstream on the left hand bank and an aqueduct structure crossing the channel approximately 80m upstream with a small weir structure in the channel. Access was not possible upstream of the weir.	
Watercourse:	River Kent			Water Framework Directive	
HISTORICAL VALUE:				Water body ID:	GB112073071370
The weir is not designated, and no licensing requirements are anticipated. The site is located in a medieval landscape, with some archaeological remains of that date present downstream, but the overall archaeological potential is, at this preliminary stage of assessment, expected to be low.				Current status:	Good Ecological Status
GEOMORPHOLOGICAL CHARACTER				SSSI	Unit: 110
Upstream				Current condition: Unfavourable - Recovering	
Average bankfull width (m):	32.5	Normal low flow width (m):	20.0	Flow diversity: Uniform.	
Average bankfull depth (m)	10.0	Normal low flow depth (m):	1.0	Bank substrate: Unable to access and vegetated banks.	
Bed substrate:		Bed substrate: Predominantly cobbles and pebbles, with some gravels, sand and boulders.			
Downstream				Flow diversity: Varied, with riffle glide sequences dominating downstream.	
Average bankfull width (m):	32.5	Normal low flow width (m):	20.0	Bank substrate: Not visible - vegetated banks.	
Average bankfull depth (m)	10.0	Normal low flow depth (m):	0.7	Bed substrate: Predominantly cobbles and pebbles, with some boulders, gravels and sand. Some bedrock outcrops.	
Flow:		Flow: Moderate			
Gradient:		Gradient: Medium			
Evidence of modification and instability:		Evidence of modification and instability: Bank protection around weir.			
Notes:		Water flowing over full width of weir at time of survey. Unable to access upstream of weir, but additional small weir noted upstream near aqueduct structure and ponding thought to extend for 100m. Sediment deposition visible up to near weir crest behind weir. Minimal difference in bed sediment composition upstream and downstream of weir, being predominantly cobbles and pebbles. Tree stump from felling near left bank upstream of weir indicates some management. Variability in flow downstream from deposited cobbles and boulders. Some large woody debris in channel upstream of weir.			
Geomorphological risk of removal		Geomorphological risk of removal low			
Weir is surrounded by agricultural land, which allows space for the channel and reduces the risk of any adjustment. There is the potential for tree loss along the banks due to drops in water level. A small weir noted upstream is potentially at risk from any bed adjustment. Sediment upstream is predominantly cobbles and pebbles which will be reworked downstream.					
ECOLOGICAL ASSESSMENT					
Extent of Backwater Effect (m)		100.0			
Alternative Passage Available		Yes			
Structure Passable		1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>			
Migratory Salmonids		✓/*			
Resident Trout		x			
Coarse Fish		x			
Spawning habitat ass.		SAC Qualifying feature (not primary reason for site selection) habitat suitability			
Upstream		1163 Bullhead <i>Cottus gobio</i>			
Downstream		Sub-optimal habitat suitability upstream of weir; optimal suitability downstream of weir. Established riparian corridor and associated features. Good substrate diversity, with no siltation issues; larger substrates for shelter. Flow diversity limited upstream reducing habitat suitability.			
Lithophilic Fish		Good			
Phytophilic Fish		Poor			
Channel veg. ass. (%)		3260 Water courses with <i>Ranunculus fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation			
Upstream		No <i>Ranunculus</i> sp. observed upstream or downstream weir. Some optimal habitat suitability (downstream weir) due to substrate/flow diversity, but re-colonisation following historical management may be limiting factor.			
Downstream		1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>			
Liverwort/Moss/Lichen		15			
Emergent Broad-Leaved					
Emergent Reeds/Sedges					
Floating Leaved (Rooted)					
Free Floating					
Submerged Broad-Leaved					
Submerged Linear-Leaved					
Submerged Fine-Leaved					
Filamentous Algae		<1			
Additional Notes:		Migratory salmonids were observed leaping, but not clearing the central fish pass during survey. The fish pass will be passable to migratory salmonids only. At some flows the wider structure may become passable to a range of species as the head jump reduces, but the structure is likely to form a significant barrier to many fish (including eel) at most flows.			
STRUCTURAL ASSESSMENT					
Approx. height of weir (m):		2		Approx. length of weir (m):	
Approx. width of weir (m):		17.5		Stability: Good condition	
Notes:					
The structure is a round nosed weir with lock gates on the left bank to a bypass channel. An existing fish pass has been installed in the centre of the channel. The structure is in good condition, although there is a lot of debris build up and a tree is stuck on the crest. The purpose of the structure is unclear. The aqueduct upstream is remote with a wide arch outside of the channel. It is not considered to be impacted by the weir. There are no structures downstream within the vicinity of the weir. There is limited evidence of erosion on the banks limited to some minor erosion exposing tree roots.					
OPTIONS					
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost
Do-nothing	no	high		Maintenance and cleaning of the structure will be required. Maintenance of current conditions - impassable to certain fish, impact on flow regime upstream and impact on sediment transfer. No improvement in SSSI targets and WFD status.	low
Full removal	high	low		Potential scour upstream leading to tree loss. Downstream movement of sediment. The existing fish pass would become redundant. The purpose of the weir is unclear; this should be confirmed to ensure no stakeholders are impacted. Additional weir upstream may become more of barrier or may be undermined. Potential requirement for in channel working.	high
Partial removal	mod	low		The existing fish pass would become redundant and a new pass would be required. There is limited benefit over a full removal in terms of reduction of risks. Potential requirement for in channel working.	high
Formal/informal/easement type fish pass	low	mod		Improvement of the existing fish pass is required, although likely only at the downstream end of this structure. A rock ramp or additional pool could suffice here. Potential requirement for in channel working.	low



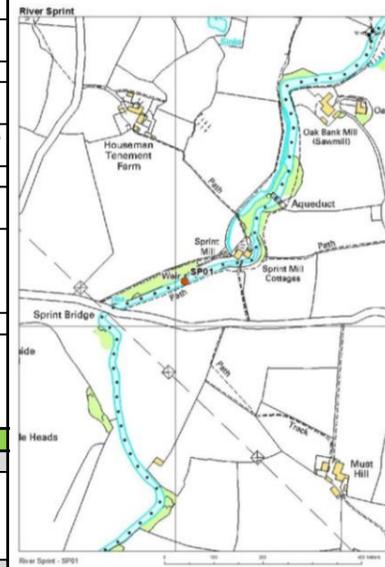
View of weir from left hand bank (SD 54614 95764).



View upstream from weir from left hand bank with aqueduct in distance and fish pass in centre (SD 54622 95764)

Date of Survey:	14/10/2014	Weir Name:	Weir at Patton Mill	BACKGROUND INFORMATION: A partially tree lined channel in a wide valley. Surrounded by agricultural fields. Old mill leat is present on right hand bank of weir.			
Weir ID:	M03	NGR:	SD 55402 97811				
Watercourse:	River Kent						
HISTORICAL VALUE: The weir is not designated, and no licensing requirements are anticipated. The site is located in a medieval landscape (Patton Mill dates back to that period), with some archaeological remains of that and a post-medieval date present in the area, but an overall low archaeological potential expected at this preliminary stage of assessment.							
Water Framework Directive				SSSI			
Water body ID: GB112073074640				Unit: 110			
Current status: Moderate Ecological Status				Current condition: Unfavourable - Recovering			
GEOMORPHOLOGICAL CHARACTER				  			
Upstream							
Average bankfull width (m):	14.0	Normal low flow width (m):	12.0		Flow diversity: Uniform		
Average bankfull depth (m)	1.3	Normal low flow depth (m):	0.5				
Bank substrate:	Partially visible - earth.	Bed substrate:	Predominantly pebbles and cobbles, with some silt, sand, gravels and leaf litter.				
Downstream							
Average bankfull width (m):	12.0	Normal low flow width (m):	10.0		Flow diversity: Varied - riffles and glides predominant.		
Average bankfull depth (m)	1.0	Normal low flow depth (m):	0.3				
Bank substrate:	Partially visible - predominantly earth, with coarse gravels and cobbles.		Bed substrate: Predominantly pebbles and cobbles, with some gravels sand and a small amount of silt.				
Gradient:	Medium		Flow: Moderate				
Evidence of modification and instability:	Bank protection (placed stone) on left hand bank downstream of weir and further bank protection upstream of weir near tributary entering. Some areas of bank slumping upstream and downstream of weir, although does not appear active. Area of cattle poaching upstream on right hand bank.						
Notes:	Water flowing over full width of weir at time of survey. Water ponded at least 120m behind weir (unable to access beyond this point along bank). Minimal difference in bed sediment composition upstream and downstream of weir, although upstream is slightly siltier. Cobble side bar deposits in channel downstream of weir, and cobble deposits upstream of weir where tributary entering channel.						
Geomorphological risk of removal:	low						
The weir is surrounded by agricultural land, with no infrastructure present, which gives space for the channel to adjust and reduces the risk of any adjustment. There is evidence of bank instability along the channel and there may be some further scour and loss of trees from the drop in water levels and scour.							
ECOLOGICAL ASSESSMENT							
Extent of Backwater Effect (m)	120.0						
Alternative Passage Available	No						
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>						
<i>Migratory Salmonids</i>	✓						
<i>Resident Trout</i>	✓/✗						
<i>Coarse Fish</i>	✗						
SAC Qualifying feature (not primary reason for site selection) habitat suitability							
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>				
Lithophilic Fish	Good	Good	Sub-optimal habitat suitability upstream and downstream of weir. Overall limited by siltation and lack of riparian corridor features (e.g. exposed bankside roots, shading etc.). Higher substrate/flow diversity and lower siltation downstream, make habitat slightly more suitable.				
Phytophilic Fish	Moderate	Poor					
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranuncion fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation				
Liverwort/Moss/Lichen		<1	No <i>Ranunculus</i> sp. observed upstream or downstream of weir. Some optimal habitat suitability exists (downstream weir particularly), but re-colonisation following historical management may be limiting factor.				
Emergent Broad-Leaved							
Emergent Reeds/Sedges	<1	5	1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>				
Floating Leaved (Rooted)			Sub-optimal habitat suitability through substrate composition downstream of weir (cleaner rocky substrates with interstitial sand/gravels), but low channel shading and siltation are limiting.				
Free Floating	<1						
Submerged Broad-Leaved							
Submerged Linear-Leaved							
Submerged Fine-Leaved	40		Additional Notes:				
Filamentous Algae	10	<1	Structure is passable to migratory salmonids, but likely only passable to other species during some flow conditions.				
STRUCTURAL ASSESSMENT							
Approx. height of weir (m):	1	Approx. length of weir (m):	2				
Approx. width of weir (m):	11	Stability:	Good condition				
Notes:							
The weir is in good condition. It is located in farm land and there are no buildings or structures in the vicinity of the weir and there is a mill race on the right bank with a pen stock. Both banks are natural and around 1-2m high with trees and vegetation. A section of the bank at the weir on the left bank is lined with a masonry wall - this is likely to be to protect farm land. There is some bank erosion on the left bank downstream of the weir. Water is impounded for around 100m upstream. There are no structures within the impacted reach.							
OPTIONS							
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost		
Do-nothing	no	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in baseline flow types and sediment patterns.		high	Weir is currently considered to be in a good condition. There is no flood risk from the weir itself. It is not considered maintenance would be required as the impacts of a collapse would be minimal.	Maintenance of current conditions - impassable to certain fish particularly at lower flows, impact on flow regime upstream and impact on sediment transfer. No improvement in SSSI targets or WFD status.	low
Full removal	high	Approximately 10 km of improved connectivity. Improved migratory potential for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish). Direct improvement of 120 m of impounded habitat. Minimal difference in bed sediment composition was observed, however riffle glide sequence and cobble side bar deposits observed outside of impact zone, and would be likely to return to impacted zone as a result of full removal. Channel migration/modification not constrained by land use or bank protection, meaning benefits would be maximised.		mod	Access would be through farm land, with surrounding roads being single track and narrow. Compound could potentially be placed on either bank on agricultural fields. There are some overhead cables in the vicinity and loss of some tree loss may be necessary for works to be implemented. Flood risk assessment and structural assessment not required due to location. Works will be minor with a short programme.	Further scour may occur upstream, with potential tree loss and bank erosion. The mill race on the right hand bank would dry up, and it is unclear whether this is still in use.	low
Partial removal	mod	Approximately 10 km of partly improved connectivity; Partly improved migratory routes for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish); Part improvement of 120 m of impounded habitat. Minimal difference in bed sediment composition was observed, however riffle glide sequence and cobble side bar deposits observed outside of impact zone, suggesting increased flow and substrate diversity would occur as a result of partial removal. Channel migration/modification not constrained by land use or bank protection, meaning benefits would be maximised.		mod	Access would be through farm land, with surrounding roads being single track and narrow. Compound could potentially be placed on either bank on agricultural fields. There are some overhead cables in the vicinity and loss of some tree loss may be necessary for works to be implemented. Flood risk assessment and structural assessment not required due to location. Works will be minor with a short programme.	There is limited reduction in risks over a full removal with a reduction in overall benefits; partial removal is not considered a realistic option here.	low
Formal/ informal/ easement type fish pass	low	No direct improvement in habitat connectivity. Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design). No improvement of 120 m of impounded habitat. Negligible change in diversity of flow types and sediment patterns within impounded reach.		mod	Structure is likely to fail in the near future so fish pass will become redundant. Access would be through farm land, with surrounding roads being single track and narrow. Compound could potentially be placed on either bank on agricultural fields. There are some overhead cables in the vicinity and loss of some tree loss may be necessary for works to be implemented.	The structure is small and remote; it is considered the benefits from implementation of a fish pass would not be reflective of the cost.	mod

Date of Survey:	15/10/2014	Weir Name:	Weir at Sprint Mill (EA gauging station)	BACKGROUND INFORMATION:		
Weir ID:	SP01	NGR:	SD 5148196090	This weir is part of an Environment Agency gauging station, which signage indicates is used as part of a flood warning system, and low flow monitoring for water resource planning. A tree-lined channel, surrounded by rough pasture fields, in a shallow valley. Immediately surrounding the weir, the right hand bank is considerably higher than the left hand bank. Residential property (Sprint Mill) approx. 110m upstream on right hand bank with access track to property over bridge. Road bridge approx. 150m downstream.		
Watercourse:	River Kent			Water Framework Directive		
HISTORICAL VALUE:				Water body ID:	GB112073071430	
The weir is not designated, nor lies within or close to any heritage designations, so no licensing in this respect is anticipated. High level data searches indicate that with the exception of the post-medieval bobbin mill (Sprint Mill) no known non-designated heritage assets are present within the vicinity of the site, and the archaeological potential is, at this preliminary stage, expected to be low.				Current status:	Moderate Ecological Status	
GEOGRAPHICAL CHARACTER				SSSI	Unit: 109	
Upstream				Current condition: Unfavourable - Recovering		
Average bankfull width (m):	17.0	Normal low flow width (m):	15.0	Flow diversity: Uniform in impact zone		
Average bankfull depth (m):	3.0	Normal low flow depth (m):	0.4			
Bank substrate:	Partial visibility - vegetated banks. Earth and bedrock.	Bed substrate:	Predominantly cobbles and pebbles. Some bedrock outcrops, gravels and sands.			
Downstream				Flow diversity: Varied - riffles predominate from bedrock, boulders and cobbles.		
Average bankfull width (m):	17.0	Normal low flow width (m):	16.0			
Average bankfull depth (m):	2.5	Normal low flow depth (m):	0.4			
Bank substrate:	Not visible - vegetated banks. Assumed earth and bedrock.	Bed substrate:	Predominantly cobbles and pebbles. Some bedrock outcrops with greater gravels and sands than upstream.			
Gradient:	Medium	Flow:	Moderate			
Evidence of modification and instability:	Concrete bed at gauging station, for approx. 10m behind weir. Concrete bank protection around gauging station and on right hand bank further upstream. Bridge upstream (access to house, Sprint Mill) and downstream (road bridge). No active bank erosion visible.					
Notes:	Water flowing over approx. 60% of weir at time of survey, within the central v-notch area. Water ponded for approximately 45m behind weir. Upstream of weir, bed sediment deposition visible up to concrete bed. Minimal difference in bed sediment composition upstream and downstream of weir, being predominantly cobbles and pebbles, and no issues of siltation apparent. Downstream of weir bedrock outcrops and cobbles causing variability in flow. At upstream bridge, higher gradient of channel and bedrock outcrops. Assumed some management of channel within the vicinity of the gauging station.					
Geomorphological risk of removal:	low					
The weir is surrounded by agricultural land, and no infrastructure in close proximity, which gives space for the channel to adjust and reduces the risk of any adjustment. There is the risk of some tree loss along the banks from a drop in water level. Bedrock was visible in the channel downstream of the weir indicating any channel adjustment would be small and slow.						
ECOLOGICAL ASSESSMENT						
Extent of Backwater Effect (m)	45.0	SAC Qualifying feature habitat suitability				
Alternative Passage Available	No	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>	Optimal habitat suitability upstream and downstream structure. Established riparian corridor and associated features (heavy shading, exposed bankside roots and undercut banks). Good substrate diversity and no siltation issues.			
Structure Passable						
<i>Migratory Salmonids</i>	✓					
<i>Resident Trout</i>	✓/*					
<i>Coarse Fish</i>	x	SAC Qualifying feature (not primary reason for site selection) habitat suitability				
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>	Optimal habitat suitability upstream and downstream structure. Established riparian corridor and associated heavy shading, exposed bankside roots and undercut banks. Good substrate diversity; no siltation. Good flow diversity downstream (and upstream, outside of backwater)		
Lithophilic Fish	Good	Good				
Phytophilic Fish	Poor	Poor				
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranuncion fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation	No <i>Ranunculus</i> sp. observed upstream or downstream weir. Some habitat suitability exists (downstream weir in particular), but re-colonisation following historical management may be limiting factor.		
Liverwort/Moss/Lichen	5	5				
Emergent Broad-Leaved						
Emergent Reeds/Sedges		<1	1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>	Optimal habitat suitability through substrate composition upstream and downstream of weir (clean rocky substrates with interstitial sand/gravels) and flushing flows downstream of weir, with shading from riparian corridor.		
Floating Leaved (Rooted)						
Free Floating						
Submerged Broad-Leaved						
Submerged Linear-Leaved						
Submerged Fine-Leaved						
Filamentous Algae	<1					
Additional Notes:						
Head difference will be passable to migratory salmonids. The head difference will diminish under some flow conditions, and the weir may even drown out. The structure should be passable to other species (including eel) during such events. However, higher velocities will hinder passage and may offset the reduced head difference to some extent.						
STRUCTURAL ASSESSMENT						
Approx. height of weir (m):	1	Approx. length of weir (m):	2			
Approx. width of weir (m):	#	Stability:	Good condition			
Notes:						
The structure is in reasonably good condition, although some minor repair works are planned. It is a v-notch weir with a concrete structure and a steel plate crest. Bed and banks for 8-10m up and downstream of the structure are concrete. There is no evidence of scour in the vicinity of the weir. The bridges up and downstream and the property upstream on the right bank are considered too remote to be impacted by the weir or any changes to it. The piers of these bridges are outside the channel.						
OPTIONS						
Options	Benefits	Technical Feasibility		Risks and Considerations	Cost	
Do-nothing	no	No change in baseline connectivity or fish migration potential. No improvement in functional habitat provision. No change in flow types or sediment patterns.	high	Weir appears in good condition although some minor repair works are planned for the near future. Maintenance will be carried out by the Environment Agency.	Maintenance of current conditions - impassable to eel and certain fish particularly at lower flows, impact on flow regime upstream and impact on sediment transfer.	low
PREFERRED OPTION						
Full removal	mod	Approximately 5 km of improved connectivity; Improved migratory potential for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish); Direct improvement of 45 m of impounded habitat. Small impounded reach on medium gradient channel. Minimal difference in bed sediment composition observed between upstream and downstream of the weir and therefore minimal improvements to bed sediment expected within the impacted zone. Riffles which predominate downstream of the weir are likely to return to impacted reach once the weir is removed.	mod	Access good on left hand bank from the road, including space for a compound and Environment Agency have access to the site for the gauging station. Some tree loss for access. In-channel works may not be required. Minimal upstream erosion expected. Bridges up and downstream considered far enough away not to be at risk from erosion.	Loss of Environment Agency gauging station which is currently used for flood warning and residents downstream at risk of flooding will lose flood warning service. Potential localised tree loss on banks immediately surrounding structure. Movement of sediment downstream. Potential in channel working required.	mod
Partial removal	low	Approximately 5 km of partly improved connectivity; Partly improved migratory routes for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish); Part improvement of 45 m of impounded habitat. Small impounded reach on medium gradient channel. Minimal difference in bed sediment composition observed between upstream and downstream of the weir and therefore minimal improvements to bed sediment expected within the impacted zone. Riffles which predominate downstream of the weir are likely to partially return to impacted reach once the weir is removed, although not to the extent as with full removal.	low	Access good on left hand bank from the road, including space for a compound. Environment Agency have access to the site for the gauging station. Some tree loss for access. In-channel works may possibly be avoided.	There will be loss of the gauging station, without reaping the full benefits of full removal. Not restoring full natural flow and sediment processes. Potential in channel working required.	mod
Formal/informal/easement type fish pass	low	No direct improvement in habitat connectivity; Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design); No improvement of 45 m of impounded habitat; no change to morphology.	mod	Access good on left hand bank from the road, including space for a compound. Environment Agency have access to the site for the gauging station. Some tree loss for access. Would not require in-channel works.	Reduction in accuracy of gauging station. Limited space for fish pass without land take on left hand bank, which would require tree removal. Option considered neutral as cost benefit likely to be very low.	low

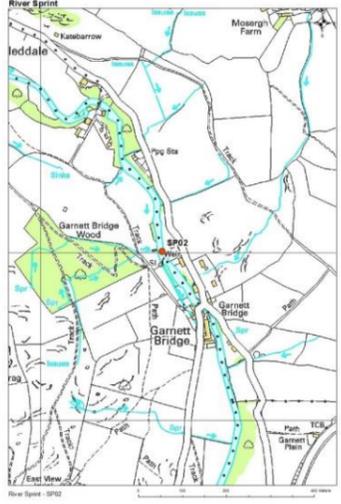


View downstream of weir from left hand bank (SD5148696090).



View upstream of weir from left hand bank (SD5147896090).

Date of Survey:	13/10/2014	Weir Name:	Weir upstream of Garnet Bridge	BACKGROUND INFORMATION:	
Weir ID:	SP02	NGR:	SD 52267 99361	A tree-lined channel within a narrow, steep valley. Predominantly surrounded by agricultural land on both banks, with some residential properties and back gardens on banks, predominantly downstream of weir. Mill leat on right hand bank. Road bridge approximately 150m downstream. Access along banks downstream of weir was not possible.	
Watercourse:	River Kent				
HISTORICAL VALUE:					
The weir is not designated, nor lies within or close to any heritage designations, therefore no licensing in this respect is anticipated. Very few post-medieval remains in the area, overall low archaeological potential anticipated at this preliminary stage of assessment.					
GEOMORPHOLOGICAL CHARACTER					
Upstream					
Average bankfull width (m):	22.0	Normal low flow width (m):	20.0	Flow diversity:	Uniform in area of impact.
Average bankfull depth (m):	1.0	Normal low flow depth (m):	0.4		
Bank substrate:	Highly vegetated banks - not visible.		Bed substrate:	Predominantly cobbles and boulders, with some pebbles, gravel, sand, bedrock and leaf litter present.	
Downstream					
Average bankfull width (m):	18.0	Normal low flow width (m):	15.0	Flow diversity:	Varied - steps, pools and rapids.
Average bankfull depth (m):	1.0	Normal low flow depth (m):	0.4		
Bank substrate:	Highly vegetated banks - not visible.		Bed substrate:	Unable to access to view - assumed to be predominantly cobbles, boulders and bedrock.	
Gradient:	High		Flow:	Moderate	
Evidence of modification and instability:	Bank protection - some placed rocks on left hand bank, both upstream and downstream. Mill leat on right hand bank. Scour on left hand bank, however stabilised by bank protection.				
Notes:	Water flowing over full width of weir at time of survey. Water ponded for approximately 50m behind weir. Access downstream of weir along bank not possible, however flow observed to be more variable, with large boulders and bedrock protruding from channel. Upstream of impact zone, and further downstream of weir, channel observed to be steep with steps and pools.				
Geomorphological Risk:	low				
The weir is surrounded predominantly by agricultural land, meaning there is space for the channel to adjust and the risk of adjustment is low. There are some residential properties and gardens on both banks, which may be at increased risk from scour and may need additional bank protection. The channel is bedrock and therefore adjustment to the channel would be slow and naturally controlled.					
ECOLOGICAL ASSESSMENT					
Extent of Backwater Effect (m)	50.0				
Alternative Passage Available	No				
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>				
Migratory Salmonids	✓				
Resident Trout	✓/x				
Coarse Fish	✓/x				
Spawning habitat ass.	Upstream	Downstream	SAC Qualifying feature habitat suitability		
Lithophilic Fish	Good	Good	Optimal habitat suitability overall, both upstream and downstream of the structure. Good substrate diversity and established riparian corridor (right bank particularly), with associated features (shading, detritus and exposed bankside roots).		
Phytophilic Fish	Poor	Poor	SAC Qualifying feature (not primary reason for site selection) habitat suitability		
			1163 Bullhead <i>Cottus gobio</i>		
			Optimal habitat suitability downstream structure; sub-optimal upstream - impounded flows limit habitat suitability. Good substrate diversity and established riparian corridor (right bank particularly), with associated features (shading, detritus and exposed bankside roots).		
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranunculus fluitans</i> and <i>Callitriche-Batrachion</i> vegetation		
Liverwort/Moss/Lichen	15		No <i>Ranunculus</i> sp. observed. Some optimal habitat suitability exists - flow/substrate should be suitable across site. Colonisation following historical management could be an issue.		
Emergent Broad-Leaved			1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>		
Emergent Reeds/Sedges			Sub-optimal habitat suitability, with shading and silt-free rocky substrates, but absence of significant discrete sand deposits which are important for population establishment.		
Floating Leaved (Rooted)			Additional Notes:		
Free Floating			Weir likely passable to migratory salmonids at most flows. However, weir also likely to drown out at higher flows, and may be passable to other fish species (including eel) during such events (though higher flow velocities during these events may inhibit migration).		
Submerged Broad-Leaved					
Submerged Linear-Leaved					
Submerged Fine-Leaved					
Filamentous Algae					
STRUCTURAL ASSESSMENT					
Approx. height of weir (m):	1	Approx. length of weir (m):			
Approx. width of weir (m):	15	Stability:	Poor condition		
Notes:					
The weir is of a rock/stone construction with a sluice gate to a mill race. The sluice is in a state of disrepair. The weir is in a poor condition with defects evident. The banks are natural with some signs of erosion, particularly downstream on the left bank. There is rock armour placed on the banks around the structure. There are lots of trees on both banks. The right bank is high and steep, whilst the left bank is low upstream and high downstream. Properties on the left bank are well removed from the channel and unlikely to be impacted by the structure.					
OPTIONS					
Options	Benefits	Technical Feasibility	Risks and Considerations	Cost	
Do-nothing	no	mod	Weir is currently considered to be in poor condition.	Maintenance of current conditions - impassable to certain fish at some flows, impact on flow regime upstream and impact on sediment transfer. Flow currently being directed to left hand bank downstream of weir, causing a scour risk here. Risk of bank collapse, tree loss and damage to gardens.	low
Full removal PREFERRED OPTION	mod	high	It is likely that the works would be simple subject to access provisions. There would not likely be any impact on flood risk. No access from the right hand bank. Access from left hand bank would be through residential properties and gardens. Roads to the area are very narrow and single track. Heritage assessment may be required. Flood risk assessment and structural assessment not needed due to location.	Some bank scour would be likely and additional bank protection measures may be needed; particularly along residential property gardens. Impact on flows within the mill leat on right hand bank - is a feature within some residential property gardens downstream.	low
Partial removal	low	mod	No access from the right hand bank. Access from left hand bank would be through residential properties and gardens. Roads to the area are very narrow and single track. Heritage assessment may be required. Flood risk assessment and structural assessment not needed due to location.	The structure is not big enough to consider a partial removal over a full removal. Impact on flows within the mill leat on right hand bank - is a feature within some residential property gardens. If removed left hand bank side of weir, so as to retain mill leat, would increase scour on left hand bank downstream which is already at risk of scour.	low
Formal/informal/easement type fish pass	low	low	Structure is likely to fail in the near future so fish pass will become redundant. No access from the right hand bank. Access from left hand bank would be through residential properties and gardens. Roads to the area are very narrow and single track.	The benefits from a fish pass are likely to be minor compared to the cost and difficulty of implementation.	mod

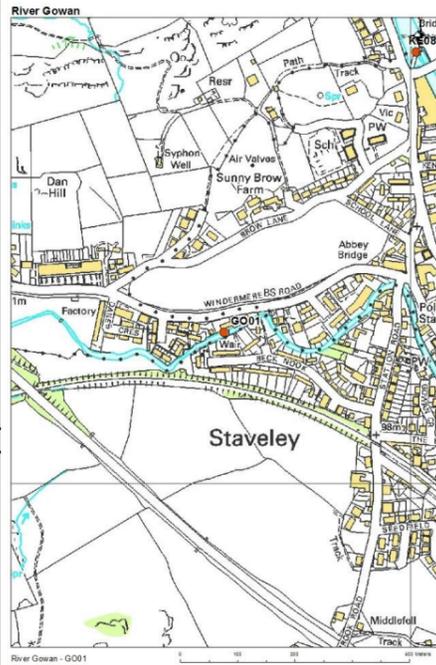


View downstream of weir from right hand bank. (SD 52267 99361)



View upstream of weir from left hand bank. (SD 52267 99361)

Date of Survey:	13/10/2014	Weir Name:	Weir at Staveley	BACKGROUND INFORMATION:		
Weir ID:	GO01	NGR:	SD 46700 98300	A partially tree-lined channel surrounded by residential properties and gardens on both banks within Staveley. A smaller, informal weir is present approximately 20m upstream. Footbridge present approximately 90m downstream. Highly constrained channel with heavy placed stone bank protection on both banks. Notice by Cumbria County Council indicating gravel removal from the channel in August 2014 to reduce flood risk.		
Watercourse:	River Kent					
HISTORICAL VALUE:						
The weir is not designated, nor lies within or close to any heritage designations, therefore no licensing in this respect is anticipated. High level data searches indicate that with the exception of the site of a post-medieval bobbin mill, no known non-designated heritage assets are present within the vicinity of the site, and the archaeological potential is, at this preliminary stage, expected to be low.						
GEOMORPHOLOGICAL CHARACTER						
Upstream						
Average bankfull width (m):	10.0	Normal low flow width (m):	12.0	Flow diveristy:	Varied - from cobbles and pebbles in channel.	
Average bankfull depth (m)	1.5	Normal low flow depth (m):	0.3			
Bank substrate:	Majority artificial bank protection, some earth visible.		Bed substrate:	Predominantly cobbles, pebbles and gravels with sand, boulders and bedrock present.		
Downstream						
Average bankfull width (m):	7.0	Normal low flow width (m):	7.0	Flow diversity:	Varied - associated with the cobbles and pebbles in channel.	
Average bankfull depth (m)	2.0	Normal low flow depth (m):	0.3			
Bank substrate:	Artificial bank protection.		Bed substrate:	Predominantly cobbles, pebbles and gravels with sand, boulders and bedrock present.		
Gradient:	Medium		Flow:	Moderate		
Evidence of modification and instability:	Heavy, placed stone, bank protection along full length of channel on both banks within vicinity of weir. Gravel removal for flood risk management. No scour evident - heavily protected banks.					
Notes:	Water flowing over full width of weir at time of survey. Weir appearing to have little impact in the channel upstream or downstream with minimal differences in flow or sediment observed between upstream and downstream. No ponding observed upstream of weir. Some evidence of channel narrowing with vegetated berms upstream of weir (mown grass). Smaller weir, approximately 20m upstream, appears to be having a greater impact on flows. Full bank protection having greater impact on channel than weir.					
Geomorphological risk of removal:	Moderate					
The weir is surrounded by residential properties and gardens within the village of Staveley. The channel has full bank protection, and there is a risk of the need for further bank protection, or additional works to the bank protection, from water level drops and scour in order to protect the properties and gardens.						
ECOLOGICAL ASSESSMENT						
Extent of Backwater Effect (m)	N/A					
Alternative Passage Available	No					
Structure Passable	1092 White-clawed (or Atlantic stream) crayfish <i>Austropotamobius pallipes</i>					
Migratory Salmonids	✓					
Resident Trout	✓/✗					
Coarse Fish	✓/✗					
SAC Qualifying feature habitat suitability						
Spawning habitat ass.	Upstream	Downstream	1163 Bullhead <i>Cottus gobio</i>			
Lithophilic Fish	Good	Good	Sub-optimal habitat suitability upstream and downstream structure. Good substrate diversity and no siltation, but reinforced banks and absence of riparian corridor/associated features (shading and exposed bankside roots). Good flow diversity upstream and downstream.			
Phytophilic Fish	Poor	Poor				
SAC Qualifying feature (not primary reason for site selection) habitat suitability						
Channel veg. ass. (%)	Upstream	Downstream	3260 Water courses with <i>Ranuncion fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation			
Liverwort/Moss/Lichen	10	10	Some <i>Ranunculus</i> sp. observed upstream downstream of weir. Some optimal habitat suitability (downstream weir in particular), but re-colonisation following historical management may be a limiting factor.			
Emergent Broad-Leaved	5	5				
Emergent Reeds/Sedges	5	5	1029 Freshwater pearl mussel <i>Margaritifera margaritifera</i>			
Floating Leaved (Rooted)			Sub-optimal habitat suitability through substrate composition upstream and downstream of weir (clean rocky substrates with interstitial sand/gravels) and flushing flows, but lack of shading is an issue.			
Free Floating						
Submerged Broad-Leaved						
Submerged Linear-Leaved			Additional Notes:			
Submerged Fine-Leaved	15		Head difference will be passable to migratory salmonids, resident brown trout and many coarse fish at some flows. As the structure is a sloped rock ramp, the head jump is gradual and may also be passable to eel.			
Filamentous Algae						
OPTIONS						
Options	Benefits		Technical Feasibility		Risks and Considerations	Cost
Do-nothing	no	No change in baseline connectivity or fish migration potential. No change in baseline flow types and sediment patterns.	high	Weir is currently in reasonable condition.	Maintenance of current conditions - although current impact of weir is considered to be low. The structure is passable to most fish species currently. Flood risk to properties on right bank might increase due to climate change. No improvement in SSSI targets or WFD status.	low
Full removal PREFERRED OPTION	low	Approximately 5 km of improved connectivity. Improved migratory potential for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish). No significant habitat impoundment upstream of structure. No ponding observed upstream of weir and therefore limited predicted change to sediment regime or flow types. Channel migration/modification highly constrained by heavy bank protection through residential area, hence benefits may be limited.	low	Limited access through residential gardens. Restricted area for working or site compound - would likely have to be remote from site. Heritage assessment will be required. Structural assessment required for buildings in the vicinity of the weir. The structure is high with potential for large deposits of silt behind it.	Scour risk at former mill downstream on the left bank and upstream alongside the properties and gardens. May require installation of additional bank protection to protect adjacent properties. Potential for minimal improvement due to additional small weir upstream which appears to be having an impact. Full bank protection in channel may be greater issue.	high
Partial removal	no	Approximately 5 km of partly improved connectivity. Partly improved migratory routes for all species (removal of barrier to spawning and local migrations for resident trout and coarse fish). No significant habitat impoundment upstream of structure. No ponding observed upstream of weir and therefore minimal change to sediment regime or flow types. Channel migration/modification highly constrained by heavy bank protection through residential area, as full removal, benefits may be limited.	low	Limited access through residential gardens. Restricted area for working or site compound - would likely have to be remote from site. Heritage assessment will be required. Structural assessment required for buildings in the vicinity of the weir. The structure is high with potential for large deposits of silt behind it.	Potentially limited benefits in risk reduction over a full removal. Rock ramp combined with reduction in weir height may improve fish pass and allow smaller species to pass. Potential for minimal improvement due to additional small weir upstream which appears to be having an impact.	high
Formal/informal/ easement type fish pass	no	No direct improvement in habitat connectivity. Improved spawning and local migratory routes for fish species (nature of species benefits are subject to design). No significant habitat impoundment upstream of structure. No change to morphology.	low	Limited access through residential gardens. Restricted area for working or site compound - would likely have to be remote from site. Full condition survey of the weir required to ensure fish pass does not become redundant. Structure may need to have significant length to overcome the head difference.	Limited space in the channel and on banks, any works would require land take.	high



View upstream of weir from bridge (SD 46700 98300).



View downstream of weir from left hand bank. (SD 46653 98245)

Approx. height of weir (m):	3.5	Approx. length of weir (m):	0.5
Approx. width of weir (m):	10	Stability:	Reasonable condition

Notes:
Weir appears to be several hundred years old, and was likely used to feed an old mill. There was no direct access to the structure from alongside the bank. It appears to be a stone construction in reasonable condition.

5. Options assessment

5.1. Scoring and Discussion

To ensure the scoring process was robust and informative, a number of summary scores were generated from the indicators. A given option may score highly in terms of the ecological and morphological benefits it delivers, but may be technically difficult or even infeasible to implement. The scoring process needs to be sensitive to this and the following scores were therefore calculated:

- Combined ecology and morphology scores;
- Combined technical feasibility and condition of weir scores;
- Total scores (all scoring indicators) without cost; and
- Total scores (all scoring indicators) with cost.

To assist with the interpretation and description of the options considered, a number of thresholds were also developed. Thresholds for characterising the ecological and morphological benefits delivered by a given option were defined as:

- High ≥ 7
- Moderate >4 and <7
- Low >0 and <4
- None 0

Thresholds for characterising the technical feasibility and condition of the weir were defined as:

- High ≥ 1.8
- Moderate > -1.8 and <1.8
- Low ≤ -1.8

At their broadest level, the scoring indicators can be applied to i) identify a site specific 'preferred option' for each weir included in the investigation; and ii) prioritise actions across all weirs investigated.

Indicative costs for each of the options are provided in Appendix D with a description and also provided in the summary sheets. The costs are categorised into:

- High $>£100k$
- Moderate $£40k -£100k$
- Low $<£40k$

5.1.1. Preferred Options

Scoring indicators were used to identify a preferred option for each weir included in the investigation. The full list of options across all structures, with a detailed breakdown of scoring for each option is provided in Appendix E.

The 'preferred option' for an individual weir is ultimately determined by a combination of factors, and can therefore be subject to interpretation as to which drivers should take priority. The option with the greatest ecological and morphological gains at each weir is full removal, without exception. However, when other factors such as the technical feasibility and cost of removal are considered, the ecological and morphological benefits may be overridden (in terms of overall scoring).

Table 5-1 presents a summary of a preferred options analysis, illustrating the impact of other factors on the preferred ecological and morphological option. Where the full removal option is maintained regardless of the other factors considered, these may be taken as definitive preferred options, providing a short-list for more detailed feasibility studies at these structures. The gauging stations (KE01, KE05, MI01, SP01), which are very important assets to the Environment Agency for flood forecasting, are unlikely to be removed in the short to medium term at least. Therefore the overall preferred option is Do Nothing. Cost appears to prohibit removal at sites GO01 and KE03, mainly due to the difficult access and potential impact to other structures and buildings (see Section 5.1.2).

Table 5-1 Preferred Options Analysis

Weir	Preferred Option: Ecological and Morphological Benefit Scoring	Preferred Option: All Scoring Without Cost	Preferred Option: All Scoring With Cost
KE02 Helsington Weir, Water Crook	Full Removal	Full Removal	Full Removal
KE04 Weir at Bowston	Full Removal	Full Removal	Full Removal
KE06 Weir at Cowan Head	Full Removal	Full Removal	Full Removal
KE07 Weir at Staveley	Full Removal	Full Removal	Full Removal
KE08 Weir at Barley Bridge, Staveley	Full Removal	Full Removal	Full Removal
MI02 Weir upstream of Meal Bank	Full Removal	Full Removal	Full Removal
MI03 Weir at Patton Mill	Full Removal	Full Removal	Full Removal
SP02 Weir upstream of Garnet Bridge	Full Removal	Full Removal	Full Removal
GO01 Weir at Staveley	Full Removal	Full Removal	Do Nothing
KE01 Weir at Sedgwick and EA gauging station	Full Removal	Do Nothing	Do Nothing
KE03 Stramongate Weir, Kendal	Full Removal	Full Removal	Do Nothing
KE05 Bowston EA gauging station	Full Removal	Do Nothing	Do Nothing
MI01 Weir upstream of Mint Bridge and EA gauging station	Full Removal	Do Nothing	Do Nothing
SP01 Weir at Sprint Mill and EA gauging station	Full Removal	Do Nothing	Do Nothing

5.1.2. Prioritised Actions

Section 5.1.1 considers preferred options on a site-by-site basis. However, options must also be considered on a catchment scale, to identify those site options that deliver maximum benefits and will therefore be considered a priority action. Scoring indicators were used to generate a short-list of prioritised actions across all weirs investigated. The full list, ranked in order of highest to lowest score (total without cost) is provided in Appendix E.

The scoring process resulted in a clear separation of eight weirs for potential partial or full removal, consistent with those identified in Section 5.1.1. Table 5-2 presents the priority actions for the eight weirs, ranked by total score (without cost). Outside of this ranked shortlist, the overall score for a given weir and option was comparatively low, or was ranked below the do nothing option for the weir. Full details of option benefits and technical feasibility are presented in Appendix E.

Notably, the only removal option outside of this short-list with an ecological and morphological benefit score of greater than 6, was KE03 – Stramongate Weir, Kendal. This is on account of a technical feasibility score of -3.6, as a consequence of the significant risks associated with the removal of this weir on the structural integrity of infrastructure through Kendal. The weir itself is also the largest structure to be included in the investigation and its removal may result in large scale mobilisation of deoxygenated silt deposits into the channel, which would require careful management. GO01 (also recommended for full removal) had a relatively low ecological and morphological benefit score of 2 and sits quite far down on the list. This is primarily because the existing impacts to the environment are minimal and so the benefits received would be marginal.

Table 5-2 Prioritised actions (ranked by total without cost).

Weir	Option	Ecological and Morphological Benefit	Technical Feasibility of Option and Condition of Weir	Total Without Cost	Total With Cost
MI03 Weir at Patton Mill	Full Removal	8.4	0.9	11.1	11.1
SP02 Weir upstream of Garnet Bridge	Full Removal	6.6	3.6	11.1	11.1
KE02 Helsington Weir, Water Crook	Full Removal	8.4	0.9	9.5	7.9
KE08 Weir at Barley Bridge, Staveley	Full Removal	8.4	0	8.5	6.9
KE06 Weir at Cowan Head	Full Removal	7.4	-0.9	7.4	5.8
KE04 Weir at Bowston	Full Removal	6.4	0	7.3	5.7
KE07 Weir at Staveley	Full Removal	6.4	0.9	7.3	5.7
MI02 Weir upstream of Meal Bank	Full Removal	7.6	-1.8	6.7	5.1

Table 5-3 summarises the morphological and ecological benefits for each prioritised action, as well as the associated constraints at each site. Full details are presented in Appendix E.

Table 5-3 Prioritised actions: summary of benefits and constraints

Description	Photograph
<ul style="list-style-type: none"> The joint top ranked option is the full removal of MI03 - weir at Patton Mill and it would result in approximately 9 km of improved habitat connectivity and enhanced migratory potential for all aquatic species (in particular, the removal of a barrier to spawning and local migrations for resident trout and coarse fish). Removal would also directly improve 120 m of currently impounded habitat through improved flow diversity and a return to a riffle-glide sequence. The weir was in good condition at survey, with access available through adjacent farmland and options available for site compound areas. Trees and overhead lines in the vicinity pose manageable constraints to the works, and the removal works are therefore likely to be relatively simple. The geomorphological risk has been assessed as low as the weir is relatively small and in a rural location so the likely impacts of bed adjustment could be easily mitigated. 	 <p>View of weir from right bank</p>
<ul style="list-style-type: none"> The joint top prioritised option, full removal of SP02 - weir upstream of Garnet Bridge, has moderate ecological and morphological benefits, but high technical feasibility. The weir was in a poor condition at survey with evident defects. Due to its rural location, good access and distance from buildings, it is likely that removal works would be relatively simple subject to access provisions, and would not have significant implications from a flood risk perspective. The removal of the structure would result in approximately 13 km of improved habitat connectivity, improved migratory potential for all aquatic species (in particular, the removal of a barrier to spawning and local migrations for resident trout and coarse fish), and direct improvement of 50 m of currently impounded habitat through improved flow diversity. This site has been assigned a low geomorphological risk based on its more rural location and bedrock channel. Some 	 <p>View of weir looking downstream</p>

Description	Photograph
<p>lateral adjustment may occur downstream following weir removal to accommodate the increased sediment supply, but there is a low risk to infrastructure and properties. The bedrock also provides a natural bed check limiting upstream erosion.</p>	
<p>For the following three options (KE02, KE08, and KE06,) weir removal is considered to have a high ecological and morphological benefit, with moderate technical feasibility. KE04 and KE07 have moderate ecological and morphological benefits and moderate technical feasibility for full removal and M102 has high benefits but a low feasibility.</p>	
<ul style="list-style-type: none"> • The removal of KE02 – Helsington Weir, Water Crook, would result in approximately 14 km of improved habitat connectivity and enhanced migratory potential for all aquatic species (in particular, the removal of a barrier to spawning and local migrations for coarse fish). • Removal would also directly improve 550 m of currently impounded habitat through improved flow diversity and minor channel migration within an agricultural field setting. • The weir was in poor condition at survey, with major defects (including broken slabs). There was also access and space available for a site compound on the left bank, which would facilitate the removal of the structure. • However, the large weir is immediately downstream of Kendal and holds a vast quantity of sediment behind it. Extensive bed and bank adjustment is likely over a long period of time. There would be a potential need for river training and scour protection and stabilisation works both upstream and downstream. The geomorphological risk of removal at this site is therefore high. • In addition, a more detailed heritage assessment and liaison with the appropriate authorities is likely to be required to ascertain whether this weir needs to be retained for historic landscape reasons. 	 <p>Side view of Helsington Weir</p>
<ul style="list-style-type: none"> • The removal of KE08 – weir at Barley Bridge, Staveley, would result in approximately 15 km of improved habitat connectivity and enhanced migratory potential for all aquatic species (in particular, the removal of a barrier to spawning and local migrations for coarse fish). • Removal would also directly improve 300 m of currently impounded habitat through improved flow diversity, redistribution of channel substrates, and some channel migration on the left hand bank into agricultural land. • The weir was generally in good condition at survey. Access was available from both banks, with space for a site compound on the left hand bank. • Weir removal at this site is considered moderate as the surrounding infrastructure could be at risk as the bed and banks adjust. • Barley Bridge is a listed structure so discussions and a more detailed assessment will be required by the LPA and English Heritage before the weir removal option is progressed. 	 <p>View of the weir</p>

Description	Photograph
<ul style="list-style-type: none"> • The removal of KE06 - weir at Cowan Head, would result in approximately 5 km of improved habitat connectivity and enhanced migratory potential for all aquatic species (in particular, the removal of a barrier to spawning and local migrations for coarse fish). • Removal would also directly improve 120 m of currently impounded habitat through improved flow diversity and return of a pool-riffle sequence. • Channel migration would be constrained by bank protection on right hand bank associated with residential properties, but may realign through the left hand bank, associated with a golf course and agricultural fields. • The structure was considered to be in fair condition at survey, with good access through a residential car park on right hand bank or through golf course on left bank as an alternative. Potential site compound areas were also available, located on the edge of the golf course or within the residential development grounds. Overhead power lines on the left hand bank were considered to be a manageable constraint at survey. • The geomorphological risk is deemed moderate at this location due to the risk of adjustment to the residential properties upstream, however, some bedrock was observed in the channel downstream so geomorphological change may be naturally limited. • The one major constraint at this site, as for KE06, is the current abstraction licence. 	 <p data-bbox="935 600 1219 627">View of Cowan Head Weir</p>
<ul style="list-style-type: none"> • The weir at Bowston KE04, if fully removed, would allow approximately 2km of improved connectivity and ease fish passage for all species. • There would be a direct improvement of 105 m of impounded habitat. • The weir is in good condition although vegetation growth is evident on and around the structure. There is evidence of scour downstream of the site and gabion mattresses and blockstone currently protect the banks. • There would be good access from the left bank and space for a compound, although there is a pipe crossing and overhead power cables in the vicinity. • The weir holds a large volume of sediment behind it and together with the scour potential and risk to properties upstream, has been assessed as moderate geomorphological risk. 	 <p data-bbox="935 1330 1267 1357">Weir at Bowston from left bank</p>
<ul style="list-style-type: none"> • The removal of KE07 – weir at Staveley, would result in approximately 3 km of improved habitat connectivity and enhanced migratory potential for all aquatic species (in particular, the removal of a barrier to spawning and local migrations for coarse fish). • Removal would also directly improve 230 m of currently impounded habitat through improved flow diversity and redistribution of channel substrates. • Channel migration would however, be constrained by bank protection on the right hand bank. There was evidence of a partial collapse in the centre of the weir at survey. • An adjacent industrial site off road had potential areas for a site compound on the right hand bank. However, access was tight between buildings (approx. 5 m width) and overhead cables were apparent during survey. Access from the left hand bank would require temporary removal of a wall and closure of a footpath, meaning that removal works would require more significant planning than some other options. • The geomorphological risk has been assessed as moderate because of the urban setting; some of the bankside industrial buildings may need to be underpinned. The structure is also 	 <p data-bbox="935 1832 1142 1859">View from left bank</p>

Description	Photograph
<p>fairly large and holds a significant quantity of sediment behind it which will be mobilised downstream.</p> <ul style="list-style-type: none"> Perhaps more importantly, certainly in the short-medium term, is the current abstraction licence. It would be extremely costly for the Environment Agency to revoke it as there is no expiry. 	
<ul style="list-style-type: none"> The removal of MI02 – weir upstream of Meal Bank, delivers high ecological and morphological benefits, delivering approximately 16km of improved connectivity if removed although the impact of the structure 100m upstream may be exacerbated. This site however has a low technical feasibility due to limited suitable site compound areas, the need for tree removals to facilitate works, and poor access to the structure. The geomorphological risk of full removal is however considered low at this site. 	 <p data-bbox="933 779 1141 808">View from left bank</p>
<p>All other prioritised actions are for partial removal and relate to the same structures. The partial removal of sites at MI03 and KE08 delivers moderate ecological and morphological benefits, with moderate technical feasibility.</p> <p>Partial removal of KE02 is also notable in that it delivers lower ecological and morphological benefits than any other option presented, but ranks highly overall because of the high technical feasibility of its partial removal. There is already an informal fish pass on the left hand bank of the structure, and extending this into the channel from the left hand bank could be undertaken with relative ease.</p>	

6. Summary and recommendations

6.1. Summary of findings

In this section, the main findings from the desk study, field study and the analysis will be summarised and followed in Section 6.2 and 6.3 by the recommendations and priority actions for future work.

Weir removal, where appropriate, does help to restore the natural habitat and ecological diversity of the river. Fish passage would be markedly improved and sediment transport and geomorphological processes regained (Section 2.2). Whilst the success of weir removal is not well documented in the UK, primarily due to the lack of pre- and post-removal monitoring, there are many academic studies that illustrate the potential benefits (Environment Agency, 2013). In the Kent catchment, weir removal would have a major positive impact on the Bullhead habitat. In many cases, the current conditions are sub-optimal, especially upstream of the weirs where there are slow and deep flows evident. At MI03 and KE04 it is sub-optimal downstream too. Weir removal would transform this habitat and provide a range of flows including shallower, faster flow, cleaner oxygenated waters and gravels. The salmonid populations would also benefit. The White-Clawed Crayfish habitats in the River Kent catchment are considered good overall, but weir removal would improve this by providing a greater range of ecological habitats and in turn providing a healthy and sustainable aquatic environment (providing the water quality is acceptable).

This project comprised a high level geomorphology, ecology and engineering assessment for 14 weirs in the River Kent SSSI and SAC Catchment. A MCA using agreed indicators and weightings helped prioritise the weirs for removal (or partial removal). The key findings include:

- MI03 Weir at Patton Mill on the River Mint and SP02 Weir upstream of Garnett Bridge on the River Sprint are the highest ranking sites for weir removal options and restoration of the natural river form and function. These are in the upper parts of the SSSI and SAC, but still provide good ecological justification for removal. The geomorphological risks and feasibility have been judged to be low.
- Removal of KE02 Helsington Weir immediately downstream of Kendal is a higher risk site, but would provide a much improved river environment. Detailed assessments would be required to understand and evaluate all the risks at this site.
- KE08 at Barley Bridge at Staveley is surrounded by historic features and listed structures so the impact of removal will need to be thoroughly considered. Weir removal here would contribute to maintenance of recovering position as the ecological benefits are deemed high at this site and there are presently no other restoration projects on this unit.
- KE06 Weir at Cowan Head has an abstraction licence which is unlikely to be revoked in the short-term.
- KE04 Weir at Bowston has a moderate ecological benefit from removal and a moderate geomorphological risk. Weir removal at this site may however help to achieve the WFD objectives for the water body by addressing some of the mitigation measures not currently in place (for example regaining natural sediment regime and geomorphological function, refer to Appendix A, GB112073071380). The water body has to reach Good Ecological Potential by 2027.
- KE07 Weir at Staveley has an abstraction licence which may preclude it from further investigation, certainly in the short-term.
- MI02 Weir upstream of Meal Bank on the River Mint has also been prioritised for removal. The ecological benefits are potentially high and the geomorphological risks are considered low. The feasibility of removal at this site is low however and the costs relatively high. There is also another weir upstream (not considered in this study) which may become more of a barrier or be undermined.

6.2. Recommendations

There are various recommendations for this project that are valid for all the future weir removals in the Kent catchment, even those that are not prioritised here. These include:

- Public consultation;
- Pre- and post-monitoring;
- Further investigations;
- Links with other catchment initiatives; and

- Maximising funding opportunities and delivery mechanisms.

6.2.1. Public consultation

It is evident from researching weir removal best practice and from professional experience that early stakeholder consultation is crucial for the success of any projects like these. The buy-in from the river users as well as landowners, farmers and the wider community is essential to aid the weir removal process through feasibility, planning, detailed design and finally removal.

It is Natural England's intention to communicate the potential opportunities for weir removal within the Kent Catchment and discuss the benefits and risks with the relevant authorities, landowners and residents. Uncertainty of bed adjustment following removal is often the greatest concern, but it can be explained that with detailed investigations and surveys, and monitoring, this uncertainty can be understood and effectively managed. Common mitigation measures for weir removal include bed checks (to avoid the risk of knick points working upstream) and bank protection (including soft options). A phased removal is also often useful to manage the accelerated sediment loading and monitor and learn from the results. A two (or more) staged approach is only possible on weirs where the structural integrity allows. Where weirs are in poorer condition, such as SP02, this could be difficult to manage and may result in collapse. Some weirs may be able to be lowered in the middle allowing some adjustment, but minimising the impact at the channel margins and risk of bank collapse. Others may be lowered (partially removed) at one side if the opportunity presents itself, for example at KE02 (Section 5.1.2). Alternatively the existing weir could be replaced with a gentler rock ramp type feature, which broadly maintains bed levels but improves fish passage and sediment continuity. This type of project was successfully completed at Bontnewydd in North Wales, where a gauging station had to be retained but the structure and surrounding habitats were vastly improved. These best practice examples are essential for reassuring the public that weir removal does not have to be risky if conducted properly through careful planning and consideration.

6.2.2. Pre- and post-monitoring

Appraisal of any river restoration project is essential for building the evidence base and learning for similar future studies. Demonstrating the success of a project is one good way of positively engaging with the communities and helping to secure funding for the next project. The River Restoration Centre (RRC) with others have developed guidelines on SMART (Specific, Measurable, Achievements, Resources, Time) objectives to help appraise projects such as weir removals in the pre and post phase (Environment Agency, 2013). These objectives help develop and set out the criteria to define success and, in some cases, does not have to be onerous or costly and could be as simple as fixed point photography. It is recommended that this guidance is followed for weir removal on the Kent catchment. The RRC also hold a record of these data and in time, this could be a good way of promoting the restoration projects carried out in the Kent catchment.

6.2.3. Further investigations

The main aim of this project was to assess the potential for weir removal and habitat restoration at each of the 14 sites, and prioritise actions for future work. The geomorphology, ecology and engineering input was invaluable for the purpose of screening and ranking in this study, but would not be adequate for a full feasibility study.. As suggested throughout the report, there are a number of investigations required to fully appraise the option of weir removal and the associated impacts. The level of investigation depends on the site specifics and the risks, but in general, these include:

- A more **detailed geomorphological assessment** to understand the upstream and downstream impacts of removal and the effects on the wider catchment.
- **Topographic survey** of the channel and possibly **modelling** (for example HEC-RAS, ISIS or CES) to evaluate the upstream and downstream bed levels, gradients, potential channel change and estimate sediment volumes. Undertaking modelling work would be particularly prudent in high flood risk areas to help forecast upstream and downstream water levels and inform a **Flood Risk Assessment**. Modelling may not be required where the geomorphological and flood risks are considered low.
- **Survey of the weir** and surrounding structures (topographic and structural assessment) to ascertain the feasibility of removal (full or partial options) and how best to approach it.
- **Collecting and analysing sediment samples** from behind the weir to consider the impact of reworking and downstream deposition. Deterioration of the existing ecology would be disastrous if the sediments mobilised downstream are contaminated. With the industrial legacy, especially with the high level of mining in the Kent catchment, it would be wise to take these precautions. If the

sediments are contaminated, and there is still the enthusiasm for removal, disposal of the sediments could be considered. This however is expensive and may lead to further issues such as increased erosion downstream if the gradient of the bed is increased, increasing stream powers, but there is limited sediment for entrainment and transfer.

- **Ecological surveys**, including aquatic (which could form part of the pre-monitoring phase and appraisal of success) and terrestrial surveys, to assess the likely impact during the removal phase.
- **Heritage assessments**, where necessary, or at least discussions with the appropriate planning authorities and English Heritage.
- **Cost-benefit analysis** to ensure there is a sound business case for removal or modification. In some instances within the Kent catchment, partial removal or adding a fish pass would not be a viable option due to the low cost-benefit.

6.2.4. Other projects and initiatives

There are numerous initiatives within the Kent catchment that are relevant to this study. The work that SCRT do is aligned with those of Natural England and the Environment Agency. The SCRT lead the Catchment Based Approach (CaBA) initiative in the Kent and Leven catchment, and have organised and implemented projects such as reconnecting the River Gowan to its floodplain. Other projects that SCRT have managed include improving eel and fish passage in the Kent Catchment and assessing the geomorphological and biological impacts of the continued sediment supply from the former Kentmere slate mines.

A strategy that is currently under consideration within the Environment Agency with direct relevance to this project is one to reduce the fluvial flood risk in Kendal. Flood storage options are being considered on the River Kent and River Mint so it would be beneficial for Natural England to continue to liaise with the Environment Agency to ensure compatibility between restoration options, such as weir removal and flood risk management initiatives.

6.2.5. Funding opportunities and delivery mechanisms

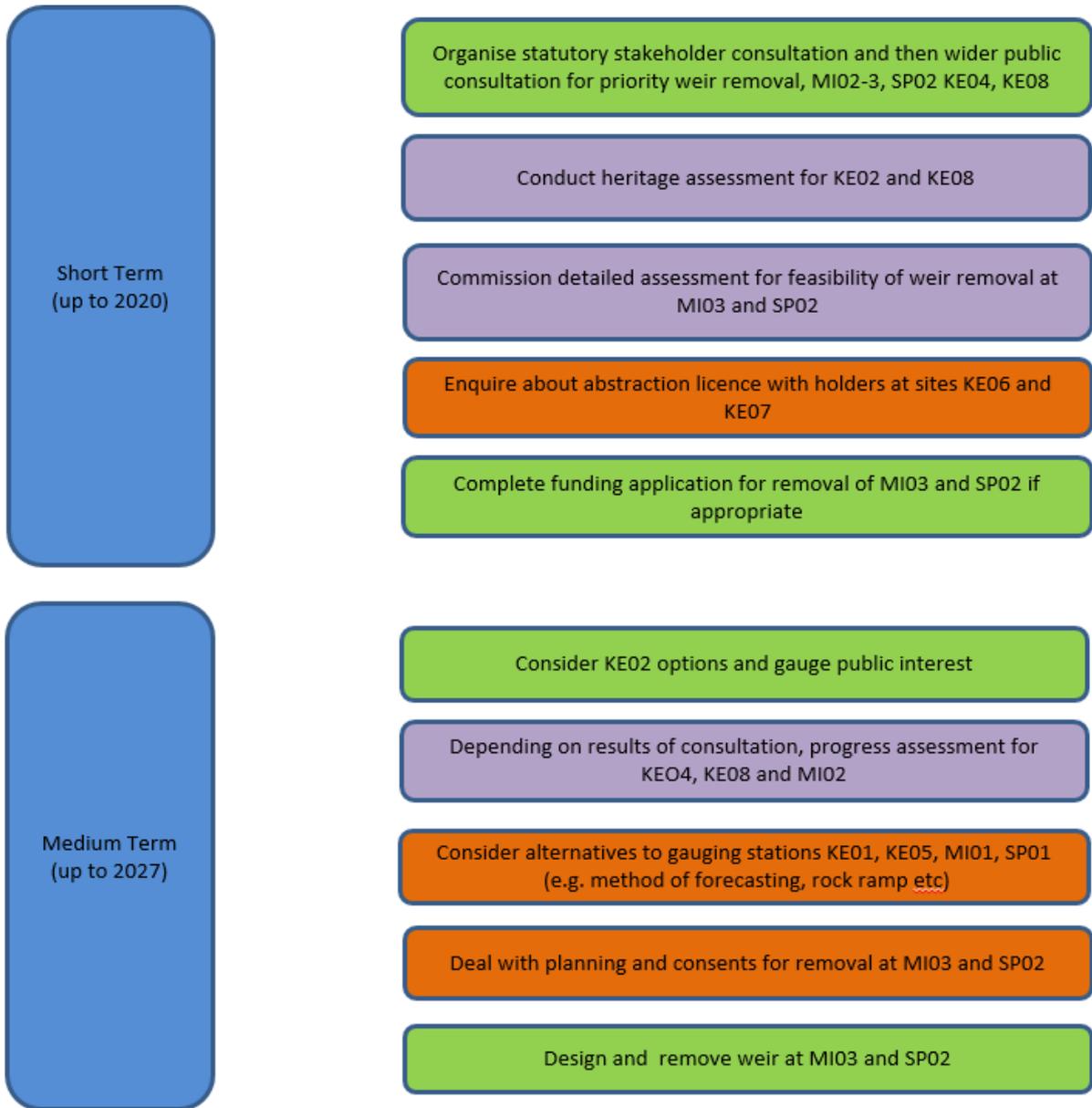
The WFD has provided the impetus for funding and implementation of river restoration projects over the past few years in the United Kingdom. Defra continue to provide monies to the Catchment Restoration Fund (CRF) which helps organisations such as SCRT to apply for and complete sustainable river management works. The SCRT may well be directly involved with future weir removal projects in the Kent catchment if together with Natural England and Environment Agency they can apply for funding from the CRF for such projects. Weir removal works could also be funded by Natural England and the Environment Agency if a business case is approved.

There may be opportunistic funding, such as from a developer wanting to restore the river near their investment, or from a landowner who no longer wishes to maintain the function and/or the weir itself. Public consultation events will help promote this restoration desire and may attract welcome support and funding.

6.3. Priority actions for future work

This study has illustrated that there are eight weirs that are shortlisted for removal, however two, SP02 and MI03 appear, with the available information, easier to progress than the others. KE06 and KE07 have abstraction licences and KE02 is high risk, although not necessarily unsurmountable. Provided there are no heritage restrictions for removal at KE08 then this stretch of river could be restored, as could KE04 and MI02. Therefore there are a number of short and medium term actions that could be taken to progress the options further (Figure 6-1).

Figure 6-1 Short and medium term priority actions for the Kent catchment, weir removal project



7. References

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Appendices

Appendix A. WFD water bodies information

Current status of the River Kent WFD water bodies

Water body name and ID	River Kent (GB112073071390)	River Kent (GB112073071380)	River Kent (GB112073071460)
	Current Status (and Predicted Status)	Current Status (and Predicted Status)	Current Status (and Predicted Status)
Current overall status	Good (Good by 2015)	Moderate (Good by 2027)	Good (Good by 2015)
Protected area designation	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive)	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive)	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive); Nitrates Directive; Urban Waste Water Treatment Directive
Hydromorphological designation	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	Heavily Modified Water Body (HMWB) (due to Power Generation; Water Storage – non-specific)	Heavily Modified Water Body (HMWB) (due to Flood Protection; Urbanisation)
Ecological status	Good (Good by 2015)	Moderate (Good by 2027)	Good (Good by 2015)
Biological elements	Fish: Good (Good by 2015)	Fish: Good (Good by 2015) Invertebrates: Good (Good by 2015)	Invertebrates: Good (Good by 2015) Macrophytes: Good (Good by 2015)
Supporting elements	All High (High by 2015)	All High (High by 2015), apart from Copper – Moderate (High by 2015)	All High (High by 2015)
Supporting conditions	Flow: Supports Good (Good by 2015) Morphology: Supports Good (Good by 2015)	Flow: Supports Good (Good by 2015)	Flow: Supports Good (Good by 2015)
Chemical status	Does not require assessment	Does not require assessment	Good
Chemical elements	N/A	N/A	All High (High by 2015)
Mitigation measures (not in place)	N/A	<ul style="list-style-type: none"> Ensure that the thermal regime in waters downstream of the impounding works is consistent with good status conditions. Ensure that good status of dissolved oxygen levels is being achieved downstream of the impounding works. Provide flows to move sediment downstream. Ensure there is an appropriate baseline flow regime downstream of the impoundment. Maintain sediment management regime to avoid degradation of the natural habitat characteristics of the downstream river. Re-engineering of the river where the flow regime cannot be modified. 	<ul style="list-style-type: none"> Sediment management strategies (develop and revise). Appropriate timing (vegetation management). Appropriate vegetation control technique. Selective vegetation control regime.

Current status of the River Mint WFD water bodies

Water body name and ID	River Mint (GB112073074640)	River Mint (GB112073071370)
	Current Status (and Predicted Status)	Current Status (and Predicted Status)
Current overall status	Moderate (Good by 2015)	Good (Good by 2015)
Protected area designation	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive)	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive)
Hydromorphological designation	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)
Ecological status	Moderate (Good by 2015)	Good (Good by 2015)
Biological elements	Fish: Good (Good by 2015)	Fish: High (High by 2015) Invertebrates: High (High by 2015)
Supporting elements	All High (High by 2015), apart from Copper Moderate (High by 2015)	All High (High by 2015)
Supporting conditions	Flow: Supports Good (Good by 2015) Morphology: Supports Good (Good by 2015)	Flow: Supports Good (Good by 2015) Morphology: Supports Good (Good by 2015)
Chemical status	Does not require assessment	Does not require assessment
Chemical elements	N/A	N/A
Mitigation measures (not in place)	N/A	N/A

Current status of the River Sprint and River Gowan WFD water bodies

Water body name and ID	River Sprint (GB112073071430)	River Gowan (GB112073071410)
	Current Status (and Predicted Status)	Current Status (and Predicted Status)
Current overall status	Moderate (Good by 2015)	Good (Good by 2015)
Protected area designation	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive)	Freshwater Fish Directive; Natura 2000 (Habitats and/or Birds Directive)
Hydromorphological designation	Not designated Artificial or Heavily Modified Water Body (A/HMWB)	Not designated Artificial or Heavily Modified Water Body (A/HMWB)
Ecological status	Moderate (Good by 2015)	Good (Good by 2015)
Biological elements	Fish: Good (Good by 2015) Invertebrates: High (High by 2015)	Fish: Good (Good by 2015) Invertebrates: High (High by 2015)
Supporting elements	All High (High by 2015), apart from Copper Moderate (High by 2015)	All High (High by 2015)
Supporting conditions	Flow: Supports Good (Good by 2015) Morphology: Supports Good (Good by 2015)	Flow: Supports Good (Good by 2015) Morphology: Supports Good (Good by 2015)
Chemical status	Does not require assessment	Does not require assessment
Chemical elements	N/A	N/A
Mitigation measures (not in place)	N/A	N/A

Appendix B. Historic Environment Considerations

Glossary	
EH	English Heritage
HER	Historic Environment Record
LBI	Listed building Grade I (nationally important) physical alterations require LBC
LBII*	Listed building Grade II* (nationally important) physical alterations require LBC
LBII	Listed building Grade II, (regionally important) physical alteration require LPA consent
LBC	Listed building consent (licence granted by EH)
LPA	Local Planning Authority
SM	Scheduled Monument (nationally important) physical alteration require SMC from EH
SMC	Scheduled Monument Consent (licence granted by EH)

River	Weir ID	NGR	Name	Relevant historic environment designations issues/permit requirements	Non-designated heritage assets/archaeological potential	Further work required/respective regional repository
River Kent	KE01	SD509875	Weir at Sedgwick and EA gauging station	Weir and gauging station not Listed (no permits required) Several LBII and one SM within 300m of weir/gauging station, possible changes to setting of assets/physical effects from changes in water regimes need assessment but considered of low likelihood	Along river and in wider surrounds numerous post-medieval industrial sites (mills, quarries, kilns etc.), probably of low-medium value	Detailed assessment/options appraisal (Cumbria HER)
River Kent	KE02	SD513906	Helsington Weir, Water Crook	Falls within or close to Watercrook Roman fort and civil settlement SM - physical alterations will require SMC	South of the weir there are considerable number of undated (probably prehistoric) and Roman sites, including ritual sites (an altar (HER19009), and Potlands Roman cemetery (HER 3108), as well as other burials. There is a potential for works to affect	Detailed assessment to inform options/mitigation incl. need for SMC (Cumbria HER)

River	Weir ID	NGR	Name	Relevant historic environment designations issues/permit requirements	Non-designated heritage assets/archaeological potential	Further work required/respective regional repository
					physical remains along the banks or for preservation conditions for buried remains to adversely change. Possibility for presence of in-river structures of various dates.	
River Kent	KE03	SD519929	Stramongate Weir, Kendal	Weir within 100mm from Stramongate Bridge SM. Potential impacts on setting of SM may require liaison with EH Lies within Kendal conservation area - works likely to require LPA consent	Large number of sites on west and north of weir. Further SM downstream (Miller Bridge, 350m), but hidden visually by bend in river.	Detailed assessment to inform options/mitigation incl. need for LPA consent
River Kent	KE04	SD497968	Weir at Bowston and EA gauging station	No licensing requirements expected - nearest LBII within approximately 250m but no visual connection expected	Along and in wider surrounds of the river numerous post-medieval industrial sites (mills, quarries etc.), probably of low value. Archaeological potential expected to be low.	Basic assessment/options appraisal (Cumbria HER)
River Kent	KE05	SD499965	Bowston EA gauging station	No licensing requirements expected - nearest LBII within approximately 250m but no visual connection expected	Along and in wider surrounds of the river numerous post-medieval industrial sites (mills, quarries etc.), probably of low value. Archaeological potential expected to be low. Some potential for historic industrial structures to be affected by changes in water regime	Basic assessment/options appraisal (Cumbria HER)
River Kent	KE06	SD492973	Weir at Cowan Head	No licensing requirements expected	Along and in wider surrounds of the river numerous post-medieval industrial sites (mills, quarries etc.), probably of low value. Archaeological potential expected to be low. Some potential for historic industrial structures to be affected by changes in water regime	Basic assessment/options appraisal (Cumbria HER)

River	Weir ID	NGR	Name	Relevant historic environment designations issues/permit requirements	Non-designated heritage assets/archaeological potential	Further work required/respective regional repository
River Kent	KE07	SD472983	Weir Staveley	No licensing requirements expected	Along and in wider surrounds of the river numerous post-medieval industrial sites (mills, quarries etc.), probably of low value. Archaeological potential expected to be low. Some potential for historic industrial structures to be affected by changes in water regime	Basic assessment/options appraisal (covered by Lake District HER)
River Kent	KE08	SD470987	Weir at Barley Bridge, Staveley	Barley Bridge is a LBII - liaison with LPA regarding setting impacts may be required	Along and in wider surrounds of the river numerous post-medieval industrial sites (mills, quarries etc.), probably of low value. Site borders on industrial park where all archaeological remains are likely to have been removed.	Basic assessment/options appraisal (covered by Lake District HER)
River Mint	MI01	SD524945	Weir upstream of Mint bridge and EA gauging station	No licensing requirements expected	Medieval landscape and historic industrial landscape; deserted medieval settlement (DMV) site downstream, but overall low archaeological potential expected.	Basic assessment/options appraisal (Cumbria HER)
River Mint	MI02	SD547958	Weir upstream of Meal Bank	No licensing requirements expected	A small number of post-medieval industrial features along river. Patton DMV lies inland from weir site, so possible some medieval activity expected, but overall low potential anticipated.	Basic assessment/options appraisal (Cumbria HER)
River Mint	MI03	SD554978	Weir at Patton Mill	No licensing requirements expected	Patton Mill is an unlisted medieval building, probably of low remaining historic value. Some sparse post-medieval and prehistoric features in wider landscape. Overall low archaeological potential anticipated.	Basic assessment/options appraisal (Cumbria HER)

River	Weir ID	NGR	Name	Relevant historic environment designations issues/permit requirements	Non-designated heritage assets/archaeological potential	Further work required/respective regional repository
River Sprint	SP01	SD516962	Weir at Sprint Mill and EA gauging station	No licensing requirements expected	Medieval landscape and historic industrial landscape features with deserted medieval settlement (DMV) site downstream, but overall low potential expected.	Basic assessment/options appraisal (Cumbria HER)
River Sprint	SP02	SD523994	Weir Upstream of Garnett Bridge	Two LBII within 150m/200m but no visual connection anticipated. No licensing requirements expected	A small number of post-medieval industrial features along river and inland. Fellside location, overall low potential anticipated.	Basic assessment/options appraisal (Cumbria HER, borders onto Lake District HER)
River Gowan	GO01	SD467983	Weir at Staveley	No licensing requirements expected	Close to known site of post-medieval bobbin mill, expected to be of low value. Overall low archaeological potential anticipated.	Basic assessment/options appraisal (covered by Lake District HER)

Limitations of the assessment

With the exception of the NHLE online sources are expressly intended for an informal use only, and do not always represent the most up-to-date dataset available. The assessment presented here therefore does not meet the scope, objectives or methodology of a full detailed historic environment desk-based assessment (as defined by the relevant guidelines of the Institute for Archaeologists (IfA)), or is to be understood as a comprehensive evaluation of any historic environment constraints that may arise from the scheme.

In addition to this caveat, it is noted that much of the data on non-designated remains provided by these repositories often consists of secondary information derived from varied sources, with limitations in terms of accuracy, such as:

- Where areas have not been subject to methodical investigation (such as many rural sites) an absence of data does not necessarily indicate an absence of heritage assets or archaeological potential, but merely an absence of record;
- Where records exist, the full extent, date and nature of known sites is often uncertain;
- The visibility of archaeological features, as crop marks, depends on local geology and land-use, as well as ground and weather conditions at the time of the record being made; and
- A number of site records, especially older records such as antiquarian finds, excavations or observations often fail to accurately locate sites.

Appendix C. Previous Studies

A review of previous studies was undertaken to provide further context for this report. The main findings of each study is summarised below.

Report title and brief description of aim	Main findings
<p>Kent Catchment Geomorphological Assessment, Orr, Block and Newson (2000)</p> <p>Desk study to analyse historical channel changes and</p> <p>Field study to map and identify erosion/depositional features/bank protection/engineered structures</p>	<ul style="list-style-type: none"> • Sediment erosion widespread within valley bottom, particularly in the River Mint catchment (due to heavy cattle poaching) • Deposition mainly in the lower River Kent catchment. • Calculations from sub-catchments highlight the importance of reducing accelerated sediment yield from the River Mint catchment + dealing with soil heaps on the upper Sprint. • Natland Mill Brook has substantial gravel deposits blocking surface water drainage. Gravel trap installed at Mintsfleet in Kendal. • 45% of main river classed as stable, 55% experiencing some form of erosion. Natural channel processes are restricted. • Climate change will impact on erosion and sediment availability.
<p>PSA3 Riverine SSSI Restoration Visions, River Kent Catchment – Restoration Vision, Jacobs (2010) (for the Environment Agency and Natural England)</p> <p>Study of River Kent catchment to provide a restoration vision for the SSSI on seven units in unfavourable condition.</p> <p>River Kent</p>	<ul style="list-style-type: none"> • Modified extensively in upper reaches so very localised erosion only where protection has failed. Very few opportunities for natural processes to prevail. Channel constrained naturally by bedrock north of Kentmere village. Channel characteristics alternate between bank protection and bedrock with steep wooded valley sides downstream of kentmere tarn. Between Gowan and Sprint confluences, sediment regime is interrupted by three large weirs and largely constrained. Natural erosional/depositional processes evident further downstream but bank protection recently implemented to protect golf course on outskirts of Kendal. • Kent, ecologically, becomes heavily constrained watercourse with coarse substrates and impassable waterfalls in its upper reaches. Isolated patches of very good quality habitat prior to Kent entering Kentmere Tarn. Below tarn the mid-section is high energy and variable depth. Compacted substrates limit spawning habitat but provide sub optimal habitat for crayfish/bullhead and fry observed in backwater slacks. • Key issues: Stone bank protection limits planform adjustment in several reaches; large weirs are a major influence on the flow and sediment regime between Staveley and Burneside. • Options: Removal of bank protection and embankments to aid more natural recovery. Weir removal also to be proposed.
<p>River Sprint</p>	<ul style="list-style-type: none"> • Upland areas modified by straightening and embankments, some of which are starting to erode. These modifications have limited number of natural sediment deposits and feature, such as pools/riffles, creating homogenous flow types. Middle reaches higher energy, but have more flow variety and more natural width/depth ratio. Bedrock/valley sides constrain channel form in these areas with a number of old mills with weirs present. • Good crayfish/bullhead habitat throughout. Salmon spawning/lamprey habitat limited to the middle third of Sprint. Habitat diversity good despite dominance of coarser sediment types and high energy flow regime. Coarse substrates and long bedrock sections dominate in lower Sprint, limiting spawning habitat development. Two natural waterfalls may cause obstruction to migratory species, limiting utilisation of upper catchment.

Report title and brief description of aim	Main findings
	<ul style="list-style-type: none"> • Key issues: Modifications in upland areas significantly altered river planform and cross-sections. Some adjustment occurring (erosion) with potential for much larger scale future change if left unmanaged. • Options: Significant restoration opportunities in upper reaches through a combination of active planform restoration/removal of bank protection. Restoration should aim to increase flow variation and reinstate more natural cross section and allow future adjustment to flow/sed regime.
River Gowan	<ul style="list-style-type: none"> • Mid-catchment river of moderate gradient with low gradient stretch in middle reaches, where topography glacially influenced. Flow moderated by Borrans reservoir. Modifications (eg reinforcements, straightening and weirs) present in urban areas of Ings and Staveley. Channel also straightened through improved grassland, and evidence of natural adjustment predominantly through narrowing and vegetation growth. • Upper Gowan demonstrates typical ecological habitat types for surrounding land use and gradient. Failing bank protection and coarse substrates provide significant cover (83%) for crayfish throughout upper reaches. Mid-section provides good fry and crayfish habitat, with increase in lower energy flow types, mixed substrates and vegetation. Lower reach through Staveley heavily urbanised with several weirs potentially restricting salmonid and bullhead migration. • Key issues: Urban areas at Ings and Staveley limit potential for restoration and have created areas of quite limited habitat through reinforcement of banks and oversizing of channel. Riparian zone lacking in some reaches. • Options: Improvements to riparian zone could have significant benefits for ecology. 4th quintile downstream recovering from past modification but has v. good habitats for ecology, limiting requirement for active restoration.
River Mint	<ul style="list-style-type: none"> • Mid-catchment river of moderate gradient with occasional steeper reaches in confined valley. Drumlins constrain valley and channel forms. Modifications are typical - agricultural embankments, bank reinforcements and straightened sections. Old weirs associated with milling still present. Most reaches geomorphologically stable – processes varied, with only limited evidence of lateral adjustment and incision. • Provides extensive crayfish/bullhead habitat along its length, with coarse substrates in upper reaches limiting habitat for juvenile salmonid. Some significant weirs pose barrier to migrating species and affect ecology upstream by ponding flow. Downstream weirs do not impede upstream migration and pockets of gravel (mixed flow types) provide suitable spawning habitats. • Key issues: Main modifications are embankments and bank reinforcements at upstream and downstream extents of reach. These modifications have limited development of marginal habitats and full pools on meander bends. Weir in middle reaches which may restrict fish passage. Unlikely the weir has impact on reach-scale morphology as it creates very little upstream ponding. • Options: Upstream, embankments and reinforcements could be removed. Although river has sinuous planform the range of in-channel habitat and flow variation is restricted, as is floodplain connectivity.

Report title and brief description of aim	Main findings
	<ul style="list-style-type: none"> • Weir approx. in middle of river should be investigated for removal/creation of natural bypass (to facilitate fish passage).
<p>River Kent Geomorphological Assessment, CBEC (2014) (for South Cumbria Rivers Trust)</p> <p>Investigate current impact of tailings on the geomorphic structure of river, inferred influence on ecology and risk of further erosion of tailings from river.</p> <p>Focus on upper River Kent; in particular the reach alongside Jumb Quarry site. Historical dammed in this location (mine tailings on both banks) until high flow event in 1997 breached dam, eroding tailings and incising new channel.</p>	<ul style="list-style-type: none"> • Fluvial audit walkover of upper reaches of River Kent indicated sediment from mine tailings has had limited impact on downstream channel. Further downstream, character of channel is influenced more by local factors – artificial embankments and bank protection. Sediment transport capacity of channel likely to have been increased by these constraints, increasing ability of river to transport excess sediment to Kentmere Tarn. Considerable sediment transport in an event similar to 1997. • Significant incision in two years – new channel formed. 2003-2013, little further incision. Mine tailings stable BUT similar event to 1997 will cause significant erosion. • Gravel trap downstream of mine tailings full and acting as sediment source.

Appendix D. Indicative costs

Cost Bands		Score
Low	< £40k	1 to 2
Medium	£40k - £100k	0
High	> £100k	-1 to -2

Weir	Option	Cost Band	Considerations	Score
KE01	Do Nothing	Low	EA will continue maintenance. Weir is in good condition.	2
	Full Removal	High	Potential in river works. EA negotiations. Access through private land. Potential for works in private land. Heritage assessment required.	-2
	Partial Removal	High	Potential in river works. EA negotiations. Access through private land. Potential for works in private land. Heritage assessment required.	-2
	Fish Pass	Low	Minor improvements to existing pass structure possible. Eel Pass already installed.	0
KE02	Do Nothing	Medium	Potential for emergency works if weir fails. Scour protection measures likely to be required as failure occurs.	1
	Full Removal	High	In river works required. Large structure to remove with vast silt deposits likely behind. Potential for river training and scour protection works downstream. Heritage Assessment may be required.	-2
	Partial Removal	Medium	Potential for smaller sections to be removed as per existing informal fish pass. Some in river working may be required. Potential to manage failure of weir, sediment release and river migration.	0
	Fish Pass	Medium	Formalisation of existing informal pass. Improved passage required for smaller species and eels. Potential for weir collapse which would negate benefits of fish pass.	0
KE03	Do Nothing	Low	Weir is well maintained.	2
	Full Removal	High	Heritage assessment required. Ecology and habitats study required. Flood risk assessment required. Structural assessments of surrounding buildings and structures required. Potential for additional work to secure buildings and structures. In river working required. Large structure with vast silt deposits likely behind.	-2
	Partial Removal	High	As for Full Removal, with reduced civils/construction costs likely.	-1
	Fish Pass	Low	Minor improvements to existing pass structure possible. In river works required.	1
KE04	Do Nothing	Low	Weir is in relatively good condition.	2
	Full Removal	High	Flood risk assessment required. Structural assessments of surrounding buildings and structures required. Potential for additional work to secure buildings and structures. In river working likely. Access is difficult.	-2
	Partial Removal	High	As for Full Removal, with reduced civils/construction costs likely.	-1
	Fish Pass	Medium	Large structure to overcome, fish pass structure likely to be large. Existing fish passes are inadequate. Additional eel pass may be required. Access may be difficult. In channel working may be required.	1
KE05	Do Nothing	Low	EA will continue maintenance. Weir is in good condition.	2
	Full Removal	Medium	Potential in river works. EA negotiations.	1
	Partial Removal	Medium	Potential in river works. EA negotiations. No benefits over Full Removal and unlikely to cost less	1
	Fish Pass	Low	Considered neutral as cost:benefit likely to be very low - very low head difference for fish to overcome.	0

KE06	Do Nothing	Low	Existing weir is largely in good condition. Existing fish pass installed. A full condition assessment may be required.	2
	Full Removal	High	Access is difficult. Access likely through private land. Heritage assessment required. Structural assessment of buildings on right bank required. Loss of abstraction to residents ponds may require additional works. In river working will be required. Likely to be prohibitive health and safety considerations with channel drop downstream of weir. Compensation for abstraction licence.	-2
	Partial Removal	High	As for Full Removal, with reduced civils/construction costs likely. A full condition assessment may be required and additional works at the sluice gate may be required.	-2
	Fish Pass	Low	Works to improve existing fish pass. Potential for additional eel pass. May require works on golf course. A full condition assessment may be required. Access is difficult. Additional works at the sluice gate may be required.	1
KE07	Do Nothing	Low	Condition assessment required as partial collapse appears to have occurred. Existing fish pass already installed.	0
	Full Removal	High	Access is very difficult to this site. In river working likely to be required. Structure is large and likely large sediment deposits behind. Compensation for abstraction licence.	-2
	Partial Removal	Medium	As for Full Removal, with reduced civils/construction costs likely. A full condition assessment may be required.	-1
	Fish Pass	Low	Minor improvements to existing pass structure possible. Potential for additional eel pass. Access is difficult.	0
KE08	Do Nothing	Low	Weir appears generally in good condition. An existing fish pass is in place. Some maintenance of this fish pass may be required.	1
	Full Removal	High	Heritage assessment required for listed structure. Heritage and structural assessments at bridge and buildings downstream. Flood risk assessment required. In channel working likely. Large structure with large sediment deposits behind likely.	-2
	Partial Removal	High	As for Full Removal, with reduced civils/construction costs likely.	-2
	Fish Pass	Low	Improvements and maintenance works to existing fish pass potential option. Additional eel pass may be required.	0
MI01	Do Nothing	Low	EA will continue maintenance. Weir is in good condition.	2
	Full Removal	Medium	Potential in river works. EA negotiations.	-2
	Partial Removal	Medium	Potential in river works. EA negotiations. No benefits over Full Removal and unlikely to cost less	-2
	Fish Pass	Low	Considered neutral as cost:benefit likely to be very low.	0
MI02	Do Nothing	Low	Structure appears in good condition. Existing fish pass in place.	2
	Full Removal	High	Access is difficult. Heritage assessment may be required as purpose and age unclear. In river working likely. Large structure with large sediment deposits behind likely.	-2
	Partial Removal	High	As for Full Removal, with slightly reduced civils/construction costs likely.	-2
	Fish Pass	Low	Access is difficult. Potential for minor improvements to existing fish pass. In river working likely. Additional eel pass may be required.	1
MI03	Do Nothing	Low	Failure of structure has limited associated risks.	2
	Full Removal	Low	Access is difficult. FRA and structural assessment not needed due to location. Works will be minor with a short programme.	0
	Partial Removal	Low	As for Full Removal, with very slightly reduced civils/construction costs likely.	0
	Fish Pass	Medium	Access is difficult. Structure is likely to fail in future so fish pass will become redundant. Likely the most expensive option given size of weir and difficult location to access.	-2
SP01	Do Nothing	Low	EA will continue maintenance. Weir is in good condition.	2
	Full Removal	Medium	Potential in river works. EA negotiations.	-1
	Partial Removal	Medium	Potential in river works. EA negotiations. No benefits over Full Removal and unlikely to cost less	-2
	Fish Pass	Low	Considered neutral as cost:benefit likely to be very low.	0

SP02	Do Nothing	Low	Failure of structure has limited associated risks.	2
	Full Removal	Low	Access is difficult. FRA and structural assessment not needed due to location. Works will be minor with a short programme. May require some scour protection works on the left bank.	0
	Partial Removal	Low	As for Full Removal, with very slightly reduced civils/construction costs likely.	0
	Fish Pass	Medium	Access is difficult. Structure is likely to fail in future so fish pass will become redundant. Likely the most expensive option given size of weir and difficult location to access.	-1
GO01	Do Nothing	Low	Structure appears in reasonable condition.	2
	Full Removal	High	Access very difficult and through private property. Heritage assessment will be required. Structural assessment required at buildings in vicinity of weir. Structure is high with likely large deposits of silt behind.	-2
	Partial Removal	High	As for Full Removal, with very slightly reduced civils/construction costs likely.	-2
	Fish Pass	High	Access very difficult. Works likely required on private land. Full condition survey of weir will be required to ensure fish pass does not become redundant. Structure may be very long to overcome large head difference at weir.	-2

Appendix E. Multi-Criteria Analysis (MCA)

Feature	Ecology			Morphological diversity		Ecology and morphology subscore	Landscape	Stakeholders		Engineering		Technical feasibility and condition of weir subscore	Cost	Total without cost	Total with cost
	Indicator	Habitat connectivity	Fish passage	Length of impact	Flow		Sediment	Heritage value	Statutory	Non statutory	Condition of weir		Technical feasibility and practicality		
Weir and options	Weighting	1	1	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.8			
KE01 Weir at Sedgwick and EA gauging station															
Do nothing	0	0	0	0	0	0	0	2	2	2	2	3.6	2	7.2	8.8
Full Removal	2	1	1	1	1	1	5.7	-1.6	-0.9	-0.9	-1.8	-0.9	-1.6	1.4	-0.2
Partial Removal	1	1	0	1	1	1	3.8	-1.6	-0.9	-0.9	-1.8	-0.9	-1.6	-0.5	-2.1
Fish Passage	0	1	0	0	0	0	1	-1.6	-0.9	0	0	1.8	0	0.3	0.3
KE02 Helsington Weir, Water Crook															
Do nothing	0	0	0	0	0	0	0	-2	0	-2	0	-1.8	1	-3.6	-2.8
Full Removal	2	1	2	2	2	2	8.4	-1.6	1.8	0	1.8	0.9	-1.6	9.5	7.9
Partial Removal	1	0	1	1	1	1	3.7	-1.6	0.9	0	0.9	1.8	0	5.7	5.7
Fish Passage	0	0	0	0	0	0	0	-2	1	0	0	0	0	0	0
KE03 Stramongate Weir, Kendal															
Do nothing	0	0	0	0	0	0	0	-2	0	2	2	3.6	2	1.8	3.4
Full Removal	2	1	2	1	1	1	6.6	-1.6	1.8	-0.9	-1.8	-3.6	-1.6	2.3	0.7
Partial Removal	1	1	1	1	1	1	4.7	-1.6	0.9	-0.9	-1.8	-0.9	-0.8	0.4	-0.4
Fish Passage	0	1	0	0	0	0	1	-2	1	0	0	1.8	1	2.1	2.9
KE04 Weir at Bowston															
Do nothing	0	0	0	0	0	0	0	-2	0	-1	0	-0.9	2	-2.7	-1.1
Full Removal	0	1	2	2	2	2	6.4	0	1.8	-0.9	0.9	-0.9	-1.6	7.3	5.7
Partial Removal	0	1	1	1	1	1	3.7	0	0.9	-0.9	0.9	-0.9	-0.8	3.7	2.9
Fish Passage	0	1	0	0	0	0	1	0	1	0	0	1.8	1	3.7	4.5
KE05 Bowston EA gauging station															
Do nothing	0	0	0	0	0	0	0	2	2	2	2	3.6	2	7.2	8.8
Full Removal	1	0	1	1	1	1	3.7	0	-0.9	0	-1.8	1.8	0.8	2.8	3.6
Partial Removal	0	0	0	1	0	0	0.9	0	-1	0	-2	-1	1	-2.7	-1.9
Fish Passage	0	0	0	0	0	0	0	0	-1	0	0	-0.9	0	-1.8	-1.8
KE06 Weir at Cowan Head															
Do nothing	0	0	0	0	0	0	0	-2	0	0	2	1.8	2	0	0
Full Removal	1	1	2	2	2	2	7.4	0	1.8	-0.9	0.9	-1.8	-1.6	7.4	5.8
Partial Removal	0	0	1	2	2	2	4.5	0	0.9	-0.9	0.9	-1.8	-1.6	3.6	2
Fish Passage	0	0	0	0	0	0	0	0	1	0	0	0	1	0.9	1.7
KE07 Weir at Staveley															
Do nothing	0	0	0	0	0	0	0	-2	0	-2	2	0	0	-1.8	-1.8
Full Removal	0	1	2	2	2	2	6.4	0	1.8	-2	2	-1	-2	7.3	5.7
Partial Removal	0	0	1	2	2	2	4.5	0	0.9	-0.9	0.9	-0.9	-0.8	4.5	3.7
Fish Passage	0	0	0	0	0	0	0	0	1	0	0	0	0	0.9	0.9

Feature	Ecology			Morphological diversity		Ecology and morphology subscore	Landscape	Stakeholders		Engineering		Technical feasibility and condition of weir subscore	Cost	Total without cost	Total with cost
	Indicator Weighting	Habitat connectivity	Fish passage	Length of impact	Flow		Sediment	Heritage value	Statutory	Non statutory	Condition of weir		Technical feasibility and practicality		
KE08 Weir at Barley Bridge, Staveley	1	1	0.9	0.9	0.9		0.8	0.9	0.9	0.9	0.9	0.8			
Do nothing	0	0	0	0	0	0	0	-2	0	0	1	0.9	1	-0.9	-0.1
Full Removal	2	1	2	2	2	8.4	-1	2	-1	1	-1	0	-2	8.5	6.9
Partial Removal	1	1	1	1	2	6.5	-1	1	-1	0	-1	-0.9	-2	4.8	3.2
Fish Passage	0	1	0	0	0	1	-1	1	0	0	0	0	0	1.1	1.1
MI01 Weir upstream of Mint Bridge and EA gauging station															
Do nothing	0	0	0	0	0	0	0	2	2	2	2	3.6	2	7.2	8.8
Full Removal	1	0	1	1	1	3.7	0	-1	0	-2	0	-1.8	-2	1	-0.6
Partial Removal	0	0	0	1	1	1.8	0	-1	0	-2	-1	-2.7	-2	-1.8	-3.4
Fish Passage	0	0	0	0	0	0	0	-1	0	0	-1	-0.9	0	-1.8	-1.8
MI02 Weir upstream of Meal Bank															
Do nothing	0	0	0	0	0	0	0	-2	0	1	1	1.8	2	0	1.6
Full Removal	2	2	2	1	1	7.6	0	2	-1	-1	-1	-1.8	-2	6.7	5.1
Partial Removal	1	2	1	1	1	5.7	0	1	-1	-1	-1	-1.8	-2	3.9	2.3
Fish Passage	0	2	0	0	0	2	0	1	0	0	1	0.9	1	3.8	2.3
MI03 Weir at Patton Mill															
Do nothing	0	0	0	0	0	0	0	-2	0	0	2	1.8	2	0	1.6
Full Removal	2	1	2	2	2	8.4	0	2	0	0	1	0.9	0	11.1	11.1
Partial Removal	1	1	1	1	1	4.7	0	1	0	0	1	0.9	0	6.5	6.5
Fish Passage	0	1	0	0	0	1	0	1	0	0	-1	-0.9	-2	1	-0.6
SP01 Weir at Sprint Mill and EA gauging station															
Do nothing	0	0	0	0	0	0	0	2	2	2	2	3.6	2	7.2	8.8
Full Removal	1	1	1	1	1	4.7	0	-1	-1	-1	1	0	-1	2.9	2.1
Partial Removal	0	1	0	1	1	2.8	0	-1	-1	-1	-1	-1.8	-2	-0.8	-2.4
Fish Passage	0	1	0	0	0	1	0	-1	0	0	1	0.9	0	1	1
SP02 Weir upstream of Garnet Bridge															
Do nothing	0	0	0	0	0	0	0	-2	0	0	1	0.9	2	-0.9	0.7
Full Removal	2	1	1	2	2	6.6	0	2	-1	2	2	3.6	0	11.1	11.1
Partial Removal	1	1	0	1	1	3.8	0	1	0	1	-1	0	0	4.7	4.7
Fish Passage	0	1	0	0	0	1	0	1	0	0	-2	-1.8	-1	0.1	-0.7
GO01 Weir at Staveley															
Do nothing	0	0	0	0	0	0	0	-2	0	0	2	1.8	2	0	1.6
Full Removal	1	1	0	0	0	2	0	2	0	0	-2	-1.8	-2	2	0.4
Partial Removal	0	0	0	0	0	0	0	1	0	0	-2	-1.8	-2	-0.9	-2.5
Fish Passage	0	0	0	0	0	0	0	1	0	0	-2	-1.8	-2	-0.9	-2.5

Feature	Indicator	Ecology			Morphological diversity		Ecology and morphology subscore	Landscape	Stakeholders		Engineering		Technical feasibility and condition of weir subscore	Cost	Total without cost	Total with cost
		Habitat connectivity	Fish passage	Length of impact	Flow	Sediment		Heritage value	Statutory	Non statutory	Condition of weir	Technical feasibility and practicality		Cost		
MI03	Full Removal	2	1	1.8	1.8	1.8	8.4	0	1.8	0	0	0.9	0.9	0	11.1	11.1
SP02	Full Removal	2	1	0.9	1.8	0.9	6.6	0	1.8	-0.9	1.8	1.8	3.6	0	11.1	11.1
KE02	Full Removal	2	1	1.8	1.8	1.8	8.4	-1.6	1.8	0	1.8	-0.9	0.9	-1.6	9.5	7.9
KE08	Full Removal	2	1	1.8	1.8	1.8	8.4	-0.8	1.8	-0.9	0.9	-0.9	0	-1.6	8.5	6.9
KE06	Full Removal	1	1	1.8	1.8	1.8	7.4	0	1.8	-0.9	0.9	-1.8	-0.9	-1.6	7.4	5.8
KE04	Full Removal	0	1	1.8	1.8	1.8	6.4	0	1.8	-0.9	0.9	-0.9	0	-1.6	7.3	5.7
KE07	Full Removal	0	1	1.8	1.8	1.8	6.4	0	1.8	-1.8	1.8	-0.9	0.9	-1.6	7.3	5.7
KE01	Do nothing	0	0	0	0	0	0	0	1.8	1.8	1.8	1.8	3.6	1.6	7.2	8.8
KE05	Do nothing	0	0	0	0	0	0	0	1.8	1.8	1.8	1.8	3.6	1.6	7.2	8.8
MI01	Do nothing	0	0	0	0	0	0	0	1.8	1.8	1.8	1.8	3.6	1.6	7.2	8.8
SP01	Do nothing	0	0	0	0	0	0	0	1.8	1.8	1.8	1.8	3.6	1.6	7.2	8.8
MI02	Full Removal	2	2	1.8	0.9	0.9	7.6	0	1.8	-0.9	-0.9	-0.9	-1.8	-1.6	6.7	5.1
MI03	Partial Removal	1	1	0.9	0.9	0.9	4.7	0	0.9	0	0	0.9	0.9	0	6.5	6.5
KE02	Partial Removal	1	0	0.9	0.9	0.9	3.7	-1.6	0.9	0	0.9	1.8	2.7	0	5.7	5.7
KE08	Partial Removal	1	1	0.9	1.8	1.8	6.5	-0.8	0.9	-0.9	0	-0.9	-0.9	-1.6	4.8	3.2
SP02	Partial Removal	1	1	0	0.9	0.9	3.8	0	0.9	0	0.9	-0.9	0	0	4.7	4.7
KE07	Partial Removal	0	0	0.9	1.8	1.8	4.5	0	0.9	-0.9	0.9	-0.9	0	-0.8	4.5	3.7
MI02	Partial Removal	1	2	0.9	0.9	0.9	5.7	0	0.9	-0.9	-0.9	-0.9	-1.8	-1.6	3.9	2.3
MI02	Fish Passage	0	2	0	0	0	2	0	0.9	0	0	0.9	0.9	0.8	3.8	2.3
KE04	Fish Passage	0	1	0	0	0	1	0	0.9	0	0	1.8	1.8	0.8	3.7	4.5
KE04	Partial Removal	0	1	0.9	0.9	0.9	3.7	0	0.9	-0.9	0.9	-0.9	0	-0.8	3.7	2.9
KE06	Partial Removal	0	0	0.9	1.8	1.8	4.5	0	0.9	-0.9	0.9	-1.8	-0.9	-1.6	3.6	2
SP01	Full Removal	1	1	0.9	0.9	0.9	4.7	0	-0.9	-0.9	-0.9	0.9	0	-0.8	2.9	2.1
KE05	Full Removal	1	0	0.9	0.9	0.9	3.7	0	-0.9	0	-1.8	1.8	0	0.8	2.8	3.6
KE03	Full Removal	2	1	1.8	0.9	0.9	6.6	-1.6	1.8	-0.9	-1.8	-1.8	-3.6	-1.6	2.3	0.7
KE03	Fish Passage	0	1	0	0	0	1	-1.6	0.9	0	0	1.8	1.8	0.8	2.1	2.9
GO01	Full Removal	1	1	0	0	0	2	0	1.8	0	0	-1.8	-1.8	-1.6	2	0.4
KE03	Do nothing	0	0	0	0	0	0	0	-1.8	0	1.8	1.8	3.6	1.6	1.8	3.4
KE01	Full Removal	2	1	0.9	0.9	0.9	5.7	-1.6	-0.9	-0.9	-1.8	0.9	-0.9	-1.6	1.4	-0.2
KE08	Fish Passage	0	1	0	0	0	1	-0.8	0.9	0	0	0	0	0	1.1	1.1
MI03	Fish Passage	0	1	0	0	0	1	0	0.9	0	0	-0.9	-0.9	-1.6	1	-0.6
SP01	Fish Passage	0	1	0	0	0	1	0	-0.9	0	0	0.9	0.9	0	1	1
MI01	Full Removal	1	0	0.9	0.9	0.9	3.7	0	-0.9	0	-1.8	0	-1.8	-1.6	1	-0.6
KE06	Fish Passage	0	0	0	0	0	0	0	0.9	0	0	0	0	0.8	0.9	1.7
KE07	Fish Passage	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0.9	0.9
KE03	Partial Removal	1	1	0.9	0.9	0.9	4.7	-1.6	0.9	-0.9	-1.8	-0.9	-2.7	-0.8	0.4	-0.4
KE01	Fish Passage	0	1	0	0	0	1	-1.6	-0.9	0	0	1.8	1.8	0	0.3	0.3
KE02	Fish Passage	0	0	0	0	0	0	-1.6	0.9	0	0	0.9	0.9	0	0.2	0.2
SP02	Fish Passage	0	1	0	0	0	1	0	0.9	0	0	-1.8	-1.8	-0.8	0.1	-0.7
KE06	Do nothing	0	0	0	0	0	0	0	-2	0	0	2	2	0	0	0
KE06	Do nothing	0	0	0	0	0	0	0	-1.8	0	0	1.8	1.8	1.6	0	1.6
MI02	Do nothing	0	0	0	0	0	0	0	-1.8	0	0.9	0.9	1.8	1.6	0	1.6
MI03	Do nothing	0	0	0	0	0	0	0	-1.8	0	0	1.8	1.8	1.6	0	1.6
GO01	Do nothing	0	0	0	0	0	0	0	-1.8	0	0	1.8	1.8	1.6	0	1.6
KE01	Partial Removal	1	1	0	0.9	0.9	3.8	-1.6	-0.9	-0.9	-1.8	0.9	-0.9	-1.6	-0.5	-2.1
SP01	Partial Removal	0	1	0	0.9	0.9	2.8	0	-0.9	-0.9	-0.9	-0.9	-1.8	-1.6	-0.8	-2.4
KE08	Do nothing	0	0	0	0	0	0	0	-1.8	0	0	0.9	0.9	0.8	-0.9	-0.1
SP02	Do nothing	0	0	0	0	0	0	0	-1.8	0	0	0.9	0.9	1.6	-0.9	0.7
GO01	Partial Removal	0	0	0	0	0	0	0	0.9	0	0	-1.8	-1.8	-1.6	-0.9	-2.5
GO01	Fish Passage	0	0	0	0	0	0	0	0.9	0	0	-1.8	-1.8	-1.6	-0.9	-2.5
KE05	Fish Passage	0	0	0	0	0	0	0	-0.9	0	0	-0.9	-0.9	0	-1.8	-1.8
KE07	Do nothing	0	0	0	0	0	0	0	-1.8	0	-1.8	1.8	0	0	-1.8	-1.8
MI01	Partial Removal	0	0	0	0.9	0.9	1.8	0	-0.9	0	-1.8	-0.9	-2.7	-1.6	-1.8	-3.4
MI01	Fish Passage	0	0	0	0	0	0	0	-0.9	0	0	-0.9	-0.9	0	-1.8	-1.8
KE04	Do nothing	0	0	0	0	0	0	0	-1.8	0	-0.9	0	-0.9	1.6	-2.7	-1.1
KE05	Partial Removal	0	0	0	0.9	0	0.9	0	-0.9	0	-1.8	-0.9	-2.7	0.8	-2.7	-1.9
KE02	Do nothing	0	0	0	0	0	0	0	-1.8	0	-1.8	0	-1.8	0.8	-3.6	-2.8

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