Improving the River Beult for People and Wildlife

Technical Report

June 2018

CAPITA

Part of the
Medway Flood Partnership

Part of the
Medway Flood Partnership

Quality Management

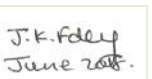
Capita

Job No	CS/088704		
Project	Improving the River Beult SSSI for People and Wildlife		
Location	Kent		
Title	Improving the River Beult SSSI Technical Report		
Document Ref	IMSE100464-CAA-00-XX-RP-EN-0001	**Issue / Revision**	P04
Date	15/06/2018		
Prepared by	L Smallwood		
Checked by	R Chase		
Authorised by	C Lawrence		

Natural England

Authorised by	James Seymour	Signature	 19/07/2018

Environment Agency

Authorised by	Julie Foley	Signature	

Revision Status / History

Rev	Date	Issue / Purpose/ Comment	Prepared	Checked	Authorised
P01	27/10/2017	For Client Review	L Smallwood	R Chase	C Lawrence
P02	22/01/2018	For Client Review	L Smallwood	R Chase	C Lawrence
P03	12/03/2018	For Client Review	L Smallwood	R Chase	C Lawrence
P04	26/04/2018	Final Issue	S Thomas, Environment Agency		

CAPITA

Contents

Figures

Tables

Executive Summary

Background

The River Beult flows through Kent from headwaters in Bethersden and Pluckley to join the River Medway at Yalding. It is designated a Site of Special Scientific Interest (SSSI) from Hadmans Bridge near Smarden to the confluence with the River Medway. It was notified in 1994 as one of the best examples of a lowland clay river in the country that still supported characteristic plants and animal species.

The River Beult is a vital natural resource for both people and wildlife. It is a source of freshwater, controls and stores flood waters, supports crop pollination and improves the wellbeing of the local community through interests such as fishing and walking. However, issues affecting the river prevent it from fulfilling its potential as a natural resource for people and wildlife. It is essential that improvements are made to allow people and wildlife to continue enjoying the wide range of benefits the River Beult can offer.

The Beult has low summer flows but also frequent winter flooding. The low flows within the Beult consist of between 50-75% waste water treatment works discharge of treated effluent.

Water levels along the river are controlled by six stop board structures, which are installed during the summer and are removed during the winter. An automated sluice and Cheveney Mill also maintain water levels upstream of Yalding. As a result, water is impounded along almost the entire length of the River Beult SSSI. Water is also abstracted from the Beult for agriculture and fisheries.

The impounded water within the Beult suffers from high algae and duckweed growth and low dissolved oxygen levels. Fish populations are vulnerable in these conditions and angling participation has declined in recent years.

Intermittent dredging and channel modifications since the 1930s removed most of the gravel and cobble sediments from the river and caused bank failures under pressures from livestock and, occasionally, recreational access.

Water from the Beult catchment contributes to flooding in Smarden, Headcorn and eight parish council areas near the confluence between the Rivers Medway, Beult and Teise. This includes the village of Yalding. Historic management of the river has contributed to increased flashiness of flooding.

Many of these issues are reflected in the assessment of the SSSI as in Unfavourable Condition. The Water Framework Directive (WFD) status of the river lists it as failing to reach Good Ecological Potential, struggling particularly with modifications, ecology, dissolved oxygen levels and phosphate pollution.

Identifying the improvements needed.

The most effective options to overcome these issues and improve the River Beult SSSI for people and wildlife have been determined using the following steps:

1. Identify what the River Beult does for people and wildlife and what it needs to do better using an ecosystem services assessment
2. Identify options that work with natural processes to benefit the needs of people and wildlife, in both the short and long term using a multi criteria analysis
3. Develop a costed, outline improvement plan for the River Beult with local stakeholders, including possible funding options

Stakeholders have been involved in this process from start to finish, contributing how they use the river, how it could be improved and reviewing the proposed improvement options through public consultation.

Proposed improvement options

Broadly, the improvement options which have been found likely to be most beneficial to people and wildlife are:

- Barrier removal: Removing stop boards and modifying the underlying concrete sills to restore flow to the river.
- Re-grade banks and create shallow berms: Modifying the river banks and channel to create a narrow, meandering low flow channel and a wider high flow channel.
- Insert gravel riffles: Return suitable gravels to the river to create several short, fast flowing shallows.
- Backwater creation: Creating wider, deeper and sheltered side channels.
- Farmer engagement: Working with farmers to get the most benefit out of habitats along the river.
- Replace Cheveney Auto-sluice with a rock ramp to maintain water levels and allow fish passage.

This report details which measures are most suitable in each segment of the SSSI and how they could benefit people and wildlife.

Implementing all the proposed measures and restarting natural processes is a long term aim and is likely to cost between £2,500,000 and £3,410,000.

The upper cost estimate would involve building options in a fully completed, semi-natural, engineered form that delivers the full range of benefits immediately.

The lower cost estimate would involve building the minimum number of options to the minimum level required to re-start natural processes and allowing these processes to do the rest. This alternative would involve less certainty about the benefits that would be delivered and how long it would take for these benefits to realise.

Vision and next steps

This plan is a tool for stakeholders in the River Beult to work together to overcome the issues facing the SSSI and create a river that provides:

- Natural flood management
- A healthy fishery with good angling participation
- A secure, clean water supply
- An attractive, resilient landscape that supports sustainable agriculture, flourishing wildlife and recreation

This improvement plan will be used by the Environment Agency, Natural England and local stakeholders to design and build improvement measures. The success of these improvements will be measured through stakeholder benefits, SSSI condition and WFD status.

1. Introduction

1.1 Overview

The River Beult flows through Kent from headwaters in Bethersden and Pluckley to join the River Medway at Yalding.

The river is designated as a Site of Special Scientific Interest (SSSI) between Hadmans Bridge near Smarden and the confluence with the River Medway in Yalding. It was notified in 1994 as part of national programme of riverine SSSI designations because it was one of the best examples of a lowland clay river in the country that still supported characteristic plants and animal species.

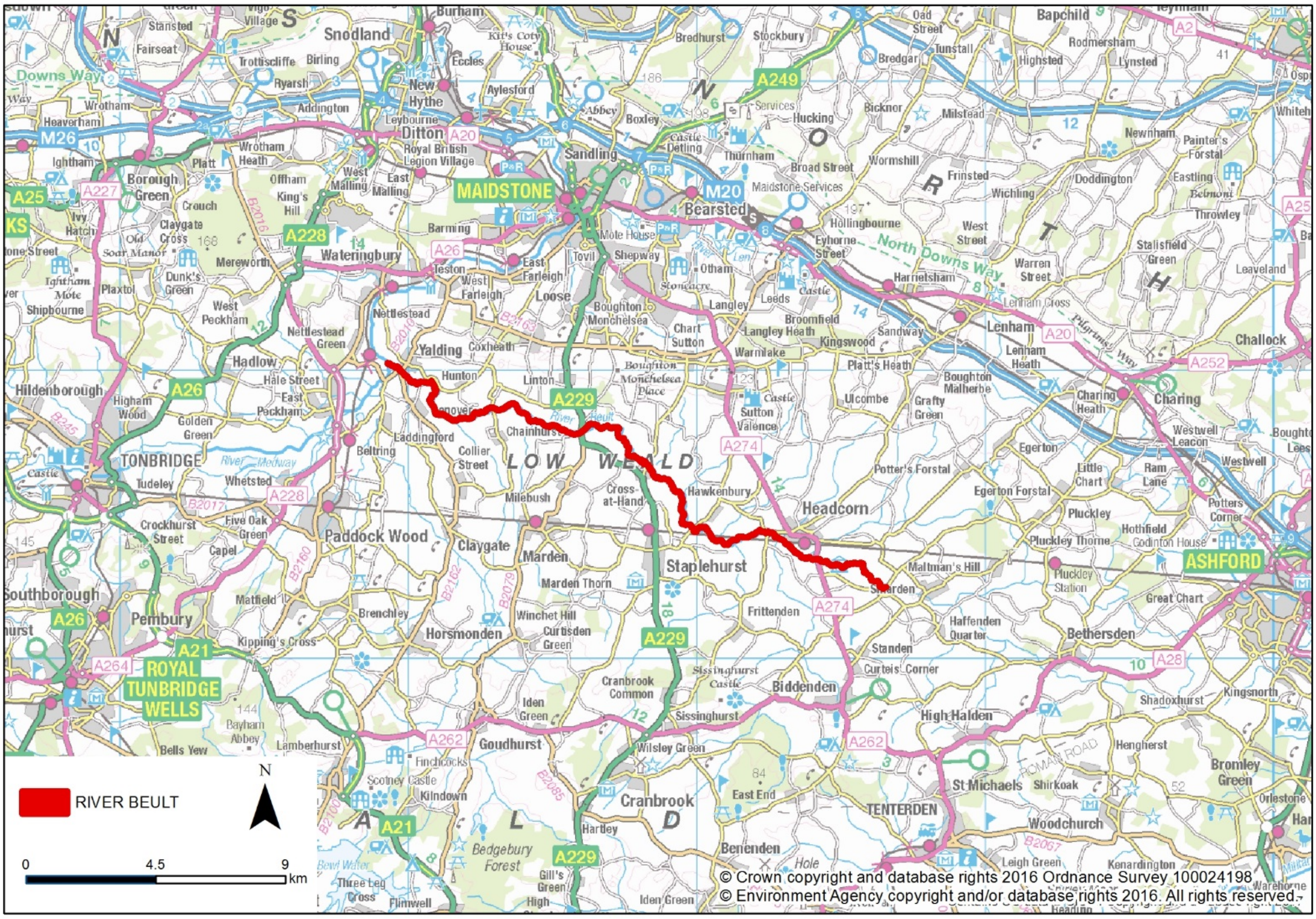


Figure 1: Location map of the River Beult SSSI

1.1.1 Geology, soils and topography

The Beult flows predominantly north-westerly, through a principally agricultural catchment, with pasture, orchards, woodland and arable land. The river drains a catchment of 277km^2, mainly rural land with scattered settlements (Natural England, 2007).

The surface geology of the River Beult catchment is dominated by Weald Clay beds, with overlying alluvial and river terrace deposits. There are minor beds of pervious

sandstones of Wealden Sands and Hythe Beds at the southern section of the catchment. As a result, the soils are heavy clays (English Nature, 2005).

The catchment offers a wide, shallow floodplain with slow flowing water over a slight gradient of <1m drop every 1km. Topography is at approximately 15m AOD (above Ordnance Survey Datum) at the Medway confluence (English Nature, 2005).

1.1.2 Hydrology

The Beult has an average annual runoff of approximately 225mm and arithmetic mean (average) flow of 2.105m^3/s with Q50 (median flow) of 0.379m^3/s. However, there is large seasonal variation, with summer lows down to 0.25m^3/s recorded, and with frequent winter flooding (English Nature, 2001).

Water flows within the Beult largely comprise surface water runoff and licensed discharges, with average low flows consisting of between 50-75% sewage treatment works discharge (English Nature, 2001).

1.1.3 Channel management and past practices

Water levels are managed along the channel using a series of stop board control structures. The stop boards are put into place during the summer so as to maintain low flow levels, and are removed during the winter. An automated sluice also maintains the water levels upstream of Cheveney Mill, near Yalding. As a result, water is impounded along the almost the entire length of the River Beult SSSI (English Nature, 2005). Even when these boards are removed, the underlying concrete sills back up water throughout most of the SSSI.

Water is abstracted from the Beult, under license, for spray irrigation and topping up reservoirs and fisheries. In addition, water is also removed via trickle irrigation as required. It is likely that trickle irrigation abstraction coincides with low flows during the summer.

The River Beult was subject to a land drainage improvement scheme in the 1930s. This led to the river being widened, deepened and straightened from Smarden to Yalding, and installation of the water level control structures that exist today, losing much of its natural features. However, upstream of Smarden, the parts of the river retain a more natural meandering morphology (Natural England, 2007).

Major dredging works were carried out on the river in the 1910's, 1940's and late 1980's (English Nature, 2005). Also, there has been further intermittent dredging and bank re-profiling undertaken since the 1960's. Some of this was maintenance dredging to remove the accumulation of fine sediments and weeds along the river bed. (English Nature, 2005). This historic management has resulted in the loss of most natural gravels from the river and contributed to bank instability and erosion. At present, maintenance within the SSSI is limited to removal of blockages that pose a flood risk.

1.2 Segment split

Following the approach taken in the River Beult Outline Restoration Plan (2007), the river has been split into 7 segments to tailor improvements to local needs. The splits are as follows:

- Segment 1: Hadmans Bridge to New Bridge
- Segment 2: Downstream of New Bridge to Stephen's Bridge
- Segment 3: Downstream of Stephen's Bridge to Hawkenbury Bridge
- Segment 4: Downstream of Hawkenbury Bridge to Hertsfield Bridge
- Segment 5: Downstream of Hertsfield Bridge to Stile Bridge
- Segment 6: Downstream of Stile Bridge to Cheveney Mill
- Segment 7: Downstream of Cheveney Mill to the Medway confluence

Each segment is split so as to include a bridge and associated water level control structure at the downstream end, with the exception of segment 1 which also includes the bridge at the upstream end. This is based on a management perspective, as any works associated with a bridge structure will require mitigation works to occur immediately upstream (and so needs to be in the same segment). Likewise many of the improvement options are dependent on modification of the water level control structure downstream which impounds flow throughout the segment.

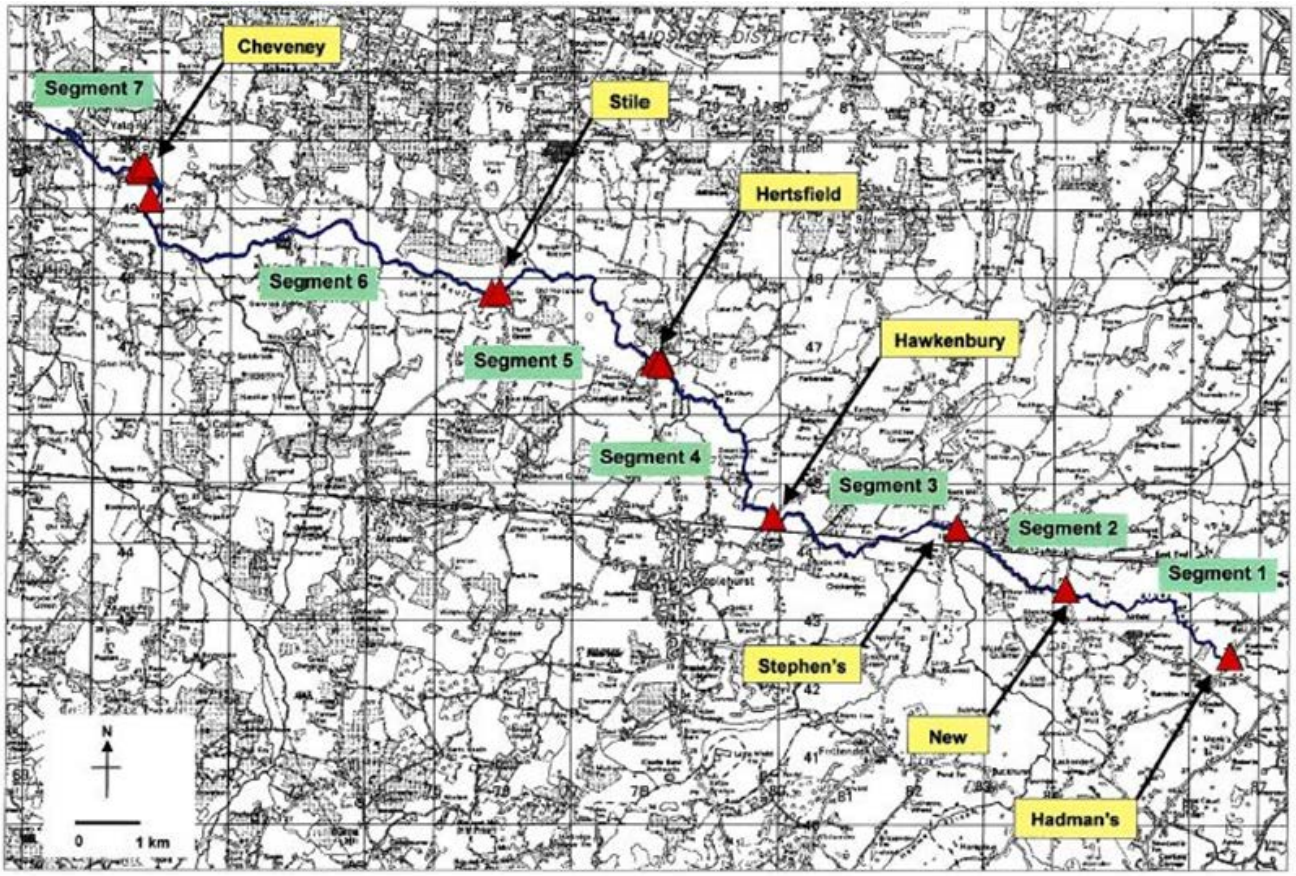


Figure 2 Location map of the split of the River into 7 segments, separated by the major bridge structures (red triangles). Map image taken from the River Beult Outline Restoration Plan (2007).

1.3 Why do we need to improve the River Beult SSSI?

The River Beult is a vital natural resource for both people and wildlife.

It is a source of fresh water for wildlife and agriculture, controls and stores flood waters, supports crop pollination and improves the wellbeing of the local community through interests such as fishing and walking.

However, issues linked to historic modifications, prevent it from fulfilling its potential as a natural resource for people and wildlife. These issues include flooding, declining angling participation, pollution, loss of habitat and species diversity, impounded water, barriers to flow and an over wide and deep channel.

Improvements are essential to allow people and wildlife to continue enjoying the wide range of benefits the River Beult can offer.

Many of these issues have affected the River Beult ever since it was designated as a SSSI. It is protected because it represents one of the best remaining examples of a lowland clay river in the country, able to support the habitats, plants and animal species expected in this kind of river.

In some areas, the river still supports characteristic clay-river flora. Two nationally scarce insects, the hairy dragonfly (*Brachytron pratense*) and a water beetle (*Haliplus laminatus*), are present in the well vegetated sections of channel. In reaches where there is still thick, emergent vegetation along the banksides there are also uncommon species such as the white-legged damselfly (*Platycnemis pennipes*) and the ruddy darter dragonfly (*Sympetrum sanguineum*). Tall reeds and grass provide cover for breeding birds, particularly the reed warbler (*Acrocephalus scirpaceus*) and reed bunting (*Emberiza schoeniclus*). Kingfisher (*Alcedo atthis*) are also present and nest in the tall bare clay banks.

A greater diversity of plants occurs where the river banks are relatively shallow and slope into shallow berms. In these places the river banks can contain great yellow cress (*Rorippa amphibia*), water plantain (*Alisma plantagoaquatica*) and purple loosestrife (*Lythrum salicaria*). Wet margins can contain flowering rush (*Butomus umbellatus*), bur-reed (*Sparganium* emersum) and bulrush (*Schoenoplectus lacustris*); whilst the channel contains five species of pondweed (*Potamogeton*), spiked water milfoil (*Myriophyllum spicatum*) and various species of water lily.

The River Beult could provide a beautiful environment for recreation and support local agriculture, however, there are large areas of the river which are damaged or polluted and not able to provide the conditions required to support local communities and wildlife.

The long history of intermittent dredging and channel modifications has resulted in few gravel and cobble sediments remaining in the river. These have not been naturally replenished as there is low flow energy to transport coarse material from the few upstream sources of sandstone, and the water level control structures and impounded flows also prevent movement.

The high nutrient content of the water from run-off and point sources and the impounded flows promote the rapid growth of duckweed (*Spirodela polyrhiza*), blue-green algal blooms and the invasive water fern *Azolla filiculoides*. They often form a continuous cover over the water surface. This makes the river unfishable and leads to severe oxygen depletion in the water below, impacting local plants and animals.

Fluvial erosion is a dominant process within the system, but due to cohesive clay banks and heavy vegetation in some areas, provides relatively little sediment input. Geotechnical erosion (bank failure) accounts for the majority of erosional input. Bank failure was largely found to have been caused by the deepening and steepening of banks, poaching by sheep or cattle, and informal recreational access (English Nature, 2005).

Flooding is also a key issue. Water from the Beult catchment contributes to flooding in Smarden, Headcorn and 8 parish council areas near the confluence between the Rivers Medway, Beult and Teise. Through the Medway Flood Action Plan, the Medway Flood Partnership are committed to working with local stakeholders to better manage water in this catchment.

Assessments of SSSI condition and Water Framework Directive (WFD) status help measure whether the river supports people and wildlife in the best way possible. These highlight the concerns about the poor ecological condition of the river. The SSSI is in Unfavourable condition due to inappropriate in-channel structures and degraded river morphology. WFD status indicates that the river is struggling with inappropriate historic modifications, poor ecology, low dissolved oxygen levels and phosphate pollution.

The key pressures the River Beult SSSI faces and their impacts on people and wildlife are summarised in Table 1.

1.4 Aim and objectives

The Environment Agency and Natural England have been working in partnership with local stakeholders, as part of the Medway Flood Action plan, to identify improvements for the River Beult SSSI. Capita were commissioned to produce an improvement plan that identifies what the SSSI currently provides for people and wildlife and how this value and benefits can be improved.

The size and scale of the improvement required for the whole River Beult SSSI makes partnership delivery across the catchment essential. This plan identifies how stakeholders can work together to develop a more natural river and floodplain that are resilient to pressures including climate change.

1.4.1 Aim

Work together to create a River Beult SSSI that provides:

- Natural flood management
- A healthy fishery with good angling participation
- A secure, clean water supply
- An attractive, resilient landscape that supports sustainable agriculture, flourishing wildlife and recreation

1.4.2 Objectives

The Environment Agency, Natural England and other stakeholders in the River Beult are working towards the vision for the SSSI through the following objectives:

1. Identify what the River Beult does for people and wildlife and what it needs to do better, using an ecosystem services assessment
2. Identify options that work with natural processes to improve the value of the river for people and wildlife, in both the short and long term
3. Develop an outline improvement plan for the River Beult with local stakeholders
4. Work with local stakeholders to design and build improvement measures
5. Measure success through stakeholder benefits, SSSI condition and WFD status.

1.5 Vision

Figure 3: An artistic interpretation of what Segment 1 could look like after improvement work.

An improved River Beult SSSI that meets its full potential as a natural resource will be mostly free from weirs, sluices and boards. This will allow free-flowing water and movement of fish and sediment. Fish-passable structures will support water levels where these are vital to heritage features and angling. There will be more space for habitat next to the river and trees casting dappled shade over the channel. Shallow berms and shallower banks will create a self-clearing channel that supports enough water in low flows for wildlife and agriculture without compromising the ability to contain high flows when this is needed. A meandering channel and appropriately

connected areas of the floodplain will be used to slow flood waters. Backwaters and varying bed depths with riffles and pools will add oxygen to the water and give fish and other aquatic wildlife places to shelter and breed. People will be able to enjoy the SSSI through recreation and it will support their livelihoods.

The image above shows what this might look like: more natural meander bends with re-graded banks, natural vegetation, shallow berms and flowing water. Added gravels create rippling, rushing water, providing aeration for wildlife and enhancing people's experiences. The channel is bordered by waving reeds and rushes and there is a diverse mix of colourful floating and emergent plants in the deep, slower sections with trailing submerged plants in the shallow, faster flowing water.

The following images show the contrast between segments 2 and 6. Segment 2 has a modified water level control structure to restore a free flowing river. Segment 6 has deep, ponded water maintained to support angling and keep the historic wheel at Cheveney Mill running. Graded banks provide habitat and better access for angling in this section.

Figure 4 - An artistic interpretation of what Segment 2 could look like after improvement work.

Figure 5 - An artistic interpretation of what Segment 6 could look like after improvement work.

1.6 Condition of the River Beult SSSI

The table below describes the pressures and impacts to people and wildlife in the River Beult.

Eco-system Service	Description	Impacts on People and Wildlife	Example Photos	Segment Most Affected
Provisioning	**Lack of trees:** Some sections of river lack trees due to historic removal.	Lack of supply of woody material which should be providing unique habitat and helping to add oxygen to the water and provide natural flood management by slowing flood flows. Lack of trees can make the banks more prone to erosion as roots help to bind the soils. Lack of shading increases water temperature and reduces oxygen content which impacts on fishery health. Lack of cover for fish and other animals.		2,4,5,6
	Lack of bank slope diversity: Uniform steep bank slopes in many segments of the river are a result of historic channel modifications.	Reduces the space available for marginal habitat that would otherwise slow pollutants and flood flows. Reduces the habitat variety along the banks, meaning fewer species can use it, limiting the amount of pollinating insects and predators of crop pests. Lack of cover and places to hide from high flows for fish and aquatic insects makes the fishery less resilient. Lack of transitional habitats between land and water which are suitable for aquatic plants.		3,4,6
Regulating	**Degraded riparian vegetation:** Loss of characteristic vegetation next to the river due to high nutrient deposition and pressures from run-off, livestock, cultivation and spray drift.	Increases the amount of surface runoff reaching the channel leading to high loads of fine sediment or dissolved nutrients polluting the water. Increases the vulnerability to erosion, leading to soil loss, endangering livestock and making access for angling more difficult.		3,4,7

	Degraded in channel vegetation: Loss of characteristic in-channel vegetation due to pollution and historic modifications to deepen and widen the channel.	Reduces habitat availability and variety. Reduces cover for fish, and habitat for aquatic invertebrates. Results in flashier flood events Reduces aesthetic value. Can contribute towards algal blooms which are toxic to people and animals.		3,4,6
	Accelerated bank erosion: Increased bank erosion due to land use from livestock poaching, and historic modifications from channel straightening.	Higher rates of bank erosion lead to greater quantities of sediment deposited further downstream. Leads to sediment pollution, and can create blockages that increase the risk of flooding.		1,5
	Lack of sediment diversity: Historic channel modifications to deepen, widen and straighten have led to uniform bed depths and uniform sediment composition. The subsequent need for dredging, and excessive silt deposition has further depleted gravels.	The shallow, faster flowing sections of river over gravel are damaged or removed by dredging and channel modification. Leaves long slow flowing 'glides' where the channel becomes choked by emergent vegetation. A balanced erosion and deposition regime is absent, leading to excessive erosion or silt deposition in some areas of the channel. Damages insect populations reliant on riffle habitat, including pollinators and predators of crop pests. Prevents recovery of gravel spawning fish		All

	Over deep channel: Historic modifications deepened the channel and dredging to increase the amount of water that it can hold means that less water spills onto parts of the floodplain that could store water away from houses.	Reduced use of floodplain means that fine sediment (which is normally deposited in the floodplain) is deposited in the river channel. This can cause blockages, and back-up water reducing flows impacting flooding. It also pollutes the water. High flows damage fish and invertebrate populations as there are few refuge habitats (lack of berms, backwaters, woody material). Flood flows are sped downstream towards local communities, whereas better use of suitable unoccupied floodplain would slow flows.		2,4,6
	Over wide channel: Over wide channel exacerbates low flows in summer and during dry winters when stopboards are removed.	Excessively wide channel with shallow flows in summer results in fish kills and impacts abstraction and livestock wet fencing. Higher water temperatures, increased siltation and reduced dissolved oxygen levels combine with poor water quality, resulting in fish kills. Channel becomes choked with emergent vegetation, creating a flood risk in flashy flood events.		All
Supporting	**Impounded flows:** Weirs, stop boards (located at each bridge structure) and sluices increase water levels upstream and cause ponding. Channel gradient is low and large lengths of channel are impounded.	Reduces the variety of flow depths and velocities, leading to long, slow and deep stretches. This restricts the variety of habitats for fish and reduces fishery health. Deep, slow impoundments facilitate coarse angling however, the slow, Ponded water leads to weed growth and poor oxygen levels, endangering fish and other aquatic life and impeding angling. Barriers prevent fish movement and prevent the fishery recovering naturally after damaging events. Barriers and impoundments prevent sediment replenishment, which result in more erosion downstream and stops the natural processes that would improve the river.		All

	Uniform flow: Historic channel modification to deepen, straighten, dredge and remove any woody material	Uniform flow leads to lack of habitat variety, build-up of sediment, more vegetation choking the channel and little oxygen during low summer flows. Reduces the ability of natural processes to improve the value of the river by moving sediment around and creating habitat features.		All
	Uniform channel shape: Historic channel modification to straighten the rivers route.	Reduces the variation in flow patterns associated with sinuous channels such as fast and slow areas. This reduces the range of habitat types associated with different flow velocities. Straightened sections have uniformly steep bank slopes reducing the natural and varied occurrence of erosion and deposition. Reduces the ability of natural processes to improve the value of the river by moving sediment around and creating habitat features. High flows damage fish and invertebrate populations as there are few refuge habitats (lack of berms, backwaters, woody material). Flood flows are sped downstream towards local communities, whereas a meandering channel shape would slow flows. Over-wide channel results in excessively shallow water in summer, affecting abstraction and livestock wet fencing.		2,3,5,6,7
Cultural	**Limited Access:** Lack of footpaths, high or steep river banks and eroded banks result in difficult access to the channel.	Poor access reduces the possibility for recreational use and appreciation of the river's natural beauty. Steep banks make accessing the river a safety concern for anglers in some places.		All

	Unnaturalness: Much of the channel has been modified and impounded.	Impoundments affect fish migration, and also lead to stagnation reducing water quality and variety of depth and flow speed. This reduces fishery health, the ability for the river to sustain valuable habitats and species and the amount of places where wildlife can take refuge from extremely high or low flows and temperatures. Historic modification has removed the natural features and processes found in the river, reducing its aesthetic value. Heritage features such as bridges and mills, which limit natural processes, do have cultural and aesthetic value of their own.		All

Table 1 Current issues of the River Beult SSSI and the ecosystem service category they fall under

2. Methodology: Ecosystem Services Assessment

2.1 Introduction to ecosystem services

The current condition of the River Beult SSSI and how it can be improved for people and wildlife has been assessed using an ecosystem services approach.

The Government's Millennium Ecosystem Assessment (MA) Report 2005 defines ecosystem services as benefits gained by people from the natural environment. For example, some features in the natural environment, such as wetlands or woodland, have the capacity to slow the passage of water, which in turn has the potential to reduce flooding. This is a characteristic of the ecosystem. The potential to prevent flooding is a benefit with a value to people, so this ecosystem characteristic is a service to people. Ecosystem services assessment takes into account the value of nature or nature's assets to people, and the benefits nature provides people.

Ecosystem services are distinguished by four categories, where the supporting services category are regarded as the basis for the services of the other three categories.

- Provisioning services – These are products obtained from ecosystems, including food, fuel and timber.
- Regulating services – These are services that provide maintenance through ecosystem processes, and includes climate regulation, water purification, flood prevention and pollination.
- Supporting services – These are services that are necessary for the production of all other ecosystem services, and includes soil formation, nutrient recycling, primary production and habitat and biodiversity. These services make it possible for the ecosystems to provide further services such as food supply, flood regulation, and water purification.
- Cultural services – These are non-material benefits people obtain through spiritual enrichment, recreation, aesthetic experiences or tourism.

Management decisions affecting ecosystem processes and functions impact on ecosystem service provision. Ecosystems therefore need to be considered in decision making in order for them to provide benefits to people.

The ecosystems associated with the River Beult include the river corridor, arable farmland connected to the river, grassland connected to the river, woodland connected to the river, and any lakes or ponds linked with the river.

Assessing ecosystem services includes determining where the current state of the natural environment is causing damage or detriment to people, as this is an important consideration for defining the value of the ecosystem. The table below describes the ecosystem services identified for the River Beult and the measures used to assess them. This information was taken from a variety of reports and studies available for the catchment and wider landscape.

Service Type	Ecosystem Services	Measures of the Ecosystem Services Provided by the River Beult
Provisioning	Freshwater	Quantity of water available for people, agriculture, plants and animals Water quality measurements
	Food	Area and quality of riparian land used for food, fruit crops and livestock rearing.
	Fibre and Fuel	Area and quality of riparian pasture used for sheep grazing and wool production Area and quality of riparian woodland harvested for timber and fuel Area and quality of riparian land used for biomass fuel crops
	Habitat	Abundance and diversity of aquatic, marginal and riparian plants Percentage tree cover Size of buffer strips Bank poaching and invasive species prevalence
Regulatory	Pollination	Area of crops reliant on pollinating insects Abundance, quality and connectivity of pollinator habitat Prevalence of pesticide and herbicide use
	Water Regulation	Quantities of irrigation, land drainage and run-off Naturalness of channel morphology, Extent of floodplain, channel capacity and flood outlines Number of features that slow run-off and flows
	Erosion Regulation	Naturalness of channel morphology allowing for erosion regulation Number of features that slow run-off and flows Prevalence of trampling by livestock (poaching) and over-shading
	Water Purification and Waste Treatment	Number of Waste Water Treatment Works Percentage of treated effluent in river flows Abundance and quality of habitats and features able to absorb and process pollutants Frequency of flows capable of dilution and processing of pollutants Water quality measurements
	Climate Regulation	Capacity to adapt for climate change: constraints on floodplain and geomorphology Area of riparian habitats including woodland that provide natural carbon sequestration
Supporting	Habitat and Biodiversity	Abundance, complexity and quality of habitats Abundance and diversity of priority species Fishery health Invasive species prevalence Amount and naturalness of channel morphology features that support habitats and species Water quality measurements

Service Type	Ecosystem Services	Measures of the Ecosystem Services Provided by the River Beult
	Nutrient Cycling	Abundance of plants and animals that process nutrients and break down organic matter. Amount of decomposing organic matter Water quality measurements including phosphate, nitrate and dissolved oxygen Naturalness of channel morphology, Prevalence of over-shading, stagnation or diverse functional habitats
	Primary Production	Abundance and diversity of plants Abundance of leaf litter and woody material sources; processing sources and sinks Naturalness of channel morphology
	Soil Formation	Prevalence of erosion, run-off, poaching, and invasive species which degrade soil structure and nutrients
Cultural	Cultural Heritage	Number of sites of archaeological and heritage value; mills; weirs and bridges; listed buildings; locally listed buildings and sites
	Recreation and Tourism	Amount of use of the river for walking, fishing or other recreational activities Degree of access to the river
	Aesthetic Value	Local appreciation of the environment Prevalence of invasive species, stagnation or natural beauty
	Existence Value	Use of the river by people SSSI condition assessment WFD status reflecting the ecological potential of the river
Notes: Where the measure on the Beult substantially provides the ESS, ‘High’ has been used; Where the measure provides marginal ESS, ‘low’ has been used; where the measure provides an unexceptional or average ESS then ‘medium’ has been used.		

Table 2 Summary of ecosystem services provided by the River Beult and how these were assessed

2.2 Ecosystem services value

2.2.1 Estimating the present value of the River Beult

Following the identification of the ecosystem services provided by the River Beult, the level - or value of those services was determined using a very low; low; medium; and high, scaling system. This was based on the measures in Table 2 using evidence available from previous surveys, reports, site visits and desk research. As an example, the values provided for the food, fibre and fuel services were determined by the area of land next to the river used for crops, livestock or timber; whereas the freshwater ecosystem service was determined using the current WFD status. This provides a measure of how well the service operates. Details for each ecosystem service can be found in Annex A. The table below lists the service level, or value, given for each segment of the River Beult.

Ecosystem Service	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7
Freshwater	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
Food	Low	High	Medium	Low	Very Low	Medium	Low
Fibre and fuel	Medium	Very Low	Medium	Medium	Medium	Medium	Medium
Habitat	Medium	Low	Very Low	Very Low	Low	Very Low	Low
Pollination	Medium	Low	Low	Medium	Low	Low	Very Low
Water regulation	Low	Low	Low	Low	Low	Low	Low
Erosion regulation	Very Low	Medium	Low	Low	Very Low	Low	Medium
Water purification and waste treatment	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Climate regulation	Very Low	Very Low	Low	Very Low	Medium	Very Low	Medium
Habitat and biodiversity	Medium	Low	Very Low	Low	Low	Very Low	Low
Nutrient cycling	Medium	Low	Very Low	Low	Low	Very Low	Very Low
Primary production	Very Low	Low	Very Low	Very Low	Low	Very Low	Very Low
Soil formation	Low	Medium	Low	Medium	Very Low	Very Low	Very Low
Cultural heritage	Low	Low	Low	Low	Low	Medium	Low
Recreation and tourism	Medium	Low	Low	Low	Medium	Low	Low
Aesthetic value	Low	Low	Low	Low	Low	Low	Low
Existence value	Low	Low	Low	Low	Medium	Low	Low

Table 3 The present value assigned to each segment for the ecosystem services

2.2.2 Key Considerations

Several key considerations should be taken forwards into the detailed design or delivery stage. These are essential to both ensure continued or improved value to services and to safeguard them from further pressures.

These are as follows:-

- Invasive species spread – Disturbance of invasive species must be considered during the detailed design and critically during the delivery phase to ensure that spread is limited. This will prevent colonisation on newly created features or sites and enable native species to colonise without unnecessary competition.
- Sediment release – The 'River Beult Geomorphological Assessment' and subsequent site visits has revealed there to be areas of loose sediments in channel, bare, unstable and/or steep bank sides that may produce a sediment pollution issue during construction. If appropriately cohesive, these may be incorporated in new features and should be considered during the detailed design phase.
- Water level and channel width – Water level is artificially high, impounded due to weir stop boards at each major bridge structure. In addition, the channel is artificially widened in many places and this must be considered during the detailed design phase to avoid undesirably low water levels.
- Stakeholder willingness to aid delivery – Stakeholder groups and individuals from the local community have expressed interest in aiding the delivery of measures to improve the River Beult. During the design phase, considerations should be made to enable the construction of certain features to be community led.
- Local stakeholder or landowner knowledge – Specific site details and information otherwise unavailable can be obtained from local knowledge of the River system. This should be considered during the design phase, particularly for historic habitats, features, or possibilities for backwaters utilising old drainage channels.
- Existing natural features – The River Beult currently supports some areas of natural geomorphological and ecological features of a lowland clay river system. A sympathetic design should be delivered to incorporate and improve these existing qualities.
- Catchment Sensitive Farming (CSF) – Involvement in Agri-environment Schemes and diffuse pollution prevention schemes would be beneficial to address run-off issues affecting the river.
- Land use and access – Some sites on the River Beult are hard to access, and this should be considered during the design phase to ensure the option and methods are suitable to account for any difficulties during construction. Opportunities to improve public access through permissive footpaths should also be discussed with landowners in conjunction with the possibility for a river warden scheme that could monitor results and potentially offset security concerns around improving access.

- Irrigation requirements – Several landowners rely on the River for irrigation purposes. During the detailed design phase, location of abstraction points must be considered.
- Planting regime – During the detailed design and delivery phase, planting should be sympathetic to the Beult's SSSI status, native and endemic to lowland clay rivers to ensure an ecologically appropriate delivery.
- Currently supported wildlife – The River Beult currently supports various habitats, plants and other wildlife. This must be considered during the design phase so as to incorporate and improve on these existing qualities overall.

2.3 Identifying improvements

Where an identified ecosystem service is under pressure and thus not providing high value, there is a need to address the issues that are leading to the low value and improve the service. (See Annex A)

A list of solutions that would lead to improvement in the ecosystem services was populated using a combination of:

- Stakeholder suggestions
- The recommended improvement actions identified in the previous Technical Note (Environment Agency, 2016) which reviewed past reports and plans, and
- Updated and added to with currently used and successful techniques focussing on lowland river systems

The list of improvement options and the ecosystem service issues they address can be found in Chapter 3.

The target service levels for 2027 and beyond are in the table below.

Ecosystem Service	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7
Freshwater	high	high	high	high	high	high	high
Food	low	high	medium	low	very low	medium	low
Fibre and fuel	medium	medium	medium	medium	medium	medium	medium
Habitat	high	high	high	high	high	high	high
Pollination	high	high	high	high	high	high	high
Water regulation	high	high	high	high	high	high	high
Erosion regulation	medium	medium	medium	medium	medium	medium	medium
Water purification and waste treatment	high	high	high	high	high	high	high
Climate regulation	high	high	high	high	high	high	high
Habitat and biodiversity	high	high	high	high	high	high	high
Nutrient cycling	high	high	high	high	high	high	high
Primary production	medium	medium	medium	medium	medium	medium	medium
Soil formation	high	high	high	high	high	high	high
Cultural heritage	low	low	low	low	low	medium	low
Recreation and tourism	medium	medium	medium	medium	medium	medium	medium
Aesthetic value	medium	medium	medium	medium	medium	medium	medium
Existence value	medium	medium	medium	medium	medium	medium	medium

Table 4: Long term targets for future levels of ecosystem services provided by the River Beult SSSI

2.4 Identifying a long list of improvement options

To determine which improvement options would most effectively re-establish natural processes and address the ecosystem service issues, an “applicability rating” was developed.

The applicability rating was developed to yield a weighting for each service dependent on its current value, how much improvement was required and when.

The scoring relies on the following principles:

- This scoring assumes that services with a low value that need to change quickly to a higher value are more important than services starting from a low value requiring little or no change in value.
- This method enables greater weight to be given to those services with a higher current value to ensure maintenance of these higher valued services.
- Greater weight is given to shorter timescales as the method assumes that near term changes are more desirable than long term changes. As the SSSI is in unfavourable condition, this drives the need for positive change in the short term. This method supports the aim of trying to achieve change in the short term without compromising delivery of long term sustainability.
- Where an improvement option was able to deliver multiple ecosystem services, the weighting was combined. This was to reflect how effective the improvement feature was in re-establishing natural processes.

The scores for each improvement feature can be found in Annex A.

This results in the higher scoring features being those which would have the greatest impact and address multiple issues affecting ecosystem services. Therefore the ‘applicability rating’ is a quantitative expression of the benefits to people and wildlife in each segment.

Examination of the long list split for each segment shows that the list is large and wide-ranging. Many solutions are universal across each segment, however there are differences. The highest scoring solutions across all the segments were insertion of gravel riffles, re-grade banks, shallow riffles and riparian planting (and barrier removal, but not in all segments). The long list can be found for each segment in their segment Chapter 8-14.

This method recognises that one option may score poorly due to only improving one particular service, but there may be no other suitable action to address the issue. During the design phase, all options from the list can, and should, be employed on a site specific basis, following further investigation. This list provides an indication of what works well at a high level review.

2.5 Identifying a short list of improvement options

2.5.1 Multi criteria analysis

To produce a suite of clear, feasible and deliverable set of options, the long list was reduced through multi criteria analysis. The criteria for the analysis was populated using previous reports available for the River Beult. These past reports were summarised in a Technical Note (Environment Agency, 2016). Each criteria was assigned a weighting which was calculated using the frequency the criteria appeared within the reports as this was a guide to the relative importance of each criteria. This was updated following stakeholder consultation to include additional weightings for flood risk management, so as to recognise the increased concern of the community and reflect the severity of recent flooding. In addition, ecology and natural processes were also given more priority to reflect the drive to improve the SSSI status.

The criteria represent factors to be considered for delivery of the project on the ground; those that better match the criteria will therefore be most effective, and the easiest to implement. The weightings, unique to each segment can be found in Annex A.

The multi criteria analysis approach was as follows for each segment:

1) Revise criteria weightings to suit the segment for:
   a) Relevance to the individual segment
   b) Concerns identified by preceding reports
   c) Any concerns that have emerged through stakeholder engagement
2) Score all the improvement options identified against the criteria
3) Apply criteria weightings to the score of each improvement option to give a weighted score against the criteria
4) Calculate the total weighted score for each improvement option
5) Multiply the total weighted score by the previously calculated applicability rating to give a final score

2.5.2 Feature dependencies

Many of the identified improvement options are known to be dependent on the joint delivery with other features. For example: Shallow berms with re-graded banks as the material to construct the shallow berm is to be won from the bank above. Also, the correct locations for pools, riffles and meanders can only be determined after impoundments such as weirs and stop boards have been removed and the natural meander wavelength becomes apparent.

To account for this, dependencies between each of the features were identified. Those with a greater number were given an additional weighting which was added to the final score. The additional weighting was applied because features upon which more options depend are more important. This approach will result in more reliable delivery of benefits from dependent features against land use change and climate change.

Finally, these final scores were ranked and the values more than one standard deviation above the mean yielded the short list for each segment. These can be found in chapters 8 to 14.

3. Improvement Options

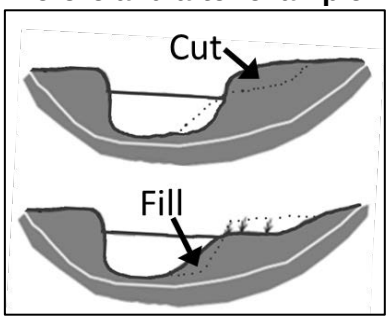
To address the issues affecting people and wildlife as identified in the ecosystem services assessment, a set of improvement options has been identified. The tables below describe each potential improvement option and the issue(s) they resolve or further impair. Further information on the specific design that should be built for the Beult is also included.

As outlined in the methods chapter 2, each improvement option has been scored and ranked. The long list contains all the improvement options that were assessed, whilst the short list contains only the top 5 highest scoring options, which would have most benefits for people and wildlife.

The improvement options are as follows:

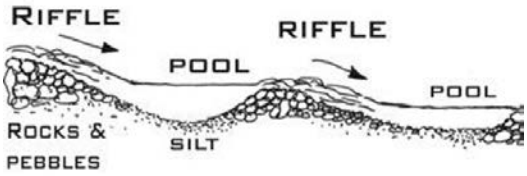
3.1 Short list

Option	Description	Pros & Cons for People and Wildlife	Build Specification
Gravel riffles	Gravel riffles are shallow but fast flowing sections of river with coarse gravel bed materials found between bends. They span the full width of the channel and are up to twice as long as they are wide. **Riffle example:** 	✓ Improve water quality and fish health by introducing more oxygen ✓ Aid channel maintenance through improving natural processes and removing the need for de-silting ✓ Regulate water levels for angling and water supply ✓ Provides specialised habitat important for river invertebrates, which are often predators of crop pests ✓ Provide spawning habitat for fish ✓ Enable safer access to river for education and some angling methods ✓ Simple to construct with low costs	Locate downstream of acute bends, pools and tributaries. Construct using sandstone pebbles to match historic evidence and River Teise reference.
Shallow berms	Berms are low, wet ledges, at or just above waterline. They create a more meandering, self-clearing channel with varied speed, direction and depth of flow **Before and after example:**  	✓ Berms can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Regulates erosion and deposition by protecting banks, directing flow and trapping sediment ✓ Aid channel maintenance through improving natural processes, reducing build-up of material in centre of channel and associated need for de-silting. . ✓ Maintains water levels in summer by creating a two stage channel. Low flows meander around the berm and keep the channel clear, whilst higher flows move over the top of the berm ✓ Provide a variety of different habitats for wildlife ✓ Enables safer access to the water for education, angling and other forms of recreation ✓ Can stabilise bank slumps by providing a buttress to prevent further slipping ✓ Low to medium complexity to build which is dependent on specific location needs ✓ Medium cost although material can be sourced from re-grading banks and creating pools. × Must avoid over-deepening the channel, when creating berms	To be located on gently curving or straight sections of channel. Construct using materials won from within the channel including transplanted vegetation. Berm length up to 1/6th of channel wavelength. Width of ½ existing channel width. Depth of 0.75m Dimensions and wavelength to be verified with a reference reach.

Re-grade banks	Reshaping the channel bank to create a gentler slope to the water's edge. The channel becomes wider at the top, whilst the bottom is narrowed often forming a shallow berm by re-using the material **Before and after example:**  	✓ Can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Enables safer access to the water for education, angling and other forms of recreation ✓ Provide a variety of different habitats for wildlife ✓ Can regulate erosion by making banks more stable ✓ Provide more of a buffer against agricultural run-off to improve water quality ✓ Can mitigate any detrimental effects of barrier removal by varying the channel shape so that it is more resilient to fluctuations in flow. ✓ Secures water supply by creating a resilient low flow channel that is less likely to dry up in summer ✓ Increases the available area of riparian habitat for crop pollinators and predators ✓ Medium complexity to build as it requires machinery ✓ Low cost	To be located on meander bends with an existing berm feature. To be located with new berm features. A 1 in 3 gradient will be built. The area of bank re-graded is to match the required material to fill the berm below
Backwaters	Backwaters are small areas of slow flowing or still water connected to the main channel at the downstream end. Backwaters can be a second or smaller channel running alongside the main channel. Backwaters can be a ponded area to the side of the main channel. **Backwater example:** 	✓ Regulate erosion and deposition by trapping sediments and debris ✓ Can temporarily store floodwater and release it slowly to reduce flood peaks to communities downstream ✓ Provides unique habitats for rare wildlife like the hairy dragonfly ✓ Improves water quality by trapping and cleaning up pollutants ✓ Improves fish population health by providing more habitat for spawning, places to find food and rear young ✓ Can protect fish from high flows and pollution by giving them refuges ✓ Support plants which encourage crop-pollinators and predators of crop-pests ✓ Medium complexity to build as it requires machinery and a small additional area of land ✓ Low cost	To be located at suitable existing drains, abstraction points, and tributaries. Other locations to be investigated. Built to a nominal length of 10m and depth of 2.5m

Barrier removal	Barrier removal is the complete removal, partial removal or modification of a weir, sluice or dam structure within a river channel to restore more natural movement of water and sediment **Before and after example:** 	✓ Opens up previously impounded stretches of river so that natural flood management measures can be installed to slow the flow of floodwaters ✓ Improves water quality by flushing through pollutants and reducing the likelihood of a large fall in oxygen levels ✓ Reduces excessive vegetation cover in the channel by speeding up flow. ✓ Provide more variety of habitats for wildlife, including more varied temperature, flow, depth and speed. ✓ Regulates erosion and deposition by encouraging sediment to move through the river system ✓ Increases the available area of riparian habitat for crop pollinators and predators ✓ Allows fish access to more spawning sites, shelter and food ✓ Enables fish migration so they can escape high flows and pollution and return when conditions improve × Medium to high complexity to build as it will require detailed investigation, machinery and monitoring × Varied cost depending on method (removal of drop boards is low, whereas construction modification will be high)	Removal of weir drop boards. Modification of concrete sills as specified in Bridges Modification Option Report (2010). Investigation into apron removal or fish pass alternatives.

3.2 Long list

Option	Description	Pros & Cons for People and Wildlife	Other Information
Pools	Pools are deep, slack water areas in contrast to the fast, shallow riffle areas. Pools are often found on the outside of meander bends. **Pool riffle sequence diagram:** 	✓ Provides a specialised habitat for wildlife that have difficulty feeding or navigating faster water ✓ Important refuge for fish, particularly in warm weather and droughts ✓ Regulate water levels for angling and water supply ✓ Medium complexity to build as it requires machinery ✓ Low cost ✓ Can lead to erosion of outer meander bends, creating a bare cliff or bank suitable for kingfishers × Can worsen instability in banks or structures	To be located upstream of bends, or on the apex of bends. Avoids areas of potential bank or structure instability. A nominal depth of 0.75m and a width of up to half the channel width
Riparian planting	Riparian planting is the creation and enhancement of riverside habitat using local, native plant species. The plants are able to withstand wet and dry conditions that result from changing river levels. Plants can be transplanted from other areas within the river channel (preferred) or in certain cases imported from nurseries, using local species. Trees can also be used to provide shading, which some riparian plant species prefer, and the trees can also change root zone wetness. **Before and after example:** 	✓ Can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Can regulate erosion by making banks more stable ✓ Increases the available area of riparian habitat for insect which can pollinate crops and regulate pests ✓ They can slow the flow of flood waters which delays the flood peak to give communities more preparation time ✓ Keeps the river cool in a warming climate by creating shade ✓ Improves water quality by buffering the river and absorbing pollutants ✓ Protects fish from high flows and predation by giving them refuge ✓ Improves fish population health by providing more habitat for spawning, places to find food and rear young ✓ Planting of trees provides vital habitat, helping to vary and redirect flow and sediment when they encroach into the channel, and provide shelter for birds, fish and insects. ✓ Simple solution with low costs	Riparian planting will follow the creation of berms and re-graded banks. They will be based on planting a minimum of 10% of the area. A minimum of 9 plants per square meter. Species will be native, lowland, and endemic to the SSSI area

Meander channel	Meandering a channel is to transform a straight channel into a winding channel. This is to force the water to flow from side to side within a channel, rather than in a straight line. Channel meandering is achieved by re-grading banks, creating shallow berms, and inserting woody material. **Meander example:** 	✓ Aids channel maintenance through improving natural processes and reducing the need for de-silting ✓ Maintains water levels in summer by creating a variable depth channel. Low flows meander around the berm, and high flows move over the top of the berm ✓ Provides a variety of different habitats for wildlife ✓ They can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Enables safer access to the water for education, angling and other forms of recreation ✓ Can stabilise bank slumps by providing a buttress to prevent further slipping ✓ Promotes erosion on outer meander bends as part of natural channel processes ✓ Low to medium complexity to build which is dependent on specific location needs × Medium cost as it is dependent on sourcing suitable material, otherwise low cost	This will be achieved through constructing the shallow berms within the channel.
Barrier by-pass	Barrier by-pass is the re-routing of the river channel around the structure. This can be partial or whole channel by-pass. This will be carried out if the structure is unable to be altered, such as for historic value or complexity of structure. **By-pass example:**  Fish bypass at Botley ©Dennis Bright	✓ Opens up previously impounded stretches of river so that natural flood management measures can be installed to slow the flow of floodwaters ✓ Reduces excessive weed cover by improving flow ✓ Regulates erosion and deposition by encouraging sediment to move through the river system ✓ Allows fish access to more spawning sites, shelter and food ✓ Enables fish migration so they can escape high flows and pollution and return when conditions improve × Requires land to build channel × Can create a large quantity of sediment for disposal × Medium complexity to build, but will require detailed investigation, machinery and monitoring × Medium cost	

Fish pass	A fish pass is a structure that enables fish and eels to migrate both up and down a structure that would otherwise prohibit their movements. **Fish pass example:** 	× Allows fish access to more spawning sites, shelter and food × Enables fish migration and helps them escape high flows and pollution and return when conditions improve × No real beneficial impact on natural processes × May only function for certain species and in certain flow conditions × Medium to high complexity to build as requires specialists and also site investigation × Medium to high cost depending on specification required	
Ecotone	An ecotone is a large transitional zone between two environment types, such as river corridor and woodland. An ecotone contains vegetation from both environments but also others unique to its conditions. The ecotone would extend wide into the floodplain. Appropriate plant species of local provenance can be imported from nurseries, or transplanted from other areas within the river channel.	✓ Increases the available area of riparian habitat for crop pollinators and predators ✓ Improves water quality by buffering the river and absorbing pollutants ✓ Can be used to encourage floodwaters onto un-occupied floodplain to reduce flood risk to properties downstream × Requires space, land and suitable geomorphology × Medium complexity to build and medium cost	Requires land/space to plant Requires suitable geomorphology
Macrophyte planting	Macrophytes are aquatic plants growing in or near water. They may be either emergent (i.e., with upright portions above the water surface), submerged or floating. Macrophyte planting is the introduction and enhancement of river and wetland vegetation using local and native species. Different to riparian planting, which is more tolerant of drying. **Macrophyte planting example:** 	✓ Increases the available area of riparian habitat for crop pollinators and predators ✓ They can slow the flow of flood waters which delays the flood peak to give communities more preparation time ✓ Keeps the river cool in a warming climate by creating shade ✓ Improves water quality by buffering the river and absorbing pollutants ✓ Aids sediment stability on newly created edges and prevents colonisation by invasive species ✓ Improves fish population health by providing more habitat for spawning, places to find food and rear young ✓ Simple to construct with low costs × If flow is impounded, it can lead to excessive vegetation growth causing further impoundment and deplete oxygen from the channel	Planting to follow the creation of berms, as they can be utilised on the wet margin of the feature. Species will be native, lowland, and endemic to the SSSI area.

Tree planting on meander bends	Tree planting on meander bends involves adding trees as part of the riparian zone above a berm feature	✓ Keeps the river cool in a warming climate by creating shade ✓ Improves water quality by buffering the river and absorbing pollutants ✓ The root mass will aid stability of banks reducing erosion, but the trees may need maintaining ✓ Planting of trees provides vital habitat, helping to vary and redirect flow and sediment when they encroach into the channel, and provide shelter for birds, fish and insects. ✓ Easy to complete and low cost × Requires space and land to plant saplings	Requires identification of open areas, lacking trees. Requires land/space to plant. Species will be native, lowland, and endemic to the SSSI area.
Coppicing	Coppicing (or pollarding) is a traditional method of woodland management. It is trimming back of branches so new shoots can develop.	✓ Allows light to reach the water surface in dark areas ✓ Improves access to the channel ✓ Allows for plant colonisation of bare banks which improves habitat and reduces erosion ✓ Reduces risk of trees falling down and weakening the river bank as their root ball comes out. ✓ Cut woody material can be re-used in the channel ✓ Easy to complete and low cost	Requires identification of over-shaded areas.
Reed beds	Reed beds are areas of dense reed type vegetation. They are usually found at the side of the channel forming a buffer between the river and a drain. They are commonly used as tertiary treatment for outflows from waste water recycling plants and septic tanks. **Reed bed example:**  Thatcham Reeds beds by Pam Brophy licensed under CC by-SA 2.0.	✓ Improves water quality by buffering the river and absorbing pollutants ✓ Keeps the river cool in a warming climate by creating shade ✓ Increases the available area of riparian habitat for crop pollinators and predators of pests × Can impound flows × Requires space and land to plant	Requires identification of outflows.

Large woody material	Large woody material is the retention or installation of sections of tree trunk, branches and limbs within the river channel. Large wood material can be used to create habitat, deflect flow, form a dam and is used in natural flood management. **Large woody material example:**  Tree fallen into river diverting flow, by Junko Bryant, licensed under CC BY-SA 3.0.	✓ Can stabilise bank slumps by providing a buttress to prevent further slipping ✓ Provides specialised habitat important for river invertebrates, which are often predators of crop pests ✓ Helps reinstate river processes such as sediment erosion and deposition, varying flow depths and speeds and providing shade and cover for fish and insects ✓ Can be used to regulate water levels for angling and water supply ✓ Can be used to encourage floodwaters onto un-occupied floodplain to reduce flood risk to properties downstream ✓ Simple to construct with low costs × May require pinning in place securely if there is a risk of them obstructing flow	Requires identification of suitable locations and sourcing of material.
Current deflectors	Current deflectors are rocks or logs used in channel to force flow in a particular direction **Current deflector example: (deflectors used with berms and by themselves):** 	✓ Can stabilise bank slumps by providing a buttress to prevent further slipping ✓ Regulates erosion and deposition by trapping sediments and debris enabling more stable banks ✓ Low complexity and low cost × Can lead to unwanted erosion and deposition if incorrectly sited × Requires free flowing water × Creates scour downstream of structure, helping keep central channel clear of sediment	Requires identification of suitable locations and sourcing of material.

Invasive species removal	Invasive species removal is the careful and complete removal of plants. Invasive species are plants that are not native to the environment and dominate other species. **Invasive species example:**  Giant Hogweed by Farbenfreude under license by CC BY-SA 3.0.	✓ Removes unwanted species, allowing native species space to colonise without competition for resources × Can leave bare areas of bank prone to erosion × Can lead to further spread if not removed properly × Difficult and costly to eradicate species completely	Identification of invasive species locations required. Remove from upstream end of catchment to downstream to prevent re-colonisation. Careful removal and disposal to prevent further spread.
Bed raising	Bed raising is using materials, often gravels, to shallow the depth of a river channel. Bed raising is often used when a channel has been extensively dredged in the past.	✓ Reduces impoundments, improving the flow of water and water quality ✓ Provides habitat important for specialised river invertebrates, which are often predators of crop pests ✓ Provides spawning habitat for some fish ✓ Enables safer access to river for education and some angling methods × Large quantities of material needed which may impact flood risk (flood risk investigation required) × Medium to high complexity to construct as detailed investigation and machinery required × Medium cost	
Fish stocking	Fish stocking is adding desired fish species to a river. Fish stocking is often performed to supplement fish populations that would disappear due to pressures without re-stocking. Fish stocking is often completed by angling clubs to support recreation.	✓ Supports fish populations by introducing new individuals ✓ Low cost × Can lead to spread of invasive non-native species and disease × Can create fish population not typical of the Beult × A focus on habitat improvement and management can reduce the reliance on stocking. × Medium complexity as requires stockist	

Notching structures	Notching structures is to create a 'v' shaped hole it the top of the weir boards allowing fish to move over the structure. **Notching example:** 	✓ Allows fish access to more spawning sites, shelter and food ✓ Enables fish migration so they can escape high flows and pollution and return when conditions improve ✓ Low cost × No real impact on natural processes × Not all sizes or species of fish are able to use the notch × Can only be utilised on suitable weirs × Medium complexity as requires specialist to construct	
Barrier retention	Barrier retention is maintaining the current weir, sluice or dam structure within the channel.	✓ Maintains the upstream impounded water levels supporting species which prefer slack water habitat × Can lead to oxygen depletion from lack of flow and eutrophication × Prevents movement of water and sediment × Results in problematic weed cover × Barrier to fish × Expensive long term maintenance	
Tree planting on bank tops	Tree planting on bank tops involves adding saplings alongside the main channel and backwaters. This differs from tree planting at meander bends as it avoids these meander areas.	✓ Keeps the river cool in a warming climate by creating shade ✓ Improves water quality by buffering the river and absorbing pollutants ✓ The root mass will aid stability of banks reducing erosion but may need maintaining ✓ Planting of trees provides vital habitat, helping to vary and redirect flow and sediment when they encroach into the channel, and provide shelter for birds, fish and insects. ✓ Easy to complete and low cost × Requires space and land to plant saplings	Requires identification of open areas, lacking trees. Requires land/space to plant and should be done in clumps or wide strips, not single lines. Species must be of native, local origin and provenance

CSF engagement	Catchment Sensitive Farming (CSF) raises awareness of diffuse water pollution from agriculture. CSF provides free training and advice to farmers in selected areas in England. The aim of the advice is to improve the environmental performance of farms and contribute towards WFD targets. Advice is only available in high priority areas for water quality.	✓ Improves water quality by reducing pollutants from run-off ✓ Improves land management beneficial to wildlife ✓ Increases the available area of riparian habitat to support crop pollinators and predators of crop pests ✓ Regulates erosion and deposition by trapping sediments and debris enabling more stable banks ✓ Potential improved soil quality and cost savings to land manager from reduced use of fertilisers × Relies on long term funding of officers	Impacts are dependent on the options available.
Buffer strips	Buffer strips are areas of land between an agricultural field and the river. These can be enriched with wildflower planting. **Buffer strip example:** 	✓ Improves water quality by buffering the river and absorbing pollutants ✓ Provide a variety of different habitats for wildlife ✓ Provides cover and a food source to mammals and birds in winter months ✓ Can stabilise bank slumps by helping to reduce run-off ✓ Easy to build and low cost × Requires space and land to build	Requires land/space. Agri-environment Schemes may be available.
Grazing Management by fencing	Fencing creates a barrier to the river channel to prevent livestock from entering. It can be either temporary to allow a site to recover and vegetation to establish, or more permanent. The first approach should always be to ensure that grazing intensity is low in which case permanent fencing will not be required.	✓ Reduces erosion by preventing trampling of bank vegetation ✓ Reduces impact of grazing on the river bank, allowing vegetation colonisation ✓ Easy to build × Allowing excessive grazing can lead to loss of vegetation through direct removal or due to reduced stability of the bank, preventing colonisation × Lack of grazing can lead to dominance of grasses, out-competing less hardy vegetation types, and an increase in dominance of invasive species such as Himalayan Balsam. × Reduces access to the river by people and other wildlife × Medium cost for long lengths of river and requires maintenance × Fencing can be damaged by flooding	

Floodplain reconnection	Floodplain reconnection involves allowing flood waters from within the river channel to access and flood onto land nearby. This can involve removal of flood embankments and construction of features to allow the passage of flood waters.	✓ Can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Increases the available area of riparian habitat for insect which can pollinate crops and regulate pests ✓ Enables safer access to the water for education, angling and other forms of recreation × Requires space and land to build × Will flood local area – assessments are required × High complexity as requires design modelling and machinery to build × Medium cost to construct	Requires land/space. Must not put people or property at increased risk of flooding.
Floodplain spillway	A floodplain spillway is a low area of land connecting the river to the wider floodplain. They are used to allow floodwaters to move from the channel onto the floodplain, to an area designed to hold floodwaters. **Floodplain spillway example at Swanton Morley:** 	✓ Can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Low cost to construct × Requires space and land to build × Medium complexity as requires design and machinery	Requires land/space. Must not put people or property at increased risk of flooding.
Drinkers	Drinkers are wooden structures erected on the bankside extending into the water. They are to limit livestock access to water to the most suitable locations. **Cattle drinker example:** 	✓ Reduces erosion and pollution by preventing trampling of river bank vegetation ✓ Reduces impact of grazing on the river bank, allowing vegetation colonisation when used in conjunction with fencing ✓ Easy to build and low cost × Results in small scale loss of riparian vegetation	

Wetlands	Wetlands are areas of land connected to the river that are either permanently or seasonally saturated with water. They contain diverse plants and animal species, some unique to the habitat. **Wetlands example at Swanton Morley:** 	✓ Improve water quality and fish health by introducing more oxygen ✓ Aid channel maintenance through improving natural processes for pollutant processing ✓ Provides specialised habitat important for river invertebrates, which are often predators of crop pests ✓ Provide a variety of different habitats for wildlife ✓ Can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Provide a buffer against agricultural run-off to improve water quality × Requires space and land to build × Medium complexity as requires design and machinery × Medium cost to construct	Requires land/space.
Creation of online bays	Online bays are semi-circular cuts out of the channel banks. They are just above bed level and retain water to the side of the main channel. They can be used in place of backwaters where space is unavailable. **Online bay example:** 	✓ Provides specialised habitat important for river invertebrates, which are often predators of crop pests ✓ Provide more of a buffer against agricultural run-off to improve water quality ✓ Can temporarily store floodwater and release it slowly to reduce flood peaks to communities downstream ✓ Provides unique habitats for rare wildlife like the hairy dragonfly ✓ Can protect fish and invertebrates from high flows and pollution by giving them refuges ✓ Low cost to construct × Requires space and land to build × Medium complexity as requires design and machinery	Requires land/space.

Excavate scrapes	Scrapes are shallow depressions with sloping edges that seasonally hold water. They are in-field wet features that are beneficial for overwintering wildfowl. **Scrape example:**  Floodplain scrape by Warren Gold (ConservationKM) under license by CC BY-SA 4.0.	✓ Provides specialised habitat important for invertebrates, which are often predators of crop pests ✓ Provide important breeding areas for birds ✓ Can be used to encourage floodwaters onto un-occupied floodplain (where appropriate) to reduce flood risk to properties downstream ✓ Provide a buffer against agricultural run-off to improve water quality and slow flow of run-off into the river ✓ Low cost to construct × Requires space and land to build × Can lead to excess deposition and sediment build-up × Medium complexity as requires design and machinery	Requires land/space.
Offline still water fishery	This is the creation of an off channel lake or series of ponds that are not connected to the river. This would provide still water fishing similar to that experienced in currently impounded sections of the river.	✓ Provides angling for specific still water species × No impact on river processes × Requires space and land to build × High complexity as requires multiple permissions, design and large machinery × Requires abstraction to fill and top up × Medium cost to construct	Requires land/space.

Table 5 Improvement options and their possible impact to the Beult

Further site specific investigation is required to formalise a design scheme for many of these long list improvement options, and as such, they are only potential solutions to the issues identified previously.

Many of the long list options are unsuitable, particularly the lowest scoring options, as they will not address the issues for people and wildlife.

The highest scoring Improvement Options have been used to form the outline design. As such, all features from the short list are utilised, alongside some of the higher scoring from the long list. The outline designs can be found for each segment in chapters 8-14.

3.3 Cheveney Autosluice options

Cheveney Autosluice has reached the end of its serviceable life and needs replacing. The current design of the autosluice supports angling and the heritage value of Cheveney Mill, however it also contributes to the problems facing the SSSI by creating a barrier to fish and impounding flows. The options considered for the sluice were as follows:

3.3.1 Option 1: Do Minimum:

Leave the structure in its present condition and open the gate to ensure water can be conveyed downstream in high flows to prevent flooding of the surrounding area. As a result, the upstream water level will no longer be maintained. No maintenance will be carried out to the structure.

3.3.2 Option 2: Continue as Present:

Retain current maintenance, operation and ownership of the structure.

3.3.3 Option 3: Whole River PSCA (otherwise Continue as Present):

Public Sector Co-operation Agreement (PSCA) would be a partnership between the Internal Drainage Board (IDB) and the Environment Agency, to help deliver maintenance of the river more efficiently. The Environment Agency will look to pass ownership and responsibility of the structures and watercourse to a third party.

3.3.4 Option 4: Sluice Only PSCA (otherwise Continue as Present):

A PSCA between the IDB and the Environment Agency to help deliver maintenance of the individual structure more efficiently. The Environment Agency will look to pass ownership and responsibility of the sluice to a third party.

3.3.5 Option 5: Refurbishment of Sluice and addition of a fish pass:

This will involve isolating the structure and taking the gates out, painting the steelwork, undertaking minor structural repairs (such as repair to concrete cracks) and installing a fish pass from the mill pond to the River Beult.

3.3.6 Option 6: Replacement of Radial Gate with a Fixed Crest Weir:

Install fixed level stop-logs to act as a weir to retain the upstream water level required. An additional channel will also be constructed to be used as a bypass to convey flow during flood events. It is proposed that the existing drain between the two branches is widened/dredged to convey this flow. A fish pass will also be installed from the mill pond to the River Beult.

3.3.7 Option 7: Replace Radial Gate with a multi-stage rock ramp:

Decommission and remove the existing radial gate. Construct a multi-staged rock ramp, 4m wide, across an 80m length downstream of the structure, aiding fish passage and to retain the upstream water level required for operation of the wheel at Cheveney Mill. Large rocks are placed in stages across the stream bed to form a series of steps. This will slow water flow and form small pockets of still water and eddies in which fish can rest. There should be at least one clear channel of water that meanders through the rock ramp at low flows.

3.3.8 Option 8: Like for Like Replacement of the Radial Gate plus a new fish pass:

Replace the structure, with a radial sluice gate, like-for-like. A fish pass will also be installed adjacent to, or included within, the structure.

The assessment method gave the following ranking of results:

Ranking	Option
1	*Option 7:* Replace radial gate with a multi-stage rock ramp
2	*Option 5:* Refurbishment of sluice and addition of a fish pass
3	*Option 3:* Whole river PSCA (otherwise continue as present)
4	*Option 8:* Like for like replacement of the radial gate plus a new fish pass
5	*Option 6:* Replacement of radial gate with a fixed crest weir
6	*Option 4:* Sluice only PSCA (otherwise continue as present)
7	*Option 2:* Continue as present
8	*Option 1:* Do minimum

3.3.9 Flood Risk Modelling

Options 5, 6 and 7, which would involve physical changes to in-channel structures have undergone preliminary flood risk modelling. Options 5 and 8 are identical for modelling purposes so only one of the two was modelled. At this stage, designs are conceptual so this modelling was preliminary. Further detailed flood risk modelling should be carried out during detailed design for the preferred option. This should be informed by a detailed topographic survey as the changes in depth reported were all within the error margin of the LIDAR data which forms the basis of the current model.

Option 5 could marginally increase flood depths to a small number of properties under the 20 year flood event scenario. If this option is progressed, further modelling will be needed to adapt the design to remove the risk.

Option 6 could increase flood depths to a significant number of properties in the Beult, Teise and Medway confluence area under the 20 year flood event scenario. This option should not be progressed.

Option 7 could increase flood depths by a couple of centimetres to several properties under the 5 year flood event scenario. This is because the rock ramp could locally increase water levels immediately upstream compared to the current operation of Cheveney Autosluice, which opens during flood events. There appears to be a low point in the left bank upstream of the sluice which results in flow across the floodplain. As described above, more detailed modelling would be required to confirm these impacts as a degree of uncertainty remains. The detailed modelling would inform any mitigation required.

4. Stakeholder Engagement

Local landowners, residents, farmers, and organisations with an interest in the River Beult were contacted by post, email and telephone and invited to help identify how people use the river and how it could be improved. Face to face meetings were arranged with key stakeholders and three public consultation workshops were held at Smarden, Headcorn and Yalding to invite members of the community to discuss methods and improvement ideas. Stakeholders were presented with the services that the river provides, the ranked improvement options and how these had been identified using the ecosystem services approach. Four key questions were asked:

- Were the criteria to prioritise the needs of people and wildlife suitable and in the correct order? If not, how should they be changed?
- Was the method for ranking the improvement options adequate?
- Were any further ideas for options to improve the river?
- Were there any improvement options that they could deliver, or deliver in partnership?

The responses could be grouped into five key themes:

- Water quality
- Water quantity including flooding
- Ecology and habitats
- Criteria ranking
- Delivery mechanism

Overall, all agreed that the method and ranking of the improvement options was adequate, particularly the high significance given to flood risk. Flood risk was seen as the most important factor and therefore of highest priority, with ecology and habitat second.

4.1 Water quality

It was a concern that the channel contains a build-up of silt, notably behind impounding structures, and that the steep banks eroded easily with many areas bare due to bank slumps. Water is murky and turbid, and the inclusion of options to address this issue were believed important.

In addition, using reed beds and wetlands for tertiary treatment of effluent was considered useful, but there was recognition that this would not completely solve the high phosphate problem. It was suggested that a partnership approach with Water Companies to implement phosphate removal measures would be effective.

4.2 Water quantity and flooding

The current flow regime is a concern, as there can be very low flows in summer that put wildlife at risk due to high water temperatures and low oxygen levels. These low flows also impact angling, wet fencing and abstraction. It was seen as a priority that any options should not risk exacerbating this problem, but equally should not increase the risk of flooding in winter.

There was support for ensuring there would be no increase in flood risk with any ecological improvement feature. Therefore flood risk remains the top high priority.

There was concern that modifying the structures to remove the impounded water would damage the fishery. Consequently, a lower water level in the current channel is not desirable and a priority to avoid. As the channel is overly-wide, options to narrow it (amongst others) will provide mitigation to avoid too low flows. Backwaters and pools will provide additional deep water for fishing and the preferred option at Cheveney Autosluice will maintain sufficient water levels to support existing angling uses in segment 6, where duckweed is less of a problem and there is the most angling participation.

4.3 Ecology and habitats

Concern was raised regarding a lack of space between cultivations for crops and the river channel. Feedback was in support of working with farmers through the Catchment Sensitive Farming initiative to promote run-off attenuation and habitat enhancement measures, such as buffer strips and cover crops.

There was concern raised that blockages of silt and rubbish in drainage ditches connected to the SSSI are detrimental to wildlife and may lead to flooding. Support was expressed for creating self-cleaning channels and designing backwaters to address this issue.

There was support for the planting of vegetation and trees, and also for the removal of inappropriate and invasive species. There was recognition that this part of the improvement plan could be fulfilled by stakeholders.

There was support for improving floodplain connectivity via bank re-grading, along with improvements to habitat for species and human access to the river. There are known to be good sections of river for wildlife, but these are not accessible. This was noted south of Headcorn and north of Marden.

4.4 Criteria

The feedback for the ranking of criteria to assess the improvement options included:

- Ecology and natural processes should have a higher priority so as to ensure there is maximum ecological benefit with any improvement option.
- Maintaining the operation of the historic mill in segment 6 should be a priority, whereas retaining other structures that do not have heritage value should not be a priority.
- Land use priority should be decreased, as ecology and natural functioning supports land use.
- Fisheries was suggested by some to be a lower priority, whereas others believed it should be higher. This was related to the quantity of water in the channel following impoundment removal, as the fishery may struggle if the water was to become too low without mitigation.

4.5 Delivery

Several offers were made to aid the delivery of the project in partnership. These included:

- Match funding
- Local information to aid design and construction

- Volunteer labour for berm building, tree planting and monitoring
- Accommodating options on land adjacent to river
- Leading improvement schemes

4.6 Conclusion

Based on this feedback, the criteria to prioritise the needs of people and wildlife for ecology, natural processes, land use and mill operation were adjusted. In addition, the importance of flood risk was re-emphasised, to ensure that no selected improvement option would have a negative impact. The method for shortlisting options ensures flood risk is accounted for with greatest weighting.

It is also recommended, as part of this improvement plan, that mitigation works be made in coordination with structure modification to ensure flows do not become damagingly low.

5. Further Recommended Actions

This section contains a brief description of further work required before and after improvement options. These have been informed by the key considerations produced by the ecosystem services assessment (see section 2.2.2). The success of the improvement options is dependent on continual stakeholder involvement. The following surveys and actions will inform the design of options:

Flood risk modelling	Flood risk modelling must form part of the detailed design of improvement options to make sure they reduce or avoid increasing flood risk to people and properties.
Abstraction points	The locations of any abstraction points within the channel must be identified as they may need to be altered. These may coincide with an improvement feature, or be affected by the change in water level from the removal of impoundments.
Geomorphology walkover	A survey is required after impoundments are removed to inform the detailed design and precise locations of the restoration options.
Ecological surveys	Appropriate ecological surveys must be built into delivery of the improvement options to provide an updated assessment of the current habitat and species of value. This will inform the design, and enable an appropriate selection of vegetation for planting the riparian and wet berm areas, and selection of areas to transplant species from. These must be undertaken within the appropriate survey season so will likely be required up to 12 months before work begins on each improvement. Invasive species are also present in the catchment and must be considered before, during and after works to stop them spreading.
Fish surveys	Gaps in fish survey data must be identified and filled to understand any likely positive or negative impacts to the river or angling clubs. Identifying existing spawning and nursery habitat will help better understand the fishery health.
Design monitoring strategy	A monitoring regime consisting of pre, during and post works will be required to examine the changes in the river. The River Restoration Centre has published PRAGMO (Practical River Restoration Appraisal Guidance for Monitoring Options) survey guidance that could be implemented.

Water company consultation	Point source pollution & phosphate Increasing processing and nutrient cycling, including through tertiary treatments, will help in the remediation of pollutants. Working with water companies to identify common work programmes, funding or contribution in kind is required.
Landowner consultation	Landowners must be consulted where design plans are associated with their land. Also, several landowners came forward during the consultation period to offer help, and this should be identified and utilised. This engagement should be coordinated with Catchment Sensitive Farming initiatives and agri-environment scheme opportunities
Bridge Structure Investigations	Investigations are required for each water level control structure under the bridges to understand what modifications are possible, prepare designs and understand the change upstream in flow regime and depth without artificial impoundments. This will enable more accurate, appropriate and sustainable design to be prepared.
Fisheries consultation	All stakeholders including angling clubs should be consulted to tailor improvement options to deliver the most benefits to the fishery. This should include a discussion of the possibility for appropriate stocking of suitable species if necessary, in conjunction with delivery of improvement options.
Listed Structures and Archaeology	The modifications to water level control structures under 5 of the bridges may require listed building consent. Consultation is required with the relevant LPA Conservation Officer or Historic England. The Kent County Council Archaeology Team should also be consulted to identify any archaeologically sensitive locations.

6. Costs

Three cost scenarios to deliver the River Beult improvement works have been produced based on a cost versus risk approach. The three scenarios use a different balance between the size and number of features that would be constructed and the degree to which they would be formed by natural processes against the timescale and certainty of the benefits being delivered. This is to allow the designs to be tailored to the river and stakeholder needs within the budgets that become available.

6.1 Scenario explanations

Quick, fully engineered	• Full construction of features to provide immediate changes to natural processes and river services; • Provides restoration of processes where possible alongside associated features • Benefits realised in relatively short timescales and are long lasting • Provides greater resilience to climate change due to more use of mature and robust features, which shapes the natural processes; • Reliable, controlled delivery of improved river services • Estimated relative cost for the whole SSSI is £58 per metre	Build specification: Remove impoundments and construct all features to full specified size
Medium, partially engineered	• Construction of effective features to provide reliable changes to natural processes and river services over time; • Will deliver identified WFD mitigation measures and achieve SSSI status change in the long term; • Copes with average climate change but will not provide resilience to extreme or unexpected climate change in the short term; • Delivers long term reliable benefits for people and wildlife through a changing river regime; • Relies on natural processes developing over time for full benefits • Estimated relative cost for the whole SSSI is £35 per metre	Build specification: Remove impoundments and reduce size of features Construct only the upstream half of berms Grade banks half as shallow as quick option Restrict planting to the reduced feature sizes
Slow, natural process driven	• Absolute minimum needed to change natural processes • May take centuries for benefits to fully realise • Probably doesn't cope with variations of climate change • Some river services are likely to be temporarily damaged e.g. low flows until the narrowed channel stabilises, including the loss of wet fencing and fish; • Relies on natural processes developing to bring about ecological change; • There may not be enough channel gradient or sediment supply for natural processes to successfully develop on their own • Estimated relative cost for the whole SSSI is £21 per metre	Build specification: Remove impoundments Features greatly reduced 75% size reduction in berms (construct upstream end only) Dig slopes reduced by 75% No planting Minimal amount of change to the channel

Table 6 Cost categories for the River Beult SSSI improvement works

Each scenario is dependent on removal of stop boards and modification of the associated concrete sills in all segments except 6 and 7. Improvements in segment 6 are dependent on the option which is chosen for Cheveney Autosluice and Segment 7 has no major water level control structures apart from one weir, which impounds a short stretch of river downstream of Cheveney Autosluice. The modification or removal of barriers has therefore been costed separately and should be added to the totals for each scenario.

The recommended options and cost for modifying the water level control structures under New Bridge and Stephen's Bridge was identified in a previous report by Jacobs (2010). The approximate cost for the structures under other bridges has been estimated using the average cost and adjusted for inflation.

6.2 Scenario costs:

1. Quick, fully engineered scenario

Segment Number	Number of features	Price per metre	Total cost
Segment 1	94	£36	**£125,100.00**
Segment 2	49	£42	**£90,600.00**
Segment 3	85	£49	**£182,800.00**
Segment 4	100	£57	**£197,700.00**
Segment 5	134	£79	**£283,000.00**
Segment 6	174	£68	**£453,800.00**
Segment 7	43	£44	**£108,600.00**
Total cost			**£1,441,600.00**

Table 7 Quick, fully engineered option costs

2. Medium, partially engineered scenario

Segment Number	Number of features	Price per metre	Total cost
Segment 1	94	£21	**£75,000.00**
Segment 2	49	£30	**£63,300.00**
Segment 3	85	£30	**£112,900.00**
Segment 4	100	£38	**£134,200.00**
Segment 5	134	£48	**£172,700.00**
Segment 6	174	£36	**£241,200.00**
Segment 7	43	£25	**£63,100.00**
Total cost			**£862,400.00**

Table 8 Partially engineered options cost

3. Slow, natural process driven scenario

Segment Number	Number of features	Price per metre	Total cost
Segment 1	70	£12	**£44,300.00**
Segment 2	39	£22	**£48,000.00**
Segment 3	64	£20	**£73,900.00**
Segment 4	74	£28	**£99,000.00**
Segment 5	99	£31	**£111,600.00**
Segment 6	122	£18	**£122,100.00**
Segment 7	31	£15	**£37,700.00**
Total cost			**£536,600.00**

Table 9 Slow, natural process driven cost option

Water level control structure modification with scenario 1 costs

Segment Number	Number of features	Features cost	Barrier removal cost*	Total cost
Segment 1	94	£125,100.00	£475,000.00	**£600,100.00**
Segment 2	49	£90,600.00	£229,000.00	**£319,600.00**
Segment 3	85	£182,800.00	£233,500.00	**£416,300.00**
Segment 4	100	£197,700.00	£233,500.00	**£431,200.00**
Segment 5	134	£283,000.00	£233,500.00	**£516,500.00**
Segment 6	174	£453,800.00	£327,000.00	**£780,800.00**
Segment 7	43	£108,600.00	£233,500.00	**£342,100.00**
Total cost		**£1,441,600.00**	**£1,965,000.00**	**£3,406,600.00**

*Table 10 Barrier removal option costs for each major bridge structure at the downstream end of each segment. Prices are taken from the 'Bridge Modifications Options Report, 2010' (*Costs are adjusted using construction output price indices from ONS)*

7. Funding

This Chapter identifies potential funding sources to aid in the delivery of the River Beult improvement works. This list has been constructed using freely available information about currently known to be available funding streams, focusing on:

- Funders that will back environmental projects
- Funders that have recently been seen to back environmental projects
- Funders that have been used to back similar specific river improvement work
- Funders used by charities and other bodies in relation to river improvement works in the UK

Improving the River Beult SSSI relies on multi-partner working between all stakeholders. Essential to this is securing funding, and a wide variety of sources are available.

Contribution in Kind (CiK) is a possible route to deliver some of the improvement works. This reduces financial costs, and engages local communities in projects. Local landowners, businesses and community groups can provide key resources including materials, man-power for construction and monitoring.

The table below lists key sources used for river improvement works alongside any relevant details available. This list is not exhaustive, as there may also be other sources suitable. It is important to note that the majority of funders identified require a not-for-profit or charitable trust to apply for schemes, and it is therefore imperative that partnerships are formed with environmental organisations within the catchment. The outline designs and justifications contained in this report will be able to form the basis of any applications.

Funding Body	Grant or Scheme	What do they support?	How much do they fund?
Defra	Flood and Coastal Risk Management Funding, Water Environment Improvement Funding, Fisheries Improvement Funding	Reducing flood risk to properties, improving WFD status, improving habitat for fish and increasing angling participation	Amount and likelihood of funding dependent on flood risk, WFD and fisheries benefits respectively
	Rural Development Programme for England: LEADER	Support micro and small businesses and farm diversification, boost rural tourism, increase farm productivity, increase forestry productivity, provide rural services, provide cultural and heritage activities	A total of £138 million is available in England between 2015 and 2020 under the scheme
	Water Environment Grant Scheme	Projects that meet WFD targets and improve SSSIs.	A total of £27 million is available nationally for delivery between 2019 and 2021
	Agri-environment Schemes	Sustainable farming options and small capital items that benefit the environment	Amount dependent on options applied for
Local Authorities	Environment and amenity funding	Environmental and amenity projects	Up to £10,000, but may be more depending on local circumstances
European Funding	EU LIFE programme	Water management, industrial wastewater treatment, river basin monitoring and improving groundwater quality	For the 2014 - 2020 funding period, it has a total budget of €34 billion
National Lottery	Landscapes Partnerships, Heritage Grants, Funds for All	Conserve areas of distinctive landscape character, Heritage restoration, protect local species or habitats Funds for all: Small capital projects, equipment, community events	Large projects £100,000 to £300,000 Small capital projects up to £10,000
Charitable Trusts	Esmee Fairbairn Foundation	Under appreciated species and habitats projects	Up to £150,000
	The David Ross Foundation	Conserve heritage, habitats, landscape, education	Up to £100,000
	The Cummins Foundation	Community engagement with natural environment projects	Up to £20,000
	Garfield Weston Foundation	Environmental projects	Up to £100,000
	People's Trust for Endangered Species	Conserving UK BAP mammals	£10,000 to £20,000
	Ernest Kleinwort Charitable Trust	Environmental projects	Up to £20,000
	Nineveh Trust	Youth and environmental projects	Up to £7,500
	Dulverton Trust	Practical conservation	Up to £5,000
	D'Oyly Carte Charitable Trust	Practical conservation	Up to £5,000
	Idlewild Trust Grant	Habitat restoration project	Up to £2,000
	Whitley Wildlife Conservation Trust	Reptile and amphibian conservation through habitat restoration	Up to £15,000
Other	AVIVA Community Fund	Supporting community led change projects	Up to £25,000

	Tesco Bags of Help	Environmental and community projects	Up to £4,000
	Water Company Grants	Environmental projects with water resources or water quality benefits	Amount and likelihood of funding depends on water resources and quality benefit
	Angling Trust Grants	Improve habitats and make more accessible facilities to enable fishing, fish refuge and fencing included	Around £5,000
	Landfill Communities Fund	Conservation of species and habitats or community projects where at least 2 landfill sites are within 10 miles	Around £50,000
	People's Postcode Lottery	Community engagement with natural environment projects, up to £20,000	Up to £20,000

Table 11 Key funding bodies that could be used for the River Beult SSSI improvement works

Chapters 8 to 14 are stand-alone sections that describe the specific costs and outline designs for each segment to facilitate further discussion with stakeholders.

8. Segment 1

8.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 1, utilising all the short listed options, and some of the long list options based on local requirements.

8.1.1 Short list

Improvement Feature	Rank
Re-grade banks	1
Barrier removal	2
Shallow berms	3
Insert gravel riffles	4
Backwater creation	5

8.1.2 Long List

Improvement Feature	Rank
CSF engagement	6
Meander channel	7
Macrophyte planting (wet)	8
Riparian planting	9
Dig pools	10
Offline still water fishery	11
Wetlands	12
Floodplain connectivity	13
Buffer strips	14
Reed beds	15
Large woody material	16
Tree planting on bank tops	17
Coppicing	18
Ecotone	19
creation of on-line bays	20
Bed raising	21
Floodplain spillway	22
excavate scrapes	23
Invasive species removal	24
Fish pass structure	25
Drinkers	26
Fish stocking	27
Notching structures	28
Current deflectors	29
Fencing	30
Tree planting on meander bends	31
Barrier by-pass	32
Barrier retention	33

8.2 Barrier removal options

As identified in the Bridges Modifications Options Report, 2010 by Jacobs, the recommended option for New Bridge was to create a wide trapezoidal channel with concrete lined sides sloping from current apron height down to just below upstream bed level at base (so infill with natural bed material can occur).

The approximate cost for Hadman's Bridge has been estimated using the average cost and adjusted for inflation from the Jacobs report (2010). This can be delivered as a standalone project, or in conjunction with the improvement work dependent on which cost scenario is chosen and mitigation required. Investigations would be required to understand whether the preferred option of creating a wide trapezoidal channel in the place of the horizontal sill in one bridge arch would be suitable for the other bridges too.

In addition, mitigation works may be required upstream of Hadman's bridge if the barrier was removed. However, this would be outside of this project area, and not SSSI designated. As a minimum, the channel will require monitoring for consideration to improve aligned with works within the project area.

8.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be ground-truthed with surveys and site investigation so as to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

8.3.1 Notes

- Preliminary modelling showed that creating a trapezoidal channel in the concrete sill under one arch of New Bridge could reduce flood depths to several properties in this segment by about 20mm during a 1 in 100 year flood event. However this is within the error margin of the LIDAR data which forms the basis of the current model and should be confirmed with more detailed modelling when this option is progressed.
- Riffles that have been included immediately downstream of backwater outlets should be point bar style features.
- A large woody material dam exists between bend 31 and 32. This should be retained subject to appropriate maintenance. These structures often naturally have pools surrounding them.
- Pool features have been included, although not quite scoring onto the short list. These will provide vital material for the construction of berms and provide vital habitat to support the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*.
- A pool exists downstream of Hadman's bridge. Features like this currently provide important fish refuges in low flows and should be retained.

8.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 1	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£12,800.00	£1,800.00	£218	**£14,600.00**
Backwaters	4	£5,100.00	£2,400.00	£189	**£7,500.00**
Berms	24	£52,700.00	£9,800.00	£137	**£62,500.00**
Riparian planting	24	£9,600.00	£1,900.00	£25	**£11,500.00**
Re-grade bank	24	£5,800.00	£19,700.00	£56	**£25,500.00**
Pools	9	£2,400.00	£1,100.00	£39	**£3,500.00**
Segment cost				**£36**	**£125,100.00**

Table 12 Fast, fully engineered option costs for segment 1

2. Medium, partially engineered option

Segment 1	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£12,900.00	£1,800.00	£218	**£14,700.00**
Backwaters	4	£5,100.00	£2,500.00	£189	**£7,600.00**
Berms	24	£26,300.00	£4,900.00	£137	**£31,200.00**
Riparian planting	24	£4,400.00	£1000.00	£23	**£5,400.00**
Re-grade bank	24	£2,900.00	£9,800.00	£56	**£12,700.00**
Pools	9	£2,400.00	£1,000.00	£38	**£3,400.00**
Segment cost				**£22**	**£75,000.00**

Table 13 Partially engineered option costs for segment 1

3. Slow, natural process driven option

Segment 1	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£12,900.00	£1,800.00	£218	**£14,700.00**
Backwaters	4	£5,100.00	£2,500.00	£189	**£7,600.00**
Berms	24	£13,200.00	£2,500.00	£138	**£15,700.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	24	£1,400.00	£4,900.00	£55	**£6,300.00**
Pools	9	£2,400.00	£1,000.00	£38	**£3,400.00**
Segment cost				**£13**	**£44,300.00**

Table 14 Natural process driven options costs for segment 1

Barrier removal costs:

New Bridge and Hadmans Bridge Barrier Removal Cost	**£475,000.00***

Table 15 Barrier removal costs at New Bridge and Hadmans Bridge adjusted using construction output price indices from ONS

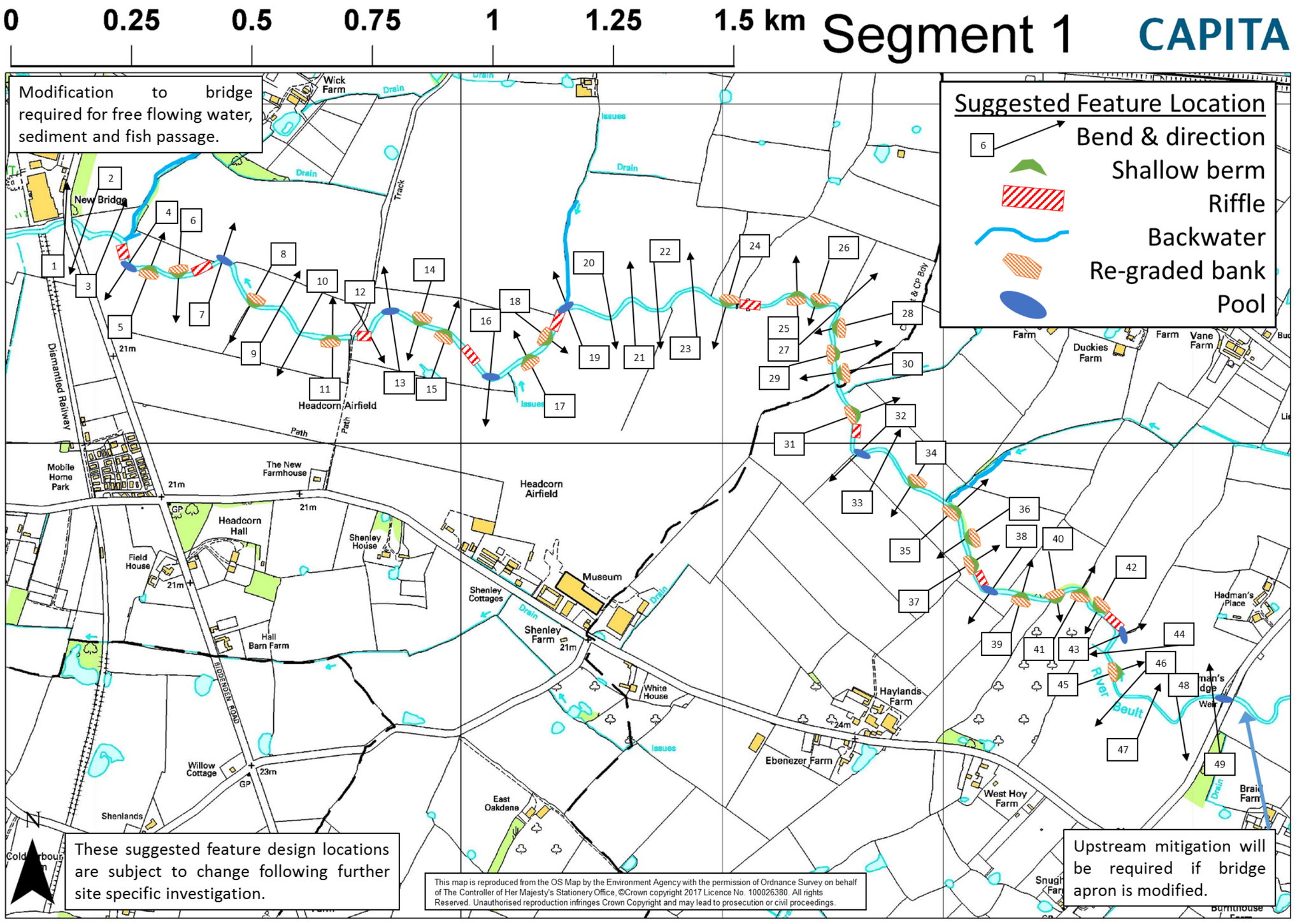


Figure 6 Map of segment 1 with the proposed outline design features

9. Segment 2

9.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 2, utilising all the short listed options, and some of the long list options based on local requirements.

9.1.1 Short list

Improvement Feature	Rank
Barrier removal	1
Re-grade banks	2
Insert gravel riffles	3
Shallow berms	4
Backwater creation	5

9.1.2 Long List

Improvement Feature	Rank
Meander channel	6
Dig pools	7
CSF engagement	8
Wetlands	9
Riparian planting	10
Macrophyte planting (wet)	11
Offline still water fishery	12
creation of on-line bays	13
Floodplain connectivity	14
Invasive species removal	15
Buffer strips	16
Ecotone	17
Reed beds	18
Tree planting on bank tops	19
Barrier by-pass	20
Coppicing	21
excavate scrapes	22
Fish pass structure	23
Floodplain spillway	24
Bed raising	25
Notching structures	26
Tree planting on meander bends	27
Current deflectors	28
Fish stocking	29
Large woody material	30
Drinkers	31
Fencing	32
Barrier retention	33

9.2 Barrier removal options

As identified in the Bridges Modifications Options Report, 2010 by Jacobs, the recommended option for Stephen's Bridge was to create a wide trapezoidal channel with concrete lined sides sloping from current apron height down to just below upstream bed level at base (so infill with natural bed material can occur). This can be delivered as a standalone project, or in conjunction with the improvement work dependent on which cost scenario is chosen and mitigation required.

9.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be ground-truthed with surveys and site investigation so as to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

9.3.1 Notes

- Preliminary modelling showed creating a trapezoidal channel in the concrete sill under one arch of Stephens Bridge could reduce flood depths to several properties in this segment by about 20-50mm during 1 in 5, 1 in 20 and 1 in 100 year flood events. However this is within the error margin of the LIDAR data which forms the basis of the current model and should be confirmed with more detailed modelling when this option is progressed.
- A backwater feature is proposed for Bend 17 on an existing drainage ditch. This is currently a drain connecting the River Sherway to the Beult. It is proposed to make this a formal backwater and improve habitat along it.
- Pool features have been included, although not quite scoring onto the short list. These will provide vital material for the construction of berms and provide vital habitat to support angling the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*
- Riffles that have been included immediately downstream of backwater outlets should be point bar style features.
- A riffle is proposed at the confluence with the Hammer stream as a confluence bar style feature.

9.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 2	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	5	£16,900.00	£1,000.00	£298	**£17,900.00**
Backwaters	7	£8,900.00	£4,300.00	£189	**£13,200.00**
Berms	10	£32,500.00	£4,100.00	£239	**£36,600.00**
Riparian planting	10	£5,400.00	£800.00	£40	**£6,200.00**
Re-grade bank	10	£3,600.00	£8,200.00	£77	**£11,800.00**
Pools	7	£3,200.00	£1,700.00	£70	**£4,900.00**
Segment cost		**£70,500.00**	**£20,100.00**	**£43**	**£90,600.00**

Table 16 Fast, fully engineered option costs for segment 2

2. Medium, partially engineered option

Segment 2	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	5	£16,900.00	£1,000.00	£299	**£17,900.00**
Backwaters	7	£8,900.00	£4,300.00	£189	**£13,200.00**
Berms	10	£16,300.00	£2,000.00	£239	**£18,300.00**
Riparian planting	10	£2,700.00	£400.00	£40	**£3,100.00**
Re-grade bank	10	£1,800.00	£4,100.00	£77	**£5,900.00**
Pools	7	£3,200.00	£1,700.00	£69	**£4,900.00**
Segment cost		**£49,800.00**	**£13,500.00**	**£30**	**£63,300.00**

Table 17 Partially engineered option costs for segment 2

3. Slow, natural process driven option

Segment 2	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	5	£16,900.00	£1,000.00	£299	**£17,900.00**
Backwaters	7	£8,900.00	£4,300.00	£189	**£13,200.00**
Berms	10	£8,100.00	£1,000.00	£237	**£9,100.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	10	£900.00	£2,000.00	£76	**£2,900.00**
Pools	7	£3,200.00	£1,700.00	£69	**£4,900.00**
Segment cost		**£38,000.00**	**£10,000.00**	**£23**	**£48,000.00**

Table 18 Natural process driven option costs for segment 2

Barrier removal costs:

Stephen's Bridge Barrier Removal Cost	**£229,000.00***

Table 19 Barrier removal costs at Stephen's Bridge adjusted using construction output price indices from ONS

Segment 2

CAPITA

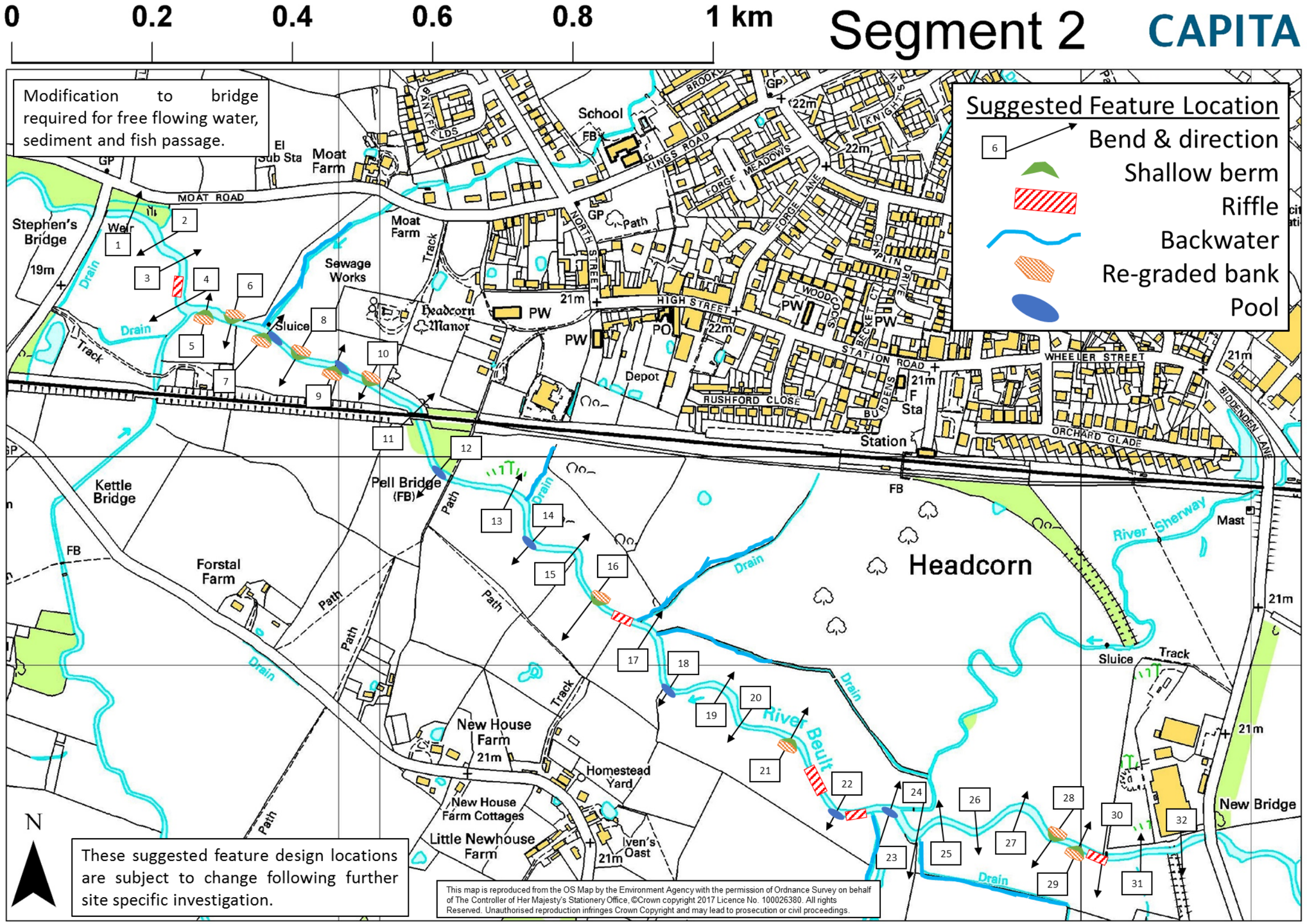


Figure 7 Map of segment 2 with the proposed outline design features

10. Segment 3

10.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 3, utilising all the short listed options, and some of the long list options based on local requirements.

10.1.1 Short list

Improvement Feature	Rank
Barrier removal	1
Re-grade banks	2
Insert gravel riffles	3
Backwater creation	4
Shallow berms	5

10.1.2 Long List

Improvement Feature	Rank
Meander channel	6
Dig pools	7
CSF engagement	8
Wetlands	9
creation of on-line bays	10
Riparian planting	11
Macrophyte planting (wet)	12
Offline still-water fishery	13
Invasive species removal	14
Floodplain connectivity	15
Buffer strips	16
Ecotone	17
Coppicing	18
Barrier by-pass	19
Tree planting on bank tops	20
excavate scrapes	21
Reed beds	22
Large woody material	23
Fish-pass structure	24
Floodplain spillway	25
Tree planting on meander bends	26
Bed raising	27
Notching structures	28
Current deflectors	29
Drinkers	30
Fencing	31
Fish stocking	32
Barrier retention	33

10.2 Barrier removal options

The Bridges Modifications Options Report, 2010 by Jacobs determined the recommended options and cost for New Bridge and Stephen's Bridge only. The approximate cost for the remaining bridges has been estimated using the average cost and adjusted for inflation. This can be delivered as a standalone project, or in conjunction with the improvement work dependent on which cost scenario is chosen and mitigation required. Investigations would be required to understand whether the preferred option of creating a wide trapezoidal channel in the place of the horizontal sill in one bridge arch would be suitable for the other bridges too.

10.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be checked with surveys and site investigation to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

10.3.1 Notes

- Preliminary modelling showed creating a trapezoidal channel in the concrete sill under one arch of Hawkenbury Bridge could reduce flood depths to one property in this segment by about 70mm during a 1 in 100 year flood event. However this is within the error margin of the LIDAR data which forms the basis of the current model and should be confirmed with more detailed modelling when this option is progressed.
- Modelling also showed that additional scour protection may be required under Hawkenbury Bridge if water impoundment was removed. This should be investigated further during detailed design.
- Pool features have been included, although not quite scoring onto the short list. These will provide vital material for the construction of berms and provide vital habitat to support angling and the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*.
- Riffles that have been included immediately downstream of backwater outlets are to be point bar style features.
- The tributary on bend 28 has an old sluice at the inlet. It is proposed to investigate removing the slabs to improve backwater habitat for fish.
- The shallow berm proposed for bend 2 should be constructed with gravel. Following the bridge modification, this could be made into a riffle if required.

10.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 3	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£29,900.00	£1,800.00	£296	**£31,700.00**
Backwaters	2	£2,600.00	£1,200.00	£190	**£3,800.00**
Berms	21	£87,400.00	£8,600.00	£238	**£96,000.00**
Riparian planting	21	£14,900.00	£1,700.00	£41	**£16,600.00**
Re-grade bank	21	£9,800.00	£17,200.00	£67	**£27,000.00**
Pools	11	£5,300.00	£2,400.00	£70	**£7,700.00**
Segment cost		**£149,900.00**	**£32,900.00**	**£50**	**£182,800.00**

Table 20 Fast, fully engineered option costs for segment 3

2. Medium, partially engineered option

Segment 3	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£29,900.00	£1,800.00	£296	**£31,700.00**
Backwaters	2	£2,600.00	£1,200.00	£190	**£3,800.00**
Berms	21	£43,700.00	£4,300.00	£238	**£48,000.00**
Riparian planting	21	£7,400.00	£800.00	£42	**£8,400.00**
Re-grade bank	21	£4,900.00	£8,600.00	£67	**£13,500.00**
Pools	11	£5,300.00	£2,400.00	£70	**£7,700.00**
Segment cost		**£93,900.00**	**£19,200.00**	**£31**	**£112,900.00**

Table 21 Partially engineered options cost for segment 3

3. Slow, natural process driven option

Segment 3	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£29,900.00	£1,800.00	£296	**£31,700.00**
Backwaters	2	£2,600.00	£1,200.00	£190	**£3,800.00**
Berms	21	£21,800.00	£2,200.00	£239	**£24,100.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	21	£2,400.00	£4,300.00	£67	**£6,800.00**
Pools	11	£5,300.00	£2,400.00	£70	**£7,700.00**
Segment cost		**£62,200.00**	**£11,900.00**	**£20**	**£73,900.00**

Table 22 Natural process driven option costs for segment 3

Barrier removal costs:

Barrier Removal Cost	**£233,500.00***

Table 23 Barrier removal costs for Hawkenbury Bridge, and adjusted using construction output price indices from ONS

Segment 3

CAPITA

0 0.25 0.5 0.75 1 1.25 1.5 km

Modification to bridge required for free flowing water, sediment and fish passage with necessary scour protection.

Remove concrete slabs of old sluice to improve backwater channel.

These suggested feature design locations are subject to change following further site specific investigation.

Suggested Feature Location

- 6 Bend & direction
- Shallow berm
- Riffle
- Backwater
- Re-graded bank
- Pool

Figure 8 Map of segment 3 with the proposed outline design features

11. Segment 4

11.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 4, utilising all the short listed options, and some of the long list options based on local requirements.

11.1.1 Short list

Improvement Feature	Rank
Barrier removal	1
Re-grade banks	2
Insert gravel riffles	3
Shallow berms	4
Backwater creation	5

11.1.2 Long List

Improvement Feature	Rank
Meander channel	6
Dig pools	7
CSF engagement	8
Wetlands	9
Riparian planting	10
creation of on-line bays	11
Macrophyte planting (wet)	12
Offline still-water fishery	13
Floodplain connectivity	14
Invasive species removal	15
Buffer strips	16
Ecotone	17
Coppicing	18
Tree planting on bank tops	19
Barrier by-pass	20
Reed beds	21
excavate scrapes	22
Large woody material	23
Floodplain spillway	24
Fish-pass structure	25
Tree planting on meander bends	26
Bed raising	27
Current deflectors	28
Notching structures	29
Drinkers	30
Fencing	31
Fish stocking	32
Barrier retention	33

11.2 Barrier removal options

The Bridges Modifications Options Report, 2010 by Jacobs determined the recommended options and cost for New Bridge and Stephen's Bridge only. The approximate cost for the remaining bridges has been estimated using the average cost and adjusted for inflation. This can be delivered as a standalone project, or in conjunction with the improvement work dependent on which cost scenario is chosen and mitigation required. Investigations would be required to understand whether the preferred option of creating a wide trapezoidal channel in the place of the horizontal sill in one bridge arch would be suitable for the other bridges too.

11.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be checked with surveys and site investigation to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

11.3.1 Notes

- Preliminary modelling showed creating a trapezoidal channel in the concrete sill under one arch of Hertsfield Bridge could reduce flood depths to several properties in this segment by about 20mm during 1 in 20 and 1 in 100 year flood events. However this is within the error margin of the LIDAR data which forms the basis of the current model and should be confirmed with more detailed modelling when this option is progressed.
- Pool features have been included, although not quite scoring onto the short list. These will provide vital material for the construction of berms and provide vital habitat to support angling and the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*.
- Riffles that have been included immediately downstream of backwater outlets are to be point bar style features.
- The proposed backwater between bend 10 and bend 13 is to only to be dug at the downstream end up-to the bend in the backwater.

11.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 4	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£47,300.00	£1,800.00	£364	**£49,100.00**
Backwaters	10	£12,800.00	£6,200.00	£190	**£19,000.00**
Berms	26	£73,800.00	£10,700.00	£187	**£84,500.00**
Riparian planting	26	£12,300.00	£1,000.00	£30	**£13,300.00**
Re-grade bank	26	£8,000.00	£21,300.00	£65	**£29,300.00**
Pools	3	£1,700.00	£800.00	£83	**£2,500.00**
Segment cost		**£155,900.00**	**£41,800.00**	**£57**	**£197,700.00**

Table 24 Fast, fully engineered option costs for segment 4

2. Medium, partially engineered option

Segment 4	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£47,300.00	£1,800.00	£364	**£49,100.00**
Backwaters	10	£12,800.00	£6,200.00	£190	**£19,000.00**
Berms	26	£36,900.00	£5,300.00	£187	**£42,200.00**
Riparian planting	26	£6,200.00	£500.00	£30	**£6,700.00**
Re-grade bank	26	£4,000.00	£10,700.00	£65	**£14,700.00**
Pools	3	£1,700.00	£800.00	£83	**£2,500.00**
Segment cost		**£108,900.00**	**£25,300.00**	**£39**	**£134,200.00**

Table 25 Partially engineered options cost for segment 4

3. Slow, natural process driven option

Segment 4	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	9	£47,300.00	£1,800.00	£364	**£49,100.00**
Backwaters	10	£12,800.00	£6,100.00	£189	**£18,900.00**
Berms	26	£18,500.00	£2,700.00	£188	**£21,200.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	26	£2,000.00	£5,300.00	£65	**£7,300.00**
Pools	3	£1,700.00	£800.00	£83	**£2,500.00**
Segment cost		**£82,300.00**	**£16,700.00**	**£29**	**£99,000.00**

Table 26 Natural process driven options cost for segment 4

Barrier removal costs:

Barrier Removal Cost	**£233,500.00***

Table 27 Barrier removal cost at Hertsfield Bridge adjusted using construction output price indices from ONS

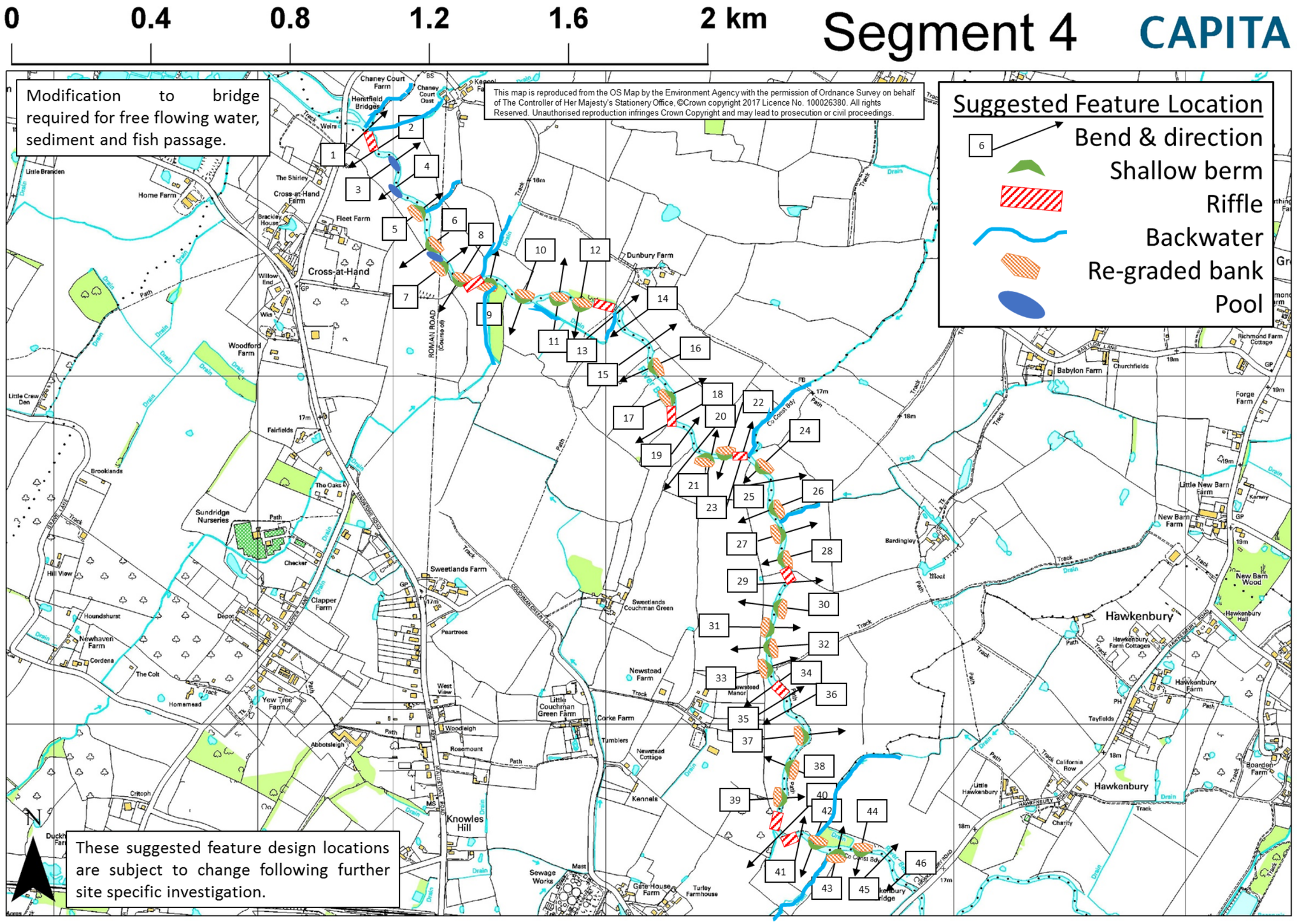


Figure 9 Map of segment 4 with the proposed outline design features

12. Segment 5

12.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 5, utilising all the short listed options, and some of the long list options based on local requirements.

12.1.1 Short list

Improvement Feature	Rank
Re-grade banks	1
Barrier removal	2
Shallow berms	3
Insert gravel riffles	4
Backwater creation	5

12.1.2 Long List

Improvement Feature	Rank
CSF engagement	6
Meander channel	7
Dig pools	8
Wetlands	9
Riparian planting	10
creation of on-line bays	11
Macrophyte planting (wet)	12
Invasive species removal	13
Floodplain connectivity	14
Ecotone	15
Offline still-water fishery	16
Buffer strips	17
Barrier by-pass	18
Reed beds	19
Tree planting on bank tops	20
Large woody material	21
Current deflectors	22
Floodplain spillway	23
excavate scrapes	24
Bed raising	25
Tree planting on meander bends	26
Coppicing	27
Fencing	28
Fish-pass structure	29
Drinkers	30
Fish stocking	31
Notching structures	32
Barrier retention	33

12.2 Barrier removal options

The Bridges Modifications Options Report, 2010 by Jacobs determined the recommended options and cost for New Bridge and Stephen's Bridge only. The approximate cost for the remaining bridges has been estimated using the average cost and adjusted for inflation. This can be delivered as a standalone project, or in conjunction with the improvement work dependent on which cost scenario is chosen and mitigation required.

12.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be checked with surveys and site investigation to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

12.3.1 Notes

- Pool features have been included, although not quite scoring onto the short list. These will provide material for the construction of berms and provide vital habitat to support angling and the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*.
- Riffles that have been included immediately downstream of backwater outlets are to be point bar style features.
- Berms are reduced in size (less wide) along the river length adjacent to the lakes to ensure there is no increase in erosion to the bank.
- Proposed backwaters on bend 16, 17 and 36 are existing drains. It is proposed to only modify the inlets to accommodate for the new water levels and improve the surrounding habitat area. Further inspection will be required to determine if material removal is required.
- There is a gauging weir downstream (in segment 6) of Stile Bridge. Output from this gauging station should be monitored for any change in levels following modification of stile bridge stop boards and sill upstream. However it is predicted that there is unlikely to be any impact.

12.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 5	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	13	£45,300.00	£3,700.00	£305	**£49,000.00**
Backwaters	3	£3,800.00	£1,800.00	£187	**£5,600.00**
Berms	35	£135,400.00	£14,400.00	£235	**£149,800.00**
Riparian planting	35	£22,600.00	£2,800.00	£40	**£25,400.00**
Re-grade bank	35	£14,800.00	£28,700.00	£68	**£43,500.00**
Pools	13	£6,000.00	£3,700.00	£75	**£9,700.00**
Segment cost		**£227,900.00**	**£55,100.00**	**£80**	**£283,000.00**

Table 28 Fast, fully engineered option costs for segment 5

2. Medium, partially engineered option

Segment 5	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	13	£45,300.00	£3,700.00	£305	**£49,000.00**
Backwaters	3	£3,800.00	£1,800.00	£187	**£5,600.00**
Berms	35	£67,700.00	£7,200.00	£235	**£74,900.00**
Riparian planting	35	£11,300.00	£1,400.00	£40	**£12,700.00**
Re-grade bank	35	£7,400.00	£14,400.00	£68	**£21,800.00**
Pools	13	£6,000.00	£2,700.00	£67	**£8,700.00**
Segment cost		**£141,500.00**	**£31,200.00**	**£49**	**£172,700.00**

Table 29 Partially engineered option costs for segment 5

3. Slow, natural process driven option

Segment 5	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	13	£45,300.00	£3,700.00	£305	**£49,000.00**
Backwaters	3	£3,800.00	£1,800.00	£187	**£5,600.00**
Berms	35	£33,800.00	£3,600.00	£234	**£37,400.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	35	£3,700.00	£7,200.00	£68	**£10,900.00**
Pools	13	£6,000.00	£2,700.00	£67	**£8,700.00**
Segment cost		**£92,600.00**	**£19,000.00**	**£31**	**£111,600.00**

Table 30 Natural process driven option costs for segment 5

Barrier removal costs:

Barrier Removal Cost	**£233,500.00***

Table 31 Barrier removal costs for Stile Bridge adjusted using construction output price indices from ONS

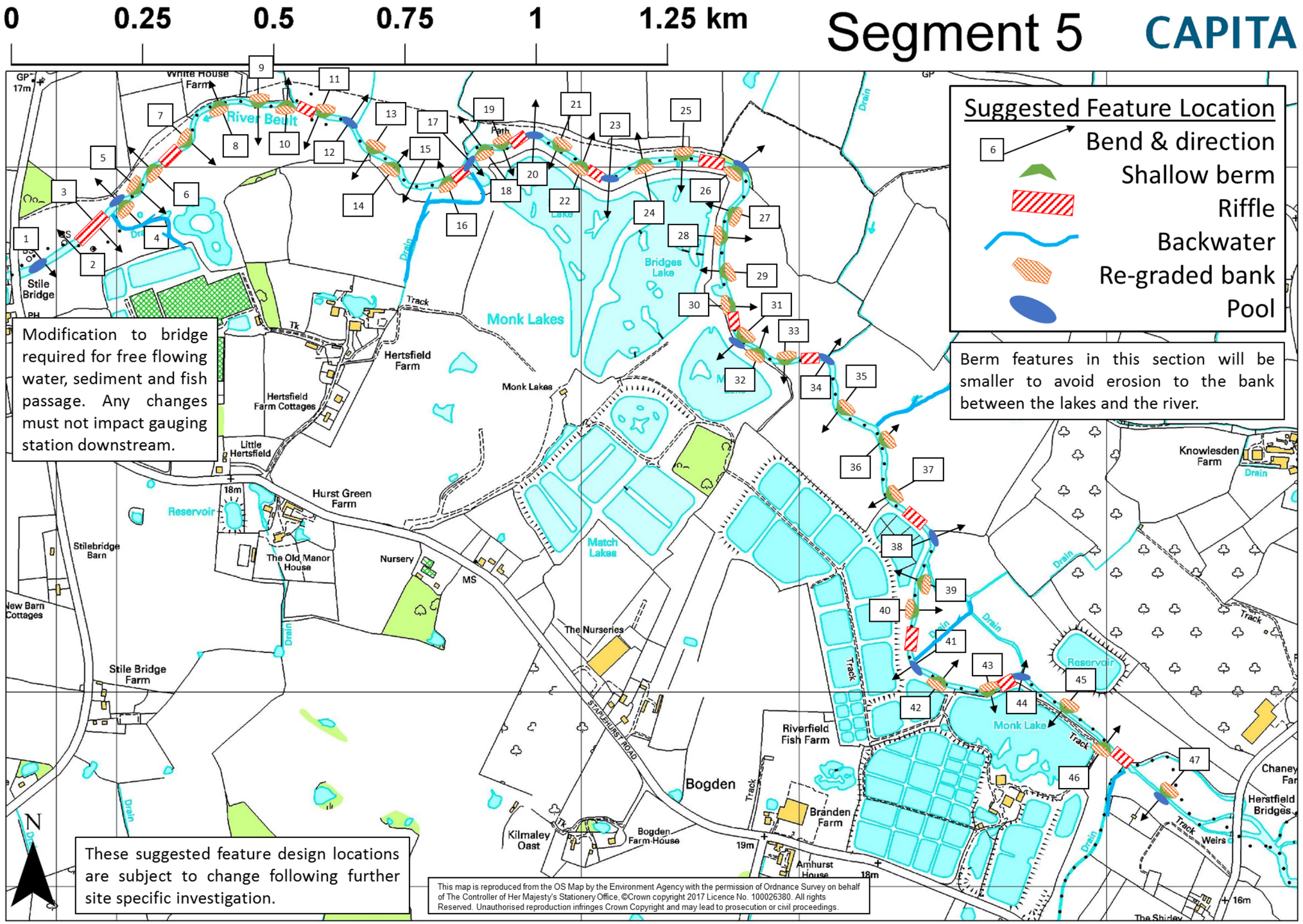


Figure 10 Map of segment 5 with the proposed outline design features

13. Segment 6

13.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 6, utilising all the short listed options, and some of the long list options based on local requirements. Mill Operation was added as a weighting criteria in this segment to reflect the heritage value of Cheveney Mill.

13.1.1 Short list

Improvement Feature	Rank
Barrier removal	1
Re-grade banks	2
Insert gravel riffles	3
Shallow berms	4
Backwater creation	5

13.1.2 Long List

Improvement Feature	Rank
Meander channel	6
Dig pools	7
Wetlands	8
CSF engagement	9
Riparian planting	10
creation of on-line bays	11
Macrophyte planting (wet)	12
Invasive species removal	13
Offline still water fishery	14
Floodplain connectivity	15
Buffer strips	16
Ecotone	17
Barrier by-pass	18
Coppicing	19
Tree planting on bank tops	20
excavate scrapes	21
Reed beds	22
Large woody material	23
Fish pass structure	24
Floodplain spillway	25
Tree planting on meander bends	26
Bed raising	27
Notching structures	28
Current deflectors	29
Drinkers	30
Fencing	31
Fish stocking	32
Barrier retention	33

13.2 Barrier removal options

The ecosystem services assessment for Cheveney Autosluice determined option 7, 'Replace the radial gate with a multi-stage rock ramp', to be the most beneficial choice. This would deliver improvements to fisheries and ecology whilst maintaining the heritage value of Cheveney Mill. This option would involve:

- Decommission and remove the existing radial gate.
- Construct a multi-staged rock ramp, 4m wide, across an 80m length downstream of the structure, aiding fish passage and to retain the upstream water level required for angling and operation of the wheel at Cheveney Mill.
- Place large rocks in stages across the stream bed to form a series of steps. This will slow water flow and form small pockets of still water and eddies in which fish can rest.
- There should be at least one clear channel of water that meanders through the rock ramp at low flows.
- Mitigate the risk of increased water levels. More detailed modelling would be required to confirm the impact and inform mitigation. Types of mitigation could include creating a low bund or widening the channel to a more natural width where it is currently constrained by the autosluice walls. It should be noted that this risk is not significant as the change in flood depth is within the error margin of the LIDAR data, which forms the basis of the current model.

The full Cheveney Autosluice options report can be found in annex B.

13.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be checked with surveys and site investigation to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

13.3.1 Notes

- Preliminary flood risk modelling showed that re-grading banks and creating berms between the Lesser Teise confluence and Cheveney Mill would increase flood depths to properties in Benover under the 5 and 20 year flood event scenarios. As a result, these options were ruled out for this reach. These measures are more appropriate further upstream where they would not increase risk to properties. If implemented, such measures will slow the flow of floodwaters, benefitting downstream communities.
- Modelling also suggested that creation of a low bund on the left bank of the Beult upstream of Cheveney Autosluice may benefit properties in Benover. This is because a low point on the left bank results in flow across the floodplain even during small flood events. This should be considered as a multi-benefit project alongside any mitigation required for the preferred option at Cheveney Autosluice.

- Pool features have been included, although not quite scoring onto the short list. These will provide material for the construction of berms and provide vital habitat to support angling and the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*.
- The proposed backwater at Bend 73 should not be dug out, but the inlet adjusted to aid flow.
- Creation of riffles is not suitable for most of this segment as the highest scoring option for Cheveney Autosluice would continue to impound water. Any riffles in the impoundment would need to be excessively large to meet the water level, and there would be insufficient flow velocity to keep them clear of fine silt.

13.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 6	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	2	£6,500.00	£400.00	£288	**£6,900.00**
Backwaters	4	£5,100.00	£2,500.00	£380	**£7,600.00**
Berms	52	£279,500.00	£21,300.00	£333	**£300,800.00**
Riparian planting	52	£46,900.00	£4,200.00	£57	**£51,100.00**
Re-grade bank	52	£30,800.00	£42,600.00	£81	**£73,400.00**
Pools	12	£9,600.00	£4,400.00	£117	**£14,000.00**
Segment cost		**£378,400.00**	**£75,400.00**	**£68**	**£453,800.00**

Table 32 Fast, fully engineered option costs for segment 6

2. Medium, partially engineered option

Segment 6	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	2	£6,500.00	£400.00	£288	**£6,900.00**
Backwaters	4	£5,100.00	£2,500.00	£380	**£7,600.00**
Berms	52	£139,700.00	£10,700.00	£333	**£150,400.00**
Riparian planting	52	£23,500.00	£2,100.00	£57	**£25,600.00**
Re-grade bank	52	£15,400.00	£21,300.00	£81	**£36,700.00**
Pools	12	£9,600.00	£4,400.00	£117	**£14,000.00**
Segment cost		**£199,800.00**	**£41,400.00**	**£36**	**£241,200.00**

Table 33 Partially engineered option costs for segment 6

3. Slow, natural process driven option

Segment 6	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	2	£6,500.00	£400.00	£289	**£6,900.00**
Backwaters	4	£5,100.00	£2,500.00	£378	**£7,600.00**
Berms	52	£69,900.00	£5,300.00	£333	**£75,200.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	52	£7,700.00	£10,700.00	£81	**£18,400.00**
Pools	12	£9,600.00	£4,400.00	£117	**£14,000.00**
Segment cost		**£98,800.00**	**£23,300.00**	**£18**	**£122,100.00**

Table 34 Natural process driven option costs for segment 6

The barrier removal for Cheveney autosluice:

Barrier Removal Cost	**£327,000.00***

Table 35 Barrier removal costs for Option 7, and adjusted using construction output price indices from ONS.

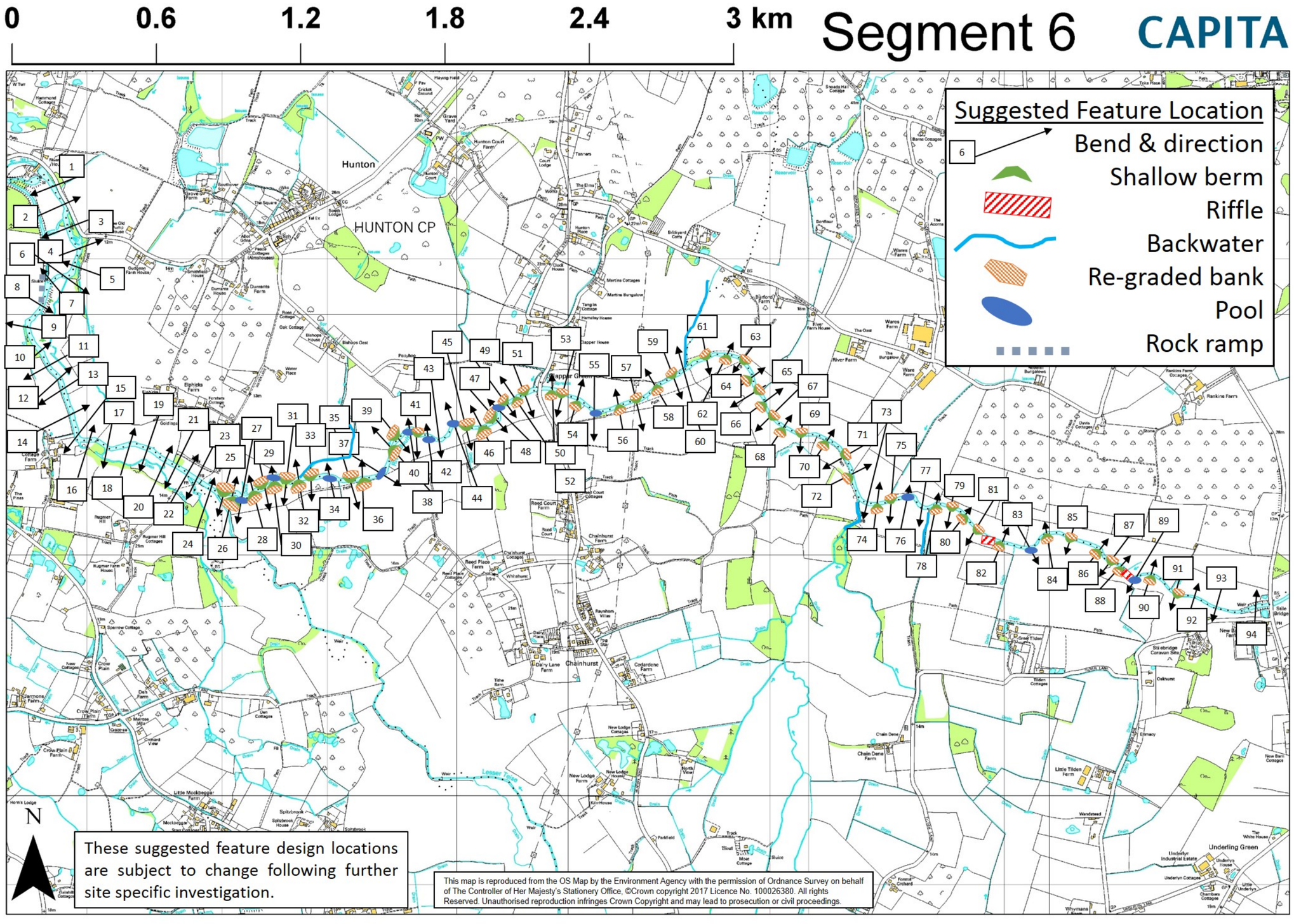


Figure 11 Map of segment 6 with the proposed outline design features

14. Segment 7

14.1 Improvement options

The tables below list the improvement options ranked from highest scoring. This has informed the creation of an outline design for segment 7, utilising all the short listed options, and some of the long list options based on local requirements.

14.1.1 Short list

Improvement Feature	Rank
Barrier removal	1
Re-grade banks	2
Insert gravel riffles	3
Shallow berms	4
Backwater creation	5

14.1.2 Long List

Improvement Feature	Rank
Meander channel	6
Dig pools	7
CSF engagement	8
Wetlands	9
Riparian planting	10
creation of on-line bays	11
Macrophyte planting (wet)	12
Invasive species removal	13
Offline still-water fishery	14
Floodplain connectivity	15
Buffer strips	16
Ecotone	17
Coppicing	18
Tree planting on bank tops	19
Barrier by-pass	20
excavate scrapes	21
Reed beds	22
Large woody material	23
Fish-pass structure	24
Floodplain spillway	25
Tree planting on meander bends	26
Bed raising	27
Notching structures	28
Current deflectors	29
Drinkers	30
Fencing	31
Fish stocking	32
Barrier retention	33

14.2 Barrier removal options

Segment 7 does not have a bridge structure, but contains a weir which acts as a 'check-point' constructed at a similar time to Cheveney Autosluice with similar grade engineering. This is different to all the weir board structures of the other segments, and therefore removal will be different. It is approximately 15m in length, and creating a short impoundment to flow, sediment and fish passage above. Therefore it is reasonable to take forward the average barrier removal price as calculated using the Bridges Modifications Options Report, 2010 by Jacobs and adjusted for inflation. This too can be delivered as a standalone project, or in conjunction with the improvement work dependent on which cost scenario is chosen and mitigation required.

14.3 Outline design

The following designs are high level, based upon the results of the ecosystem service assessment. The designs must be checked with surveys and site investigation to understand and include all specific environmental and geotechnical information. This will inform specific berm sizes, gravel positions and size, backwater dimensions, accurate quantities of materials, pool locations and include any specific design methodologies and protections required to ensure the designs are appropriate. As such, these current designs are subject to change.

14.3.1 Notes

- Options in this reach have not been modelled as the existing model did not show overwide or overdeep sections. Detailed topographical surveys should input to further modelling, which would be required to inform detailed design.
- Pool features have been included, although not quite scoring onto the short list. These will provide material for the construction of berms and provide vital habitat to support angling and the scarce invertebrates recorded in this SSSI: white legged damselfly *Platycnemis pennipes* and hairy dragonfly *Brachytron pratense*.
- Riffles that have been included immediately downstream of backwater outlets are to be point bar style features.
- All berms in this segment should be constructed to a lower level than the other segments with a net removal of material, as they are aimed at creating a self-cleaning channel to maintain conveyance and contribute towards reducing flood risk.

14.4 Costs

The cost to deliver the outline designs is as follows:

1. Quick, fully engineered option

Segment 7	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	3	£12,300.00	£600.00	£358	**£12,900.00**
Backwaters	1	£1,300.00	£600.00	£190	**£1,900.00**
Berms	12	£59,800.00	£4,900.00	£312	**£64,700.00**
Riparian planting	12	£9,400.00	£1,000.00	£50	**£10,400.00**
Re-grade bank	12	£6,200.00	£9,800.00	£77	**£16,000.00**
Pools	3	£1,900.00	£800.00	£90	**£2,700.00**
Segment cost		**£90,900.00**	**£17,700.00**	**£44**	**£108,600.00**

Table 36 Fast, fully engineered option costs for segment 7

2. Medium, partially engineered option

Segment 7	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	3	£12,200.00	£600.00	£356	**£12,800.00**
Backwaters	1	£1,300.00	£600.00	£190	**£1,900.00**
Berms	12	£29,900.00	£2,500.00	£312	**£32,400.00**
Riparian planting	12	£4,700.00	£500.00	£50	**£5,200.00**
Re-grade bank	12	£3,100.00	£4,900.00	£77	**£8,000.00**
Pools	3	£1,900.00	£900.00	£93	**£2,800.00**
Segment cost		**£53,100.00**	**£10,000.00**	**£26**	**£63,100.00**

Table 37 Partially engineered option costs for segment 7

3. Slow, natural process driven option

Segment 7	Number of features	Materials and earthworks	Labour and plant cost	Price per meter	Total cost
Riffles	3	£12,200.00	£600.00	£356	**£12,800.00**
Backwaters	1	£1,300.00	£600.00	£190	**£1,900.00**
Berms	12	£15,000.00	£1,300.00	£314	**£16,300.00**
Riparian planting	0	£0.00	£0.00	£0	**£0.00**
Re-grade bank	12	£1,500.00	£2,500.00	£77	**£4,000.00**
Pools	3	£1,900.00	£800.00	£90	**£2,700.00**
Segment cost		**£31,900.00**	**£5,800.00**	**£15**	**£37,700.00**

Table 38 Natural process driven option costs for segment 7

Barrier removal costs:

Barrier Removal Cost	**£233,500.00***

Table 39 Barrier removal cost for impoundments across segment 7 adjusted using construction output price indices from ONS

Segment 7

CAPITA

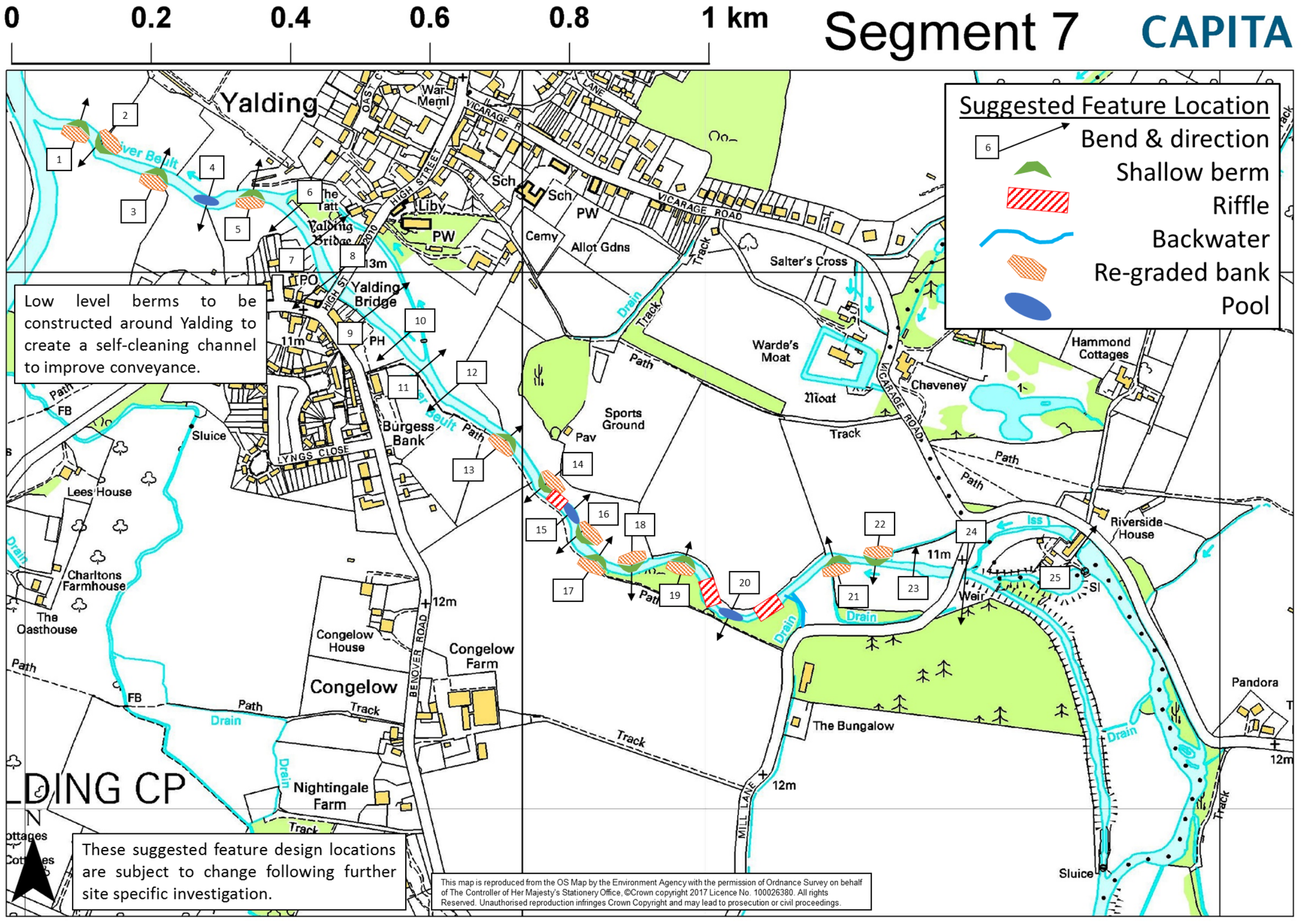


Figure 12 Map of segment 7 with the proposed outline design features

15. Glossary

Apron, or bridge apron – A form of scour protection consisting usually of timber, concrete, or paving placed alongside bridge abutments to prevent undermining.

Catchment – The area of land that drains (over and underground) into the river channel.

Confluence – The point at which two rivers or streams meet.

Conveyance – The ease at which water is able to flow. Better or improved conveyance would be less disrupted flow, free from impoundment.

Diffuse pollution – Created from the loss of chemicals (phosphates & nitrates, pesticides, herbicides) and fine sediments from land into the water through run-off.

Dissolved oxygen – A state of oxygen that is contained within the river water.

Diversity – Having more variety or types.

Eutrophication – A point a body of water gets to where the sheer cover on the surface of the water creates a lack of oxygen in the water below leading to the death of animals and plants.

Floodplain – An area of land adjacent to the river which experiences floods during high flows.

Geotechnical – A branch of civil engineering concerned with the engineering behaviour of sediments.

Ground-truthed – Relates to on-the-ground survey or inspection to ensure correct placement of an improvement feature.

Habitat – An ecological or environmental area containing particular plants or animals.

Impoundment – A stopping of water flow creating a large pond (or reservoir like) area of still water.

Macrophyte – A plant that grows in or near to water.

Natural flood management – Using natural processed to reduce the risk of flooding.

Poaching – Large animal (cattle or sheep) accessing the river trample the river banks, creating loss of vegetation, loosening of soil and leading to bank collapse and sediment entering the water.

SSSI – Site of Special Scientific Interest – A classification given to a site by Natural England.

Stagnation – The point at which water is no longer flowing leading to excessive algae and vegetation growth

Stakeholder - An individual, landowner, business or community group that has an interest in the River.

Tertiary treatment – An additional cleaning process to remove pollutants (nitrates or phosphates) from water exiting a sewage treatment or package treatment plant and entering a river.

Unfavourable condition – A condition assessment of the SSSI. It is not meeting ecological and sustainability targets.

Water Framework Directive (WFD) status – An assessment of the biological and chemical elements of a river system.

16. References

English Nature, 2001. River Beult SSSI conservation Strategy, English Nature.

English Nature 2005. River Beult Geomorphological Assessment Report, English Nature.

Environment Agency, 2010. River Beult Restoration: Bridges Modification Options Report, Environment Agency.

Environment Agency, 2016. River Beult Restoration Plan Technical Note, Environment Agency.

Environment Agency, 2017b. The River Medway Partnership: objectives, members and action plan, Environment Agency.

Natural England, 2007. River Beult Outline Restoration Plan, Natural England.

Other

PRAGMO (Practical River Restoration Appraisal Guidance for Monitoring Options) survey guidance http://www.therrc.co.uk/monitoring-guidance

The River Restoration Centre, 2017. Manual of river restoration techniques. http://www.therrc.co.uk/manual-river-restoration-techniques

17. Annex A: Ecosystem Services Assessment

17.1 Measures of ecosystem services

The following measures were used to assess the current level of service provided by the River Beult SSSI.

Service Type	Ecosystem Services	Measures of the Ecosystem Services Provided by the River Beult
Provisioning	Freshwater	Quantity of water available for people, agriculture, plants and animals Water quality measurements
	Food	Area and quality of riparian land used for food, fruit crops and livestock rearing.
	Fibre and Fuel	Area and quality of riparian pasture used for sheep grazing and wool production Area and quality of riparian woodland harvested for timber and fuel Area and quality of riparian land used for biomass fuel crops
	Habitat	Abundance and diversity of aquatic, marginal and riparian plants Percentage tree cover Size of buffer strips Bank poaching and invasive species prevalence
Regulatory	Pollination	Area of crops reliant on pollinating insects Abundance, quality and connectivity of pollinator habitat Prevalence of pesticide and herbicide use
	Water Regulation	Quantities of irrigation, land drainage and run-off Naturalness of channel morphology, Extent of floodplain, channel capacity and flood outlines Number of features that slow run-off and flows
	Erosion Regulation	Naturalness of channel morphology allowing for erosion regulation Number of features that slow run-off and flows Prevalence of trampling by livestock (poaching) and over-shading
	Water Purification and Waste Treatment	Number of Waste Water Treatment Works Percentage of treated effluent in river flows Abundance and quality of habitats and features able to absorb and process pollutants Frequency of flows capable of dilution and processing of pollutants Water quality measurements
	Climate Regulation	Capacity to adapt for climate change: constraints on floodplain and geomorphology Area of riparian habitats including woodland that provide natural carbon sequestration
Supporting	Habitat and Biodiversity	Abundance, complexity and quality of habitats Abundance and diversity of priority species

Service Type	Ecosystem Services	Measures of the Ecosystem Services Provided by the River Beult
		Fishery health Invasive species prevalence Amount and naturalness of channel morphology features that support habitats and species Water quality measurements
	Nutrient Cycling	Abundance of plants and animals that process nutrients and break down organic matter. Amount of decomposing organic matter Water quality measurements including phosphate, nitrate and dissolved oxygen Naturalness of channel morphology, Prevalence of over-shading, stagnation or diverse functional habitats
	Primary Production	Abundance and diversity of plants Abundance of leaf litter and woody material sources; processing sources and sinks Naturalness of channel morphology
	Soil Formation	Prevalence of erosion, run-off, poaching, and invasive species which degrade soil structure and nutrients
Cultural	Cultural Heritage	Number of sites of archaeological and heritage value; mills; weirs and bridges; listed buildings; locally listed buildings and sites
	Recreation and Tourism	Amount of use of the river for walking, fishing or other recreational activities Degree of access to the river
	Aesthetic Value	Local appreciation of the environment Prevalence of invasive species, stagnation or natural beauty
	Existence Value	Uses of the river by people SSSI condition assessment WFD status reflecting the ecological potential of the river
Notes: High, medium, low and very low values have been used to summarise the results for the different units of measurement that apply to each ecosystem service.		

Table 40: Measures of ecosystem services provided by the River Beult SSSI:

17.2 Present level of ecosystem services

Ecosystem Service	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7
Freshwater	very low	very low	very low	very low	very low	very low	very low
Food	low	high	medium	low	very low	medium	low
Fibre and fuel	medium	very low	medium	medium	medium	medium	medium
Habitat	medium	low	very low	very low	low	very low	low
Pollination	medium	low	low	medium	low	low	very low
Water regulation	low	low	low	low	low	low	low
Erosion regulation	very low	medium	low	low	very low	low	medium
Water purification and waste treatment	medium	medium	medium	medium	medium	medium	medium
Climate regulation	very low	very low	low	very low	medium	very low	medium
Habitat and biodiversity	medium	low	very low	Low	low	very low	low
Nutrient cycling	medium	low	very low	low	low	very low	very low
Primary production	very low	low	very low	very low	low	very low	very low
Soil formation	low	medium	low	medium	very low	very low	very low
Cultural heritage	low	low	low	low	low	medium	low
Recreation and tourism	medium	low	low	low	medium	low	low
Aesthetic value	low	low	low	Low	low	low	low
Existence value	low	low	low	Low	medium	low	low

Table 41 The value assigned to each segment for the ecosystem service

17.3 Improvement solutions

The list of improvement options and the ecosystem services they improve can be found in the table below.

Improvement Options	Freshwater	Food	Fibre and fuel	Habitat	Pollination	Water regulation	Erosion regulation	Water purification and waste treatment	Climate regulation	Habitat and biodiversity	Nutrient cycling	Primary production	Soil formation	Cultural heritage	Recreation and tourism	Aesthetic value	Existence value
Re-grade banks				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
Insert gravel riffles	✓			✓		✓		✓		✓	✓	✓		✓	✓		✓
Shallow berms	✓			✓	✓	✓		✓		✓	✓	✓		✓	✓		✓
Barrier removal		✓		✓						✓	✓	✓			✓	✓	✓
Backwater creation				✓	✓	✓			✓	✓	✓	✓			✓		
Meander channel				✓		✓				✓		✓				✓	
Dig pools				✓		✓				✓	✓	✓					
CSF engagement				✓			✓	✓		✓			✓			✓	
Wetlands				✓					✓	✓	✓	✓	✓				
Riparian planting	✓			✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓
creation of on-line bays										✓	✓	✓					
Macrophyte planting (wet)	✓				✓			✓									✓
Invasive species removal				✓									✓	✓	✓	✓	
Offline still water fishery				✓						✓					✓	✓	✓
Floodplain connectivity			✓	✓		✓			✓		✓	✓					
Buffer strips							✓			✓					✓		
Ecotone				✓	✓					✓							
Coppicing				✓								✓			✓		

Improvement Options	Freshwater	Food	Fibre and fuel	Habitat	Pollination	Water regulation	Erosion regulation	Water purification and waste treatment	Climate regulation	Habitat and biodiversity	Nutrient cycling	Primary production	Soil formation	Cultural heritage	Recreation and tourism	Aesthetic value	Existence value
Tree planting on bank tops			✓	✓	✓				✓	✓		✓					✓
Barrier by-pass				✓						✓							
Excavate scrapes										✓	✓	✓					✓
Reed beds	✓		✓					✓									
Large woody material						✓											
Fish pass structure										✓					✓		
Floodplain spillway				✓		✓											
Tree planting on meander bends				✓						✓		✓					
Bed raising				✓		✓				✓							
Notching structures										✓					✓		
Current deflectors				✓			✓										
Drinkers													✓				
Fencing							✓						✓				
Fish stocking															✓		
Barrier retention		✓												✓			

Table 42 The list of improvement options and ecosystem services they can have positive impacts towards

17.4 Applicability rating

To determine which of improvement options would provide the most effective impact to re-establish natural processes and address the ecosystem service issues, an applicability rating was developed.

The applicability rating looks at each ecosystem service to assess the level of service required for a sustainable delivery of a healthy river. However, there is a recognition that any rate of change to a service would be variable due to the timescales of different needs or the size of change that could be delivered and/or absorbed by the river. Consequently, the timescale was further divided into the following epochs:

I. Present to near future (up to 2021)
II. Beyond the present change timescale into medium term (2021 to 2027), and
III. Long term (beyond 2027).

These timings follow Water Framework Directive (WFD) timescales, as this would be appropriate given WFD is a major regulatory driver for change.

The tables below show the value, assigned to each timeframe.

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Habitat	medium	medium	high	high
Pollination	medium	high	high	high
Water purification and waste treatment	medium	high	high	high
Habitat and biodiversity	medium	medium	high	high
Nutrient cycling	medium	medium	medium	high
Fibre and fuel	medium	medium	medium	medium
Food	low	low	low	low
Water regulation	low	high	high	high
Soil formation	low	medium	high	high
Cultural heritage	low	low	low	low

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Recreation and tourism	medium	medium	medium	medium
Aesthetic value	low	medium	medium	medium
Existence value	low	medium	medium	medium
Freshwater	very low	low	medium	high
Erosion regulation	very low	low	medium	medium
Climate regulation	very low	low	medium	high
Primary production	very low	low	medium	medium

Table 43 Segment 1 value improvement aims over time

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Food	high	high	high	high
Erosion regulation	medium	medium	medium	medium
Water purification and waste treatment	medium	high	high	high
Soil formation	medium	medium	high	high
Habitat	low	medium	high	high
Pollination	low	high	high	high
Water regulation	low	high	high	high
Habitat and biodiversity	low	medium	high	high
Nutrient cycling	low	medium	medium	high
Primary production	low	low	medium	medium

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Cultural heritage	low	low	low	low
Recreation and tourism	low	medium	medium	medium
Aesthetic value	low	medium	medium	medium
Existence value	low	medium	medium	medium
Freshwater	very low	low	medium	high
Fibre and fuel	very low	low	medium	medium
Climate regulation	very low	low	medium	high

Table 44 Segment 2 value improvement aims over time

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Fibre and fuel	medium	medium	medium	medium
Water purification and waste treatment	medium	high	high	high
Food	medium	medium	medium	medium
Pollination	low	high	high	high
Water regulation	low	high	high	high
Erosion regulation	low	low	medium	medium
Climate regulation	low	low	medium	high
Soil formation	low	medium	high	high
Cultural heritage	low	low	low	low
Recreation and tourism	low	medium	medium	medium

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Aesthetic value	low	medium	medium	medium
Existence value	low	medium	medium	medium
Freshwater	very low	low	medium	high
Habitat	very low	medium	high	high
Habitat and biodiversity	very low	medium	high	high
Nutrient cycling	very low	medium	medium	high
Primary production	very low	low	medium	medium

Table 45 Segment 3 value improvement aims over time

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Pollination	medium	high	high	high
Water purification and waste treatment	medium	high	high	high
Soil formation	medium	medium	high	high
Fibre and fuel	medium	medium	medium	medium
Food	low	low	low	low
Water regulation	low	high	high	high
Erosion regulation	low	low	medium	medium
Habitat and biodiversity	low	medium	high	high
Nutrient cycling	low	medium	medium	high
Cultural heritage	low	low	low	low

Recreation and tourism	low	medium	medium	medium
Aesthetic value	low	medium	medium	medium
Existence value	low	medium	medium	medium
Freshwater	very low	low	medium	high
Habitat	very low	medium	high	high
Climate regulation	very low	low	medium	high
Primary production	very low	low	medium	medium

Table 46 Segment 4 value improvement aims over time

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Fibre and fuel	medium	medium	medium	medium
Water purification and waste treatment	medium	high	high	high
Climate regulation	medium	medium	medium	high
Recreation and tourism	medium	medium	medium	medium
Existence value	medium	medium	medium	medium
Habitat	low	medium	high	high
Pollination	low	high	high	high
Water regulation	low	high	high	high
Habitat and biodiversity	low	medium	high	high
Nutrient cycling	low	medium	medium	high
Primary production	low	low	medium	medium
Cultural heritage	low	low	low	low

Aesthetic value	low	medium	medium	medium
Food	very low	very low	very low	very low
Freshwater	very low	low	medium	high
Erosion regulation	very low	low	medium	medium
Soil formation	very low	medium	high	high

Table 47 Segment 5 value improvement aims over time

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Food	medium	medium	medium	medium
Fibre and fuel	medium	medium	medium	medium
Water purification and waste treatment	medium	high	high	high
Cultural heritage	medium	medium	medium	medium
Pollination	low	high	high	high
Water regulation	low	high	high	high
Erosion regulation	low	low	medium	medium
Recreation and tourism	low	medium	medium	medium
Aesthetic value	low	medium	medium	medium
Existence value	low	medium	medium	medium
Freshwater	very low	low	medium	high
Habitat	very low	medium	high	high
Climate regulation	very low	low	medium	high
Habitat and biodiversity	very low	medium	high	high

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Nutrient cycling	very low	medium	medium	high
Primary production	very low	low	medium	medium
Soil formation	very low	medium	high	high

Table 48 Segment 6 value improvement aims over time

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Fibre and fuel	medium	medium	medium	medium
Erosion regulation	medium	medium	medium	medium
Water purification and waste treatment	medium	high	high	high
Climate regulation	medium	medium	medium	high
Habitat	low	medium	high	high
Water regulation	low	high	high	high
Habitat and biodiversity	low	medium	high	high
Cultural heritage	low	low	low	low
Recreation and tourism	low	medium	medium	medium
Aesthetic value	low	medium	medium	medium
Existence value	low	medium	medium	medium
Food	low	low	low	low
Freshwater	very low	low	medium	high
Pollination	very low	high	high	high

Ecosystem Service	Existing Level of Service	Near Term To 2021	Medium Term To 2027	Long Term Beyond 2027
Nutrient cycling	very low	medium	medium	high
Primary production	very low	low	medium	medium
Soil formation	very low	medium	high	high

Table 49 Segment 7 value improvement aims over time

The applicability rating was developed to yield a weighting for each service dependent on its current value and how much was required to improve, and when. The following scoring system was used, presented in the table below.

Near future:	high	medium	low	very low
Present:				
High	0.7	0.3		
Medium	0.8	0.4		
Low	0.9	0.5	0.1	
Very Low	1	0.6	0.2	
Medium Term:	high	medium	low	very low
Near future:				
High	0.07	0.03		
Medium	0.08	0.04		
Low	0.09	0.05	0.01	
Very Low	1	0.06	0.02	
Long Term:	high	medium	low	very low
Medium Term:				
High	0.007	0.003		
Medium	0.008	0.004		
Low	0.009	0.005	0.001	
Very Low	1	0.006	0.002	

Table 50 Weightings applied for improvement over time

- This scoring assumes that services starting from a low value need to change quickly to a higher value and are thus more important than services starting from a low value requiring little or no change in value.
- This method enables greater weight to be given to those services with a higher current value so as to ensure maintenance of these higher valued services.
- Greater weight is given to the shorter timescales as the method assumes that near term changes are more desirable than long term changes (using the 1/100ths and 1/1000ths). As the SSSI is in unfavourable condition, this drives the need for positive change in the short term. This method supports the aim of trying to achieve change in the short term without compromising delivery of long term sustainability.
- Where an improvement feature was able to deliver multiple benefits, the weighting was combined. This was to reflect how effective the improvement feature was in re-establishing natural processes.

These scores were added together for each timescale to give a total 'absolute applicability' weighting for each ecosystem service within each segment. The table below shows the scoring.

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Habitat	0.4	0.08	0.007	0.487
Pollination	0.8	0.07	0.007	0.877
Water purification and waste treatment	0.8	0.07	0.007	0.877
Habitat and biodiversity	0.4	0.08	0.007	0.487
Nutrient cycling	0.4	0.04	0.008	0.448
Fibre and fuel	0.4	0.04	0.004	0.444
Food	0.1	0.01	0.001	0.111
Water regulation	0.9	0.07	0.007	0.977
Soil formation	0.5	0.08	0.007	0.587
Cultural heritage	0.1	0.01	0.001	0.111

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Recreation and tourism	0.4	0.04	0.004	0.444
Aesthetic value	0.5	0.04	0.004	0.544
Existence value	0.5	0.04	0.004	0.544
Freshwater	0.2	0.05	0.008	0.258
Erosion regulation	0.2	0.05	0.004	0.254
Climate regulation	0.2	0.05	0.008	0.258
Primary production	0.2	0.05	0.004	0.254

Table 51 Applicability rating as calculated for segment 1

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Food	0.7	0.07	0.007	0.777
Erosion regulation	0.4	0.04	0.004	0.444
Water purification and waste treatment	0.8	0.07	0.007	0.877
Soil formation	0.4	0.08	0.007	0.487
Habitat	0.5	0.07	0.007	0.577
Pollination	0.9	0.07	0.007	0.977
Water regulation	0.9	0.07	0.007	0.977
Habitat and biodiversity	0.5	0.04	0.008	0.587
Nutrient cycling	0.5	0.04	0.08	0.548
Primary production	0.1	0.05	0.004	0.154

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Cultural heritage	0.1	0.01	0.001	0.111
Recreation and tourism	0.5	0.04	0.004	0.544
Aesthetic value	0.5	0.04	0.004	0.544
Existence value	0.5	0.04	0.004	0.544
Freshwater	0.2	0.05	0.008	0.258
Fibre and fuel	0.2	0.05	0.004	0.254
Climate regulation	0.2	0.05	0.008	0.258

Table 52 Applicability rating as calculated for segment 2

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Fibre and fuel	0.4	0.04	0.004	0.444
Water purification and waste treatment	0.8	0.07	0.007	0.877
Food	0.4	0.04	0.004	0.444
Pollination	0.9	0.07	0.007	0.977
Water regulation	0.9	0.07	0.007	0.977
Erosion regulation	0.1	0.05	0.004	0.154
Climate regulation	0.1	0.05	0.008	0.158
Soil formation	0.5	0.08	0.007	0.587
Cultural heritage	0.1	0.01	0.001	0.111
Recreation and tourism	0.5	0.04	0.004	0.544

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Aesthetic value	0.5	0.04	0.004	0.544
Existence value	0.5	0.04	0.004	0.544
Freshwater	0.2	0.05	0.08	0.258
Habitat	0.6	0.08	0.007	0.687
Habitat and biodiversity	0.6	0.08	0.007	0.687
Nutrient cycling	0.6	0.04	0.007	0.647
Primary production	0.2	0.05	0.004	0.254

Table 53 Applicability rating as calculated for segment 3

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Pollination	0.8	0.07	0.007	0.877
Water purification and waste treatment	0.8	0.07	0.007	0.877
Soil formation	0.4	0.08	0.007	0.487
Fibre and fuel	0.4	0.04	0.004	0.444
Food	0.1	0.01	0.001	0.111
Water regulation	0.9	0.07	0.007	0.977
Erosion regulation	0.1	0.05	0.004	0.154
Habitat and biodiversity	0.5	0.08	0.007	0.587
Nutrient cycling	0.5	0.04	0.008	0.548
Cultural heritage	0.1	0.01	0.001	0.111

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Recreation and tourism	0.5	0.04	0.004	0.544
Aesthetic value	0.5	0.04	0.004	0.544
Existence value	0.5	0.04	0.004	0.544
Freshwater	0.2	0.05	0.008	0.258
Habitat	0.6	0.08	0.007	0.687
Climate regulation	0.2	0.05	0.008	0.258
Primary production	0.2	0.05	0.004	0.254

Table 54 Applicability rating as calculated for segment 4

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Fibre and fuel	0.4	0.04	0.004	0.444
Water purification and waste treatment	0.8	0.07	0.007	0.877
Climate regulation	0.4	0.04	0.008	0.448
Recreation and tourism	0.4	0.04	0.004	0.444
Existence value	0.4	0.04	0.004	0.444
Habitat	0.5	0.08	0.007	0.587
Pollination	0.9	0.07	0.007	1.077
Water regulation	0.9	0.07	0.007	1.077
Habitat and biodiversity	0.5	0.08	0.007	0.587

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Nutrient cycling	0.5	0.04	0.008	0.547 should be 0.548
Primary production	0.1	0.05	0.004	0.154
Cultural heritage	0.1	0.01	0.001	0.111
Aesthetic value	0.5	0.04	0.004	0.544
Food	0	0	0	0
Freshwater	0.2	0.05	0.008	0.258
Erosion regulation	0.2	0.05	0.004	0.254
Soil formation	0.6	0.08	0.007	0.687

Table 55 Applicability rating as calculated for segment 5

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Food	0.4	0.04	0.004	0.444
Fibre and fuel	0.4	0.04	0.004	0.444
Water purification and waste treatment	0.8	0.07	0.007	0.877
Cultural heritage	0.4	0.04	0.004	0.444
Pollination	0.9	0.07	0.007	0.977
Water regulation	0.9	0.07	0.007	0.977
Erosion regulation	0.1	0.05	0.004	0.154
Recreation and tourism	0.5	0.04	0.004	0.544
Aesthetic value	0.5	0.04	0.004	0.544

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Existence value	0.5	0.04	0.004	0.544
Freshwater	0.2	0.05	0.008	0.258
Habitat	0.6	0.08	0.007	0.687
Climate regulation	0.2	0.05	0.008	0.258
Habitat and biodiversity	0.6	0.08	0.007	0.687
Nutrient cycling	0.6	0.04	0.008	0.647
Primary production	0.2	0.05	0.004	0.254
Soil formation	0.6	0.08	0.007	0.687

Table 56 Applicability rating as calculated for segment 6

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Fibre and fuel	0.4	0.04	0.004	0.444
Erosion regulation	0.4	0.04	0.004	0.444
Water purification and waste treatment	0.8	0.07	0.007	0.877
Climate regulation	0.4	0.04	0.008	0.448
Habitat	0.5	0.08	0.007	0.587
Water regulation	0.9	0.07	0.007	0.977
Habitat and biodiversity	0.5	0.08	0.007	0.587
Cultural heritage	0.1	0.01	0.001	0.111
Recreation and tourism	0.5	0.04	0.004	0.544

Ecosystem Service	Existing to Near weighting	Near to medium weighting	Medium to long weighting	Total Weighting:
Aesthetic value	0.5	0.04	0.004	0.544
Existence value	0.5	0.04	0.004	0.544
Food	0.1	0.01	0.001	0.111
Freshwater	0.2	0.05	0.008	0.258
Pollination	0.9	0.07	0.007	0.977
Nutrient cycling	0.6	0.04	0.008	0.647
Primary production	0.2	0.05	0.004	0.254
Soil formation	0.6	0.08	0.007	0.687

Table 57 Applicability rating as calculated for segment 7

17.5 Long list

The long list of improvement options was ranked for each segment using the applicability rating. The score for each option is the sum of absolute applicability scores for every ecosystem service the option would benefit (Table 4).

To produce a suite of clear, feasible and deliverable set of options, the long list was reduced through multi criteria analysis.

The criteria represent different needs of people and wildlife that the river supports. The ecosystem services that the River Beult SSSI provides were prioritised by giving each of these criteria weightings based on previous studies and stakeholder feedback.

Rank	Criteria	Rationale	Weighting
1	Flood Risk Management	People need to be protected from flooding	1.00
2	Water Quality	People and wildlife need clean water	0.90
3	Fisheries Management	Anglers rely on healthy fish with well-connected habitat	0.81
4	Water Management	People and wildlife need enough water supply to thrive	0.63
5	Natural Processes	People and wildlife are affected by erosion and deposition	0.48

6	Ecology		0.48
7	Land Use		0.40
8	Structures		0.39
9	Access		0.30
10	Legal		0.20
11	Mill Operation (only applies in segment 6)		0.10
12	Social Relationships		0.07
13	Education		0.03

Table 58 Criteria weightings as applied to each segment with exception on segment 6

These criteria weightings were applied separately to each segment. Without the division into Segments, and the consideration of the uniqueness of each reach, the use of only river wide criteria would homogenise the river to the detriment of individual SSSI Units.

The multi criteria analysis approach is as follows for each segment:

1. Revise criteria weightings to suit the segment for:
    a. Relevance to the individual segment
    b. Concerns identified by preceding reports
    c. Any concerns that have emerged through stakeholder engagement
2. Score all the improvement options previously identified against the criteria. The aspects considered for scoring the criteria are found in the table below. A 2 score indicates a strong positive impact; 1 a positive impact; 0 is a neutral impact; -1 a negative impact; -2 a strong negative impact. The table below demonstrates the assessment (table 21).
3. The weighting is applied to the score of each improvement option to give a weighted score
4. The total weighted score is counted for each improvement option
5. The applicability rating, as previously calculated, is incorporated as a multiplied factor to give a final total score

	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.00	0.07	0.03					
A:	**In-channel:**																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	3.454	26.250	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	1.231	8.605	10
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	1.521	12.427	7
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	4.295	34.403	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0	-0.14	0.03		5.81	2.863	16.634	5
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0	-0.07	0.03		3.995	0.1	0.400	32
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		2.8	0.544	1.523	25
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	4.331	22.651	3
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	5.097	11.468	9
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	0.877	2.701	19
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.556	11.783	8
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	0	0.07	0.06		1.89	0.254	0.480	31
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	0.798	2.989	18
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	0	0.07	0.06		4.08	1.135	4.631	15
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	0.977	3.664	16
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.254	0.911	29
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0	0.07	0.03		1	1.665	1.665	24
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	1.675	1.926	21
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	0.977	1.285	27
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		2.14	0.544	1.164	28
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0	0.07	0		-2.92	0.544	-1.588	33
B:	**Bank Top:**																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	0	0.07	0.06		1.72	1.933	3.325	17
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	2.262	14.341	6
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	0.798	5.331	14
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	0.264	0.506	30
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0	-0.14	0.03		3.72	1.489	5.539	13
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0	-0.14	0.03		1.925	0.977	1.881	22
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	0.587	1.297	26
C:	**Floodplain:**																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0	0.07	0.06		7.1	0.845	6.000	12
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	0.254	2.238	20
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	0.798	1.819	23
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	1.632	6.120	11
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	2.91	19.715	4
																Mean:	3.99		7.09	
																SD:	2.62		8.51	
																High imp:	6.60		15.61	
																Low imp:	1.37		-1.42	

Table 59 Segment 1 MCA

	Segment 2		1	2	3	4	5	6	7	8	9	10	11	12	13					
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.00	0.07	0.03					
A:	**In-channel:**																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	4.363	33.159	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	2.687	18.782	7
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	2.685	21.936	6
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	5.01	40.130	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0	-0.14	0.03		5.81	4.319	25.093	5
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0	-0.07	0.03		3.995	1.164	4.650	20
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		2.8	1.131	3.167	23
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	5.887	30.789	3
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	5.812	13.077	10
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	2.141	6.594	17
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.656	12.244	11
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	0	0.07	0.06		1.89	1.164	2.200	27
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	1.121	4.198	21
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	0	0.07	0.06		4.08	1.389	5.667	18
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	0.1	0.375	30
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.577	2.069	28
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0	0.07	0.03		4.61	1.665	7.676	15
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	2.141	2.462	25
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	0.544	0.715	29
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		2.14	1.131	2.420	26
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0	0.07	0		-2.92	0.544	-1.588	33
B:	**Bank Top:**																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	0	0.07	0.06		1.72	3.197	5.499	19
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	2.585	16.389	8
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	1.131	7.555	16
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	0.1	0.192	32
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0	-0.14	0.03		3.72	2.354	8.757	14
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0	-0.14	0.03		1.925	1.554	2.991	24
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	0.1	0.221	31
C:	**Floodplain:**																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0	0.07	0.06		7.1	1.968	13.973	9
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	1.133	9.982	13
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	1.677	3.824	22
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	2.796	10.485	12
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	4.466	30.257	4
																Mean:	4.09		10.48	
																SD:	2.57		10.90	
																High imp:	6.66		21.38	
																Low imp:	1.53		-0.41	

	Segment 3		1	2	3	4	5	6	7	8	9	10	11	12	13					
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.00	0.07	0.03					
A:	In-channel:																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	5.475	41.610	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	3.252	22.731	7
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	2.895	23.652	6
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	5.904	47.291	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0	-0.14	0.03		5.81	4.884	28.376	4
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0	-0.07	0.03		3.995	1.374	5.489	19
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		2.8	1.231	3.447	24
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	4.884	25.543	5
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	6.162	13.865	11
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	2.351	7.241	17
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.656	12.244	12
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	0	0.07	0.06		1.89	1.628	3.077	26
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	1.485	5.561	18
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	0	0.07	0.06		4.08	1.135	4.631	22
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	1.077	4.039	23
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.687	2.463	29
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0	0.07	0.03		4.61	2.362	10.889	14
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	2.351	2.704	27
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	0.544	0.715	32
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		2.14	1.231	2.634	28
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0	0.07	0		-2.92	0.544	-1.588	33
B:	Bank Top:																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	0	0.07	0.06		1.72	3.149	5.416	20
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	3.382	21.442	8
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	1.231	8.223	16
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	0.587	1.124	31
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0	-0.14	0.03		3.72	2.565	9.542	15
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0	-0.14	0.03		1.925	1.664	3.203	25
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	0.587	1.297	30
C:	Floodplain:																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0	0.07	0.06		7.1	2.862	20.320	9
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	1.588	13.990	10
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	2.132	4.861	21
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	3.006	11.273	13
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	4.92	33.333	3
																Mean:	4.09		12.14	
																SD:	2.57		12.28	
																High imp:	6.66		24.42	
																Low imp:	1.53		-0.14	

Table 61 Segment 3 MCA

	Segment 4		1	2	3	4	5	6	7	8	9	10	11	12	13					
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.00	0.07	0.03					
A:	**In-channel:**																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	5.276	40.098	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	3.053	21.340	7
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	2.795	22.835	6
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	5.276	42.261	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0	-0.14	0.03		5.81	4.685	27.220	5
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0	-0.07	0.03		3.995	1.274	5.090	20
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		2.8	1.131	3.167	25
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	6.153	32.180	3
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	6.078	13.676	10
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	2.152	6.628	17
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.556	11.783	12
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	0	0.07	0.06		1.89	1.528	2.888	26
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	1.485	5.561	18
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	0	0.07	0.06		4.08	1.135	4.631	21
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	0.977	3.664	23
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.687	2.463	28
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0	0.07	0.03		4.61	1.775	8.183	15
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	2.251	2.589	27
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	0.544	0.715	32
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		2.14	1.131	2.420	29
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0	0.07	0		-2.92	0.544	-1.588	33
B:	**Bank Top:**																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	0	0.07	0.06		1.72	3.207	5.516	19
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	2.695	17.086	8
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	1.131	7.555	16
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	1	1.915	31
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0	-0.14	0.03		3.72	2.724	10.133	14
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0	-0.14	0.03		1.925	1.664	3.203	24
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	1	2.210	30
C:	**Floodplain:**																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0	0.07	0.06		7.1	2.334	16.571	9
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	1.389	12.237	11
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	1.933	4.407	22
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	2.906	10.898	13
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	4.045	27.405	4
																Mean:	4.09		11.42	
																SD:	2.57		11.49	
																High imp:	6.66		22.91	
																Low imp:	1.53		-0.07	

Table 62 Segment 4 MCA

	Segment 5		1	2	3	4	5	6	7	8	9	10	11	12	13				
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.00	0.07	0.03					
A:	**In-channel:**																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	3.824	29.062	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	2.689	18.796	7
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	2.686	21.945	6
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	5.151	41.260	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0	-0.14	0.03		5.81	3.233	18.784	8
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0	-0.07	0.03		3.995	1.165	4.654	18
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		2.8	0.578	1.618	29
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	4.801	25.109	3
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	5.409	12.170	10
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	2.142	6.597	15
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.112	9.736	12
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	0	0.07	0.06		1.89	1.165	2.202	26
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	0.587	2.198	27
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	0	0.07	0.06		4.08	1.135	4.631	19
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	0.977	3.664	21
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.841	3.015	22
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0	0.07	0.03		4.61	1.818	8.381	13
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	2.142	2.463	25
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	1	1.315	31
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		2.14	0.578	1.237	32
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0	0.07	0		-2.92	1	-2.920	33
B:	**Bank Top:**																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	0	0.07	0.06		1.72	2.144	3.688	20
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	3.527	22.361	5
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	0.832	5.558	17
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	0.941	1.802	28
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0	-0.14	0.03		3.72	2.111	7.853	14
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0	-0.14	0.03		1.925	1.564	3.011	23
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	0.687	1.518	30
C:	**Floodplain:**																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0	0.07	0.06		7.1	2.399	17.033	9
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	1.125	9.911	11
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	1.125	2.565	24
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	1.709	6.409	16
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	3.666	24.837	4
																Mean:	4.09		9.77	
																SD:	2.57		10.22	
																High imp:	6.66		19.99	
																Low imp:	1.53		-0.45	

	Segment 6		1	2	3	4	5	6	7	8	9	10	11	12	13					
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.10	0.07	0.03					
A:	**In-channel:**																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	5.476	41.618	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	3.253	22.738	7
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	2.895	23.652	6
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	6.263	50.167	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0.2	-0.14	0.03		6.01	4.885	29.359	4
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0.1	-0.07	0.03		4.095	1.374	5.627	18
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		2.8	1.231	3.447	24
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	6.453	33.749	3
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	7.065	15.896	10
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	2.351	7.241	17
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.656	12.244	12
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	-0.1	0.07	0.06		1.79	1.628	2.914	26
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	1.485	5.561	19
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	-0.1	0.07	0.06		3.98	1.135	4.517	22
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	0.977	3.664	23
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.687	2.463	29
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0.1	0.07	0.03		4.71	2.462	11.596	13
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	2.351	2.704	27
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	0.544	0.715	32
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		2.14	1.231	2.634	28
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0.1	0.07	0		-2.82	0.544	-1.534	33
B:	**Bank Top:**																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	-0.1	0.07	0.06		1.62	3.407	5.519	20
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	3.482	22.076	9
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	1.231	8.223	16
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	0.687	1.316	31
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0.1	-0.14	0.03		3.82	2.824	10.788	15
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0.1	-0.14	0.03		2.025	1.664	3.370	25
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	0.687	1.518	30
C:	**Floodplain:**																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0.1	0.07	0.06		7.2	3.121	22.471	8
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	1.589	13.999	11
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	2.133	4.863	21
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	3.006	11.273	14
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	4.054	27.466	5
																Mean:	4.11		12.54	
																SD:	2.57		12.73	
																High imp:	6.68		25.27	
																Low imp:	1.54		-0.19	

Table 64 Segment 6 MCA

	Segment 7		1	2	3	4	5	6	7	8	9	10	11	12	13					
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Total Raw Score	Total Weighted Score	Applicability Rating	Total Scoring:	Ranking
	Solutions		1.00	0.90	0.81	0.63	0.48	0.40	0.39	0.48	0.30	0.20	0.00	0.07	0.03					
A:	In-channel:																			
1	Insert gravel riffles	Raw Score:	-1	2	2	2	2	1	2	2	1	2	0	1	2	18				
		Weighted score:	-1	1.8	1.62	1.26	0.95	0.4	0.78	0.96	0.3	0.4	0	0.07	0.06		7.6	5.285	40.166	2
2	Dig pools	Raw Score:	1	1	2	2	2	0	0	2	-1	2	0	2	2	15				
		Weighted score:	1	0.9	1.62	1.26	0.95	0	0	0.96	-0.3	0.4	0	0.14	0.06		6.99	3.062	21.403	6
3	Meander channel	Raw Score:	2	2	2	2	2	-2	1	2	-1	2	0	-2	1	11				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.8	0.39	0.96	-0.3	0.4	0	-0.14	0.03		8.17	2.695	22.018	5
4	Re-grade banks	Raw Score:	2	1	2	1	2	-1	1	2	2	2	0	-1	1	14				
		Weighted score:	2	0.9	1.62	0.63	0.95	-0.4	0.39	0.96	0.6	0.4	0	-0.07	0.03		8.01	5.814	46.570	1
5	Barrier removal	Raw Score:	2	1	2	-1	2	1	-2	2	1	1	2	-2	1	10				
		Weighted score:	2	0.9	1.62	-0.63	0.95	0.4	-0.78	0.96	0.3	0.2	0	-0.14	0.03		1	4.694	4.694	19
6	Barrier by-pass	Raw Score:	1	1	2	-1	1	-1	1	1	0	1	1	-1	1	7				
		Weighted score:	1	0.9	1.62	-0.63	0.475	-0.4	0.39	0.48	0	0.2	0	-0.07	0.03		1	1.174	1.174	29
7	Fishpass structure	Raw Score:	0	1	2	0	0	0	-1	1	0	1	0	-1	2	5				
		Weighted score:	0	0.9	1.62	0	0	0	-0.39	0.48	0	0.2	0	-0.07	0.06		1	1.131	1.131	30
8	Shallow berms	Raw Score:	0	1	2	0	2	0	0	2	1	2	0	1	1	12				
		Weighted score:	0	0.9	1.62	0	0.95	0	0	0.96	0.3	0.4	0	0.07	0.03		5.23	6.262	32.750	3
9	Riparian planting	Raw Score:	-1	0	1	-1	2	1	0	2	1	2	0	0	2	9				
		Weighted score:	-1	0	0.81	-0.63	0.95	0.4	0	0.96	0.3	0.4	0	0	0.06		2.25	6.616	14.886	9
14	Ecotone	Raw Score:	-1	1	1	0	2	0	0	2	0	2	0	0	2	9				
		Weighted score:	-1	0.9	0.81	0	0.95	0	0	0.96	0	0.4	0	0	0.06		3.08	2.151	6.625	16
10	Macrophyte planting (wet)	Raw Score:	-1	2	1	1	2	0	0	2	0	2	0	0	2	11				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	0	0.4	0	0	0.06		4.61	2.656	12.244	11
11	Tree planting on meander bends	Raw Score:	1	-1	1	-2	2	0	0	2	0	1	-1	1	2	6				
		Weighted score:	1	-0.9	0.81	-1.26	0.95	0	0	0.96	0	0.2	0	0.07	0.06		1.89	1.428	2.699	24
12	Coppicing	Raw Score:	1	0	1	-1	1	0	0	2	2	2	0	1	2	11				
		Weighted score:	1	0	0.81	-0.63	0.475	0	0	0.96	0.6	0.4	0	0.07	0.06		3.745	1.385	5.187	17
13	Reed beds	Raw Score:	-1	2	1	1	2	0	0	2	-2	2	-1	1	2	9				
		Weighted score:	-1	1.8	0.81	0.63	0.95	0	0	0.96	-0.6	0.4	0	0.07	0.06		4.08	1.135	4.631	21
15	Large woody material	Raw Score:	0	1	1	0	2	0	0	2	-1	2	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.95	0	0	0.96	-0.3	0.4	0	0	0.03		3.75	0.977	3.664	22
16	Current deflectors	Raw Score:	0	1	1	0	1	0	1	1	1	1	0	0	1	8				
		Weighted score:	0	0.9	0.81	0	0.475	0	0.39	0.48	0.3	0.2	0	0	0.03		3.585	0.587	2.104	26
17	Invasive species removal	Raw Score:	0	0	1	0	2	1	1	2	2	2	1	1	1	14				
		Weighted score:	0	0	0.81	0	0.95	0.4	0.39	0.96	0.6	0.4	0	0.07	0.03		4.61	2.362	10.889	12
18	Bed raising	Raw Score:	-2	1	1	-1	2	0	0	2	0	1	0	-1	1	4				
		Weighted score:	-2	0.9	0.81	-0.63	0.95	0	0	0.96	0	0.2	0	-0.07	0.03		1.15	2.151	2.474	25
19	Fish stocking	Raw Score:	0	0	2	0	-1	0	0	0	0	0	0	2	1	4				
		Weighted score:	0	0	1.62	0	-0.475	0	0	0	0	0	0	0.14	0.03		1.315	0.544	0.715	32
20	Notching structures	Raw Score:	0	0	2	0	0	0	-1	1	0	2	0	0	1	5				
		Weighted score:	0	0	1.62	0	0	0	-0.39	0.48	0	0.4	0	0	0.03		1	1.131	1.131	30
21	Barrier retention	Raw Score:	0	-1	-1	-1	-2	0	2	-1	0	0	1	1	0	-2				
		Weighted score:	0	-0.9	-0.81	-0.63	-0.95	0	0.78	-0.48	0	0	0	0.07	0		1	0.544	0.544	33
B:	Bank Top:																			
1	Tree planting on bank tops	Raw Score:	1	-1	1	-1	2	-2	0	2	0	1	-1	1	2	5				
		Weighted score:	1	-0.9	0.81	-0.63	0.95	-0.8	0	0.96	0	0.2	0	0.07	0.06		1.72	2.949	5.072	18
2	CSF engagement	Raw Score:	1	2	1	1	2	1	0	1	0	1	0	1	0	11				
		Weighted score:	1	1.8	0.81	0.63	0.95	0.4	0	0.48	0	0.2	0	0.07	0		6.34	3.282	20.808	7
3	Buffer strips	Raw Score:	1	2	1	1	2	-1	0	2	2	1	0	1	2	14				
		Weighted score:	1	1.8	0.81	0.63	0.95	-0.4	0	0.96	0.6	0.2	0	0.07	0.06		6.68	1.131	7.555	15
4	Fencing	Raw Score:	0	1	-1	1	1	2	0	1	-2	0	0	1	-1	3				
		Weighted score:	0	0.9	-0.81	0.63	0.475	0.8	0	0.48	-0.6	0	0	0.07	-0.03		1.915	0.687	1.316	28
5	Floodplain connectivity	Raw Score:	2	1	-1	1	2	-2	2	1	-1	0	1	-2	1	5				
		Weighted score:	2	0.9	-0.81	0.63	0.95	-0.8	0.78	0.48	-0.3	0	0	-0.14	0.03		3.72	2.475	9.207	14
6	Floodplain spillway	Raw Score:	2	1	-1	0	1	-2	1	1	-2	0	1	-2	1	1				
		Weighted score:	2	0.9	-0.81	0	0.475	-0.8	0.39	0.48	-0.6	0	0	-0.14	0.03		1.925	1.564	3.011	23
7	Drinkers	Raw Score:	0	1	0	1	0	1	0	1	-1	0	0	1	1	5				
		Weighted score:	0	0.9	0	0.63	0	0.4	0	0.48	-0.3	0	0	0.07	0.03		2.21	0.687	1.518	27
C:	Floodplain:																			
1	Wetlands	Raw Score:	2	2	1	2	2	-2	1	2	-2	1	1	1	2	13				
		Weighted score:	2	1.8	0.81	1.26	0.95	-0.8	0.39	0.96	-0.6	0.2	0	0.07	0.06		7.1	2.772	19.681	8
2	creation of on-line bays	Raw Score:	2	2	2	2	2	-1	1	2	-1	2	0	1	2	16				
		Weighted score:	2	1.8	1.62	1.26	0.95	-0.4	0.39	0.96	-0.3	0.4	0	0.07	0.06		8.81	1.498	13.197	10
3	excavate scrapes	Raw Score:	0	1	-1	2	2	-2	0	2	-1	1	0	-2	2	4				
		Weighted score:	0	0.9	-0.81	1.26	0.95	-0.8	0	0.96	-0.3	0.2	0	-0.14	0.06		2.28	2.042	4.656	20
4	Offline stillwater fishery	Raw Score:	0	0	2	1	1	-2	1	2	1	1	0	2	2	11				
		Weighted score:	0	0	1.62	0.63	0.475	-0.9	0.425	0.8	0.3	0.2	0	0.14	0.06		3.75	2.806	10.523	13
5	Backwater creation	Raw Score:	2	1	1	2	2	-2	1	2	0	2	0	1	2	14				
		Weighted score:	2	0.9	0.81	1.26	0.95	-0.9	0.425	0.8	0	0.4	0	0.07	0.06		6.775	3.506	23.753	4
																Mean:	3.89		10.85	
																SD:	2.50		11.76	
																High imp:	6.38		22.61	
																Low imp:	1.39		-0.91	

17.6 Option dependencies

Many of the identified improvement options are known to be dependent on the joint delivery with other features. For example, shallow berms with re-graded banks as the material to construct the shallow berm is to be won from the bank above.

To account for this, dependencies between each of the options were identified. Those with a greater number were given an additional weighting which was added to the final score.

ID	Feature	Comment	Frequency of occurance	Weighting based on significance limit	Primary Link:	Secondary link:	Tertiary Link:
1	Re-grade banks	in channel feature	5	1.0	shallow berms	meander channel	riparian planting
2	Insert gravel riffles	in channel feature	3		barrier removal	shallow berms	dig pools
3	Shallow berms	in channel feature	6	1.2	re-grade banks	barrier removal	macrophyte planting
4	Backwater creation	in channel feature	3		barrier removal	dig pools	creation of on-line bays
5	Barrier removal	in channel feature	9	1.9	fishpass structure	barrier bypass	bed raising
6	CSF engagement	flood plain feature					
7	Meander channel	in channel feature	2		re-grade banks	Shallow berms	creation of on-line bays
8	Macrophyte planting (wet)	in channel feature	3		Shallow berms	Ecotone	Invasive species removal
9	Riparian planting	in channel feature	2		re-grade banks	Invasive species removal	Ecotone
10	Dig pools	in channel feature	2		insert gravel riffles	barrier removal	backwater creation
11	Offline stillwater fishery	flood plain feature					
12	Wetlands	flood plain feature					
13	Floodplain connectivity	flood plain feature					
14	Buffer strips	flood plain feature					
15	Reed beds	flood plain feature					
16	Large woody material	in channel feature	0		coppicing	Shallow berms	Insert gravel riffles
17	Tree planting on bank tops	in channel feature	1		Tree planting on meander bends	coppicing	Invasive species removal
18	Coppicing	flood plain feature					
19	Ecotone	in channel feature	2		Riparian planting	Macrophyte planting (wet)	Invasive species removal
20	creation of on-line bays	in channel feature	3		Backwater creation	Meander channel	Re-grade banks
21	Bed raising	in channel feature	1		Insert gravel riffles	Dig pools	Barrier removal
22	Floodplain spillway	flood plain feature					
23	excavate scrapes	flood plain feature					
24	Invasive species removal	in channel feature	5	1.0	Re-grade banks	Backwater creation	Riparian planting
25	Fishpass structure	in channel feature	3		Barrier retention	Barrier by-pass	barrier removal
26	Drinkers	in channel feature	0		Barrier retention	Barrier removal	creation of on-line bays
27	Fish stocking	in channel feature	0		Barrier retention	Barrier removal	Barrier by-pass
28	Notching structures	in channel feature	0		Barrier retention	Barrier by-pass	Barrier removal
29	Current deflectors	in channel feature	0		meander channel	shallow berms	macrophyte planting
30	Fencing	flood plain feature					
31	Tree planting on meander bends	in channel feature	2		Tree planting on bank tops	coppicing	Invasive species removal
32	Barrier by-pass	in channel feature	3		barrier removal	Barrier retention	Fishpass structure
33	Barrier retention	in channel feature	5	1.0	barrier removal	Fishpass structure	Barrier by-pass
		number	23				
		Total	60				
		mean	2.61				
		SD	2.25				
		Mean + 2xSD	7.11				
		Mean + SD	4.86				
		Mean - SD	0.36				

Table 66 Improvement option dependencies

18. Annex B: Cheveney Autosluice Options Report

18.1 Background

The River Beult has been historically modified to support the operation of the mill wheel at Cheveney Mill. This mill pre-dates the designation as a SSSI. In the late 1930s a flood relief channel was created to bypass the mill in high flows, flow to this channel and water levels upstream were subsequently managed by an automated radial sluice: Cheveney Autosluice. The combination of the mill and autosluice retain deep impounded water upstream, which supports the activities of nine angling clubs.

However, the mill and autosluice present a barrier to the free movement of fish, water and sediment. As a result the fishery is less resilient to damaging pollution and flow events because fish cannot escape or re-colonise. The movement of fish to more suitable spawning habitat is also restricted. The impounded flows combine with poor water quality to result in algal blooms and excessive weed cover in places.

The autosluice has reached its end of life and risks catastrophic failure due to poor condition if there are no changes. This would result in returning the channel to a natural flow, however, the ability to operate the historic mill wheel would be lost, with it some of the heritage value of the structure. The current angling activities of a significant number of clubs would also have to change in this scenario. Stakeholder feedback has suggested that this would lead to a further decline in angling participation.

To address these issues, whilst reducing or avoiding any increase in flood risk, eight end of life options for the sluice were appraised through an ‘Initial Appraisal of the Cheveney Auto Sluice Refurbishment Project’. That report did not consider impacts to the SSSI in detail.

The eight options have been analysed using the same ecosystem services assessment as the rest of the SSSI to understand how best to improve the River Beult SSSI for people and wildlife. This ranked the options, with those most beneficial to people and wildlife ranked highest.

The options considered were as follows:

18.1.1 Option 1: Do Minimum:

Leave the structure in its present condition and open the gate to ensure water can be conveyed downstream in high flows to prevent flooding of the surrounding area. As a result, the upstream water level will no longer be maintained. No maintenance will be carried out to the structure. The structure will eventually fail, resulting in reversion to a natural channel.

18.1.2 Option 2: Continue as Present:

Retain current maintenance, operation and ownership of the structure. The structure will eventually fail, resulting in reversion to a natural channel.

18.1.3 Option 3: Whole River PSCA (otherwise Continue as Present):

Public Sector Co-operation Agreement (PSCA) would be a partnership between the Internal Drainage Board (IDB) and the Environment Agency, to help deliver

maintenance of the river more efficiently. The Environment Agency will look to pass ownership and responsibility of the structures and watercourse to a third party.

18.1.4 Option 4: Sluice Only PSCA (otherwise Continue as Present):

A PSCA between the IDB and the Environment Agency to help deliver maintenance of the individual structure more efficiently. The Environment Agency will look to pass ownership and responsibility of the sluice to a third party.

18.1.5 Option 5: Refurbishment of Sluice and addition of a fish pass:

This will involve isolating the structure and taking the gates out, painting the steelwork, undertaking minor structural repairs (such as repair to concrete cracks) and installing a fish pass from the mill pond to the River Beult.

18.1.6 Option 6: Replacement of Radial Gate with a Fixed Crest Weir:

Install fixed level stop-logs to act as a weir to retain the upstream water level required. An additional channel will also be constructed to be used as a bypass to convey flow during flood events. It is proposed that the existing drain between the two branches is widened/dredged to convey this flow. A fish pass will also be installed from the mill pond to the River Beult.

18.1.7 Option 7: Replace Radial Gate with a multi-stage rock ramp:

Decommission and remove the existing radial gate. Construct a multi-staged rock ramp, 4m wide, across an 80m length downstream of the structure, aiding fish passage and to retain the upstream water level required. Large rocks are placed in stages across the stream bed to form a series of steps. This will slow water flow and form small pockets of still water and eddies in which fish can rest. There should be at least one clear channel of water that meanders through the rock ramp at low flows.

18.1.8 Option 8: Like for Like Replacement of the Radial Gate plus a new fish pass:

Replace the structure, with a radial sluice gate, like-for-like. A fish pass will also be installed adjacent to, or included within, the structure.

18.2 Methodology

The method involved the same ecosystem services assessment and multi-criteria analysis as that applied to the other improvement options for the SSSI. This methodology is detailed in the main report and Annex A.

18.3 Criteria

The criteria and their weightings were the same as those used to rank the restoration measures, with the addition of a timeliness criteria, and the removal of Mill Operation criteria.

The timeliness criteria was added to favour options that will deliver improvements in a shorter timescale, to reflect the fact that the structure is at the end of its design life. It was given a weighting just below that of ecology.

Mill operation was removed as a criteria to avoid double counting. One of the aims of this assessment was to maintain mill operation.

The criteria are as tabled below:

Rank	Criteria	Weighting
1	Flood Risk Management	1.00
2	Water Quality	0.90
3	Fisheries Management	0.81
4	Water Management	0.63
5	Natural Processes	0.48
6	Land Use	0.40
7	Structures	0.39
8	Ecology	0.48
9	Timescale	0.39
10	Access	0.30
11	Legal	0.20
12	Social Relationships	0.07
13	Education	0.03

Table 67 Criteria weightings applied to the auto sluice options

18.4 Applicability rating methodology

As with the segment assessments, each option was scored against how many ecosystem services would benefit, which were identified as requiring improvement.

Option Number	Option Description	Applicability Rating
1	Do Minimum	2.132
2	Continue as Present: EA operate & Maintain	0.544
3	Do Minimum 1: whole river PSCA; Sluice to IBD	2.165
4	Do Minimum 2: Sluice to IDB	1.621
5	Renew & Improve: refurb & add fish pass	2.462
6	Convert to fixed crest + fish pass	1.374
7	Replace with long rock ramp	3.907
8	Like for like replacement + fish pass	1.231

Table 68 Applicability rating scores for each option

As per the previous river segment method, the applicability rating was the applied to the total weighted scores for each option to give a total score.

	Criteria ID:		1	2	3	4	5	6	7	8	9	10	11	12	13	14						
	Criteria:		Flood Risk Management	Water Quality	Fisheries Management	Water Management	Natural Processes	Land Use	Structures	Ecology	Access	Legal	Mill (or structures') Operation	Social Relationships	Education	Timescale	Total Raw Score	Total Weighted Score	Ranking	Applicability Ranking	Total Score	New Rank
	Criteria Weightings:		1.00	0.90	0.81	0.63	0.48	0.45	0.43	0.40	0.30	0.20	0.00	0.07	0.03	0.39						
Option Number	Options												NA as will be double counting; was 0.1									
1	Do Minimum	Raw Score:	-2	-2	-2	-2	2	-1	-2	2	-1	-2		-2	2	-2	-12					
		Weighted score:	-2	-1.8	-1.62	-1.26	0.95	-0.45	-0.85	0.8	-0.3	-0.4	0	-0.14	0.06	-0.78		-7.79	8	2.132	-16.6083	8
2	Continue as Present:	Raw Score:	0	-1	-1	-1	-1	0	0	-2	0	-1		0	0	-1	-8					
	EA operate & Maintain	Weighted score:	0	-0.9	-0.81	-0.63	-0.475	0	0	-0.8	0	-0.2	0	0	0	-0.39		-4.205	7	0.544	-2.28752	7
3	Do Minimum 1:	Raw Score:	1	1	-1	2	-1	2	0	-1	0	2		-1	-1	1	4					
	whole river PSCA; Sluice to IBD	Weighted score:	1	0.9	-0.81	1.26	-0.475	0.9	0	-0.4	0	0.4	0	-0.07	-0.03	0.39		3.065	2	2.165	6.635725	3
4	Do Minimum 2:	Raw Score:	1	-1	-1	1	-2	1	1	-2	0	1		-1	-1	2	-1					
	Sluice to IDB	Weighted score:	1	-0.9	-0.81	0.63	-0.95	0.45	0.425	-0.8	0	0.2	0	-0.07	-0.03	0.78		-0.075	6	1.621	-0.12158	6
5	Renew & Improve:	Raw Score:	0	1	1	1	-2	1	1	1	1	1		2	1	-1	8					
	refurb & add fish pass	Weighted score:	0	0.9	0.81	0.63	-0.95	0.45	0.425	0.4	0.3	0.2	0	0.14	0.03	-0.39		2.945	3	2.462	7.25059	2
6	Convert to fixed crest + fish pass	Raw Score:	-1	2	1	0	-1	-1	1	1	-1	2		0	1	-1	3					
		Weighted score:	-1	1.8	0.81	0	-0.475	-0.45	0.425	0.4	-0.3	0.4	0	0	0.03	-0.39		1.25	5	1.374	1.7175	5
7	Replace with long rock ramp	Raw Score:	-1	2	2	0	1	-2	2	2	-2	2		1	2	-1	8					
		Weighted score:	-1	1.8	1.62	0	0.475	-0.9	0.85	0.8	-0.6	0.4	0	0.07	0.06	-0.39		3.185	1	3.907	12.4438	1
8	Like for like repacement + fish pass	Raw Score:	0	1	1	0	-1	0	2	1	2	1		2	0	-2	7					
		Weighted score:	0	0.9	0.81	0	-0.475	0	0.85	0.4	0.6	0.2	0	0.14	0	-0.78		2.645	4	1.231	3.255995	4
																	Mean:	4.43			1.54	
																	SD:	2.22			8.68	
																	High imp:	6.65			10.21	
																	Low imp:	2.20			-7.14	

Table 69 Multi criteria analysis results for Cheveney auto sluice options

The results in rank order are as follows:

Ranking	Option	Simple Score	Score with Applicability Ranking added
1	Option 7: Replace Radial Gate with a multi-stage rock ramp	3.185	12.444
2	Option 5: Refurbishment of Sluice and addition of a fish pass	2.945	7.251
3	Option 3: Whole River PSCA (otherwise Continue as Present)	3.065	6.636
4	Option 8: Like for Like Replacement of the Radial Gate plus a new fish pass	2.645	3.256
5	Option 6: Replacement of Radial Gate with a Fixed Crest Weir	1.250	1.718
6	Option 4: Sluice Only PSCA (otherwise Continue as Present)	-0.075	-0.122
7	Option 2: Continue as Present	-4.205	-2.288
8	Option 1: Do Minimum	-7.790	-16.608
Mean:		4.43	1.54
Standard Deviation:		2.22	8.68
Mean + 1 SD		6.65	10.21
Mean - 1 SD		2.20	-7.14

Table 70 Results of the options assessment. Option 7 is the outcome to take forwards

In terms of the score with Applicability Ratings added:

- Option 7 scores more than mean + 1 standard deviation (>10.21), and so is particularly robust, benefitting lots of ecosystem services.
- Option 1 scores less than mean - 1 standard deviation (<-7.14), and so is particularly fragile as it negatively affects several high priority needs.

18.5 Summary:

The main benefits of each option, which led to the above results are as follows:

1. Option 7: Replace Radial Gate with a multi-stage rock ramp:
    - Oxygenates water
    - Supports current angling practices on a particularly well-used section of the Beult fishery
    - Maintains the heritage value of the mill by maintaining a level of water to operate the wheel

- Enables multi-species fish passage even in low flows
- Moves towards Good Ecological Potential under WFD
- Could provide education opportunities

This delivers more of the important criteria than any other option.

2. Option 5: Refurbishment of Sluice and addition of a fish pass:
    - Oxygenates water
    - Enables fish passage
    - Moves towards Good Ecological Potential under WFD

This delivers obligations well, scores highly.

3. Option 3: Whole River PSCA (otherwise Continue as Present):
    - Could allow water levels to be managed better for surrounding land use
    - Allows greater input from landowners
    - Moves towards Good Ecological Potential under WFD

This delivers existing important criteria, so scores well.

4. Option 8: Like for Like Replacement of the Radial Gate plus a new fish pass:
    - Oxygenates water
    - Enables fish passage
    - Moves towards Good Ecological Potential under WFD

This simply repeats what the present does but removes its major short comings in terms of length of life and fish passage; in many ways this is the average option.

5. Option 6: Replacement of Radial Gate with a Fixed Crest Weir and a fish pass:
    - Oxygenates water
    - Enables fish passage

This delivers obligations, but less well than Option 5.

6. Option 4: Sluice Only PSCA (otherwise Continue as Present:
    - Quick

The only advantage with this option is that it is potentially quick in terms of EA obligations. However, it does not address any of the problems.

7. Option 2: Continue as Present:
    - Return to a natural channel eventually

The eventual failure of the asset would result in formation of a natural channel but this would be uncontrolled and may result in a loss of some ecosystem services.

8. Option 1: Do Minimum:
    - Return to a natural channel eventually
    - Enable fish passage in some flows

The eventual failure of the asset would result in formation of a natural channel but this would be uncontrolled and would result in a loss of some ecosystem services.