Restoring the Yorkshire Derwent

River Restoration Plan

Final report
June 2010

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CONTENTS

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VISION FOR THE RIVER DERWENT SSSI

The River Derwent from Ryemouth to Barmby Barrage is a lowland river unique in England and Wales. However, although designated as a Site of Special Scientific Interest (SSSI) the river and floodplain is suffering from a range of pressures resulting from both past and current management of the river and surrounding land. Our vision is to improve the ecological health of the river by restoring the mosaic of characteristic habitats needed for the wildlife to recover and thrive.

The character of the restored River Derwent

Our vision for the River Derwent SSSI is to work towards a river system which has:

A reach of the River Derwent showing open areas for bird communities on one bank, and more vegetation on the opposite bank providing shading for aquatic communities and shelter for riparian species

- Variable river depths and speeds along the length of the river providing areas of gravel and stony substrate and backwater for fish spawning and resting.
- Shallow margins with river plants which can grow out into the river when flows are low and gently sloping river banks.
- Reduced artificial impoundment (weirs, sluices. etc.) so that impacts on river function are reduced, and there is free passage for fish.
- A mixture of tree cover of varied age structure providing shady spots for wildlife to shelter with a pre-dominance of open stretches for bird life in the Lower Derwent valley.
- Floodplain used by the river at times of high flow to replenish land with sediments and reduce sediment loading within the river.

An area of well-connected floodplain near Stamford Bridge, showing the development of floodplain wetland habitats

An area of well-connected floodplain near Kirkham, showing the development of marginal habitats

How can we deliver restoration?

- Continue positive management of reaches already in good ecological health.
- Support and allow the river to recover where natural processes are already working well.
- Assist natural recovery by changing management or undertaking selective river restoration works.
- Remove manmade features where they damage the function and ecology of the river, whilst recognising the need to protect people and property from flooding, maintain regionally important water supplies and also the cultural, historic and landscape aspects.
- Actively restore the river channel where the characteristic features of the river can only be achieved by habitat re-creation.
- Reduce pressures from excessive sediment runoff.
- Ensure the river is adaptable into the future to new pressures such as climate change.

Keys to success

- Learn from early actions and actions already implemented in other rivers under threat.
- Working together as a community, with support from landowners, across the Derwent valley.
- Accepting that sustainable recovery will be over longer timescales and will depend on funding.
- Having a plan which is adaptable to new challenges and opportunities.
- Maintaining the vision of restoring a site of national importance.
- Building solutions through consensus which can benefit people and wildlife.

1. INTRODUCTION

The River Derwent Site of Special Scientific Interest

The Yorkshire River Derwent is a major tributary of the River Ouse, located to the north and east of York. The river rises on Fylingdales Moor in the North York Moors National Park, and flows south until it meets the River Hertford. It then flows west through the Vale of Pickering, resumes its southerly direction through the Vale of York, and joins the River Ouse at Barmby-on-the-Marsh.

The river has been designated as a Site of Special Scientific Interest (SSSI) from its confluence with the River Rye to its downstream confluence with the River Ouse (with the exception a short sections through Malton) (**Figure 1.1**). SSSIs are areas that have been notified as being of special interest under the Wildlife and Countryside Act 1981 and cover the country's very best wildlife and geological sites. Natural England works with land owners and managers, to monitor and conserve these important sites.

The Yorkshire River Derwent has been designated for its natural lowland character as well as the particular characteristics:

- Classic **lowland river profile** with diverse flora and fauna.
- **Aquatic plant community** characteristic of lowland rivers including un-branched bur-reed (*Sparganium emersum*), yellow water-lily (*Nuphar lutea*), flowering rush (*Butomus umbellatus*), shining pondweed (*Potamogeton lucens*), arrowhead (*Sagittaria sagittifolia*) and narrow-leaved water-parsnip (*Berula erecta*).
- **Diverse fish communities** including bleak (*Alburnus alburnus*) and ruffe (*Gymnocephalus cernuus*).
- **Rich assemblage of invertebrates** including mayflies (*Baetis buceratus*, *Heptagenia fuscogrisea* and *Brachycerus harisella*) as well as the banded agrion dragonfly (*Agrion splendens*).
- **The breeding bird community** including common sandpiper (*Actitis hypoleucos*), dipper (*Cinclus cinclus*), kingfisher (*Alcedo atthis*), yellow wagtail (*Motacilla flava*) and grey wagtail (*Motacilla cinerea*).

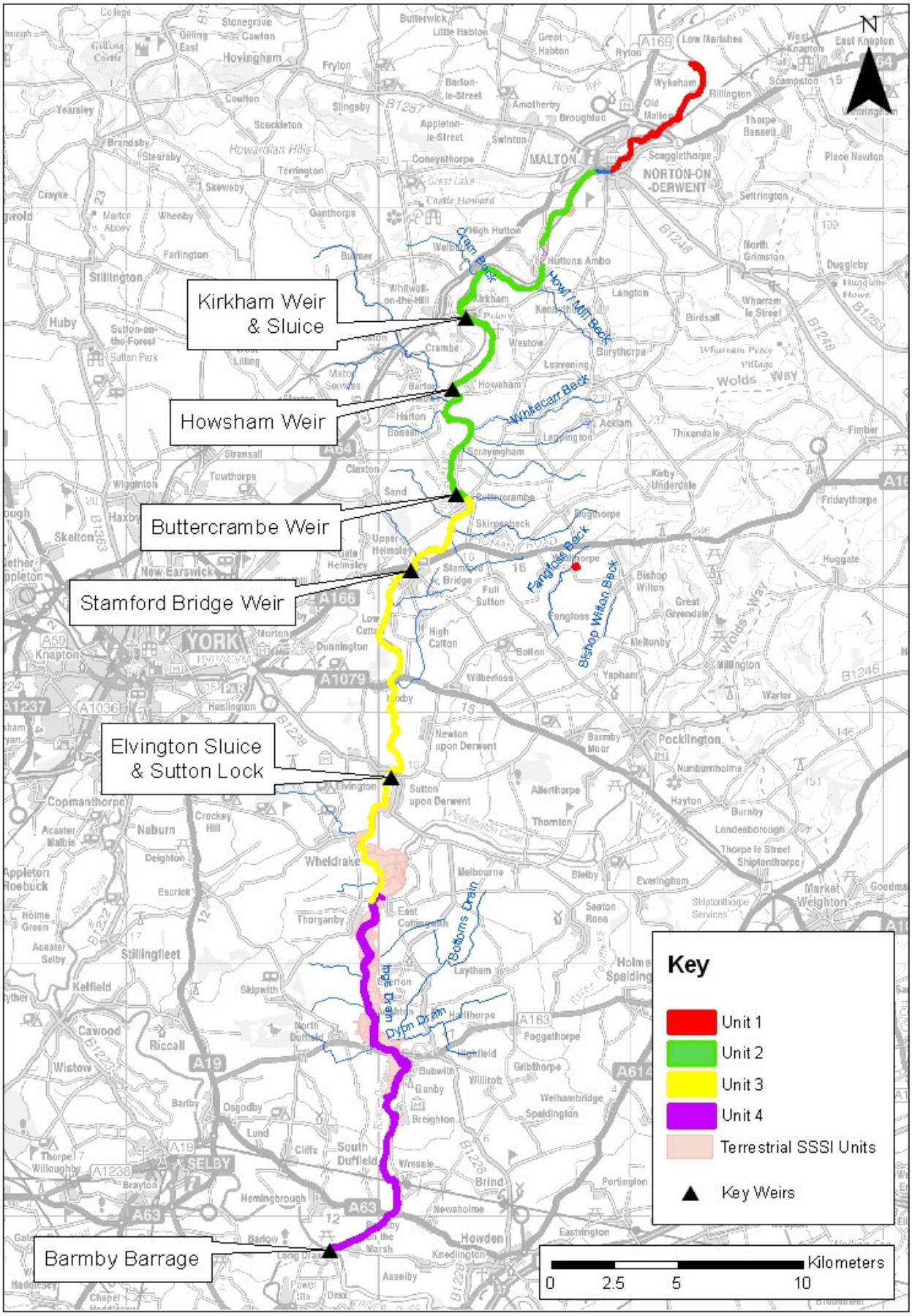
The River Derwent SSSI is divided into 21 SSSI units, which Natural England uses in order to manage and monitor the condition of the site. Four of these units relate to the river itself, whilst the remainder relate to land-based supporting habitats along the river corridor. The four river-based units are detailed in **Table 1.1** and their location illustrated in **Figure 1.1**.

Table 1.1: Location of SSSI Units within the River Derwent SSSI

SSSI Unit	Upstream and downstream SSSI Unit boundaries	Length of river
1	Ryemouth to Malton	8km
2	Malton to Buttercrambe	21km
3	Buttercrambe to The Beck	24km
4	The Beck to Barmby Barrage	17km
	Total	70km

Find out more
River Derwent SSSI citation
http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003398.pdf

Figure 1.1: Map of the SSSI units



Other interest features

In addition to being designated as a SSSI, the River Derwent is also internationally designated as a Special Area of Conservation (SAC) under the EC Habitats Directive. All terrestrial SACs in England are, like the River Derwent, also Sites of Special Scientific Interest (SSSIs). The additional SAC designation is recognition that some or all of the wildlife and habitats are particularly valued in a European context. The SAC designation is based on the following interest features:

- Natural lowland river character.
- Assemblage of floating and submerged plants, including *Ranunculion fluitantis* and *Callitricho-Batrichion* communities.
- River lamprey.
- Sea lamprey.
- Bullhead.
- Otter.

Otter footprint near Malton

Find out more
River Derwent SAC site details
http://www.jncc.gov.uk/ProtectedSites/SACselection/sac.asp?EUCode=UK0030253

Favourable condition and the need for restoration

The Government's target for the condition of SSSIs
The condition of all SSSIs in England, including the River Derwent, is assessed by Natural England against site-specific Conservation Objectives. These objectives are shown in **Table 1.2**. A SSSI unit is assessed to be in "favourable condition" if the SSSI is being adequately conserved and is meeting its Conservation Objectives. The Government has set a Public Service Agreement (PSA) target to bring into favourable or recovering condition 95% of the area of Sites of Special Scientific Interest (SSSIs) in England by 2010. This is an ambitious target, which Defra is working closely with Natural England and a wide range of other stakeholders to achieve. The Environment Agency is responsible for a number of solutions agreed with Natural England to help meet the PSA target.

Current condition of the River Derwent SSSI
Although the River Derwent has been recognised for its ecological value, it has been heavily modified over time for a variety of different reasons, including flood defence, land drainage, water supply and navigation. As a result, the river channel is deep and uniform in shape, with embankments along much of its length and several sets of weirs and sluices. All these changes have impacted to some extent upon its ecological value. Natural England's Condition Assessment in both 2003 and 2009 identified that all four river SSSI units in the River Derwent are still in an unfavourable condition.

Reasons for unfavourable condition

According to the condition assessment undertaken by Natural England in 2003, the River Derwent SSSI is in unfavourable condition for the following reasons:

- Diffuse pollution from agriculture and runoff.
- Siltation.
- Inland flood defence works.
- Inappropriate in-channel structures.

Table 1.2: Conservation objectives and physical habitat requirements

Type	Interest feature
a) General conservation objectives	
Flow	Flow regime should be characteristic of the river. There should be no obvious shortage of water availability within the unit. Ecological flow criteria (e.g. for passage of migrating fish) should also be complied with.
Habitat structure - substrate	No excessive siltation. Channels should contain characteristic levels of fine sediment for the river type.
Habitat structure - channel and banks	Channel form should be generally characteristic of river type, with predominantly unmodified planform and profile.
Habitat structure - channel and banks	Bank and riparian zone vegetation structure should be near natural.
Habitat functioning - suspended solids	No unnaturally high suspended solid loads.
Negative indicators - in-stream barriers	No artificial barriers significantly impairing characteristic migratory species from essential life cycle movement.

Type	Interest feature	Physical habitat attribute
b) Species conservation objectives (SSSI)		
Vegetation	Flora characteristic of lowland rivers	Moderate to high nutrient levels
		Still or slow flowing water
		Soft sediments
		Deep water
Invertebrates	Rich assemblage of invertebrates	Terrestrial and aquatic habitats containing diverse vegetation communities for feeding, breeding and over wintering
Birds	Excellent breeding bird community	Healthy fish and invertebrate communities for feeding
		Shelter and nesting sites
Fish	Diverse fish communities	Vegetation or stony/gravely substrates for spawning (depending on species)
		Shallow areas with low flow velocities for nursery habitats
		Availability of invertebrate prey and smaller fish for feeding
c) Species conservation objectives (SAC)		
Vegetation	Assemblage of floating and submerged plants	Swift to moderate, clear flows
		Channel dominated by clean, stable gravel
		Adequate in-channel light
Fish	River Lamprey & Sea Lamprey	Channel dominated by clean, stable gravel for spawning
		Appropriate shelter for adult fish
		Stable silt or sand dominated substrate for nursery habitats
		Areas of shallow low velocity flow for nursery habitats
		Organic detritus for nursery habitats
		Tree roots / large woody debris for migration
	Bullhead	Swift to moderate, clear flows
		Channel dominated by clean, stable gravel
		Riffle habitat features
		Macrophyte cover <40%
		Shading
		No barriers >18cm
		Tree roots / large woody debris
Mammals	Otter	Bankside shelter for day cover
		Undisturbed areas for holts
		Adjacent wetland floodplain habitat
		Suitable habitat for fish for feeding pups
		Shelter and nesting sites

Restoration of the River Derwent

The Environment Agency and Natural England are therefore working together with their partners to restore the river towards a more favourable condition. In order to produce a plan for the physical restoration of the River Derwent SSSI, a catchment wide fluvial geomorphological study has been undertaken to assess the physical functioning of the river, and how it impacts on the river ecology. The findings from this study can be found in the Technical Report accompanying this River Restoration Plan (Royal Haskoning, 2010).

Fluvial geomorphology is the study of landforms associated with river channels and the processes that form them. It considers the process of sediment transfer (erosion, transport and deposition) in river channels and also the relationship between channel forms and processes. Geomorphological processes help to create a variety of habitats within a river with different physical characteristics relating to flow depths, flow velocities, bed and bank material and channel and marginal vegetation. These habitats are critical to supporting the ecological interest features of the River Derwent SSSI.

The importance of geomorphology is reflected in Natural England's Conservation Objectives (2008) for the River Derwent SSSI, which relate to appropriate flow, sediment and channel form within the river habitat as well as the presence of designated species. Specific physical attributes required by the ecological interest features of the SSSI are detailed in **Table 1.2**.

Further Information Sources

Government PSA Target:
http://www.defra.gov.uk/wildlife-countryside/protected-areas/sssi/psa.htm

Current Condition Assessment for the River Derwent SSSI:
http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1003398

Aims and objectives of the River Restoration Plan

Actions to restore the physical structure of the river to a better condition for ecology have been set out in the River Derwent Restoration Plan. The plan aims to use the linkages between ecology and geomorphology identified in the accompanying Technical Report to identify opportunities and constraints for managing, conserving and enhancing the river and returning the SSSI to favourable or recovering condition. The plan suggests a range of catchment-scale and reach-based solutions that if implemented will help to restore the river to favourable condition. The plan then identifies the actions needed to deliver the solutions and prioritises which should be taken over the short, medium and long term. The ultimate goal is to move towards a more naturally functioning and un-constrained system that is able to adjust and respond to changes without constant management.

However, it is recognised that the River Derwent supports a wide range of other interests in addition to ecology (e.g. agriculture and public water supply) and that all of these need to be taken into account when planning actions.

Structure of this report

The report is divided into five sections as outlined in **Table 1.3**.

Table 1.3: Contents of the River Restoration Plan

Section		Content	Recommendation for use
1	Introduction	Explains the purpose of the plan	Use this section to understand why and how the restoration plan has been developed for the River Derwent SSSI.
2	Key issues	Outlines the key issues which affect the River Derwent SSSI	Use this section to obtain a catchment-scale overview of the key issues underlying the current unfavourable condition of the River Derwent SSSI. This includes a description of the cause of the issues and how they are affecting ecology within the SSSI. Potential solutions relevant to each issue are highlighted.
3	Potential solutions	Outlines potential solutions for restoring the SSSI to favourable condition	Use this section to find out what solutions are proposed in the River Restoration Plan in order to tackle the key issues identified and bring the SSSI into favourable or recovering condition. Solutions have been colour coded for easy identification.
4	Reach-based restoration solutions	Outlines how and where the solutions could potentially be implemented	Use this section to identify, at a reach-scale, where it is proposed that the solutions identified are applied. It should be noted that catchment-scale solutions are not included in this section but are covered in the action plan as strategic actions.
5	Action plan	Sets out the actions needed to deliver the solutions identified at the reach scale	Use this section to find out what actions are proposed when so that you can get involved.

Intended audience

This report is primarily intended for use by river managers planning improvements to the River Derwent SSSI or other capital works that are likely to have an impact on physical habitat conditions within the SSSI. A list of further information sources is provided for those who require more detailed information about the issues raised, and can be found at the back of this report (page 104).

2. KEY ISSUES IN THE DERWENT CATCHMENT

Key issues

A detailed investigation of the geomorphological and ecological behaviour of the River Derwent has been undertaken, the results of which are presented in the accompanying Technical Report. As a result of this investigation, which combined a detailed walkover survey of the entire catchment and a comprehensive review of existing data and reports, four key issues that are currently having an adverse impact on the condition of the SSSI have been identified.

- Fine sedimentation.
- Channelisation and disconnection of the river from the floodplain.
- Lack of bankside shelter and shading.
- In-channel structures.

For each of these issues this section provides the information identified in **Table 2.1**.

Table 2.1: Information provided for each of the four key issues

Section	Contents
What the issue is	The underlying causes of the issue are described together with the resulting physical conditions and why they are an issue.
Where it occurs	This section describes the location of the issue and whether it is catchment-wide or more localised. Particular spatial trends and any locations where the issue is most significant are highlighted.
How it affects the SSSI	The impacts on the SSSI are identified, in terms of both condition of the overall lowland river habitat and specific requirements of SSSI and SAC designated species.
What the potential solutions are	Potential solutions that may contribute to tackling the issue and achievement of favourable or recovering condition are identified. In most cases, more than one solution is identified. Further details of these solutions are provided in Section 2.

FINE SEDIMENT SUPPLY AND DEPOSITION

What is the issue?

Sedimentation describes the settling out of fine sediment (muds, silts and sands) on the river bed. Rivers only transport sediment when the rate of flow is sufficient to pick up and transport particles. Sediment is deposited and stored when the rate of flow slows or when there is too much sediment to be transported. If the sediment is not transported it is deposited on the river bed (a process known as sedimentation). Although supply of sediment to the river system is an important element of natural river functioning, when there is a prolonged and or excessive build up of sediment, this can be a problem for a range of species that depend on the conditions of the river bed for habitat, shelter or food sources.

Where does it occur?

Large quantities of fine sediment are supplied to the river as a result of inwash from the wider catchment. The soils in the area are fine and easily erodible, and are therefore prone to erosion. Cultivation and grazing can serve to increase erosion rates to erode the soil. The network of field drains and tributaries that feed into the Derwent provides a direct route for sediment to enter the river.

Sedimentation is occurring throughout the River Derwent SSSI, and is particularly prevalent in the lower reaches of the river. Sedimentation at the downstream end of the catchment, between Elvington and the Barmby Barrage, has increased the bed levels by an average of 0.4m since 1998 (JBA Consulting, 2006). This was preceded by periods where the bed lowered, probably as a result of dredging. If sedimentation continues at the current rate, bed levels may reduce the potential for navigation to occur.

Tilled land adjacent to Dyon Drain

Localised trampling of banks by livestock

How does it affect the SSSI?

Sedimentation

Fine sedimentation has a detrimental effect on the main habitat requirements of the key SSSI interest species including aquatic plants such as *Ranunculion fluitantis* and associated aquatic plant communities. Deposition of fine sediment is a key issue for aquatic vegetation due to reduced light availability for attached aquatic plants effecting photosynthesis and can also reduce biomass of algae communities and aquatic plants (macrophytes) through direct smothering of existing plants. Fine sedimentation is one of the main reasons for the SSSI units being in unfavourable condition.

Excessive fine sedimentation can lead to a lack of diversity in the structure of the bed. While gravel shoals may not be expected to be extensive in lowland rivers, any debris or larger material that is present can become covered by sediments so that there is only one type of sediment present. This reduces the diversity of the invertebrate fauna, restricting presence to only those species that can tolerate a soft, muddy substrate (e.g. chironomid larvae and oligochaete worms, many of which are associated with poor water quality). Generally, low diversity in habitat structure can lead to low diversity in invertebrates and aquatic plants. This in turn can have a negative impact on the fish and birds that depend on them for shelter and feeding.

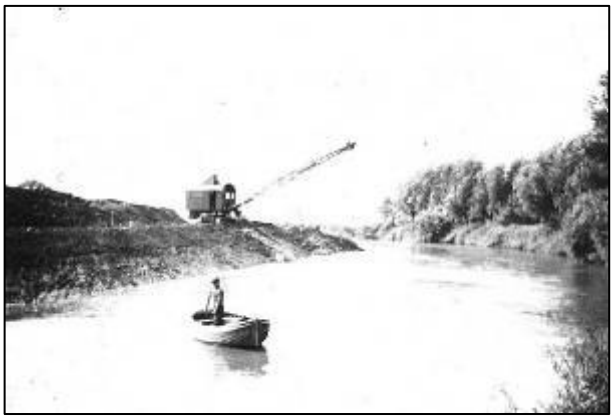
The lower River Derwent is a lowland river with a gentle gradient, and predominantly fine-grained geology. As a result, the bed material is generally fine. However, there are a few exceptional areas where gravel and stony substrate is present. Several important areas are located immediately downstream of four of the weirs (Kirkham, Howsham, Buttercrambe and Stamford Bridge). In these areas, the hydraulic conditions result in shallow, faster

flow with areas of gravel and cobble scoured clean. In addition, areas of gravel bed occur in the lower reaches at Bracey Bridge and Gravel Pit Farm. These are associated with natural geological outcrops. Due to the scarcity of these coarser habitats, fine sedimentation can have a major impact on the ecosystem. Where coarser sediments are present, sedimentation will inhibit their use by flora and fauna that normally rely on them. For example, silting of salmonid fish or lamprey spawning beds can smother eggs and larvae, thereby reducing breeding success and limiting use by species that prefer a stony substrate for sheltering in and for nest building (e.g. bullhead).

Historic modification of the river

A large proportion of the River Derwent channel has been historically channelised to allow navigation upstream, or to increase channel capacity. These works were undertaken along much of the river in the 1940s and 1950s, and have resulted in an overwidened and overdeepened channel (see **Channelisation and disconnection from the floodplain** for more information). Examples of the impact these works had on the river channel are shown in these photographs, which were taken while the works were being undertaken.

Channelisation works downstream of Old Malton in 1949 created a significantly wider river channel



The river was widened considerably in 1935. The image on the left shows the river before the works started, and the image on the right shows the resulting channel, which is more than twice as wide as the original channel.

The impacts of fine sedimentation in the River Derwent are exacerbated by the legacy of historical modifications, which has left a significant proportion of the channel over-deep. In addition, the major weir and sluice structures within the River Derwent result in localised impoundment of water upstream. This reduces the flow rate within the channel, and leads to localised fine sediment deposition on the bed. The cumulative effect of these weirs on the sediment transport system is significant as they limit the opportunity to transfer sediment downstream and consequently alter natural river processes.

Historic management of the river

Dredging has historically been used to reduce sedimentation by physically removing fine sediment that has accumulated on the river bed. However, this solution is only short-term as it treats the symptoms of sedimentation and not the underlying causes. Sedimentation is a natural process that occurs in response to fine sediment supply and slow flow velocities, often occurring due to over widening or over deepening of the channel.

Dredging out of fine sediment, which is reducing the capacity of the channel, results in continuation of the process of sedimentation and can adversely impact on river habitat. Dredging is therefore not identified as a solution to the issue of sedimentation though where excessive siltation has occurred selective dredging may be required for reasons of flood risk management or navigation.

Suspended sediments and turbidity

Fine sediments can become suspended in the water column during low flows, due to their small size and low density. This can lead to high turbidity or cloudiness of the water. High turbidity levels can reduce the amount of light reaching the lower levels and thereby inhibit the growth of submerged plants. The effect is particularly intense in systems such as the lower River Derwent that also lack shallow areas and gently sloping banks. The vast majority of the channel area is deep due to historical channel modifications and therefore susceptible to light failing to penetrate to the substrate at high turbidity levels. When light fails to penetrate to the bed, submerged plants are unable to grow and this in turn adversely affects the fish and invertebrates that rely on them for food and cover. Reduced photosynthesis (by which plants use light to convert carbon dioxide to oxygen) can also result in a lower daytime release of oxygen into the water, which can be harmful to aquatic life.

High fine sediment supply via tributaries and field drains

Floating leaved and emergent macrophytes do not suffer so much from turbidity as their leaves are not obscured from the light by turbid water. SAC and SSSI interest macrophyte species that are adversely impacted include river water-crowfoot (*Ranunculus fluitans*) and shining pondweed (*Potamogeton lucens*) as the leaves of these plants are completely submerged. The remaining interest species (e.g. water-starworts, arrowhead and narrow-leaved water-parsnip) have a combination of submerged, emergent and floating leaves, and so are not impacted to the same extent by the high turbidity.

Mammals and birds are unlikely to be adversely affected by the high turbidity, because they are generally able to hunt in murky conditions. However, fish can become stressed at excessively high turbidity levels. Suspended sediments can clog and damage delicate gill structures and reduce disease resistance leading to lower growth rates, reduction in feeding success and eventually even death. Suspended sediments transport a significant proportion of nutrients and contaminants in river systems, and can result in accumulation of contaminants in particulate feeders such as filter feeding invertebrates and lamprey ammocoetes.

What are the potential solutions?

The main solutions that could potentially be implemented to help address the issues relating to fine sedimentation are:

- Investigate and manage sediment input using a range of techniques such as buffer strips and other farming practices together with selective management of vegetation.
- Selectively restrict livestock access to banks.

The main aim of these solutions is to reduce the supply of sediment from the land into the river channel, through reducing the production of sediment, preventing it entering the drainage network, and, if it does become entrained, retaining it within the drains rather than the main channel. These solutions can be applied locally, but need to be considered on a wider catchment scale in order to be most effective. More details about each of these solutions are provided in the **Potential Solutions** section.

CHANNELISATION AND DISCONNECTION FROM THE FLOODPLAIN

What is the issue?

Large parts of the lower River Derwent have been straightened and dredged to increase the capacity of the channel, in order to improve land drainage and the conveyance of flood waters, and allow navigation along the river (see photographs under *Historic modification of the river* in the **Fine sediment supply and deposition** section). As a result, the river has been overdeepened and has steep, near-vertical banks which reduces the availability of habitat for marginal vegetation typical of the river type. This channel modification, or channelisation, has also resulted in a channel which is generally uniform, and there is little diversity in the rates of flow. Under less modified conditions, a range of flow types would be present, including shallower and faster sections as well as longer sections of slow flowing water.

The uniformity of the channel and banks mean that the habitats that the river is able to support are limited. In addition, large flood embankments have been constructed adjacent to the river channel along a large proportion of the river, particularly along lower reaches. These structures, which can be more than 2 m high, limit the diversity of the bank habitat and can cut the river off from the floodplain by acting as a physical barrier to the free passage of water, sediment and wildlife.

The increased channel capacity means that, under most conditions, flow velocities are considerably lower than they previously were. As a result, the transport capacity of the water column is reduced, resulting in sustained accumulation of sediments in the river channel.

Uniform conditions along the river

Large embankments along the River Derwent

Where does it occur?

The entire lower Derwent has been subject to a degree of channelisation (**Figure 2.1**). Much of the river has been over deepened, and several meanders have been cut off, including modifications post-1850s downstream of Ryemouth and Elvington, and at South Duffield Ings and Barmby on the Marsh (**Figure 2.2**).

Flood embankments have been constructed along a considerable proportion of the river channel. In the upper parts of the SSSI, these embankments are discontinuous, and protect areas of floodplain land around Malton, Scrayingham and Kexby. The embankments become more continuous further downstream, and the majority of both banks downstream of the confluence between the Pocklington Canal and the River Derwent are embanked.

Figure 2.1: Location of flood embankments within the River Derwent SSSI

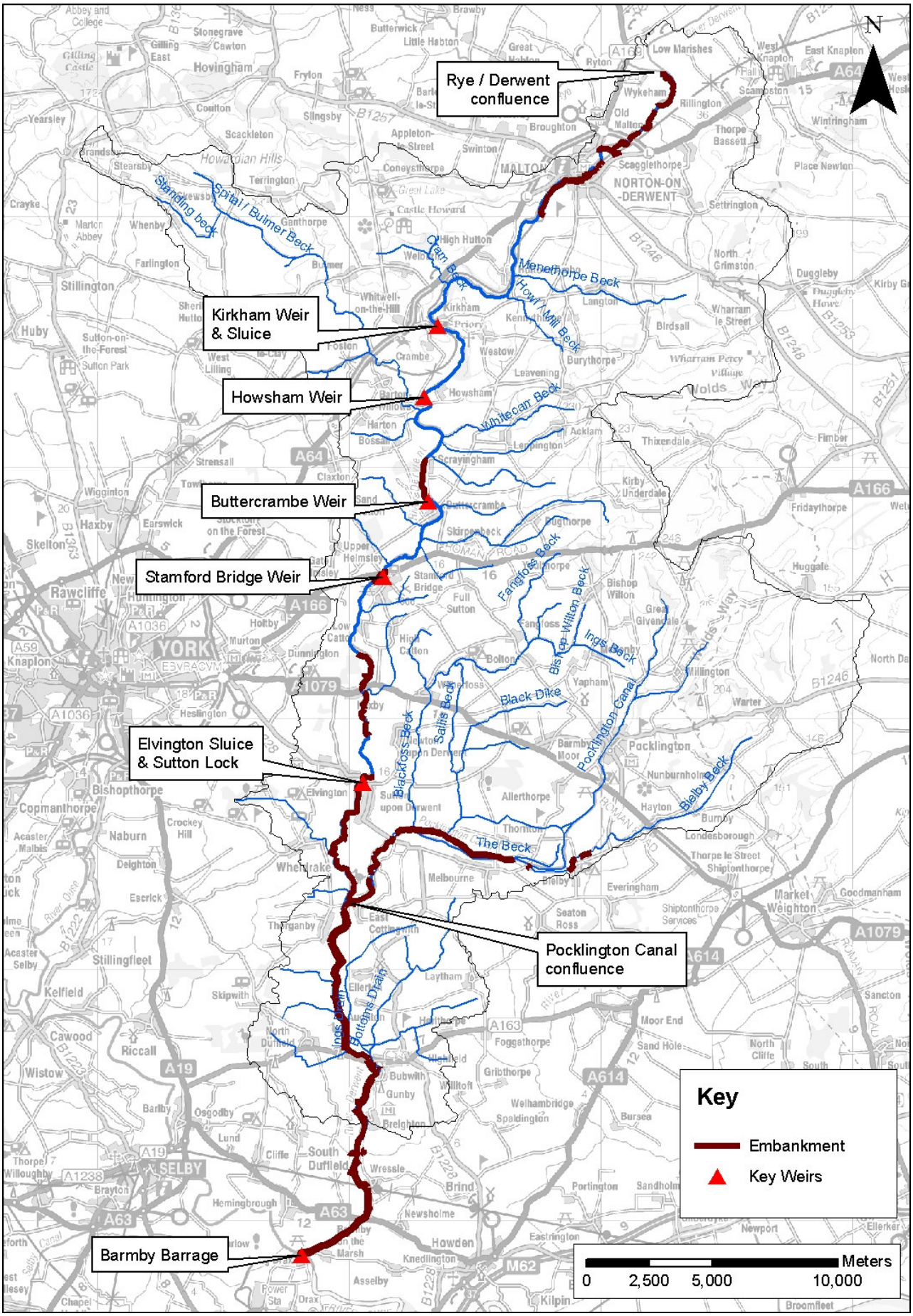
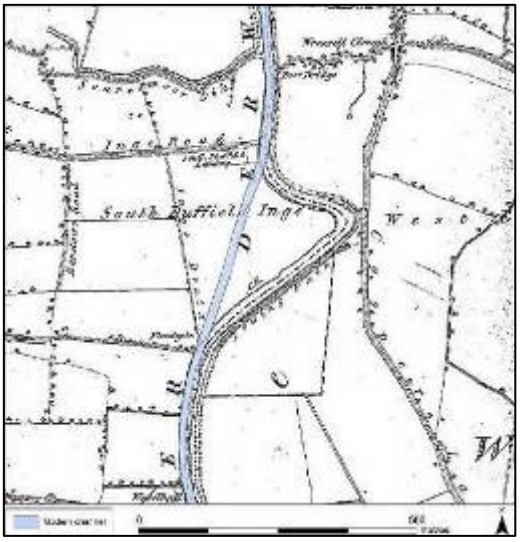
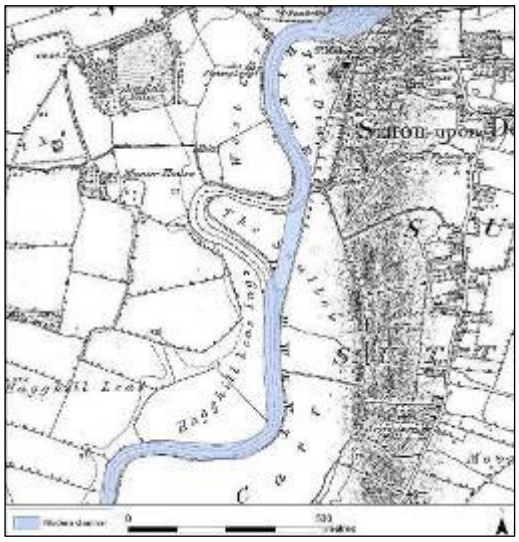


Figure 2.2: Cut off meanders in the River Derwent catchment



Meander cut-off at South Duffield Ings, post 1850 (showing historic mapping and current river course)



Meander cut-off at Sutton-on-Derwent (occurred c. 1946) (showing historic mapping and current river course)

How does it affect the SSSI?

Channelisation and disconnection from the floodplain impact on the River Derwent SSSI in several ways. Deepening of the channel and steepening of the banks restricts the occurrence of shallower in-channel and marginal habitats. These habitats are important in providing the diversity required to support the full range of aquatic plants, fish and invertebrates that characterise the SSSI, as well as mammals and birds that prey on them.

The embankments disconnect the river from its natural floodplain. This restricts the potential for transfer and storage of water, sediment and nutrients on the floodplain in periods of high flow, and limits the development of floodplain wetland habitats that are important for breeding birds. The embankments also limit drainage back into the river in parts of the catchment. It should be noted that parts of the floodplain in the lower reaches of the catchment are of high botanical interest, and as such have been designated as a SAC.

The embankments also restrict the development of good quality habitats on the bank top. This means that parts of the bank are lacking in shelter for mammals and some bird species (see **Lack of shelter and shading** for more information), although some birds prefer more open conditions. Open conditions are particularly important in the Lower Derwent valley, where they provide high quality habitats for overwintering birds for which the Lower Derwent valley is designated a Special Protection Area (SPA).

What are the potential solutions?

The main solutions that could potentially be implemented to help address channelisation and disconnection from the floodplain are:

- Alter flood embankments.
- Bank rehabilitation to improve the profile of the channel margin.
- Enhance floodplain wetland habitats.
- River rehabilitation (in-channel).

More details about each of these solutions are provided in the **Potential Solutions** section.

LACK OF BANKSIDE SHELTER AND SHADING AND OVERSHADING

What is the issue?

Bankside shelter includes trees and vegetation that are found along the top of the river banks. Bankside vegetation, often referred to as a riparian buffer zone, can contribute to favourable conditions by:

- Providing bankside shading and shelter in exposed tree roots.
- Growing roots that bind and stabilise channel banks, limiting bank erosion.
- Trapping fine sediment in surface runoff, preventing it entering the channel.

The shelter and shading provided by bankside vegetation is important for designated SSSI and SAC species, both in the channel (e.g. fish, invertebrates) and along the channel banks (otters and breeding birds). When large areas of the river bank are exposed and lacking in bankside vegetation, the range of potential habitats for these designated species is limited. However, excessive or over shading can also be detrimental to the quality of the river habitats by limiting the amount of light available for plants to photosynthesise. It is therefore important to obtain a balance between providing enough shelter for mammals, birds, fish and invertebrates, and excessive shading for aquatic plants to survive. In addition, the waterfowl that spend the winter in the lower Derwent favour areas of open, exposed floodplain, and the habitats could be degraded if the banks become too shaded. A mosaic of bankside vegetation would be ideal for the range of species present in the River Derwent, with some open areas where aquatic macrophytes could take hold (given a suitable bank profile) and waterfowl can thrive, and other tree-lined areas to provide cover for other species.

Lack of shelter and shading due to lack of bankside vegetation

Potential for excessive shading due to lack of tree management

Where does it occur?

Bankside shelter is lacking from several reaches of the River Derwent SSSI throughout the catchment, but is particularly apparent in a long stretch at the downstream end, where flood embankments limit the development of trees and shrubs on the bank top (**Figure 2.3**). As a result, habitat for several of the species described above can be limited. However, this open landscape at the downstream end is important to the birds of the Lower Derwent Valley SPA. Overshading is also present along many reaches through the River Derwent SSSI, in places along both banks (**Figure 2.4**). In some instances, these figures show both lack of shelter and overshading in the same reach. This indicates that both cover conditions have been observed within part of these reaches.

How does it affect the SSSI?

Lack of bankside vegetation contributes to uniform conditions along the river and a lack of habitat diversity. This can have an adverse impact on a number of the designated SSSI and SAC species that occur in the River Derwent. Above the waterline, lack of bankside trees and shrubs can mean that the shelter required to support breeding birds and mammals, such as otters, is not available. Roots of bankside trees are particularly important for otters, which use holes in the bank supported by the roots as holts and breeding dens. These are often well hidden and very difficult for potential predators to access. Below the waterline, a lack of plant roots and woody debris that falls off the trees can mean there is insufficient shelter for aquatic invertebrates and fish, such as lamprey, which use this shelter as they migrate upstream to spawn. Fish may also be adversely affected by a lack of shading from bankside trees, which helps to protect them from predation.

Figure 2.3: Reaches within the SSSI where lack of shelter is an issue

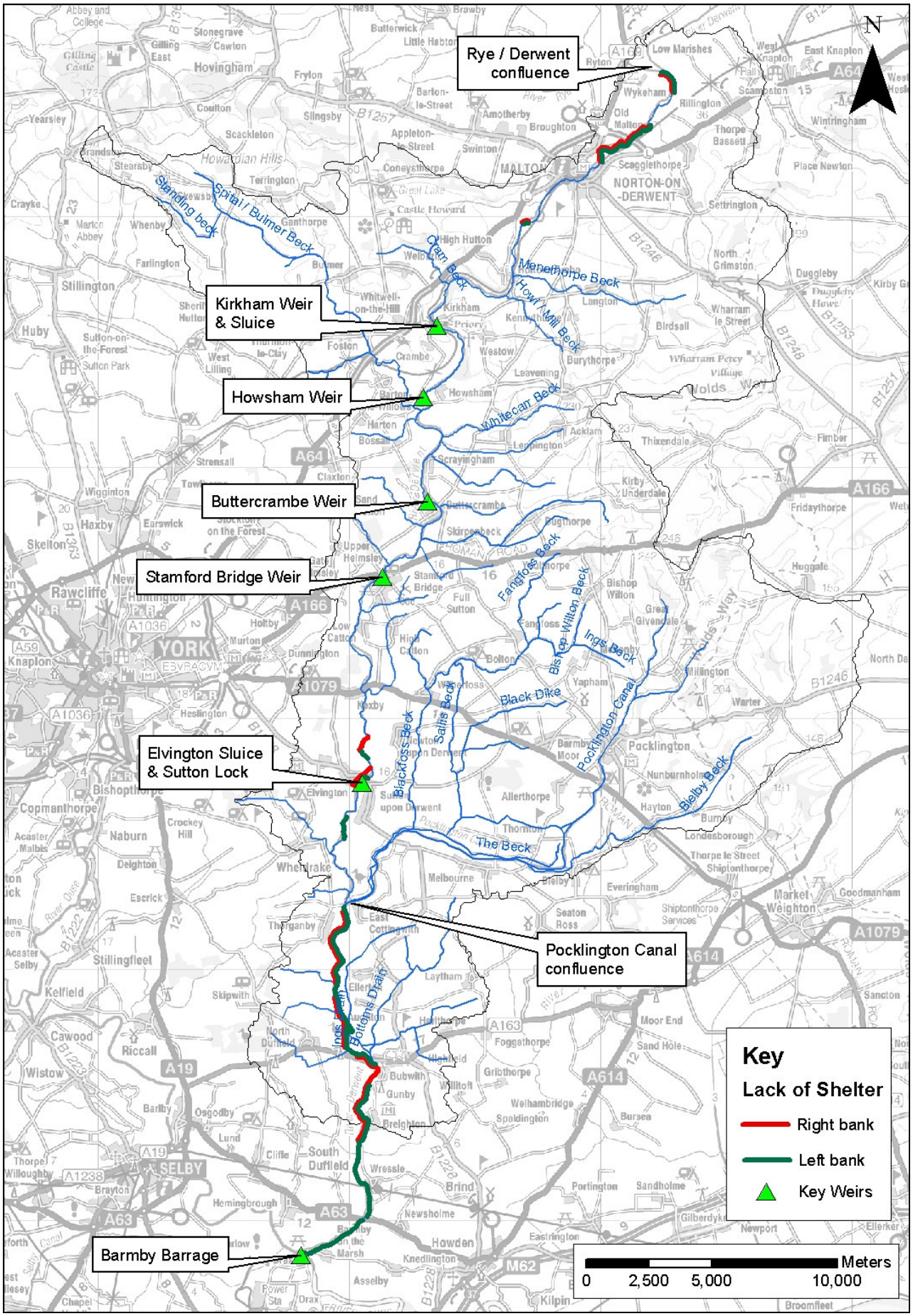
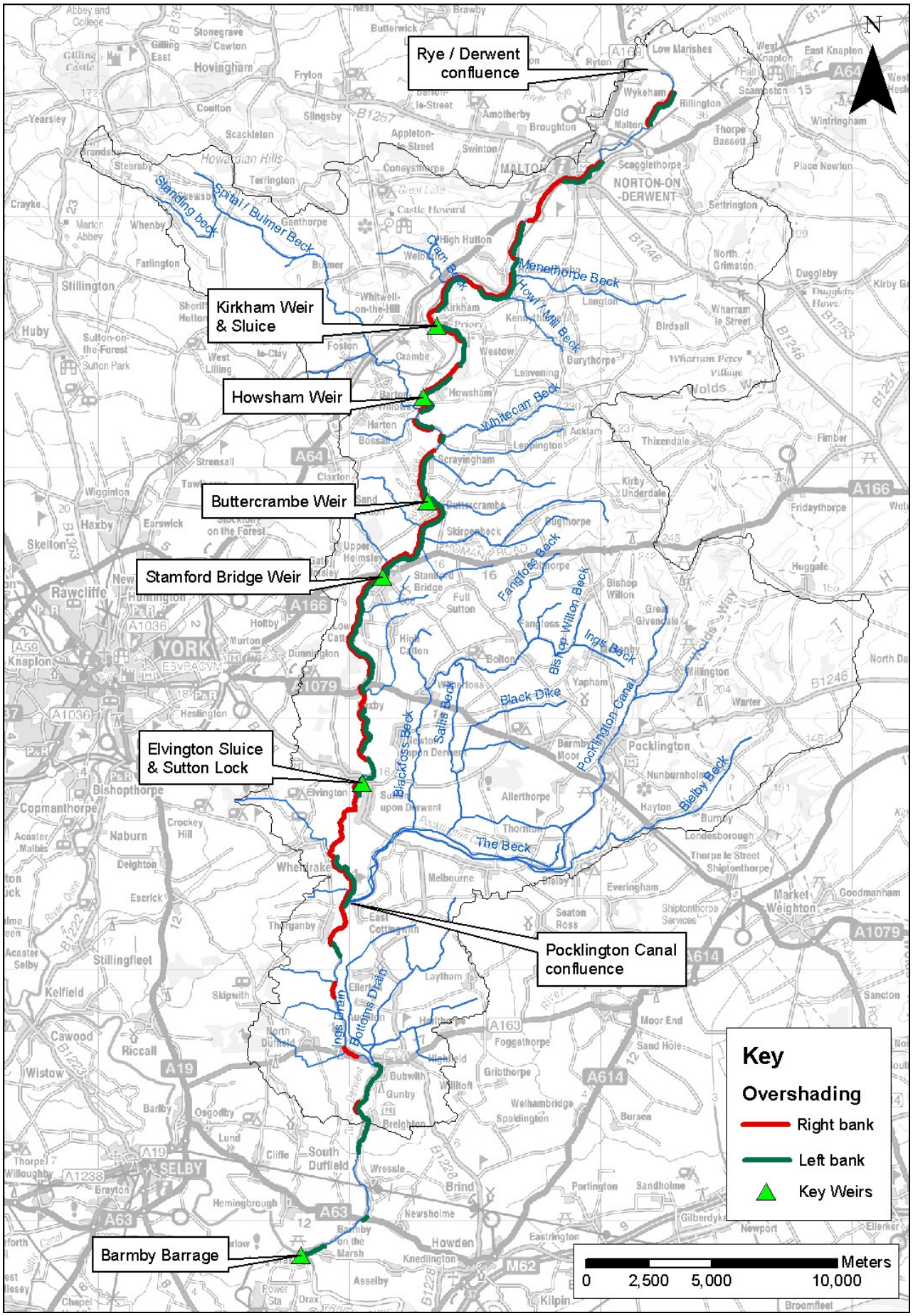


Figure 2.4: Reaches with in the SSSI that are heavily shaded



Too much bankside shelter and shading can also have a detrimental impact on the SSSI and designated species. Many aquatic plants are sensitive to overshading, which limits their ability to photosynthesise. As a result, reaches with very dense bankside vegetation can lack healthy vegetation in the channel. This can therefore have knock-on impacts on the invertebrates and fish that live in the water, and the mammals and birds that prey on them.

Research by the Countryside Survey (2010) demonstrates that the diversity of aquatic invertebrates increases with bankside vegetation (woody cover), although it decreases when the cover becomes too tall. It is therefore important that bankside habitats have a suitable structure to provide sufficient shelter and to allow aquatic communities to thrive, whilst avoiding problems associated with over shading.

What are the potential solutions?

The main solutions that could potentially be implemented to help address the lack of shelter and shading and overshading along parts of the river are:

- Tree, shrub and non-native invasive plant management.
- Bank rehabilitation.

The main aim of these solutions is to enhance the quality of the river banks and the habitats they support and where possible improve habitats in the adjacent floodplain areas. These solutions could be implemented locally to deliver real improvements at the reach scale. This could lead to major improvements on a much larger scale, when actions in neighbouring reaches are considered together.

In addition, measures to **preserve favourable conditions**, where they already exist should also be considered, including the solutions:

- Preserve existing quality habitats.
- Preserve existing woody debris in the river channel.

More details about each of these solutions are provided in the **Potential Solutions** section.

IN-CHANNEL STRUCTURES

What is the issue?

In-channel structures, such as weirs and sluices, that are built across a river channel alter flow patterns and disrupt downstream transport of sediment. An in-channel structure such as a weir or sluice alters the natural flow patterns of a river by impounding water upstream. This increases water levels and makes slows the rate of flow, leading to the deposition of sediment upstream of the structure. Depending on the size of the in-channel structure, its influence can propagate for a considerable distance upstream and downstream. These effects can be detrimental to river habitats by encouraging sedimentation on the river bed and creating uniform flow conditions. Flow over the obstruction can also become very rapid leading to erosion of the bed and banks associated with the weir pool downstream.

In addition, in-channel structures can act as a physical barrier to the free movement of aquatic species in the river channel if they are not able to swim past or jump over them. Some fish species, including salmonids and lamprey, spawn in the upper reaches of the catchment (upstream of the River Derwent SSSI), where the substrate is coarser. The presence of in-channel barriers within the SSSI may limit the upstream migration and therefore breeding of these species. Strong-swimming fish species may be able to pass barriers when flows are high enough, but weaker swimmers, including many coarse fish and lamprey may not be able to do this. A fish pass may allow fish to pass upstream of a structure, but require careful design in order to make them suitable for all fish species. The presence of structures within the channel can therefore limit the movement of fish within the river, and have a detrimental effect on fish populations and those of the species that prey on them.

Where does it occur?

There are six major in-channel structures within the River Derwent SSSI: Kirkham Weir and Sluices, Howsham Weir, Buttercrambe Weir, Stamford Bridge Weir, Elvington Sluice and Sutton Lock, and Barmby Barrage (**Figure 1.1**). Whilst each of the structures results is impoundment upstream, the key control on water levels within the River Derwent SSSI (as far upstream as Elvington Sluice) is the Barmby Barrage, situated downstream of the SSSI. A brief description of each of the structures within the River Derwent SSSI as well as Barmby Barrage is provided below.

Kirkham Weir and Sluices

The River Derwent splits at Kirkham around a small island. Kirkham Weir spans the right channel, and there is an existing fish pass towards the right bank. Across the left channel there is a set of sluices, which comprise two 6 m by 1.5 m steel doors set in a concrete and sheet pile structure. The sluices are owned (as is the weir and island) and operated as flood risk management assets by the Environment Agency. Although their role is currently under review, they are designed to protect properties between Howe Bridge and Kirkham from inundation during major flood events and to retain water levels in the river between Old Malton and Kirkham during periods of low flow. Kirkham weir and sluices is likely to prevent lamprey migration to the spawning habitats in the upper catchment. The structure does incorporate a fish pass, but this requires modification to make it more effective.

Howsham Weir

Howsham Weir is a relatively low structure that incorporates a working turbine for hydropower generation. The weir was originally constructed to increase water levels for Howsham Mill and is currently owned by the Environment Agency. Although the structure does not include a fish pass, it is reported that it is passable during normal flow conditions by most fish species that are found in the river (Yorkshire Fishery Board, 1946). A low level of lamprey spawning takes place downstream of the structure, and lamprey may pass it when flows are suitable.

Buttercrambe Weir

Buttercrambe Weir is a concrete structure that is owned by the Environment Agency and used for flow gauging for the purpose of water resources management. The structure is too high to pass in most flow conditions, and does not incorporate a fish pass. There is some suitable coarse substrate for fish spawning below the weir, and it is thought that lamprey spawning takes place here at a low level. The Environment Agency commissioned Hydro-Logic (2009) to examine the potential to improve fish passage at this site.

Stamford Bridge Weir

Stamford Bridge Weir is a concrete structure that is located in the town of Stamford Bridge. The weir was originally constructed to raise water levels for Stamford Bridge Mill and is currently owned by the Environment Agency. The structure is too high to be easily passed by lamprey and other weak swimmers. However, it does incorporate a fish pass that is functional, although some fish appear reluctant to use it. This may be because it does not contain any low-flow backwaters or areas of reduced flow velocity. There is a sluice (guillotine gate) in the old navigation cut.

Elvington Sluice and Sutton Lock

Elvington Sluice consists of two counter-balanced concave steel gates set in a concrete superstructure. The sluice is owned and operated by the Environment Agency, and is used to maintain water levels in the river to facilitate water abstraction for the strategically important water treatment works at Elvington. A fish pass has been installed at the site, which allows free movement of lamprey, coarse fish and salmonids upstream of the sluice. This contains backwaters with slower flow that can be used for resting. This is important for lamprey as they are not strong swimmers.

Sutton Lock consists of a guillotine structure at the upstream end and a conventional lock gate at the downstream end. The structure is owned by the Environment Agency (with the exception of the lock gate, which is owned by Yorkshire Wildlife Trust), and is used to a limited extent by boat owners for navigation upstream of Elvington Sluice.

Barmby Barrage

Barmby Barrage is owned by the Environment Agency and consists of two vertical lifting gates set in a concrete structure, and a lock to allow boat passage upstream. The structure is operated for several purposes:

- To prevent water from the tidal River Ouse entering the lower River Derwent;
- To ensure that water is deep enough for abstraction to take place at the strategically important Loftsome Bridge Water Treatment Works, and;
- To keep water levels high enough for boats to pass upstream. This is required to comply with Clause 13 of the Barmby Tidal Barrage Order, which requires boat access to be provided.

The structure does not include a fish pass, but is passable to many species during moderate to high flows.

How does it affect the SSSI?

One of the major effects of in-channel structures on the River Derwent SSSI is the physical obstruction of free fish passage along the river. The only structures with effective fish passes are Elvington Sluice and Stamford Bridge Weir, although fish are reportedly reluctant to use the latter under fast flow conditions. Barmby Barrage lacks a fish pass, but it is likely to be passable during higher flows, and can be operated to allow fish to pass upstream. Howsham Weir and Buttercrambe Weir both lack a fish pass, and the fish pass at Kirkham Weir is not suitable for weaker swimmers because flow is too strong. As a result, the upstream movement of lamprey and many coarse fish species is impeded by the presence of these in-channel structures. This limits the range of the populations, and prevents them from reaching habitats and spawning grounds in the upper parts of the catchment.

The other major effect of the in-channel structures is to impound the flow of water behind them. This increases water levels upstream of the structures, and minimises flow diversity by creating slow, uniform flow conditions. The alterations to the hydrological regime of the river caused by in-channel structures promote increased sedimentation in the channel, exacerbating the problems caused by increased channel capacity and high sediment supply (see **Fine sedimentation** for more information).

It should be noted that turbulent flow downstream of the weirs helps to prevent the accumulation of fine sediment, creating areas with coarser bed material that provide good habitat for aquatic plants and ideal habitats for lamprey, bullhead and coarse fish such as barbel. For example, the largest and most important lamprey spawning site in the lower Derwent is located downstream of Stamford Bridge weir, and five of the eight sites where bullhead are recorded are also located downstream of the weirs and Elvington Sluice. When considering actions to address the pressures created by the in-channel structures, it is necessary to ensure that suitable habitat for key species remains in place in the river to ensure that SSSI and SAC obligations are complied with. This needs to be balanced with the probability that the impounding effects of the structures are likely to negatively impact upon much larger areas of habitat than are created by the presence of the structures, and new areas of spawning habitat may be created by their modification/removal.

What are the potential solutions?

The main solutions that could potentially be implemented to help address the problems created by in-channel structures are:

- Remove the structure.
- Modify the structure.
- Alter the operation of the structure.
- Provide a suitable fish pass.

The main aim of removal/alteration of structures is to restore river function / form and remove their impounding effects. Free fish passage is an additional legal requirement. The main aim of these solutions is to alter the existing structures to reduce impoundment, increase flows and improve fish passage. These solutions could potentially lead to wide improvements in the River Derwent SSSI.

More details about each of these solutions are provided in the **Potential Solutions** section.

A more detailed review of the issues created by in-channel structures and the potential solutions at each site is presented in the accompanying technical report. This information has been used to make a full assessment of the options to remove or modify the structures, and has been used to inform the discussion in later sections of this report.

3. POTENTIAL SOLUTIONS

Potential solutions to the key issues

Several solutions need to be implemented within the River Derwent catchment in order to help address the key issues and contribute to achievement of favourable condition of the SSSI. This section of the River Restoration Plan outlines these solutions, focussing on the aim of each solution, and how it could potentially be implemented.

Thirteen solutions have been identified within five broad categories (**Table 3.1**). The majority of solutions are intended to address one or more of the key issues described in the previous section. However, it should also be recognised that good habitat conditions and features already exist within the River Derwent SSSI. The solutions identified therefore include those that involve preservation of current favourable conditions.

Table 3.1: Potential solutions to tackle the key issues in the River Derwent SSSI

Category	Solution	Key issues addressed			
		Fine sedimentation	Channelisation and disconnection from the floodplain	Lack of shelter and shading and over-shading	In-channel structures
A - Changing agricultural and land drainage management practices	Investigate and manage fine sediment input	✓			
	Selectively restrict livestock access to banks	✓		✓	
B - Alter flood embankments	Remove, breach, lower or set back embankments	✓	✓	✓	
C - Enhance riparian, wetland and marginal habitats	Tree,shrub and non-native invasive plant management)	✓		✓	
	Bank rehabilitation		✓	✓	
D - Modify in-channel structures	Remove structures	✓			✓
	Modify structures	✓			✓
	Alter operation of structures	✓			✓
	Provide a suitable fish pass				✓
E - Preserve existing habitats	Preserve existing quality habitats	n/a	n/a	n/a	n/a
	Preserve existing woody debris in the river channel	n/a	n/a	n/a	n/a

Finding out more about the solutions

Section 3 provides information on each category of solution, pointing to key guidance which can be referred to for more information. The categories are colour coded using the colours shown in Table 3.1. This colour coding is repeated in Section 4 when labelling the solutions that apply in each reach of the River Derwent, making it easy to cross-reference to the information contained Section 3. For example:

Solution category

C - Enhance riparian, wetland and marginal habitats

(Refer to Section 3 for guidance)

Implementing solutions on the ground

To take forward the solutions in practice there will be some important considerations that will need to be taken into account. Section 5 shows an action plan which can be used to take forward the solutions for delivery on the ground over the short, medium and long term. In many cases the first action to be taken towards implementing the solution will be to investigate the feasibility of whether the solution, that is whether it is sustainable and takes into account the function of the river for both wildlife and those who use the river now and into the future. A key part of this must also be to take into account climate change and how the plan takes account of the need for solutions to be adaptable to climate change.

Climate change implications for the Derwent

The latest climate projections (UKCP09) produced by the UK Climate Impacts Programme (UKCIP) suggest that, over the next 20-50 years, temperatures and precipitation levels in the River Derwent catchment could be considerably different to current conditions. The main changes that are likely to occur are:

- Increased annual average daily temperatures: Temperatures are predicted to increase by up to 2°C by the 2020s, and 3°C by the 2050s.
- Decreased summer precipitation: Summer precipitation levels are predicted to decrease by up to 10% by the 2020s and up to 30% by the 2050s. This is likely to reduce river flows in the summer, and reduce the amount of water available to wetland habitats and grazing livestock. Although not in the UKCIP projections, recent summer floods of 2007 and 2008 caused prolonged inundation in the hay meadows which fringe the lower Derwent.
- Increased winter precipitation: Winter precipitation levels are predicted to increase by up to 10% by the 2020s and up to 20% by the 2050s. This is likely to increase flows during the winter, leading to increased flood frequency and more sediment runoff.
- This means that, over the next 50 years, summers are likely to become warmer and drier and winters are likely to become warmer and wetter.

The plan must therefore take into account the changing climate to ensure that the river is resilient and adaptive to change.

A. Changing agricultural and land drainage management practices

A.1. Investigate and manage fine sediment input

This solution would help to address the issue of ***Fine sedimentation****.*

Heavily maintained field drain with limited bankside vegetation

Aim

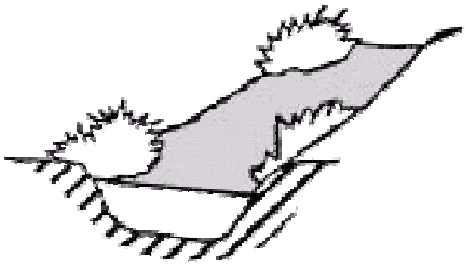
The aim of this solution is to change the way drainage ditches and land drains are maintained, in order to help retain sediment within them and prevent it reaching the main river channel. By working with landowners, farmers and Internal Drainage Boards (IDBs) to change current practices of management of agricultural drains it should be possible to reduce sediment supply from the numerous tributaries and field drains that flow into the River Derwent. Although this solution can be targeted at individual watercourses, it will be most effective if it is applied at a catchment-wide scale to address sediment supply to the main river.

Description

The Internal Drainage Boards are currently responsible for the maintenance of large parts of the drainage network. They undertake a range of activities, including grass cutting, weed removal, de-silting and debris removal. Grass is cut from mid-July until the end of the growing season, and de-silting works are undertaken on a rolling programme, or when a specific need is identified. Drainage networks that are not within the control of any of the local IDBs are managed by individual land owners. The current maintenance regime could potentially be modified in order to reduce the amount of sediment that enters the main river from wider catchment sources. Changes to the ditch maintenance regime could offer cost savings to the land owner, and help to retain valuable topsoil and nutrients on the land. Three measures that could be introduced as part of a revised maintenance regime are described below.

Reduce the frequency and extent of drain clearance

At present, many field drains are cleared of debris and sediment on a regular basis. A reduction in the frequency and extent of drain clearance in parts of the catchment could help to reduce the supply of sediment to the River Derwent SSSI by retaining it in the drains. Ditch maintenance could be undertaken on a rotational basis, leaving part of the network left untouched. Ideally, an individual section of drain should only be cleared every three to four years. When a drain is cleared, the resulting sediments should be spread on the adjacent fields, and not allowed to enter the drainage network.



Vegetation left uncleared on alternate banks

Encouraging the growth of vegetation in the channel

Vegetation and small blockages can be used to slow flows and encourage sediment to settle within drains, so long as this does not impede the drainage of the surrounding land. These drains can be maintained on a rotational basis so that they do not become too heavily overgrown. Ideally up to half of the vegetation in a drain should be left uncleared to enable recolonisation.

Installing sediment traps within the river channel

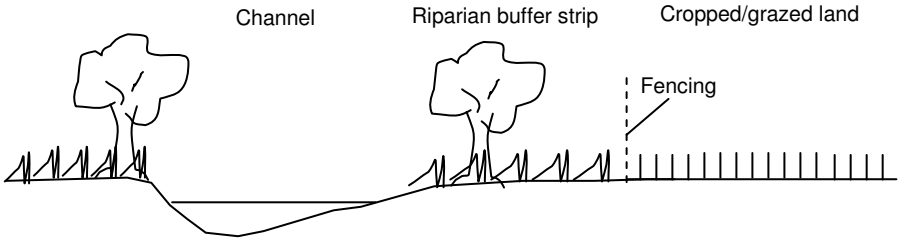
In addition to encouraging the growth of vegetation to slow flows and trap sediment within the drainage channel, it could also be possible to install small sediment traps. These structures could be made from dead natural materials such as willow, and can be used to impound small amounts of water in the ditches. This will encourage sediment to settle behind the structures. Sediment traps can be cleared on a rotational basis as part of the ditch maintenance regime.

These measures could be implemented by landowners, potentially, as part of an Environmental Stewardship Agreement (see **Appendix A**) and by Internal Drainage Boards as part of their Biodiversity Action Plans.

Good buffer strip along the River Derwent

Installing buffer strips adjacent to watercourses

A buffer strip is an area of land adjacent to a watercourse that is left uncropped in order to intercept surface drainage and minimise soil erosion. Buffer strips can effectively reduce the amount of sediment and pollutants carried by runoff to tributaries and drainage networks by slowing down surface flows and encouraging sediment to settle out. Buffer strips can be comprised of a mixture of natural plants, including grasses, shrubs and trees, and therefore can also provide valuable habitats for invertebrates, mammals and birds. This solution could be applied widely for maximum benefit, but could also be targeted in areas where sediment supply is particularly high, due to factors such as soil erodibility, topography, and land management practices.



Schematic diagram of a buffer strip

Buffer strips are typically between 1 and 50 m wide. They should be at least 5 m wide to be effective, and their optimum width is approximately 20 m. Wider strips with thicker vegetation are typically more effective at trapping sediment than narrower strips with less dense vegetation cover. In practice, the exact width of the features is largely dependent on the space available for their creation, the erodibility of the underlying soils, the steepness of the valley slopes, and the nature of surrounding land use.

Buffer strips could potentially be established in a number of areas in the river catchment. To be most effective, they could be established next to the tributaries and field drains that drain easily erodible soils, particularly where they are cropped right up to the water's edge or grazed heavily. In this case, it may be necessary to fence off the strips to prevent them being trampled by livestock. In addition, this measure could also be introduced adjacent to the main river in areas where sediment supplied through direct runoff is a concern.

This measure should ideally be implemented alongside other measures to limit sediment supply. For example, it is likely to have maximum benefit if used in conjunction with changes to the ditch maintenance regime to limit the amount of sediment that is supplied from catchment sources. This measure could be implemented by landowners potentially as part of an Environmental Stewardship Agreement (see **Appendix A**).

Climate change adaptation: Changing agricultural and land drainage management practices

Solutions aimed at changing agricultural and land drainage management practices can contribute towards climate change adaptation in several ways.

- **Increased annual average daily temperatures:** Improved conditions for vegetation growth in the channel and riparian zone could increase cover to help mitigate against temperature increases if management practices are altered.
- **Decreased summer precipitation:** Reduced summer flows could increase livestock trampling pressures, so improved watercourse management could prevent further increases in sediment supply.
- **Increased winter precipitation:** An altered land management regime could help to mitigate potential increases in sediment runoff from agricultural land, which are likely to occur in response to increased rainfall.

See identified Further Information Sources for more detailed guidance.

A.2. Selectively restrict livestock access to banks

This solution would to help address the issues of ***Fine sedimentation*** *and* ***Lack of shelter and shading****.*

Aim

The aim of this solution is to help control cattle trampling along the banks of the main river, in order to limit bank erosion and the input of sediment to the river channel. In addition, this solution can also be used to capitalise on the effects of trampling in areas where it has already occurred, for by allowing trampled banks to revegetate and provide new habitats. This solution could be applied locally in areas where trampling is a particular problem.

Description

Trampling can be defined as alterations to the bank profile caused by livestock as they seek drinking water from the river channel, or walk along the bank top. Trampling changes the bank structure by decreasing its steepness and creating a more gradual, often stepped profile with little vegetation and exposed sediments. Livestock trampling occurs along the entire course of the River Derwent, and is particularly prevalent downstream of the Rye-Derwent confluence, in the reach downstream of Stamford Bridge, and in the lower reaches downstream of Bubwith.

Where livestock trampling is not controlled, large sections of bank can collapse and become devoid of vegetation cover, and as such become sources of sediment into the river channel. However, if a formerly trampled bank is allowed to revegetate, it can provide good quality habitats for marginal and bankside flora and fauna. Some of the best habitats for mammals, birds and submerged plants have developed on sections of the bank that have been altered by trampling and then allowed to revegetate.

There are two main techniques that could potentially be employed to restrict livestock access to banks:

- Fencing off trampled areas; and
- Introducing a rotational grazing system.

Fencing off trampled areas

An effective method to prevent trampling is to fence off grazed river banks to prevent access to badly affected areas so that they can revegetate. It will be important to allow some management of bank habitats to continue to ensure that the botanical interest of the river banks are maintained and that they continue to provide high quality habitats for invertebrates and other interest features. Allowing grazing to continue in a targeted and controlled manner, for example by periodically relocating fences once banks have recovered, is likely to be an effective way of achieving this aim. In fenced off areas, drinking water supply for livestock can be maintained through the provision of galvanised troughs, the installation of a piped water supply, or creating defined access points to the river. These access points can simply consist of areas of bank that are left unfenced for a period, which are later fenced off when trampling becomes heavy. The fence can then be reinstated and removed from another part of the bank to maintain access. Alternatively, fixed access points with wooden reinforcement (e.g. railway sleepers) could be installed, although these ultimately offer less flexibility.

Fencing of riparian buffer zone with defined cattle access point

Rotational grazing

In a rotational grazing strategy, livestock are only allowed in the riparian zone for short periods of time to drink and graze (typically less than a week) and only when conditions are dry and bank erosion is minimised. Livestock can be restricted from having direct access to the stream (see above), and drinking points can be rotated throughout the year to allow adequate time for the river banks to recover before grazing is resumed.

See identified Further Information Sources for more detailed guidance.

B. Alter flood embankments

B.1. Remove, breach, lower or set back embankments

This solution would mainly help to address the issue of ***Channelisation and disconnection of the river from the floodplain****. It could also help to address the issues of* ***Fine sedimentation*** *and* ***Lack of bankside shelter and shading****.*

Aim
The aim of this solution is modify the existing flood embankments that fringe much of the river channel in order to improve the connectivity between the channel and the floodplain, increase the potential for overbank storage of fine sediments, and improve the quality of riparian habitats. This measure could be applied locally to address the issues posed by individual structures, but is likely to be more effective if applied on a wider scale.

Description
Large reaches of the River Derwent are fringed by substantial embankments. These structures were first constructed prior to the production of the 1st Edition Ordnance Survey maps of the area in the 1850s, but were modified and rebuilt in the 1940s and 1950s. Many of the embankments in the upper Derwent are overtopped by relatively modest floods, and are intended to keep water in the floodplain ings rather than let it return quickly to the river channel. Others, particularly in the lower Derwent, are higher and were designed to reduce flood frequency, and, when they overtop during large floods, store water on the floodplain and allow it to drain gradually through the cloughs. However, problems with the cloughs that allow water to drain back into the river mean that a large proportion of the lower Derwent floodplain does not drain naturally, and the ings remain wet for prolonged periods, impacting on the internationally important SSSI habitats. The presence of the embankments reduces inundation frequency, particularly during small floods, and therefore limits the potential for floodplain storage of fine sediments. In addition, many of the flood embankments that fringe the river currently prevent the development of riparian habitats, due to their close proximity to the channel edge. In cases where the embankments are set back from the edge of the channel, the current management regime often prohibits the development of natural riparian habitats.

There are five main solutions that could potentially be implemented to help address the issues associated with the embankments:

- Remove the embankments;
- Breach the embankments;
- Lower the embankments;
- Set back the embankments; and
- Improve the clough drainage system.

Removal of the embankments
In some reaches, there could be potential to remove the embankments entirely using an excavator or equivalent construction equipment. This will be a time-consuming process, and produce large quantities of material. In some cases, it may be possible to reuse the material to enhance the geomorphology of the channel (see solution C2) or spread it across the ground surface. However, the latter option would not be an option in the floodplain SSSI at the downstream end of the catchment. This area is also designated as an SAC, and the MG4 hay meadows that it supports are likely to be adversely affected by increased flood frequency and duration during the spring and summer. Furthermore, the material may have to be transported off site for disposal or re-use.

Removal of the embankments will increase the frequency of overbank flooding, and the land behind the former embankments will become wet more often. However, it will also drain more naturally, and as a result may not necessarily be inundated for longer periods. This solution will deliver the most potential benefits to the river and floodplain by fully restoring channel-floodplain connectivity, removing sediment from the river channel, and allowing natural riparian and floodplain wetland habitats to develop. In addition, removal of the embankments could potentially have benefits for flood risk in line with Defra's *Making Space For Water* policy, by increasing floodplain attenuation of floodwaters from lower magnitude events. However, the grassland communities supported by the floodplain SSSI units in the lower Derwent are highly sensitive to changes in wetness, and the likely impacts of changing the flooding regime will need to be carefully considered on a site-by-site basis before any action is taken.

Breach the embankments
Instead of complete removal, it could be possible to breach the embankments. This can be specifically targeted at the cloughs in order to allow the drainage system to enter the river more freely, but could also include strategic breaches in long unbroken sections of embankment. The material arising from the breaches need not be

transported off site for disposal. Instead, it could be replaced on the back end of the remaining sections of the embankment, making them wider but retaining their existing height.

Breaching the embankments will allow water to inundate the floodplain more regularly, and may help the floodplain to drain more naturally. This measure does not offer any significant opportunities to reduce channelisation and improve the riparian zone, but may benefit parts of the designated floodplain grassland SSSIs and SAC adjacent to the river channel. However, additional flooding during the spring and summer is likely to be detrimental to the grassland habitats that this area supports.

Lower the embankments

It could also be possible to lower the crest height of the embankments to allow them to overtop more frequently. The material skimmed of the top of the structures could be reinstated on the rear-facing side, with the end result that they are lower and wider. Care must be taken where this abuts designated SSSI hay meadows, in order to prevent deterioration in their status.

This solution will allow the embankments to be overtopped more frequently, and therefore help to remove more sediment from the river channel. However, it will not help to address the issues associated with poor drainage, since there will be no improved route for water to return to the channel, will not increase floodplain connectivity, and is unlikely to provide any significant opportunities for the creation of new riparian and floodplain habitats. The grassland habitats supported in the lower Derwent SSSIs and SAC are unlikely to benefit from increased inundation frequency or duration, particularly during the spring and summer. Measures to improve the drainage, such as breaching the floodplain, may be required in combination with lowering for maximum effectiveness.

Set back the embankments

As an alternative, it could be possible to remove the existing embankments and replace them at another location away from the river channel. The material removed from the original structures can be re-used to construct new embankments further away from the river channel.

This solution creates an enlarged and more natural floodplain on either side of the river channel. The degree of set back that is appropriate is dependant on the land use behind the existing floodplain; for example, it may be necessary to maintain defences around settlements or roads. In parts of the Derwent catchment, however, the land rises relatively steeply behind the floodplain that is currently defended by the embankments. There is generally little development in these areas, which are primarily used for agriculture. The land beyond the natural floodplain is typically above the limit of inundation of event the largest flood, and as such it is unlikely to be necessary to set back the embankments in these areas.

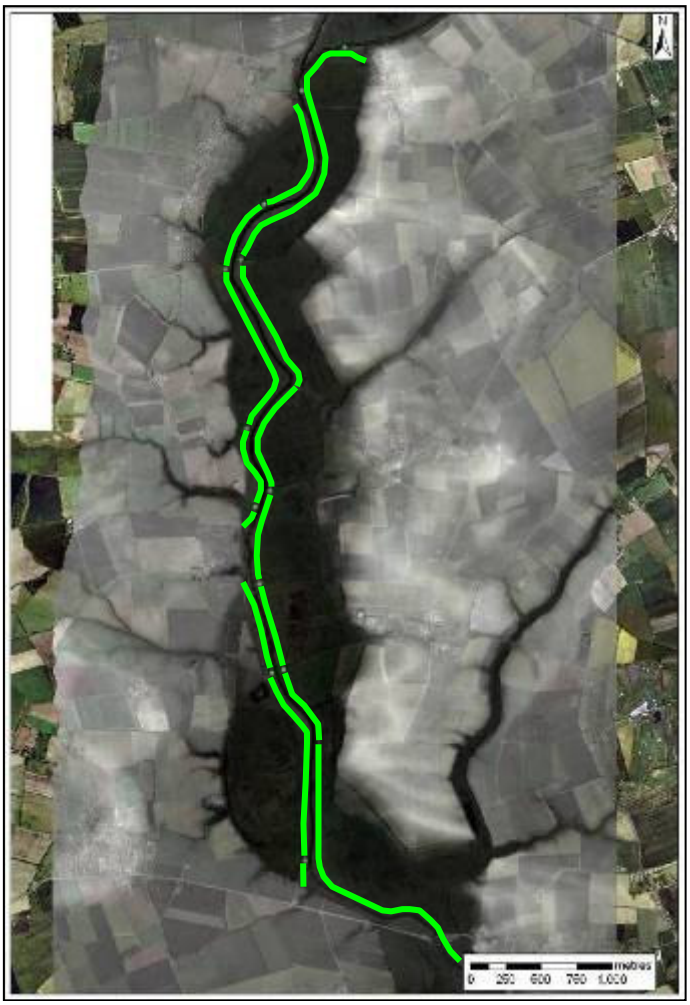
Improvements to the clough drainage system

As an alternative to modifying the embankments themselves, it could be possible to alter the clough drainage system which punctuates them. Many of the cloughs do not function effectively, and as a result the drainage of the floodplain can be impeded, leading to flooding of the agricultural land and hay meadows located behind the embankments. There are several reasons for the ineffectiveness of the cloughs, including the small size of the channels, sedimentation which prevents the outfall valves operating, and high water levels in the Derwent, which prevents water draining into the river.

There are two main measures that could help to directly address these issues, namely increasing the capacity of the cloughs, and improving the operation of the outlet valves. In addition, measures to alter the embankments (see above), reduce fine sediment supply (Solution A) and impoundments due to structures could also help to address this issue.

What is the best solution?

Of the potential solutions, **complete removal of the embankments** is likely to deliver the greatest range of improvements to the river and adjacent riparian and floodplain habitats. Due to the topography of the lower Derwent valley, it may be possible to remove many of the embankments without increasing flood risk for settlements and infrastructure. However, the solution will need to be consistent with the Derwent Catchment Flood Management Plan and ensure that the existing SSSI/SAC habitats on the floodplain are not adversely impacted. Furthermore, the costs of this measure (which include capital works and disposal of materials) will be high in comparison to the other solutions.



Figures 3.1 and **3.2** demonstrate that the land surface becomes considerably higher behind the floodplain ings, and inundation during even the largest floods is confined to a relatively small area. Notable exceptions include the embankments that were constructed as part of flood alleviation schemes at Old Malton, Malton and Stamford Bridge, and the embankment that protects Loftsome Bridge Water Treatment Works from flooding.

Figure 3.1: A LiDAR image of part of the lower Derwent valley. The colours become lighter as the ground gets higher. This shows that, in this reach, the river is bounded by a low, narrow floodplain, behind which the land rises considerably.

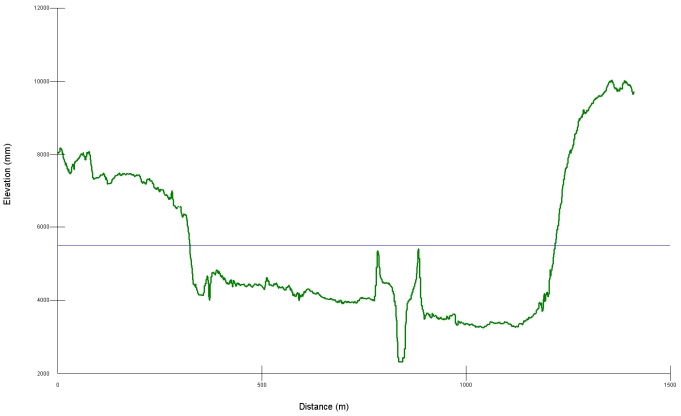


Figure 3.2: A floodplain cross section through part of the lower Derwent valley. The embankments are overtopped frequently, and the higher ground beyond the floodplain remains dry. The blue line indicates the level of a small flood (with a 1:1.5 year return period).

Climate change adaptation: Alter flood embankments

Solutions aimed at altering flood embankments in the catchment can contribute towards climate change adaptation in several ways:

- **Decreased summer precipitation:** Decreased summer precipitation will reduce flow levels, so removal or lowering of embankments will help to maximise inundation frequency and maintain wetland habitats.
- **Increased winter precipitation:** Increased winter precipitation will increase flow levels, so removal or modification of selected embankments will allow more frequent floodplain attenuation of high flow events.
- **Summer extreme events:** The recent summer floods of 2007 and 2008 caused prolonged inundation in the hay meadows which fringe the lower Derwent, although this has not been predicted in the UKCIP projections referred to in this report. Modifications to the embankments to improve drainage would have helped to minimise the impacts of this process.

C. Enhance riparian, wetland and marginal habitats

C.1. Tree, shrub and non-native invasive plant management

This solution would help to address the issue of ***Lack of bankside shelter and shading and overshading*** *and* ***Fine sedimentation.***

Aim

The aim of this solution is to achieve targeted sympathetic tree and shrub management (i.e. selective clearance) to improve habitats in over shaded reaches of the river; also to establish natural bank habitats adjacent to the river channel, particularly in areas that are open and exposed. This will increase the availability of shelter and shading for mammals and birds that live in and around the river, and improve habitats in the channel for fish. This reach-scale solution could bring real benefits in the reaches where it is implemented, and will help to provide good habitats along the entire river corridor if implemented in a targeted manner.

Description

In many reaches, riparian vegetation cover is very dense. This limits light penetration and restricts habitat development. This can be addressed through a combination of targeted, sympathetic felling, coppicing, pollarding and branch trimming to reduce the density of vegetation cover and improve riparian and in-channel habitats. Voracious species (e.g. willows) could be especially targeted in this way. Where vegetation clearance is undertaken, care must be taken to ensure that the banks do not become too exposed. It is also important to note that newly planted areas must also be maintained to prevent them becoming overgrown. Control of non-native invasive plants can also be undertaken.

A reach with dense vegetation cover on both banks

A reach with very limited shelter and shading

Long reaches of the River Derwent are relatively exposed, with steep banks and little cover from bankside trees and shrubs. This means that fish are vulnerable to predation, and there is insufficient cover for mammals and birds. However, these reaches mostly occur in the Lower Derwent Valley where an open landscape is required for SPA designated birds. Where such conditions occur elsewhere along the SSSI the main solution is to plant suitable vegetation cover along the bank top. Water tolerant tree species are generally appropriate, although voracious species such as willow may need to be avoided. Smaller plants could also be planted in particularly exposed areas. This will increase shelter on the bank top, and provide root systems and woody debris for shelter in the channel.

When trees and shrubs are established on the bank top, care should be taken to ensure that cover does not become dense enough to cause overshading in the channel. Rather than planting trees to provide thick cover along extended stretches of bankline, it will be more appropriate to target planting more carefully in order to create a more diverse mixture of light and shade in the river channel, particularly for spawning gravels and large pools, whilst still improving cover on the bank itself. Planting could therefore take the form of small linear clumps interspersed with more open areas of bank. For example, one half to two thirds of the banks identified for planting could be left open to allow light to reach the banks and channel. Clumps should contain between 5 and 20 trees, utilising a mixture of trees and shrubs to produce maximum structural diversity. The ratio of trees to shrubs should be approximately 1:2. Clump locations should be chosen to complement the natural features of the channel, such as on the inside of bends, adjacent to spawning gravels, or in locations that already have some vegetation present.

Young trees with a maximum of 1 or 2 years growth should be planted where possible, as they generally have the highest survival and growth rates. Plants should be sourced from native populations of local provenance. A list of some species that may be suitable is provided in **Table 3.3**.

Table 3.3 Species potentially suitable for establishment of bankside vegetation along the River Derwent SSSI

Trees	**Shrubs**
Ash (*Fraxinus excelsior*)	Crack willow (*Salix fragilis*)
Aspen (*Populus tremula*)	White willow (*Salix alba*)
Crab apple (*Malus sylvestris* ssp. *Sylvestris*)	Oak (*Quercus robur*)
Wych elm (*Ulmus glabra*)	Gean (*Prunus avium*)
Rowan (*Sorbus aucuparia*)	Blackthorn (*Prunus spinosa*)
Goat willow (*Salix caprea*)	Hawthorn (*Crataegus monogyna*)
Grey Willow (*Salix cineria*)	Field rose (*Rosa arvensis*)
Bird cherry (*Prunus padus*)	Hazel (*Corylus avellana*)

Steep and degraded bank habitats would also benefit from further rehabilitation to improve the bank profile and allow a suitable vegetation community to establish naturally. Suitable techniques are described in more detail under Solution C2.

See identified Further Information Sources for more detailed guidance.

C.2. Bank rehabilitation

This solution would help to address the issues of ***Lack of bankside shelter and shading*** *and* ***Channelisation and disconnection of the river from the floodplain****.*

Aim

The aim of this solution is to improve the river banks and the habitats they offer by altering the structure of the banks and establishing new habitats. This will improve the quality of habitats for a range of species that live on and around the river banks, including emergent and marginal plants, mammals and birds. This solution will be most effective if it is targeted in individual reaches, although it may also help to improve longer sections of the river.

Description

The lower River Derwent has been historically channelised, and as a result a large proportion of the channel has a uniform, modified cross section with steep banks and a relatively flat bed. These banks often lack suitable niches for plant habitats to develop at the bank base and next to the water line. The lack of shallow areas adjacent to the bank restricts the occurrence of the water-tolerant and aquatic plants such as river-water crowfoot and shining pondweed, as well as habitat suitable for fish fry, invertebrates, birds and mammals.

The main solution to the lack of varied bank habitats in some reaches is to undertake targeted bank rehabilitation. This consists of two main techniques that both aim to reduce the uniformity of the bank and provide a range of niches for different habitats:

- Bank reprofiling; and
- Creation of aquatic ledges.

A reach of the River Derwent where marginal ledges have developed. These support reeds and water tolerant grasses

Bank reprofiling

River banks can be artificially reprofiled to reduce their gradient and create shallow areas next to the channel edge. For example, a bank with a steep, uniform slope right down to the edge of the channel can be reprofiled to incorporate shallow ledges just under the water line, areas of vertical river cliff, and intermediate ledges that lead to a more stepped profile. This process is generally undertaken using an excavator. If the bank material is particularly easy to erode, it may be necessary to stabilise the front edge of the bank using vegetation or geotextile matting. This can be pre-planted, and will allow natural vegetation to colonise. However, the cohesiveness of the bank material in the Derwent catchment suggests that this may not be necessary in all reaches.

Creation of aquatic ledges

In addition to reprofiling the banks, new ledges could be created along the edge of the river. This can by building up the river bank from its base to the low water mark, using material from the bed where possible. Alternatively, material from regraded river banks or breached or removed flood embankments (provided they are not contaminated) could also be utilised to create aquatic ledges. Newly created aquatic ledges can be protected with planted geotextile matting and/or aquatic vegetation to prevent it eroding. The end result is a series of narrow ledges in and around the water line that provide good habitats for emergent and marginal plants and help vary water flow speed and depth.

Climate change adaptation: Enhance riparian, wetland and marginal habitats

Solutions aimed at enhancing riparian, wetland and marginal habitats can contribute towards climate change adaptation in several ways:

- **Increased annual average daily temperatures:** Improved riparian habitats will provide additional shelter and shading for in-channel species, helping to regulate water temperatures.
- **Decreased summer precipitation:** Reduced summer precipitation could lead to stresses in important habitats, making the presence of high quality in-channel and riparian habitats more important for SSSI interest features.
- **Increased winter precipitation:** Increased winter precipitation could increase the frequency of overbank flooding, providing suitable conditions for wetland habitat development in more locations.

See identified Further Information Sources for more detailed guidance.

D. Modify in-channel structures

*This solution is intended to address the issue of **In-channel structures**, and, as a secondary action, **Fine sedimentation**.*

Aim
The aim of this set of solutions is to improve the natural form and function of the River Derwent, improving flow conditions and improving habitats for SSSI interest features such as fish, aquatic plants and invertebrates. Several potential solutions can be implemented to address in-channel structures, depending on the type and condition of each structure, their current use, and the benefits to the SSSI. Alternative options include:

1. Remove the structures.
2. Modify the structures.
3. Alter the operation of the structures.
4. Install a fish pass.
5. Other solutions selected on a site-specific basis.
6. Do nothing (retain the structure in place).

An engineering assessment of the main structures has been undertaken alongside a qualitative assessment of the options to address each structure. The detailed results of this process are presented in the accompanying Technical Report, and a summary is presented in the subsequent sections of this Restoration Plan.

Potential for removal of each structure has been considered as a starting point, because this option is likely to deliver the greatest benefits to the SSSI in terms of flow and sediment regime and in-channel habitats for key interest features. If that is unlikely to be achievable due to overriding constraints, alternative options to modify each structure or change the way it is operated have been considered. If these options are not possible, interim measures to install a fish pass are considered. The "Do nothing" option is only considered if the structure cannot be removed or modified, and it already incorporates provision for fish passage.

A description of the main options for addressing each structure is provided in the subsequent sections. This presents a preliminary analysis of each potential option, based on data that are currently available. It is, however, recommended that more detailed feasibility studies are undertaken before any structures are removed or modified.

Climate change adaptation: Modify in-channel structures
The solutions aimed at modifying in-channel structures can contribute towards climate change adaptation in the following way:

- **Decreased summer precipitation:** Decreased summer precipitation will reduce flows over in-channel structures, potentially making them more of a barrier to fish passage. The modification or removal of these structures will therefore help to ensure that they remain passable to fish populations during predicted lower flows.

D.1 Remove structures

This solution would be intended to address the issues of ***In-channel structures*** *and a secondary issue* ***Fine Sedimentation****. However, implementation of this solution is constrained by several factors within the River Derwent SSSI.*

Aim

The aim of this solution is to remove in-channel structures where possible, in order to create more natural patterns of flow and sediment movement, and allow free passage of fish and other aquatic organisms along the river channel. This measure is specifically targeted in individual reaches, but is likely to help improve much larger reaches of the river.

Description

If a structure is no longer required for water level control or flood risk management, it could be possible to remove it. For example, structures originally built to raise water levels for milling (e.g. Howsham and Stamford Bridge) may no longer be required if the mill no longer exists. The removal of a structure can provide significant benefits to the river channel by restoring characteristic water depths and flow velocities, reducing siltation of gravel substrates and allowing free movement of fauna.

Buttercrambe Weir

Invasive works within the river channel are required in order to remove an in-channel structure. The nature of the works is dependent on the type of structure, but will typically involve breaking up the main elements above the river bed using heavy construction equipment. Removal of the foundations of the structure will require greater excavation. Construction of temporary dams in the river is likely to be required to create dry areas in which to work. Measures to prevent the escape of sediments and potential contaminants from construction equipment into the river would be required, and materials would need to be transported off site for disposal.

Removal of the structures is likely to have maximum benefit for the SSSI, by reducing impoundment, increasing flow velocities and morphological diversity, reducing fine sedimentation and turbidity, and allowing the free movement of fish and other aquatic organisms. However, there are a number of constraints that need to be considered before a structure can be removed. Potential constraints include the current function of each structure (e.g. flow gauging and public water supply), the impact of removal upon existing in channel habitats (e.g. coarse gravels in the weir pools and fine sediments for spawning lamprey in mill leats), and the heritage value of each structure.

The removal of structures within the River Derwent SSSI requires careful consideration taking into account the function and cultural heritage and socioeconomic aspects of each structure, together with the potential impacts on existing channel stability, ecological value and flow constraints. Several of the structures are still required for water level control for strategic water supply across Yorkshire as part of the Yorkshire Grid or flood risk management purposes. A brief summary of the potential for removal of each of the structures is provided in **Table 3.4** and based on the engineering survey and weir option assessment detailed in the accompanying Technical Report. Further investigation into the feasibility of removing weirs needs to be undertaken alongside consultation with parties likely to be affected by the option.

River rehabilitation may need to be implemented upstream as part of weir removal to reinstate a more natural channel form. Further information is provided in Solution C2.

Table 3.4: Potential for removal of in-channel structures within the River Derwent SSSI

Structure	Potential for removal of the structure
Kirkham weir and sluice	Removal of the weir, in conjunction with bed regrading, will deliver considerable benefits to the River Derwent SSSI by reducing impoundment for up to 14 km upstream. This could potentially offer the opportunity to expand and enhance the existing gravel habitats that are located downstream of the structure, improve fish passage, and reduce impoundment upstream of the structure. However, the design of the regraded channel would need to ensure that flow is sufficiently swift to prevent an increase in sedimentation and subsequent damage to existing in-channel habitats (including gravels in the weir pool downstream). It is therefore recommended that a feasibility study is undertaken to examine the potential to remove the structure in more detail, including a more detailed assessment of the impacts of removal on flow conditions, benefits to the SSSI, and the constraints associated with weir removal. If the structures cannot be removed, consideration should be given to altering operation of Kirkham sluice to reduce impoundment and improve fish passage (see **D2: Modify structures**).
Howsham weir	Removal of the weir, in conjunction with bed regrading, could potentially offer the opportunity to expand and enhance the existing gravel habitats that are located downstream of the structure, improve fish passage, and reduce impoundment. However, any solution will need to ensure that the gravel habitats downstream of the structure are not compromised or equivalent habitat is created, for example by maintaining sufficiently rapid flow to prevent the accumulation of fine sediments. This option will deliver greatest benefits if the weir upstream at Kirkham is also removed. Subject to the findings of investigations at Kirkham weir and sluice it is recommended that a feasibility study is undertaken to examine the potential to remove the structure in more detail, including a more detailed assessment of the impacts of removal on flow conditions, the hydropower function of the structure, benefits to the SSSI, and the constraints associated with weir removal.
Buttercrambe weir	A feasibility study by Hydrologic (2009) has identified several major constraints associated with the removal or alteration of Buttercrambe weir: • The weir has an ongoing flow gauging function, and this may be incompatible with removal or modification of the structure; • The gravel habitats maintained by turbulent flow over the structure could potentially be damaged if it were removed or modified; and • The stable sediments in the mill leat may be compromised if the structure were to be removed or modified. The use of the structure for flow gauging means that complete removal of the structure is unlikely to feasible or affordable in the short to medium term. Following a dedicated study by Hydrologic (2009) a Larinier fish pass design is being progressed for installation at this site. However, it is recommended that the removal of the structure is considered again in the long-term at the end of its life span, due to the scale of the impoundment upstream of the structure. It may, for example, be possible to replace the weir with a hydro-acoustic flow gauge in the future.
Stamford Bridge weir	Removal of the weir, in conjunction with bed regrading, will deliver considerable benefits to the SSSI by the reducing impoundment which currently extends upstream to Buttercrambe. This could potentially offer the opportunity to expand and enhance the existing gravel habitats that are located downstream of the structure, improve fish passage, and reduce impoundment. Any solution will need to ensure that the gravel habitats downstream of the structure are not compromised or equivalent habitat is created, for example by maintaining sufficiently rapid flow to prevent the accumulation of fine sediments. It is therefore recommended that a feasibility study is undertaken to examine the potential to remove the structure in more detail, including a more detailed assessment of the impacts of removal on flow conditions, benefits to the SSSI, and the constraints associated with weir removal.
Elvington sluice	The sluice is primarily used to maintain water levels to allow abstraction for public water supply at Elvington Water Treatment Works to occur without interruption. The removal of the sluices and regrading of the river bed (approximately 1 km upstream, and potentially the same length downstream) could offer the opportunity to reduce impoundment and improve the overall quality of the SSSI habitats. However, this is unlikely to be compatible with the existing function of the structure to retain water levels to enable abstraction for public water supply. This is a major strategic function for the Yorkshire region and thus is of overriding public interest. The structure should therefore be retained. However, it may be possible to alter the operating protocol of the structure to reduce the impoundment whilst maintaining the current functions (see **D3: Alter operation of structures**). In addition, it may be possible to improve fish passage (see **D4: Provide a suitable fish pass**).
Barmby Barrage	The barrage has a current function to retain water levels for public water supply abstraction at Loftsome Bridge Water Treatment Works which cannot be compromised, and is also operated to maintain water depths for navigation. These constraints (especially the water level control for abstraction) preclude any significant structural alterations at the site. However, it may be possible to alter the operating protocol of the structure to reduce the impoundment whilst maintaining one or both of the current functions (see **D3: Alter operation of structures**). In addition, it may be possible to improve fish passage (work is already underway to trial suitable measures) (see **D4: Provide a suitable fish pass**).

D.2. Modify structures

This solution is intended to address the issue of ***In-channel structures*** *and a secondary issue* ***Fine Sedimentation****.*

Aim
The aim of this solution is to modify in-channel structures to improve the passage of fish and other aquatic organisms along the river channel. This measure is specifically targeted in individual reaches, but could potentially help improve much larger reaches of the river.

Description
It may not be possible to remove many of the structures that are currently in the River Derwent channel due constraints such as their current water level control function or the habitats that they support. However, it could be possible to physically modify the structures so that they continue to increase water levels and/or maintain clean gravels for spawning habitats, whilst making them more easily passable to fish, water and sediment.

There are several ways in which existing structures can be modified, including:

- Reduce the crest height of a weir to allow fish to pass upstream during lower flows and decrease impoundment levels;
- Cut a v-notch channel into a weir to allow fish to swim up the structure;
- Replace overshot sluice gates with an undershot system to improve the passage of sediment downstream and fish upstream.

The physical alteration of a weir can be technically difficult, depending on the nature of the original structure. For example, it can be difficult and therefore time consuming and expensive to cut a channel in an existing reinforced structure, and older structures may not be stable enough to be modified easily. It can, therefore, be more cost effective to remove a structure and replace it with one of a more suitable design than to modify an existing and potentially unstable structure (although in this instance the weirs are very large). A brief summary of the potential to modify each of the in-channel structures is provided in **Table 3.5**.

Table 3.5: Potential for modification of structures within the River Derwent SSSI

In-channel structure	Potential for modification of the structure
Kirkham weir and sluice	It is recommended that, in the first instance, a feasibility study is undertaken to determine whether this structure can be removed as the preferred option. Options to modify the structure should also be investigated during the same feasibility study, and developed further if removal is not feasible. It may be possible to modify the weir to make it passable by fish and reduce impoundment, for example by lowering the crest height. The sluices could potentially be replaced with an undershot system that allows the free passage of sediment and fish, although implications for their flood defence function would need to be investigated. Alterations to the operating protocol of the structure could be considered as an alternative (see **D3: Alter operation of structures**).
Howsham weir	It is recommended that, in the first instance, and subject to the findings of investigations at Kirkham weir and sluice, a feasibility study is undertaken to determine whether this structure can be removed as the preferred option. Options to modify the structure should also be investigated during the same feasibility study, and developed further if removal is not feasible. There may be potential to modify the weir by reducing its crest height to reduce impoundment and make it easier for fish to pass upstream. This could maintain turbulent flow sufficiently to retain the gravel spawning habitats located downstream of the weir, and could potentially incorporate the existing turbine for hydropower generation.
Buttercrambe weir	The structure is too high to allow fish to pass. Potential to lower the height of the crest whilst retaining the valuable gravel habitats downstream would help to reduce the upstream extent of impoundment behind the structure, but would be detrimental to the gauging capability of the weir. The provision of a fish pass at this location is therefore a feasible short term alternative. A dedicated study of the weir undertaken by Hydro-Logic (2009) also recommends this option. In the long term, it is recommended that a feasibility study to investigate options to remove the weir at the end of its life span and replace it with a hydro-acoustic flow gauge is undertaken.
Stamford Bridge weir	It is recommended that, in the first instance, a feasibility study is undertaken to determine whether this structure can be removed as the preferred option. Options to modify the structure should also be investigated during the same feasibility study, and developed further if removal is not feasible. The structure incorporates a functioning fish pass, so it does not need to be modified to improve fish passage. However, the structure could potentially be modified to reduce impoundment, for example by lowering the height of the crest. Potential modifications would need to be designed carefully to prevent damage to the important lamprey spawning habitats located downstream of the structure.
Elvington sluice	The design of the sluice and its role in retaining water levels for water supply abstraction purposes mean that it will not be feasible to modify the main structure, without major changes to the existing water abstraction mechanism. This is not possible given that it is an important strategic water supply source for Yorkshire.
Barmby Barrage	The design of the barrage and its function in maintaining river levels for public water supply abstraction means that it will not be feasible to modify this structure. The barrage is passable by fish during some flow conditions.

D.3. Alter operation of structures

*This solution would help to address the issue of **In-channel structures**, and a secondary issue **Fine Sedimentation**. It is only applicable to structures that can be operated (i.e. Kirkham Sluice, Stamford Bridge Sluice, Elvington Sluice and Barmby Barrage), and does not apply to fixed weirs.*

Aim

The aim of this solution is to alter the operation of in-channel structures to improve the passage of fish and other aquatic organisms, and help reduce impoundment in the main river channel. This measure is specifically targeted in individual reaches, but could potentially help improve much larger reaches of the river.

Description

Where removing or modifying in-channel structures to reduce the effects of impoundment and improve fish passage are not feasible, it may be possible to alter the way structures are operated. Some structures are operated manually in response to a pre-defined timetable or prevailing conditions in the river channel, whilst others are operated automatically to maintain conditions in the river within a fixed set of parameters. These protocols could potentially be altered to be more sympathetic to the natural functioning of the river system. For example, a set of sluices that are used to impound water to reduce flood risk could be opened more frequently during low flows to improve patterns of flow and sediment movement and the passage of aquatic organisms. However, any changes to the operating protocol of a structure would need to ensure that the primary function is not adversely affected. For example, it is likely to be easier to alter the protocol of a flood risk management structure than it is to alter the operation of a structure that is designed to maintain water levels within tight constraints for purposes of strategic public water supply abstraction.

Elvington Sluice

There may be potential to alter the current operating protocols of the sluices and barrage so that they are left fully open for longer periods. The impounding effects of the sluices will be removed, and more natural patterns of flow and sediment movement will be adopted. In addition, fish and other aquatic organisms will be able to move freely past the structures.

A brief summary of the potential for modifying the operation of in-channel structures is provided in **Table 3.6**.

Table 3.6: Potential for modification of the operation of sluices within the River Derwent SSSI

In-channel structure	Potential for modification of the structure operating protocol
Kirkham sluice	The sluice is currently used for flood defence purposes. It has recently been left open for longer than usual due to a prolonged period of wet weather, which resulted in unusually high numbers of salmon upstream in the River Rye. This means that changes to the operating protocol of the structure could help to improve fish passage into the upper catchment and reduce impoundment upstream. For example, it may be possible to keep the sluices open under most flow conditions, and only close them when absolutely necessary. However, removal of the weir should be considered in the first instance.
Stamford Bridge sluice	The sluice, which is situated in the former navigation channel, is operated for flood defence purposes. It could be possible to alter the way in which the structure is operated during periods of low to moderate flow to improve fish passage and reduce impoundment. During periods of higher flow, the current operating protocol could be adopted to ensure that the current flood defence
Elvington sluice	The sluice is primarily used to maintain water levels to allow abstraction for public water supply to occur without interruption. It is therefore unlikely to be possible to alter the current operating protocol to reduce impoundment in the river channel. However, it may be possible to alter the operation of the sluice within these constraints to reduce the impact of the structure. It is therefore recommended that the potential to modify the operating protocol of the structure is investigated in more detail.
Barmby Barrage	The barrage is operated within tight constraints to ensure that water levels are sufficiently high to allow continuous water abstraction, navigation, and prevent the ingress of tidal waters from the River Ouse. The operating protocol of the structure was amended in 2003 to reduce improve water level control and prevent the oscillation of water levels. It is therefore unlikely to be feasible to alter the operating protocol further to deliver improvements to the river channel (e.g. by reducing impoundment) whilst continuing to fulfil the primary objectives of the structure, although this could be investigated further. Additional measures are to be trialled to improve lamprey access, including alterations to the operation of the navigation lock.

D.4. Provide a suitable fish pass

*This solution is intended to address the issue of **In-channel structures**.*

Aim

The aim of this solution is to provide fish passes on structures that are currently impassable, in order to allow free movement of fish (particularly interest features such as lamprey) in the River Derwent. This measure is specifically targeted in individual reaches, but if all impassable structures are addressed this will help to improve passage in the whole river. This option should only be considered if it is not possible to remove or modify a structure, since it has limited benefits to the condition of the SSSI as a whole.

Fish pass at Elvington

Description

In-channel structures can often act as a physical barrier to the free movement of fish in a river channel. In order to help solve this problem and allow fish to move upstream of the obstruction, a fish pass can be installed. A variety of different types of fish pass are commonly used in England and Wales, and they generally fall into three main categories:

- Stepped fish passes: In this approach, the height that must be passed is divided into a series of smaller steps that fish can jump up. Small traverses (essentially small weirs) on each level are used to create pools for fish to rest in between jumps.
- Sloped fish passes: In this approach, a slope is provided for water to spill down. This can be relatively steep, and baffles are provided to slow down the flow sufficiently for fish to swim up the slope.
- Bypass channels: in this approach, a new channel is cut into the river bank adjacent to the obstruction to allow fish to swim past it.

When considering which fish pass to use, it is important to consider the needs of the species that will use the structure. For example, salmon and trout are strong swimmers and can therefore use most types of pass. However, many of the important species in the River Derwent, including lamprey and coarse fish such as barbel, are weaker swimmers and need gentler flow. Streaming pool and weirs (stepped) fish passes, v-notch weirs and bypass channels are all likely to be suitable for these species.

Several of the in-channel structures in the lower River Derwent currently lack any provision for fish passage, while some of the fish passes that have already been installed are not particularly effective. It is therefore important to improve fish pass provision to allow free movement of fish along upstream to the upper River Derwent catchment. An overview of potential improvements at each in-channel structure is provided in **Table 3.7**.

Table 3.7: Potential improvements to fish passage at in-channel structures

In-channel structure	Consideration of the potential to improve fish passage
Kirkham weir and sluice	It is initially recommended that the structure is removed to deliver maximum benefit to the SSSI, or modified if this is not feasible. If the structure cannot be removed or modified, there may be potential to improve the existing fish pass. The weir is bypassed by a fish pass, but flow is generally too strong for weak swimming fish to use it. This could therefore be modified or replaced for one of a more appropriate design, such as a gentler streaming pool and weir pass or a bypass channel. This may not be necessary if the adjacent sluices are opened more frequently to allow fish to pass further upstream.
Howsham weir	It is initially recommended that the structure is removed to deliver maximum benefit to the SSSI, or modified if this is not feasible. If the structure cannot be removed or modified, there may be potential to install a fish pass. However, it is reported that it is passable during normal flow conditions by most fish species that are found in the river (Yorkshire Fishery Board, 1946). It is thus likely that lamprey, which usually migrate up the river in higher flows will be able to pass through this weir. A fish pass is therefore not considered to be necessary at this site.
Buttercrambe weir	The weir is too high for fish to pass upstream during normal flows, and it does not include a fish pass. A dedicated study undertaken by Hydro-Logic (2009) which assessed a range of options, including removal of the weir, and a fish pass was recommended as the short term preferred option. A Larinier fish pass design is being progressed for installation at the site.
Stamford Bridge weir	It is initially recommended that the structure is removed to deliver maximum benefit to the SSSI, or modified if this is not feasible. If the structure cannot be removed or modified, there may be potential to improve the existing fish pass. The weir is too high to be passed by weak swimming fish species, but it does include a working fish pass. However, fish can be reluctant to use it, and may take several attempts before they are successful. It may therefore be necessary to modify the structure slightly to make it easier for fish to use, for example by creating more backwaters with low velocity flow in which fish can rest between jumps.
Elvington sluice	The sluice incorporates a-functioning fish pass, though the entrance to the pass could probably be better sited and the upstream exit tends to get partially blocked by silt, debris and aquatic plants. It may therefore be necessary to modify the structure to make it more effective, for example by altering its entrance and exit.
Barmby Barrage	Although it does not include a fish pass, the barrage is often passable by some fish species. However, measures to ease the passage of river and sea lamprey and salmon are being trialled, including installation of a temporary lamprey ramp and alterations to the operation of the navigation lock.

What is the best solution for each structure?

The previous sections demonstrate that several measures could be applicable to address the issues caused by each weir in the Derwent SSSI. The options that have been identified as suitable for further development are summarised in **Table 3.8**. These recommendations are based upon the engineering and geomorphological assessments which have been undertaken for each structure, presented in the accompanying Technical Report.

Table 3.8: Recommended options to be investigated over the plan timescale to address in-channel structures

In-channel structure	D1: Remove structure	D2: Modify structure	D3: Alter operation	D4: Provide a suitable fish pass
Kirkham weir and sluice	✓	✓	√	✓ (modify)
Howsham weir	✓	✓	n/a	x
Buttercrambe weir	✓	×	n/a	✓
Stamford Bridge weir	✓	✓	✓	✓ (modify)
Elvington sluice	×	×	✓	✓ (modify)
Barmby Barrage	×	×	✓	✓

These assessments are based on a visual inspection of the structure and of the geomorphology of the river upstream and downstream. As such, they represent a high-level assessment of options that may be possible to implement at each site. However, further investigations are required in order to confirm these initial judgements and develop more detailed options for each structure.

In particular, these assessments have been made in the absence of detailed water and bed level information for each structure, and it has therefore not been possible to undertake a detailed appraisal of the potential options on existing conditions in the river. Further information, including detailed measurements of water levels and bed bathymetry, is therefore required before more detailed options can be developed and the impacts of potential actions appraised thoroughly.

Options to remove, modify or alter the operation of the structures are potentially constrained by the existing function of each structure, including flow gauging and water supply. Furthermore, potential negative impacts on the SSSI also need to be considered. The weirs currently provide the only areas on the lower river with the hydraulic conditions required to provide clean, silt-free substrates. These areas are currently vital for lamprey spawning as well as providing areas where *R. fluitans* can take root. Any changes to the flow conditions which are likely to result from changes to the structures will therefore need to be considered carefully before any further action is taken.

The main action recommended in the Restoration Plan at this stage is therefore to undertake more detailed feasibility studies to identify potential options to address the issues caused by the following in-channel structures:

- Kirkham weir (short term priority).
- Howsham weir (medium term priority, subject to findings of investigations at Kirkham weir and sluice).
- Buttercrambe weir (long term priority, with fish pass as short term measure).
- Stamford Bridge weir (short term priority).

If it is not feasible to remove these structures, options to modify or change their operation should then be considered. Options to install or improve fish passes should only be applied if no other measures to reduce impoundment and improve conditions within the SSSI are feasible.

See identified Further Information Sources for more detailed guidance.

E. Preserve existing habitats

E.1. Preserve existing quality habitats

Aim

The aim of this solution is to ensure that the high-quality habitats that currently exist in the river catchment are preserved and protected from degradation. This measure should be implemented at a catchment scale for maximum benefit, although there may be specific sites that provide habitat that it is particularly important to protect.

Existing wetland habitat

Description

Although the River Derwent has been heavily affected by human modifications, and the SSSI is in unfavourable condition, it does still provide good quality habitats for a wide range of plants, invertebrates, fish, birds and mammals. These habitats are found throughout the river catchment and river corridor, and include a diverse range of features such as:

- Reaches with suitable gravel substrate for in-channel vegetation growth.
- Existing in-channel and marginal vegetation communities.
- Reaches with gravel/pebble/cobble substrate for fish spawning.
- Reaches with a fine substrate for lamprey nursery habitats.
- Stretches of the channel with good flow and morphological diversity.
- Stretches of the channel with shelter for aquatic organisms but sufficient light for plants to thrive.
- River banks with a suitable profile to provide habitats for emergent and marginal vegetation.
- River banks with suitable vegetation cover for mammals and birds.
- Floodplain wetland.

Existing examples of these habitats should be preserved in order to maintain the integrity of the river SSSI and prevent it from degrading further. Changes to current management practices or development that could potentially damage these habitats should be avoided where possible, and measures to minimise the potential impacts of any changes should be adopted on a site-specific basis.

Areas of high quality habitat to be preserved should be clearly flagged in Environment Agency/Natural England GIS systems so that they can be fully taken into account in the consenting process.

Climate change adaptation: Preserve existing habitats

The solutions aimed at preserving existing habitats are unlikely to contribute directly towards climate change adaptation in the River Derwent. However, measures to preserve existing high quality habitats in the catchment should help to ensure that these are not lost as a result of changing temperatures and precipitation patterns.

E.2. Preserve existing woody debris in the river channel

Aim
The aim of this solution is to preserve woody debris in the river channel, in order to provide cover for fish and aquatic invertebrates. This measure should be targeted on a catchment scale for maximum benefit.

Description
Woody debris is formed from trees and branches that fall into the river. Depending on the size of the debris and the strength of flow in the river, this debris can remain in situ or become transported further downstream. Woody debris is therefore rarely static, and is often moved downstream during periods of high flow.

There are large quantities of woody debris in some reaches of the River Derwent (**Figure 3.3**). Woody debris is generally most likely to be found upstream of Elvington. The banks further downstream are more exposed, although there are areas of woody debris in isolated reaches. Proportionally large deposits are found in the reaches upstream and downstream of Kirkham, and upstream of Buttercrambe.

Existing Large Woody Debris (LWD) within the River Derwent SSSI

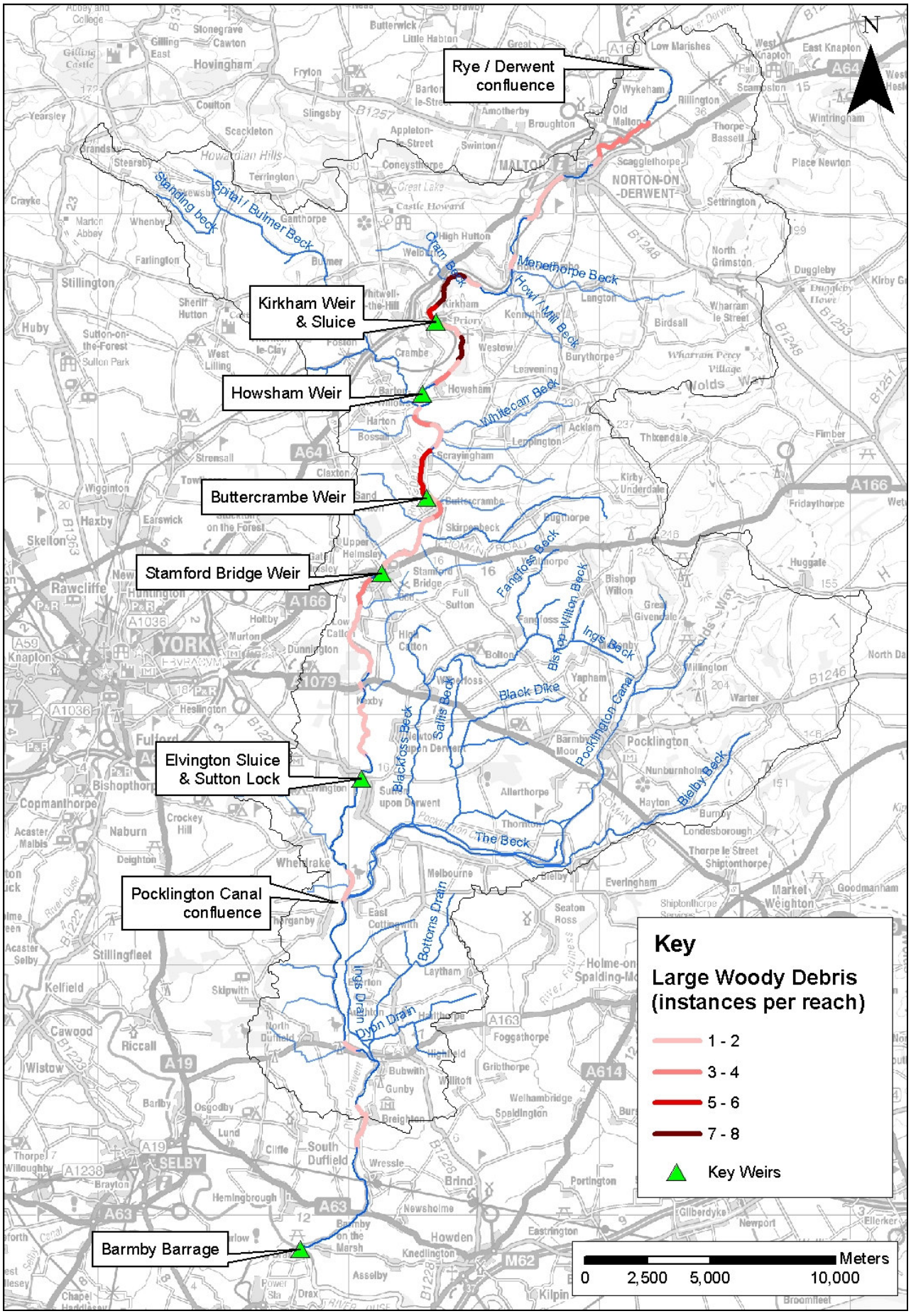
Woody debris is generally sourced from areas of banks with thick tree lining, but any bankside vegetation could potentially be a source of woody debris. This provides an important refuge for fish, which is particularly important in the uniform channel of the Derwent. In some reaches, species such as lamprey and bullhead are reliant on the cover provided by woody debris to protect them from predators. In addition, some fish species use woody debris to spawn on when in-channel vegetation and coarse bed material are unavailable. Accumulations of woody debris can also provide a substrate for invertebrates and aquatic plants, which helps to increase the biodiversity of an otherwise uniform river channel.

It is therefore important to ensure that woody debris in the river channel is preserved, so that it can continue to provide valuable habitats for a range of aquatic life. The practise of routinely removing all woody debris from the river channel should be discouraged where possible, in order to allow more natural levels of wood to remain in the channel. This could be helped through the provision of information on the beneficial qualities of in-channel debris to landowners and other parties who clear debris from the river.

This solution does not intend that all removal of woody debris in the catchment should cease. A large debris accumulation could potentially cause structural damage or block flow through bridges, causing an increase in flood risk. In cases such as these where any potential benefits are outweighed by increased risk, it is recommended that sensitive management of woody debris is undertaken.

Environment Agency/Natural England should give guidance on woody debris in the River Derwent SSSI and ensure that trees are not removed by default.

Figure 3.3: Location of existing Large Woody Debris within the River Derwent SSSI



4. REACH-BASED RESTORATION SOLUTIONS

The subsequent sections provide details of how the specific solutions could be implemented on a reach-by-reach basis. An annotated aerial photograph is provided for each reach, alongside details of the type of solution that could potentially be implemented. Many of these actions require further investigation and will also need an appropriate assessment to ensure that there are no adverse effects on the River Derwent SAC or Lower Derwent Valley SPA/SAC/Ramsar.

The reaches

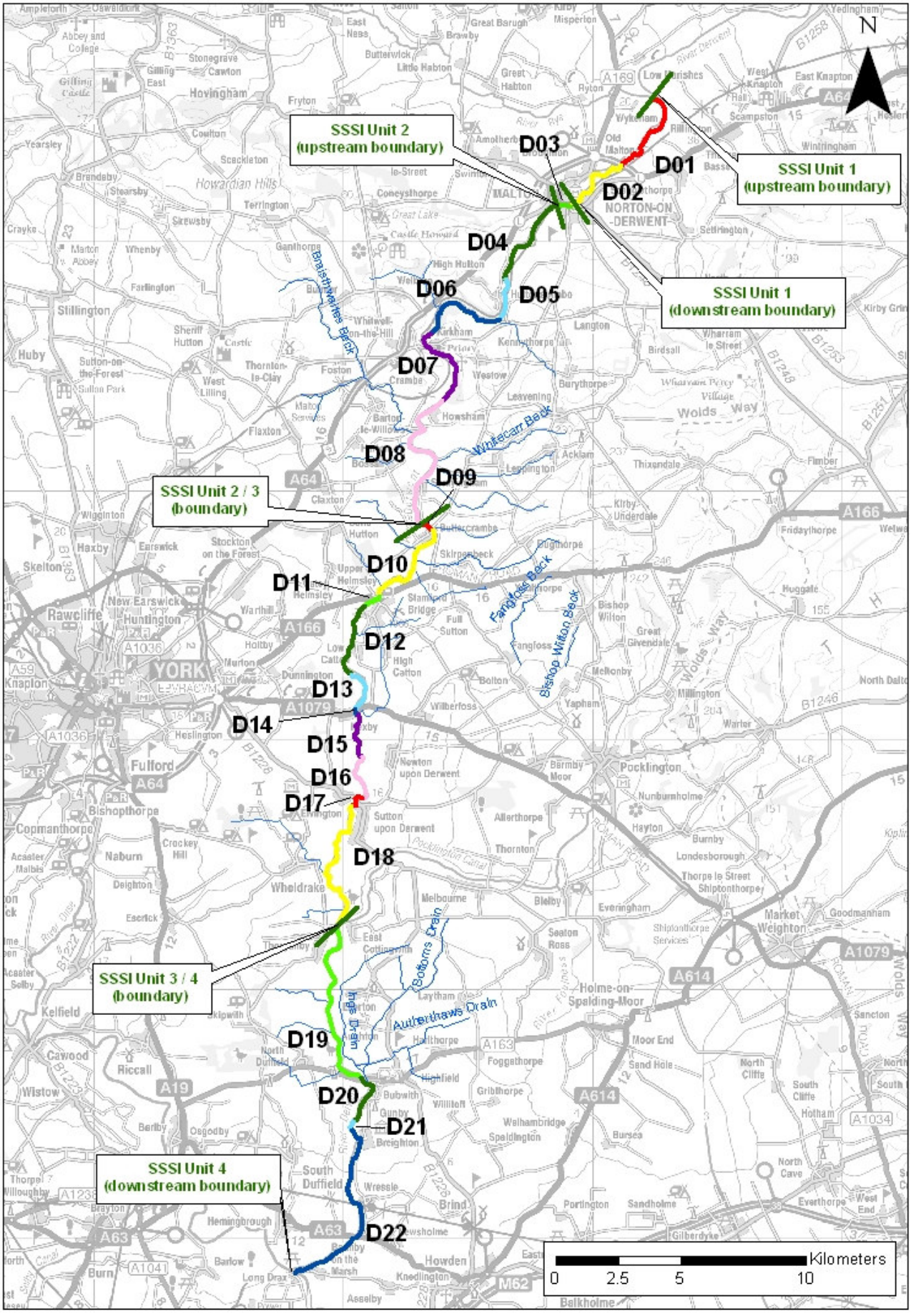
The river channel has been sub-divided into 22 individual reaches, based on the prevailing geomorphological and ecological characteristics of each reach (**Figure 4.1**). A brief breakdown of the boundaries of each reach is provided in the table below. Further information on how the river was subdivided, and on the geomorphological and ecological characteristics of each reach, is provided in the accompanying Technical Report.

SSSI Unit	Reach	Upstream limit	Downstream limit
Unit 1	D01	Rye – Derwent confluence	A64 road bridge
	D02	A64 road bridge	Upstream limit of Malton
	D03	Upstream limit of Malton	Downstream limit of Malton
Unit 2	D04	Downstream limit of Malton	Upstream limit of Low Hutton
	D05	Upstream limit of Low Hutton	Howl and Mill Beck
	D06	Howl and Mill Beck	End of Kirkham Park Wood
	D07	End of Kirkham Park Wood	End of Howsham Wood
	D08	End of Howsham Wood	Buttercrambe Weir
Unit 3	D09	Buttercrambe Weir	End of Buttercrambe Weir reach
	D10	End of Buttercrambe Weir reach	Upstream limit of Stamford Bridge
	D11	Upstream limit of Stamford Bridge	Downstream limit of Stamford Bridge
	D12	Downstream limit of Stamford Bridge	Downstream border of Low Catton
	D13	Downstream border of Low Catton	Upstream limit of Kexby
	D14	Upstream limit of Kexby	Downstream limit of Kexby
	D15	Downstream limit of Kexby	Upstream of Sutton Wood
	D16	Upstream of Sutton Wood	Upstream limit of Elvington
	D17	Upstream limit of Elvington	Downstream limit of Elvington
	D18	Downstream limit of Elvington	Confluence with Pocklington Canal
Unit 4	D19	Confluence with Pocklington Canal	Bubwith
	D20	Bubwith	Upstream limit of Menthorpe
	D21	Upstream limit of Menthorpe	Downstream limit of Menthorpe
	D22	Downstream limit of Menthorpe	Barmby Barrage

Reach Summary Sheets

The following pages contain summary sheets for each reach which identify the solutions recommended for each reach. The solutions are colour coded to reflect the four key issues established in **Section 2** of this River Restoration Plan, plus the preservation of existing habitat.

Figure 4.1: Location of River Restoration Plan reaches D01 to D22 (and SSSI units) along the River Derwent SSSI




D01
Improve marginal, riparian and floodplain habitats through planting
Manage sediment input from the upper River Derwent and Rye catchments
West Moor Drain
Rillington Beck
Investigate the potential to modify the East Wykeham embankment to promote floodplain sedimentation and development of riparian habitats
Manage sediment input from tributaries and field drains and establish buffer strips next to the main watercourses
Settrington Beck
0
500
Meters

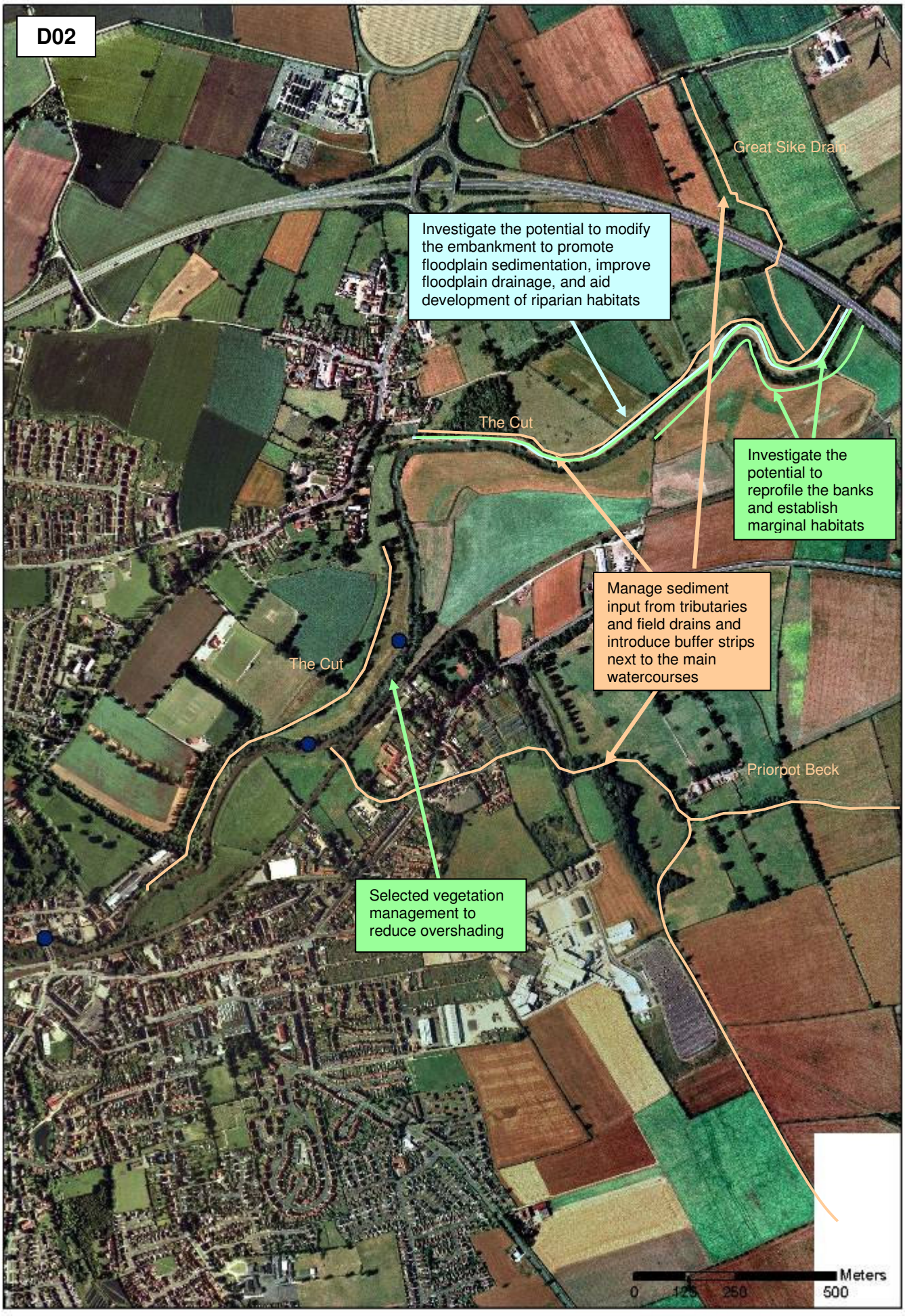
Reach D01 – Rye/Derwent confluence to A64 road bridge

Opportunities for enhancement

The River Derwent follows a sinuous course but has been straightened and deepened by historical dredging for the purposes of flood risk management and land drainage. This has resulted in steep banks and little diversity in channel shape and flow conditions. The river could be enhanced through the reach in places by planting to increase shelter for different species. This could be selective to ensure that the current light availability for aquatic plants is not reduced. The floodplain is already wet in the upper part of the reach and these wet areas could be enhanced to provide good conditions for birds, mammals and vegetation to flourish. Wetland enhancement could either be through reducing the land elevation to increase wetness and/or through consideration of restoring the frequency of floodplain through removal of the embankment. In addition, there are actions that could be taken to contribute to the catchment wide initiative of reducing sediment supply.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from the upper River Derwent and Rye catchments**	Fine sedimentation	The tributaries of the upper River Derwent and Rye catchments drain into the river at the upstream end of this reach. These waters contain a high concentration of suspended sediments. Input from these sources should be managed in order to help reduce the amount of fine sediment that is currently transported by the river. This could potentially be achieved through changes to land use (e.g. the promotion of Entry Level and Higher Level Stewardship), changes to the maintenance regime of each watercourse, and the establishment of buffer strips in areas where sediment supply is at its greatest.
A.1 A.2	**Manage sediment input from tributaries and field drains and establish buffer strips next to the main watercourses**	Fine sedimentation	There is approximately 9.5 km of watercourse draining into reach D01, including West Moor Drain, Rillington Beck and Settrington Beck. Sediment sourced by these drains is transported directly into the river. The maintenance regime of the watercourses that drain into this reach could be reviewed to reduce the quantities of fine sediment supplying the river. This could include reducing the frequency of drain clearance, the encouragement of vegetation growth within the channels and the construction of sediment traps. Riparian buffer strips could also be established along the banks of the major drains that feed into this reach, particularly in areas where sediment supply due to cultivation or trampling by cattle is at its highest.
B.1	**Investigate the potential to modify the East Wykeham embankment to promote floodplain sedimentation and development of riparian habitats**	Fine sedimentation Lack of shelter and shading	The East Wykeham Ings embankment (2 km long and 1.5 m high) could potentially be removed in order to allow more regular inundation of the floodplain removing sediment from the main channel and encouraging wetlands to develop. The Espersykes Farm and Wyse House embankments further downstream could also be considered for lowering or breaching, but these would benefit a smaller area and the benefit may therefore not outweigh the cost. A feasibility study to develop a better understanding of sediment build up and transport in SSSI Units 1 and 2 may also be desirable.
C.1	**Improve marginal, riparian and floodplain habitats through planting**	Lack of shelter and shading	Native trees could be planted along 1 km of the right-hand bank from the Rye confluence to West Moor Drain and along 0.7 km of left-hand bank from 0.2 km upstream of agricultural drain to West Moor Drain. This would provide tree root cover for lamprey in the river itself as well as shelter and rest sites for otters and shading for bullhead.


D02
Great Sike Drain
Investigate the potential to modify the embankment to promote floodplain sedimentation, improve floodplain drainage, and aid development of riparian habitats
The Cut
Investigate the potential to reprofile the banks and establish marginal habitats
Manage sediment input from tributaries and field drains and introduce buffer strips next to the main watercourses
The Cut
Priorpot Beck
Selected vegetation management to reduce overshading
N
Meters
0
250
500

Reach D02 – A64 road bridge to Upstream limit of Malton

Opportunities for enhancement

The river follows a gently meandering course in this reach. Historical dredging works have created a deep, uniform and partially straightened channel. This means that there is very little diversity in the physical structure of the channel, banks which are steep, and as a result there is little marginal habitat. The river could be enhanced reprofiling of the banks in the upper parts of the reach, and planting of suitable species along the banks to create a more varied mixture of open and shaded areas. Modifications to one of the flood embankments could help to reconnect the floodplain and improve riverside habitat. Finally, attempts to limit the input of sediment from tributaries and field drains will contribute to a reduction in fine sedimentation both locally and throughout the whole reach.

Potential restoration measures

Measure		Issues addressed	Description
A.1 **A.2**	**Manage sediment input from tributaries and field drains and introduce buffer strips next to the main watercourses**	Fine sedimentation	Approximately 14.8 km of tributaries and field drains drain into the reach and supply the River Derwent with sediment. These watercourses include Great Sike Drain, Priorpot Beck and The Cut. The maintenance regime of the watercourses that drain into this reach could be reviewed to reduce the amount of fine sediment that is supplied to the river. This could include reducing the frequency of drain clearance, the encouragement of vegetation growth within the channels, and the construction of willow sediment traps. In addition, riparian buffer strips could be created along both banks of the major drains, particularly in areas that are heavily cultivated or grazed
B.1	**Investigate the potential to modify the embankment to promote floodplain sedimentation, improve floodplain drainage, and aid development of riparian habitats**	Fine sedimentation Channelisation Lack of shelter and shading	The riverside embankment upstream of Old Malton (1.3 km long and 1 m high) could potentially be removed in order to allow more regular inundation of the floodplain, removing sediment from the main river and encouraging the development of riparian habitats.
C.1	**Undertake selective vegetation management to prevent overshading**	Lack of shelter and shading	Undertake selective vegetation management (e.g. thinning or removal of selected trees and shrubs) on both banks in the middle of the reach to allow more light to reach the channel and combat the effects of overshading.
C.2	**Investigate the potential to reprofile the banks and establish marginal habitats**	Channelisation Lack of shelter and shading	There is potential to reprofile the steep banks on both sides of the river in the top 1.3 km of this reach. Sections of bank could be reprofiled to give a gentle gradient, particularly in areas where there no tree cover, and additional aquatic plants could be planted. This will improve habitats for marginal plants and invertebrates, and the birds and fish that prey on them.


D03
N
Preserve existing habitat for water crowfoot and other aquatic plant species
Metres
0
50
100

Reach D03 – Upstream limit of Malton to Downstream limit of Malton

Opportunities for enhancement

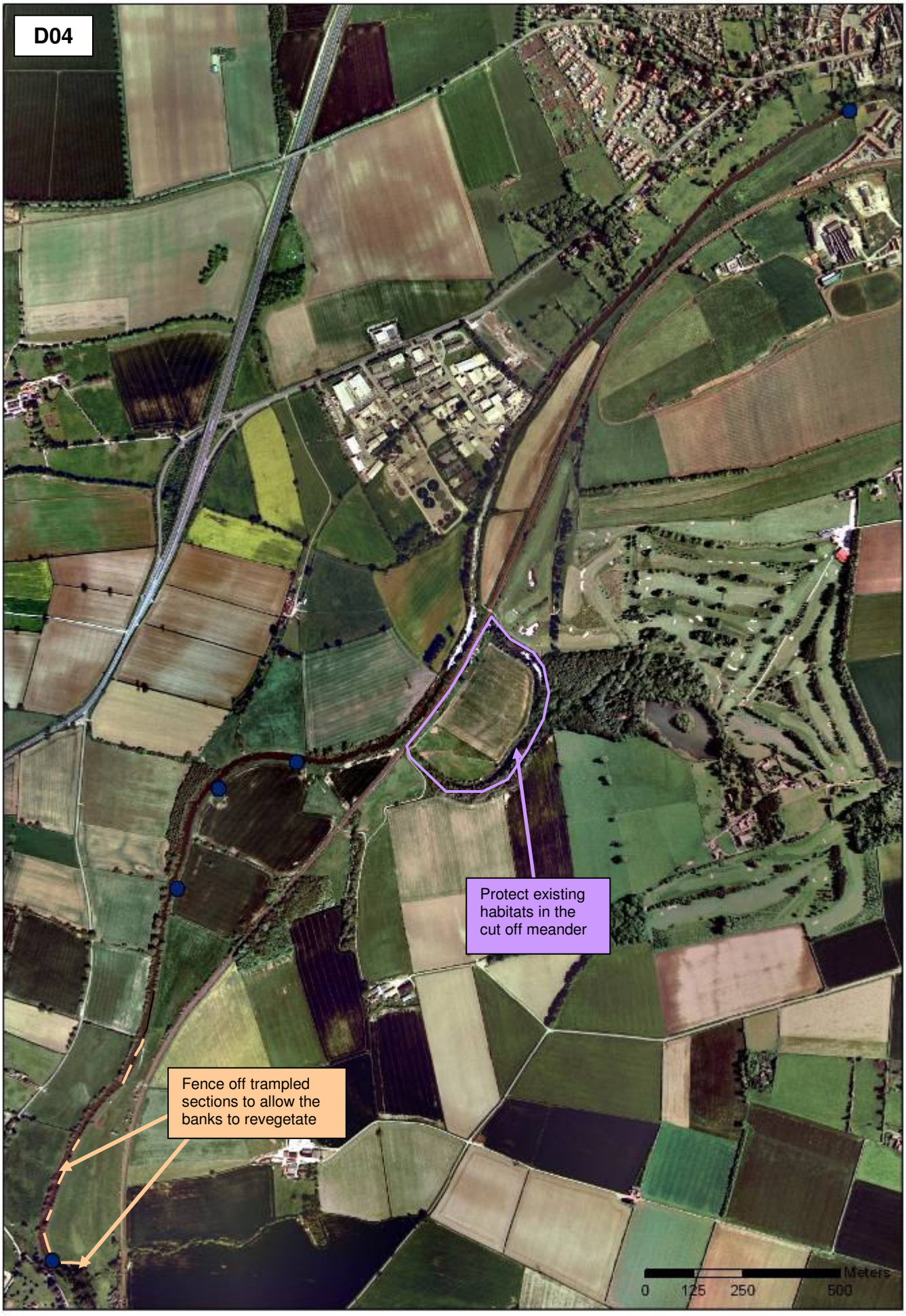
The river is constrained by bank protection as it flows through Malton and Norton. Several surface water outfalls divert runoff from the town directly into the main river. The quality of this water could potentially be improved through the introduction of a Sustainable Urban Drainage System in the town. Mill Beck, a tributary of the River Derwent, flows into the river through an outfall in a protected reach. The urbanised nature of the reach means that there are unlikely to be any significant opportunities to improve the river without compromising the needs of existing riparian land uses. The area has a high risk of flooding and a flood defence scheme was completed in 2002, and there are limited options to improve the river habitats without conflicting with this scheme. However, small areas of more natural banks could potentially be enhanced to improve habitat quality (see photograph). In addition, previous surveys have suggested that the channel around the island at County Bridge provides good habitat for water crowfoot and other plant species, and this should be preserved.

An artificial bank in Norton, showing the Mill Beck outfall

An area with more natural banks in Malton

Potential restoration measures

Measure		Issues addressed	Description
E.1	**Preserve existing habitat for water crowfoot and other aquatic plant species**	Lack of shelter and shading	Previous surveys have shown that the channels around the island at the upstream end of the reach provide good habitat for water crowfoot and other aquatic plants. Although no plants were observed during a recent re-survey, habitats in the reach should benefit if this area was maintained. Gravel habitats downstream of the bridge should also be preserved.


D04
Protect existing habitats in the cut off meander
Fence off trampled sections to allow the banks to revegetate
Meters
0
125
250
500

Reach D04 – Downstream limit of Malton to Upstream limit of Low Hutton

Opportunities for enhancement

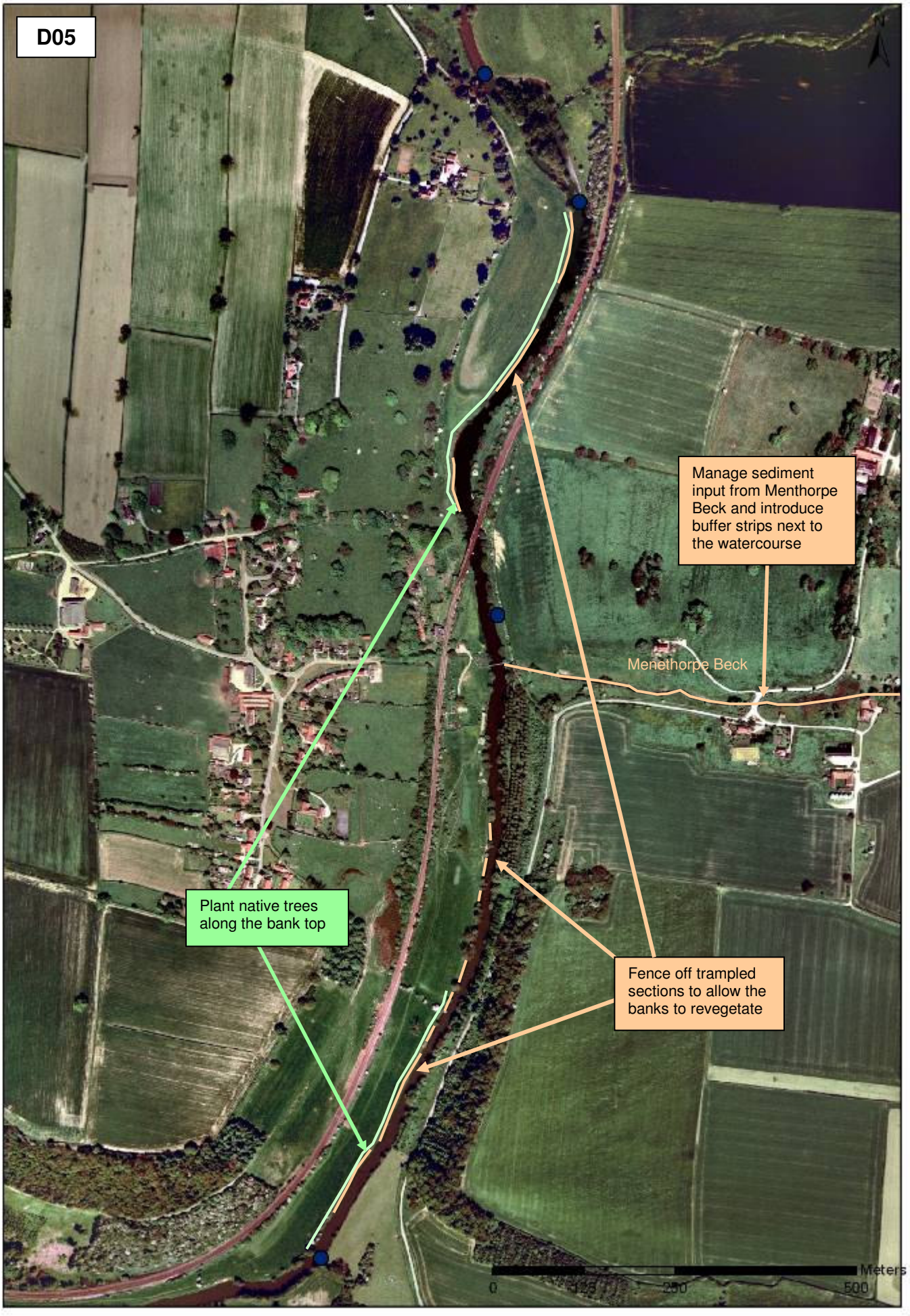
Downstream of Malton, the river resumes a sinuous course. Parts of the channel have been straightened, and the large meander in the middle of the reach was cut off when the railway line was constructed. The banks are generally steep, and have been heavily trampled by cattle at the downstream end of the reach. In places, this has formed shallow areas at the base of the banks, and has allowed marginal plants to colonise the area, resulting in a positive contribution to the SSSI. Allowing controlled trampling along these banks provides the opportunity for banks to be naturally reprofiled. If access to these areas is restricted, the banks could revegetate and new marginal and riparian habitats could develop. The large cut-off meander on the left bank currently provides very high quality habitat for floodplain wetland and aquatic species (see photographs), and should therefore be protected to ensure that it does not deteriorate.

Floodplain habitat in the cut off meander

Freshwater habitat in the cut off meander

Potential restoration measures

Measure		Issues addressed	Description
A.2	**Fence off trampled sections to allow the banks to revegetate**	Shelter and shading Channelisation	Cattle trampling is focussed at the very downstream extent of the reach, immediately upstream of Cherry Islands, for approximately 0.5 km. Individual areas of trampling vary in size between 2 m and 5 m along the bank. If some of these areas were to be temporarily or rotationally fenced off, the banks would revegetate and new riparian and marginal habitats would develop. Access to water for grazing livestock could potentially be maintained through the provision of reinforced access points. Alternatively, areas of the bank could be left unfenced to allow continued access for the cattle. These areas could be rotated periodically, to ensure that the banks do not become too degraded and the positive benefits are realised.
E.1	**Protect existing habitats in the cut off meander**	Shelter and shading Fine sedimentation	The wetland habitat around the cut-off meander should be protected to ensure the continued presence of otter habitat, and maintain greater habitat diversity to benefit SSSI invertebrate and bird populations. In order to retain open water habitats in the cut off, it may be necessary to undertake targeted vegetation management (see Measure C.1 for details). In addition, a flap valve between the river and cut off is stuck open, allowing water to back up into the cut off during high flows. This may need to be repaired to preserve the integrity of the existing habitats.


D05
Manage sediment input from Menthorpe Beck and introduce buffer strips next to the watercourse
Menethorpe Beck
Plant native trees along the bank top
Fence off trampled sections to allow the banks to revegetate
Meters
0
250
500

Reach D05 – Upstream limit of Low Hutton to Howl / Mill Beck

Opportunities for enhancement

The River Derwent follows a relatively straight course in this reach, with uniform channel and flow conditions and a deep bed. This lack of diversity is likely to have been caused by historical dredging for navigation purposes. The right bank of the channel has been affected by cattle trampling, has collapsed in places, and is lacking in bank-top shelter and marginal habitats (see photograph). Himalayan balsam, an alien invasive plant, is extremely prevalent in this reach, particularly on the left bank. The trampling and bank collapse provides a good opportunity to produce a more varied bank profile which supports a wider range of riparian and emergent habitats. These habitats could develop if areas of trampling were fenced off to prevent cattle access and allow them to revegetate. Shelter and shading could also be increased through the planting of trees and other suitable plants on the bank top. In addition, the amount of sediment supplied from Menethorpe Beck could be reduced to contribute towards catchment-wide measures aimed at reducing sediment supply to the main river.

A collapsed section of the right-hand bank along the River Derwent

Potential restoration measures

Measure		Issues addressed	Description
A.1 **A.2**	**Manage sediment input from Menthorpe Beck and introduce buffer strips next to the watercourse**	Fine sedimentation	Menethorpe Beck, which has a length of approximately 37 km, drains into the river in this reach. The maintenance regime of the beck could be reviewed in order to reduce the volume of fine sediment that is supplied to the river. This could include reducing the frequency of drain clearance, encouraging the growth of vegetation in the channel, and constructing sediment traps. Riparian buffer strips could also be established along both banks of the beck, particularly in areas where cultivation or grazing are most intense.
A.2	**Fence off trampled sections to allow the banks to revegetate**	Lack of shelter and shading Channelisation	Trampling occurs on a large proportion of the right bank of the river, and is most heavy in the 0.75 km reach downstream of the railway bridge at Low Hutton. These areas could be temporarily or rotationally (e.g. 5yr) fenced off to allow the banks to revegetate, and new marginal habitats would develop. Where necessary, grazing livestock could be provided with access to drinking water using reinforced access points. Alternatively, trampled areas could be fenced off on a rotational basis. This would ensure that the banks do not become too degraded, whilst maintaining access to the river at points along the reach.
C.1	**Plant native trees along the bank top**	Fine sedimentation	Native trees could be planted on the right bank of the river, especially at the trampled areas downstream of the railway bridge. This would provide tree root cover for lamprey and provide shelter and rest sites for otters and shading for bullhead and other fish species. Sections of the left bank are well vegetated, so planting on the right bank should only occur in areas where there is no cover on the opposite bank.


D06
Howl / Mill Beck
Manage sediment input from the tributaries and introduce buffer strips next to the watercourses
Fence off trampled sections and allow the banks to revegetate
Manage sediment input from Cram Beck and introduce buffer strips next to the watercourse
Undertake selective vegetation management to prevent overshading
Cram Beck
N

Reach D06 – Howl / Mill Beck to End of Kirkham Park Wood

Opportunities for enhancement

The River Derwent follows a meandering course, in which individual reaches have been straightened and channelised due to the construction of a railway line adjacent to the river. As a result, the channel is deep and uniform, and offers little variety in terms of physical habitat and flow conditions. Parts of this reach have been heavily trampled (see photograph), which has allowed the development of good areas of marginal habitat in places. Trampling has helped to reprofile the banks, and has created shallow areas that are ideal for the development of marginal and emergent habitats. The river could be enhanced if these areas were to be fenced off to allow them to revegetate naturally. In addition, the amount of sediment supplied from the tributaries and surrounding land could be reduced to contribute towards catchment-wide measures aimed at reducing the supply of fine sediments. Soils are reported to be particularly erodible, so solutions to reduce sediment supply should be targeted in this reach.

Cattle trampling has partially reprofiled the steep banks

Potential restoration measures

Measure		Issues addressed	Description
A.1 **A.2**	**Manage sediment input from the tributaries and introduce buffer strips next to the watercourses**	Fine sedimentation	Mill Beck, Howl Beck and Cram Beck, which have a combined length of 35.7 km, drain into the River Derwent in this reach. The maintenance regime of these watercourses could be reviewed to reduce the amount of fine sediment that they supply to the river. This could include reducing the frequency of drain clearance, the encouragement of vegetation growth, and the construction of sediment traps in the drains. Riparian buffer strips could be established along both banks of the major tributaries that feed into this reach, particularly in areas where cultivation or stocking densities are particularly intensive. Buffer strips could also be established adjacent to the main river, to reduce the amount of sediment that is supplied through direct runoff when it rains heavily.
A.2	**Fence off trampled sections and allow the banks to revegetate**	Lack of shelter and shading Channelisation	Approximately 1 km of the right bank at the upstream end of the reach, between Howl/Mill Beck and the railway line, has been affected by cattle trampling. Livestock access along this bank could be (temporarily or rotationally) restricted by the provision of fencing, which will allow the banks to revegetate and new habitats to develop. Reinforced access points could be provided along the bank, so that cattle are still able to access drinking water. Alternatively, trampled areas could be fenced off in rotation, which would ensure that the banks do not become too degraded whilst maintaining access to the river at points along the reach.
C.1	**Undertake selective vegetation management to prevent overshading**	Lack of shelter and shading	Undertake selective vegetation management (e.g. thinning or removal of selected trees and shrubs) on both banks at the downstream end of the reach to allow more light to reach the channel and combat the effects of overshading.


D07
N
Investigate the feasibility of removing or modifying Kirkham Weir, modifying the operation of the sluice, or replacing the fish pass
Field drain
Manage sediment input from field drains and erodible soils
Undertake selective vegetation management to prevent overshading
0
125
250

Reach D07 – End of Kirkham Park Wood to End of Howsham Wood

Opportunities for enhancement

The River Derwent flows along two large meanders in this reach. Towards the upstream end of the reach, the channel splits around a small island. Kirkham Weir is located on the right channel and a set of sluices are located on the left channel. The weir is old, is currently in a relatively poor condition, and includes a fish pass that is not suitable for coarse fish and lamprey species (see photograph). The weir creates turbulent flow that cleans fine sediments from the gravels, which has created good habitat for barbel, bullhead and water crowfoot downstream of the structure. Kirkham Sluices are located on the left channel, and currently used to help manage flood risk. The soils in this reach are easily erodible, and work to decrease sediment supply will be beneficial. The reach would also benefit from improved fish passage, either through replacing the fish pass on the weir or changing the way the sluices are operated. The left bank upstream of Kirkham Bridge has excellent marginal habitats, and these should be retained if the banks are reprofiled.

The fish pass at Kirkham Weir, which is currently unsuitable for many fish species

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from field drains and erodible soils**	Fine sedimentation	The soils in this reach are particularly erodible, and supply fine sediments directly into the river and into a field drain. Riparian buffer strips could be established along the banks of the main river and field drain to help reduce sediment supply into the drainage system. In addition, the maintenance regime of the field drain could be reviewed to help reduce the transfer of sediment from the drains into the main river channel. For example, the frequency of drain clearance could be reduced, vegetation could be allowed to grow, and sediment traps could be installed.
C.1	**Undertake selective vegetation management to prevent overshading**	Lack of shelter and shading	Undertake selective vegetation management (e.g. thinning or removal of selected trees and shrubs) on both banks at the downstream end of the reach to allow more light to reach the channel and combat the effects of overshading.
D.1 D.2 D.3 D.4	**Investigate the feasibility of removing or modifying Kirkham Weir, modifying the operation of the sluice, or modifying the fish pass**	In-channel structures	Kirkham Weir causes considerable impoundment upstream, and the SSSI would benefit from removal of the structure. The feasibility of removing the structure should be considered in the first instance. This action may need to be combined with upstream river restoration If removal is found to be unfeasible, options to modify the structure or alter the operation of the adjacent sluices should be explored. If all these options are not feasible, the existing fish pass could be modified or replaced to make it suitable for a greater range of fish species.


D08
N
Braisthwaites Beck
Investigate the potential to remove or modify Howsham Weir
Fence off trampled sections and allow the banks to revegetate
Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses
Leppington Beck
Swallowpits / Evers Beck
Investigate the potential to modify the Bridge End Fields embankment to promote floodplain sedimentation and the development of riparian habitats
0
250
500
1,000
Meters

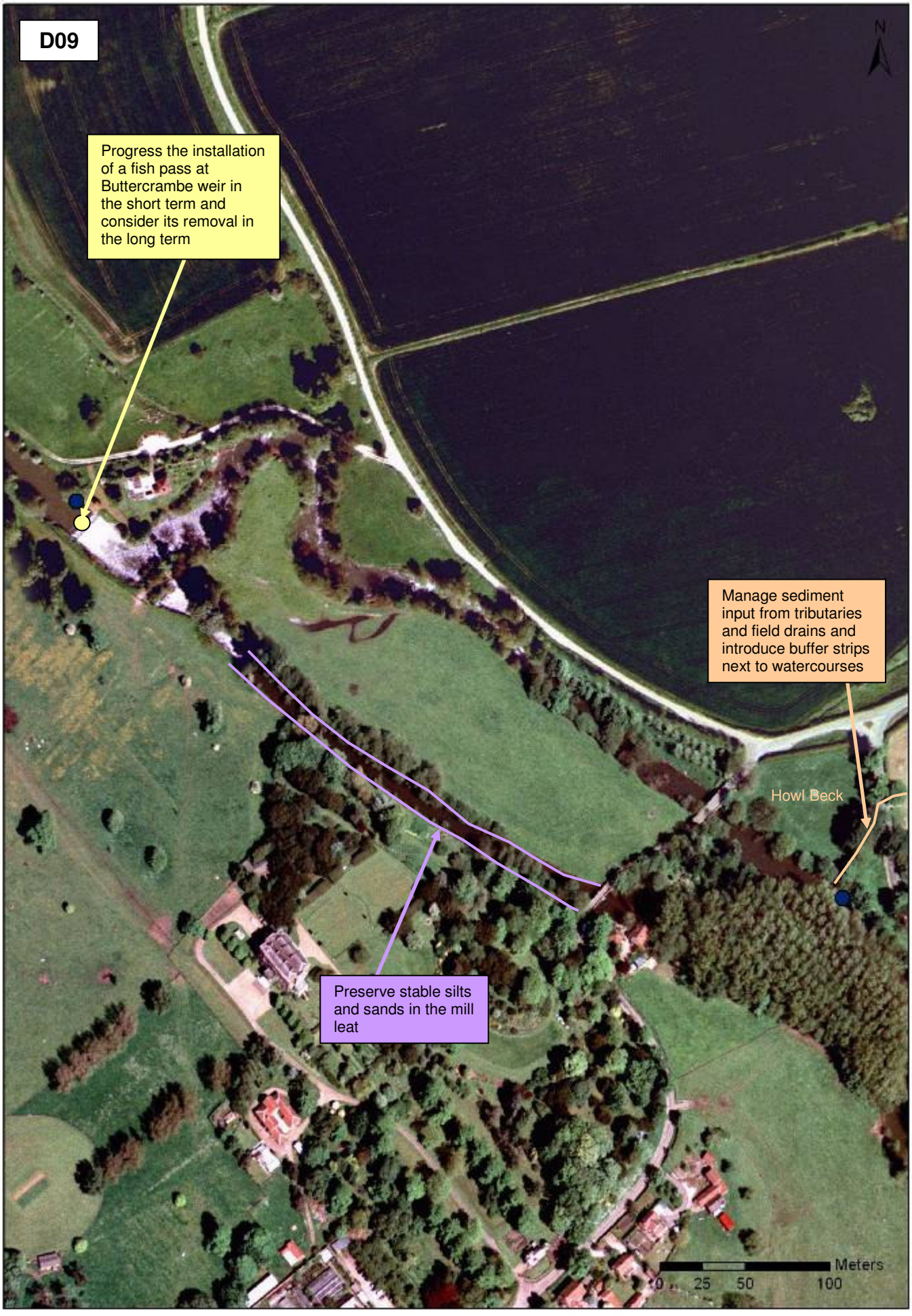
Reach D08 – End of Howsham Wood to Buttercrambe Weir

Opportunities for enhancement

The River Derwent flows along a sequence of meanders in this reach, although parts of the channel at the downstream end appear to have been historically straightened. As a result, much of the channel is deep, with steep banks and little flow diversity. The channel is crossed by Howsham Weir towards the upstream end of the reach. This structure is currently in a relatively poor condition, and incorporates a small turbine for which is used for power generation. It does not include a fish pass, but is passable during normal low flow conditions by most fish species that are found in the river. The weir has created an area of swift, shallow flow that provides good habitat for water crowfoot and fish such as bullhead. Historical trampling has created a stepped bank profile in some areas, improving the habitat value of the banks. Trampling continues to impact on the banks downstream of Howsham Bridge. This reach could be improved if the trampled banks were managed to allow them to revegetate, and floodplain habitats were enhanced through potential changes to the embankments. The supply of sediment from the tributaries and field drains that drain into the channel could be managed.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses**	Fine sedimentation	Approximately 120 km of tributaries and field drains feed into this reach, supplying the River Derwent with large quantities of sediment. These watercourses include Braisthwaites Beck, Leppington Beck, Swallowpit Beck and Evers Beck. The maintenance regime of these watercourses could potentially be reviewed in order to reduce the amount of sediment that the supply to the main river. The frequency of drain clearance could be reduced, plants could be encouraged to grown in the channel and trap sediment, and sediment traps could be installed. There may also be potential to establish riparian buffer strips along the banks of these watercourses, particularly in areas that are most heavily cultivated or grazed. Several lengths of watercourse in this reach currently have buffer strips as they pass through land in Environmental Stewardship. This measure could build on these existing features to extend their influence.
A.2	**Fence off trampled sections and allow the banks to revegetate**	Lack of shelter and shading Fine sedimentation	Trampling in this reach is focussed on the 1 km-long stretch of channel downstream of Howsham Bridge. Discrete areas of the right bank are more heavily trampled, but trampling is more widespread on the left bank. Fencing off (temporarily or on a rotational basis) some of these areas would allow the banks to revegetate, and marginal and riparian habitats for mammals, invertebrates and birds would develop. Any measures undertaken in this reach would need to ensure that cattle are still able to drink from the river. Reinforced access points could be created, or some trampled areas could remain unfenced. These unfenced areas could be periodically rotated to allow the bank to recover.
B.1	**Investigate the potential to modify the Bridge End Fields embankment to promote floodplain sedimentation and the development of riparian habitats**	Fine sedimentation Lack of shelter and shading	The Bridge End Fields embankment (2 km long and 0.5 m high) could potentially be removed to allow more regular inundation of the floodplain. This will remove sediment from the main channel, and could encourage the development of improved habitats on the bank top and floodplain.
D.1 D.2	**Investigate the potential to remove or modify Howsham Weir**	In-channel structures	Howsham Weir causes considerable impoundment upstream, and the SSSI would benefit from removal of the structure. This action may need to be combined with upstream river restoration The feasibility of removing the structure should be considered in the first instance, and subject to the findings of investigations at Kirkham weir and sluice. If removal is found to be unfeasible, options to modify the structure should be explored.


D09
N
Progress the installation of a fish pass at Buttercrambe weir in the short term and consider its removal in the long term
Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses
Howl Beck
Preserve stable silts and sands in the mill leat
Meters
0
25
50
100

Reach D09 – Buttercrambe Weir to End of Buttercrambe Weir reach

Opportunities for enhancement

The river follows a relatively straight course in this reach, although there is a tight meander towards the upstream end. The channel is deep with steep, high banks, and has been straightened in the past. Buttercrambe Weir is located at the upstream end of the reach (see photograph below). The weir is relatively high and is impassable by many fish species during normal flows. Flow downstream of the weir is relatively fast, which has produced good habitats for aquatic plants and spawning fish. The mill leat, which splits off from the main river downstream of the weir, is generally undisturbed and supports good habitat for lamprey that should be protected (see photograph below). The reach could be improved through the provision of a fish pass on Buttercrambe Weir. Also, sediment supply from Howl Beck could be managed to reduce the amount of fine sediment entering the main river.

Buttercrambe Weir

The mill leat downstream of the Buttercrambe Weir

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses**	Fine sedimentation	Howl Beck, which is approximately 6.6 km long, drains into the river in this reach, supplying sediment from the surrounding catchment. The drain was formerly a high quality chalk stream, but siltation has damaged the habitats it contained. The maintenance regime of the beck could be reviewed to reduce the amount of sediment that is supplied to the river in this reach, and measures to retain sediment in the drainage system could be implemented.
D.4 D.1	**Progress the installation of a fish pass at Buttercrambe weir in the short term and consider its removal in the long term**	In-channel structures	In the short term, removal of Buttercrambe weir, which has an important flow gauging function is not feasible. The structure does not currently incorporate a fish pass, and it is too high for many fish species to pass upstream in most flow conditions (particularly lamprey). The installation of a fish pass at Buttercrambe Gauging Station should therefore be progressed in the short term to improve fish passage. In the long term, at the end of the life span of the structure, it is recommended that options to remove the weir and replace it with a hydro-acoustic flow gauge are considered.
E.1	**Preserve stable silts and sands in the mill leat**	Lack of shelter and shading	The mill leat downstream of Buttercrambe Weir is sheltered from high flows, and therefore contains a large amount of stable fine sediments. These sediments provide excellent habitat for young lamprey, which may remain in this area for several years until they are ready to migrate to the sea. These undisturbed sediments should, if possible, be retained to ensure that this habitat remains in place, at least until such time as the weir is removed.


D10
N
Fence off trampled sections and allow banks to revegetate
Ran Beck
Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses
Barlam Beck
Flawith Beck
125
250
500

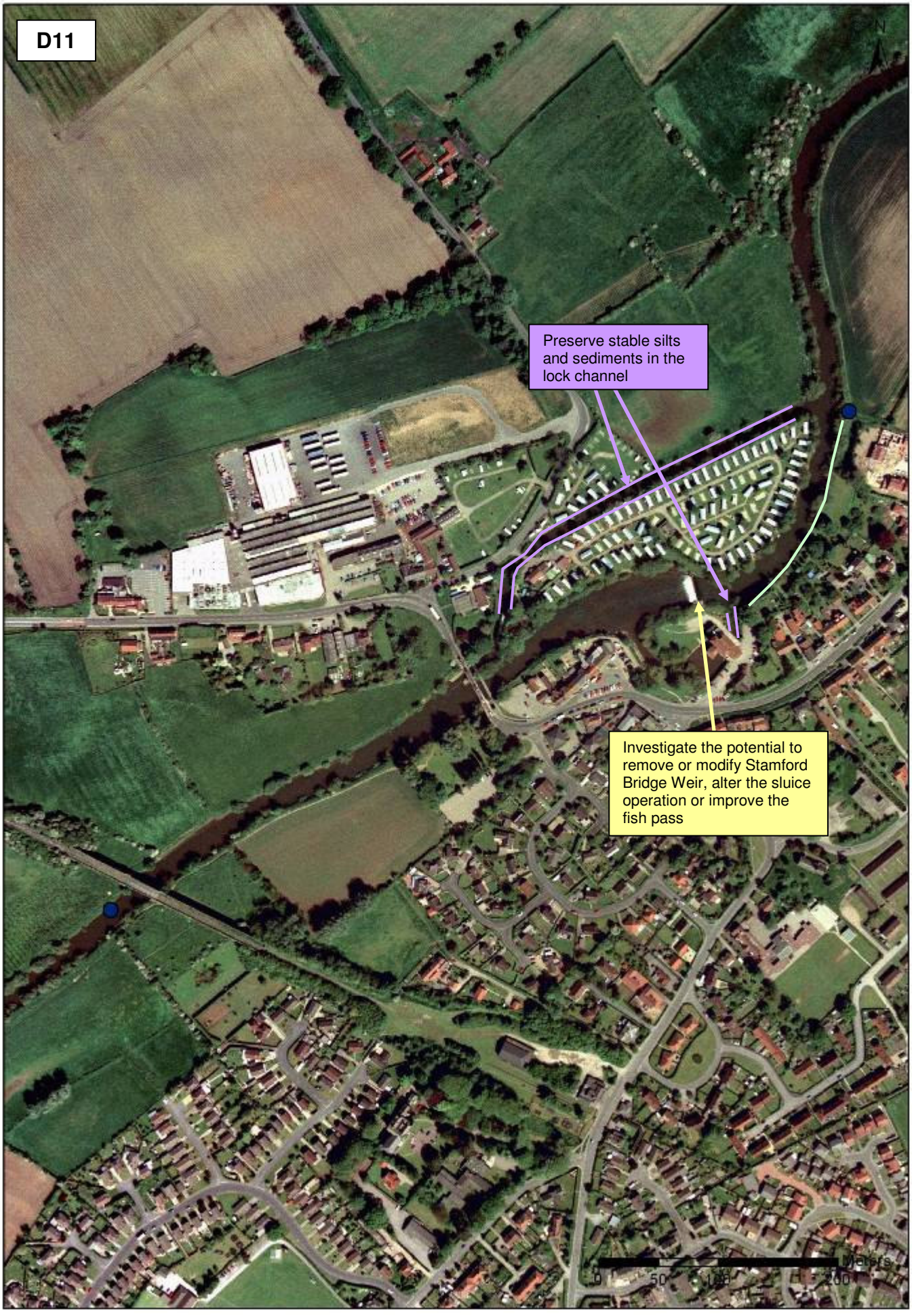
Reach D10 – End of Buttercrambe Weir reach to Upstream limit of Stamford Bridge

Opportunities for enhancement

In this reach, the River Derwent flows through a series of small meanders. Large sections have been deepened and straightened historically, creating a uniform channel with steep banks and very little flow diversity. The steep banks at the upstream end of the reach have been heavily trampled in places. Wetland habitats have formed on the low floodplain on the inside of the major meander bends. Four major tributaries enter the main river, suggesting that sediment supply in this reach is high. This reach could be improved by the management of sediment input from the tributaries, and the improvement of the river banks.

Potential restoration measures

Measure		Issues addressed	Description
A.1 **A.2**	**Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses**	Fine sedimentation	Approximately 46 km of watercourse drain into this reach, including Ran Beck, Barlam Beck, and Flawith Beck. Together, these supply large quantities of sediment to the River Derwent. The maintenance regime of the watercourses could be reviewed in order to reduce the quantities of sediment that are supplied to the river, and steps could be taken to reduce the amount of sediment that is transferred into the main channel. Riparian buffer strips could also be established along both banks of the watercourses, particularly in areas where sediment supply from ploughing or livestock trampling is at its highest.
A.2	**Fence off trampled sections and allow banks to revegetate**	Lack of shelter and shading Fine sedimentation	In this reach, trampling occurs along the left-hand bank for approximately 1 km upstream of Barlam Beck. Marginal vegetation is beginning to establish in places. This process could be enhanced if areas of heavy trampling were to be fenced off and allowed to revegetate. Access to water for grazing livestock can be maintained through the provision of fixed drinking points, or by leaving parts of the bank unfenced on a rotational basis.


D11
N
Preserve stable silts and sediments in the lock channel
Investigate the potential to remove or modify Stamford Bridge Weir, alter the sluice operation or improve the fish pass
0
50
100
200
Metres

Reach D11 – Upstream limit of Stamford Bridge to Downstream limit of Stamford Bridge

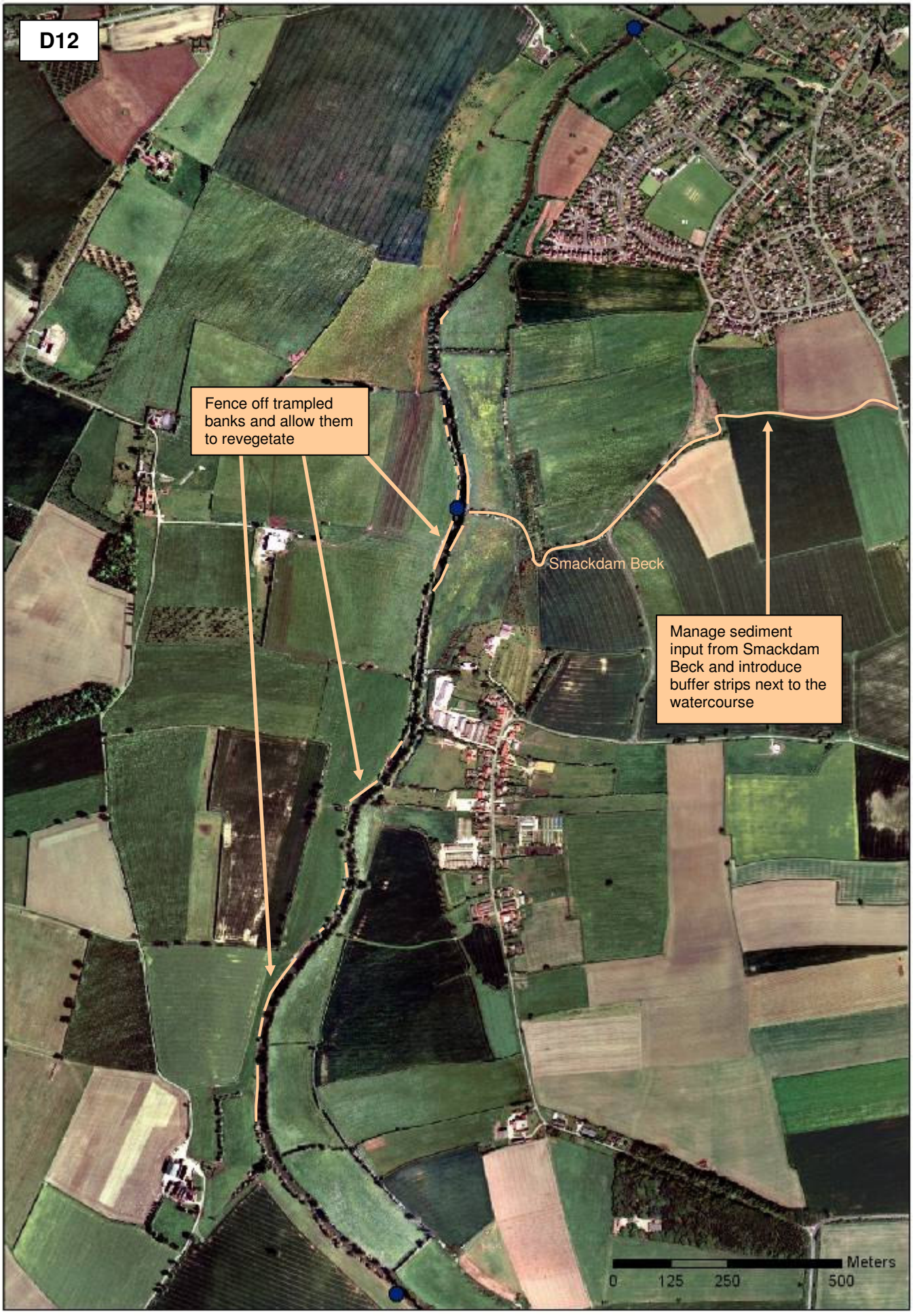
Opportunities for enhancement

The River Derwent follows a slightly meandering course in this reach, and is constrained by the urban area of Stamford Bridge on both banks. The channel been historically straightened and deepened, and as a result has steep banks with concrete reinforcement. The channel is crossed by Stamford Bridge Weir, which adds some flow diversity to a short stretch of the channel. The weir incorporates a fish pass that generally works well, although fish can sometimes be reluctant to use it. The weir is bypassed by a lock channel (see photograph) that supports good nursery habitat for lamprey, which should be preserved. There is a sluice (guillotine gate) in the old navigation cut. The river could be enhanced through minor improvements to the fish pass. In addition, there may be potential to limit sediment input from the town.

Stamford Bridge lock channel

Potential restoration measures

Measure		Issues addressed	Description
D.1 D.4	**Investigate the potential to remove or modify Stamford Bridge Weir, alter the sluice operation or improve the fish pass**	In-channel structures	Stamford Bridge Weir causes considerable impoundment upstream, and the SSSI would benefit from removal of the structure. The feasibility of removing the structure should be considered in the first instance. If removal is found to be unfeasible, options to modify the structure or alter the operation of the adjacent sluice should be explored. If all these options are not feasible, the existing fish pass could be modified slightly to make it easier for fish to use.
E.1	**Preserve stable silts and sediments in the lock channel**	Lack of shelter and shading	Although it is currently used, the lock channel that bypasses Stamford Bridge Weir contains relatively stable silts and sands that provide good nursery habitat for lamprey. These sediments should be preserved to ensure that this habitat remains in place. However, this should not compromise actions to remove the weir, which will create improved in-channel habitats for all SSSI and SAC species.


D12
Fence off trampled banks and allow them to revegetate
Smackdam Beck
Manage sediment input from Smackdam Beck and introduce buffer strips next to the watercourse
Meters
0
125
250
500

Reach D12 – Downstream limit of Stamford Bridge to Downstream border of Low Catton

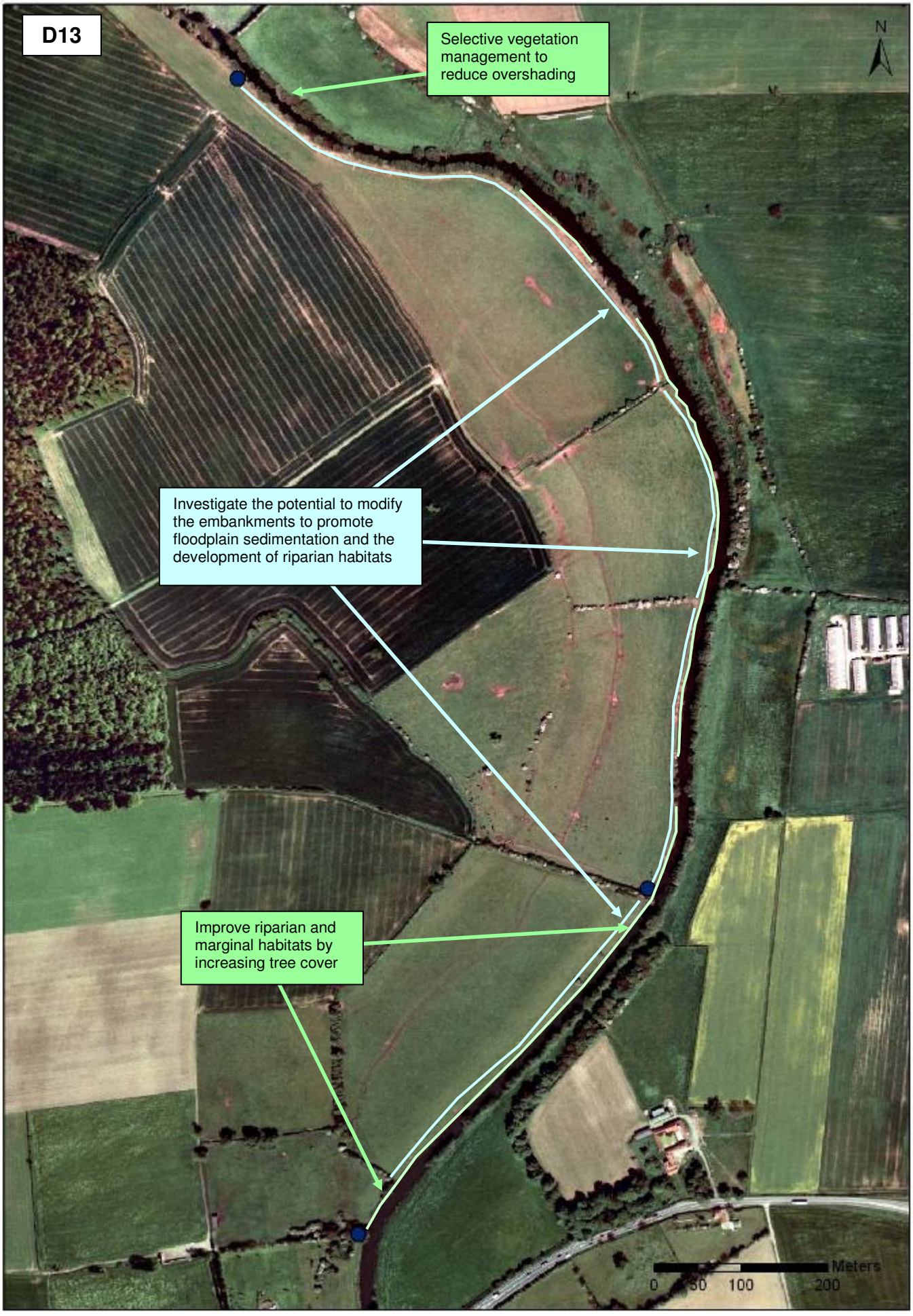
Opportunities for enhancement

The River Derwent follows a relatively straight course, and has been subject to historical channelisation and dredging. As a result, the channel is deep and uniform, with steep banks and little flow diversity. Large sections of the bank have been subject to cattle trampling (see photographs), which has created a shallower bank profile and allowed marginal habitats to develop in places. Smackdam Beck, a small tributary, joins the channel and supplies sediment from the wider catchment into the main river. This reach could be improved if sediment input from the beck were to be managed, and if existing trampling was used as a basis to improve the variety of habitats that the banks provide.

Heavy trampling along the left bank of the River Derwent

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from Smackdam Beck and introduce buffer strips next to the watercourse**	Fine sedimentation	Smackdam Beck, which has a length of approximately 5.8 km, drains into this reach and supplies the River Derwent with sediment. The maintenance regime of the beck could be reviewed in order to reduce the amount of sediment that reaches the main river. Suitable solutions in this reach could include reducing the frequency of drain clearance, trapping sediment in the tributary by encouraging vegetation growth or constructing willow sediment traps. Riparian buffer strips could also be established along both banks of the beck, particularly in heavily ploughed or grazed areas.
A.2	**Fence off trampled banks and allow them to revegetate**	Lack of shelter and shading Fine sedimentation	Trampling by livestock occurs along the right-hand bank opposite Low Catton for approximately 1.5 km. On the left bank, livestock trampling occurs from the edge of Stamford Bridge for approximately 1 km to just upstream of Low Catton. Although marginal habitats have begun to develop in some places, additional areas of trampling (temporarily or on a rotational basis) could be fenced off to allow the banks to revegetate more quickly. Access to water for grazing livestock can be maintained by leaving parts of the bank unfenced on a rotational basis, or by constructing reinforced drinking points at intervals along the banks.


D13
Selective vegetation management to reduce overshading
N
Investigate the potential to modify the embankments to promote floodplain sedimentation and the development of riparian habitats
Improve riparian and marginal habitats by increasing tree cover
Meters
0
50
100
200

Reach D13 – Downstream border of Low Catton to Upstream limit of Kexby

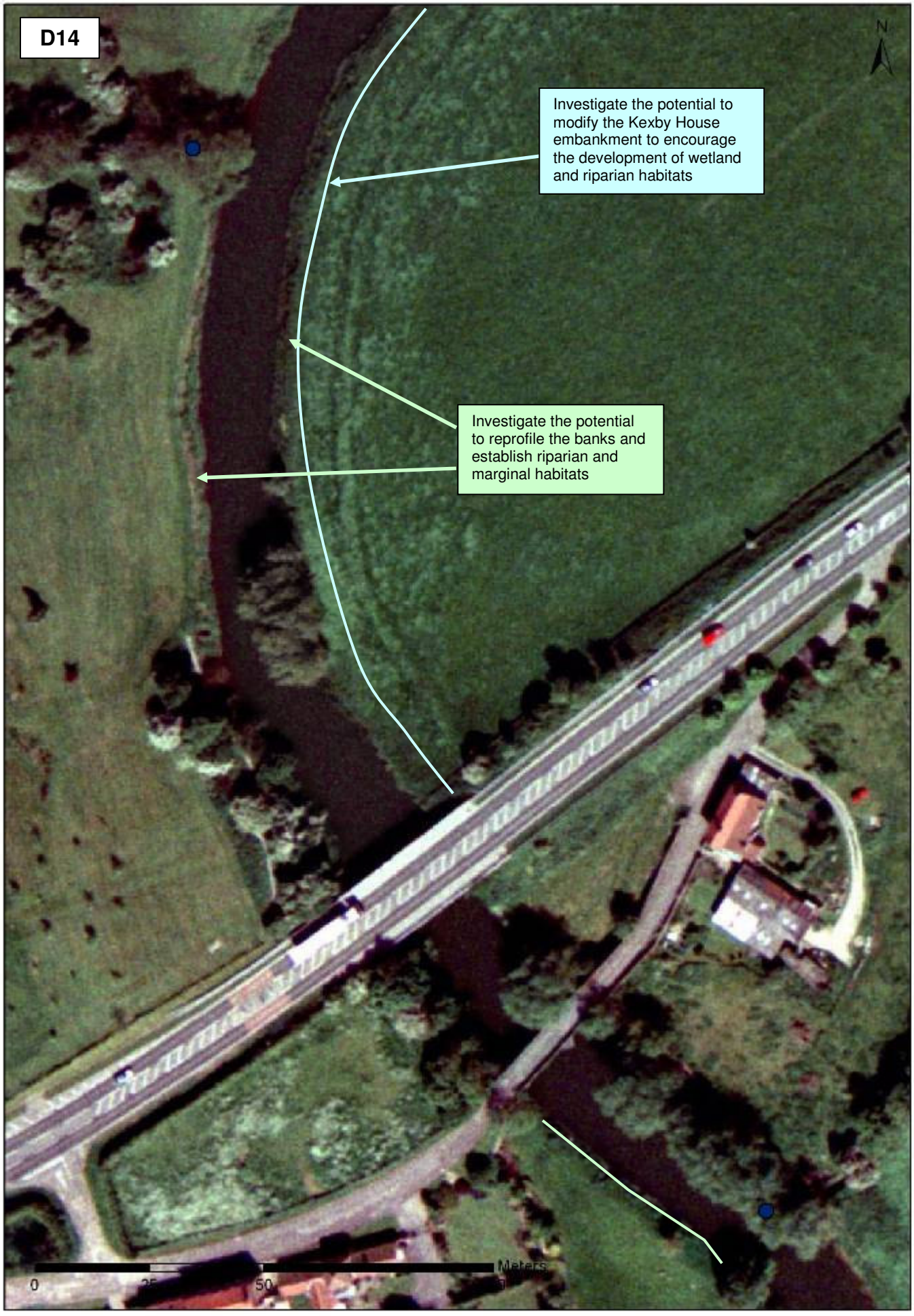
Opportunities for enhancement

This reach is located on a gentle meander that has been deepened and straightened by historical dredging. The left bank of the river is very close to the valley edge along the majority of the reach, and a series of low flood embankments have been constructed in front of the lower ground on the right bank. The embankments were constructed directly on top of the bank, and as a result there are very few shrubs and trees and the bank is exposed (see photograph). In this reach, the river could potentially be enhanced through selective planting to increase shelter and shading on the right bank. There may also be potential to remove or breach the embankments on the right bank to improve the bank and floodplain habitats, and allow sediment to be stored on the floodplain.

Much of the right-hand bank is exposed and lacking in bankside vegetation cover

Potential restoration measures

Measure		Issues addressed	Description
B.1	**Investigate the potential to modify the embankments to promote floodplain sedimentation and the development of riparian habitats**	Fine sedimentation Lack of shelter and shading	The embankments in this reach, which are separated by field drains, have a total length of 2.1 km and a maximum height of 0.5 m. These structures could potentially be removed to allow more regular inundation of the floodplain, which would help to improve sediment from the channel. Removal of the embankment would also encourage the development of wetland habitats on the floodplain, and provide the opportunity for bank-top habitats to develop.
C.1	**Improve riparian and marginal habitats by increasing tree cover**	Lack of shelter and shading	Native trees could be planted along exposed parts of the right bank. This would provide tree root cover in the channel for fish species and bankside shelter for otters and other mammals and birds. Planting could be used to create areas of shelter along the channel, whilst preventing the river becoming overshaded.
C.1	**Undertake selective vegetation management to prevent overshading**	Lack of shelter and shading	Undertake selective vegetation management (e.g. thinning or removal of selected trees and shrubs) on both banks at the upstream end of the reach to allow more light to reach the channel and combat the effects of overshading.


D14
N
Investigate the potential to modify the Kexby House embankment to encourage the development of wetland and riparian habitats
Investigate the potential to reprofile the banks and establish riparian and marginal habitats
0
50
Meters

Reach D14 – Upstream limit of Kexby to Downstream limit of Kexby

Opportunities for enhancement

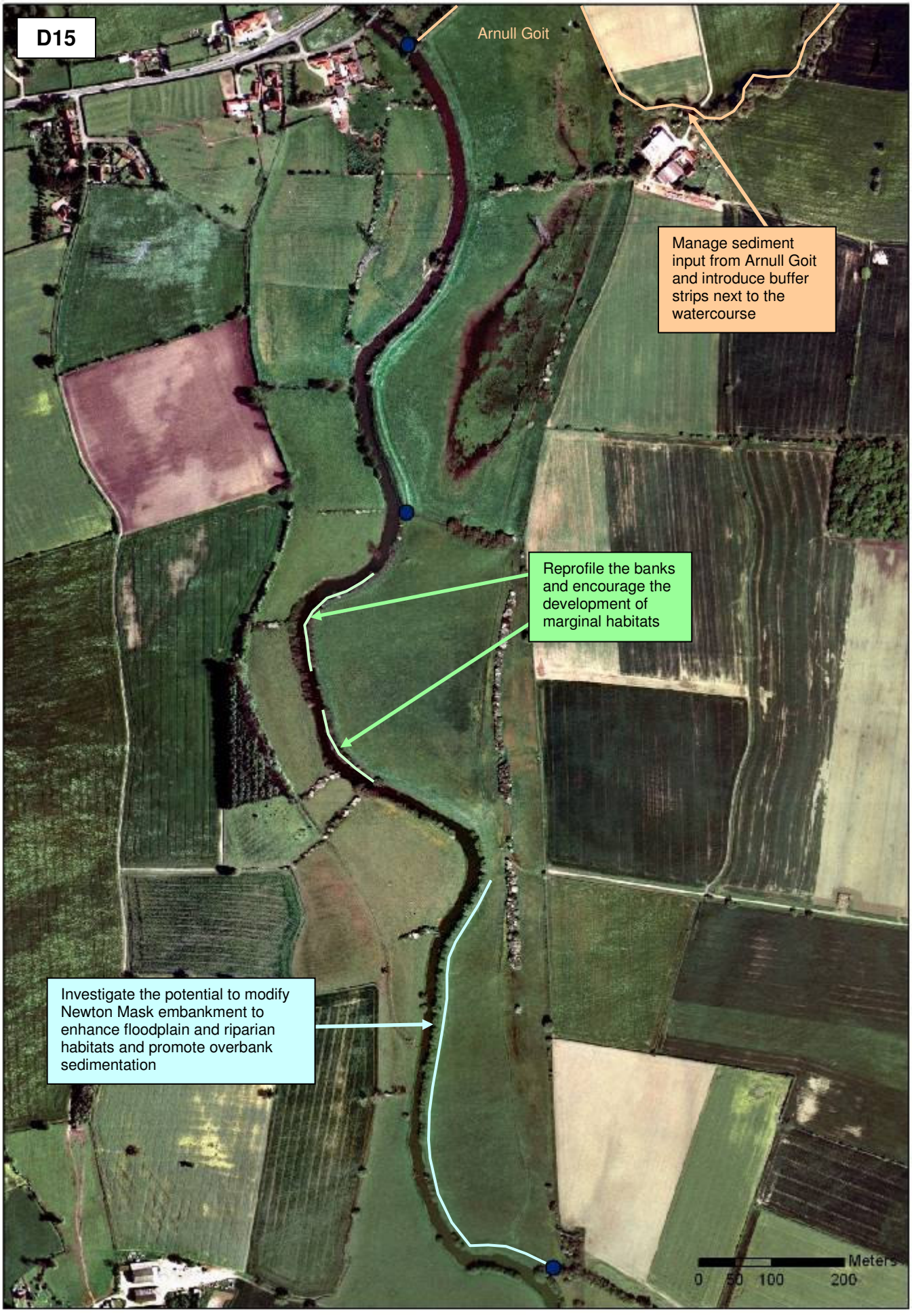
This reach is located on a meander bend that has been historically deepened to increase the capacity of the channel. As a result, the river is very deep, with steep banks and uniform flow conditions. An embankment is located on top of the left bank, and the channel is crossed by two road bridges. Large parts of the banks are exposed, although there is some tree cover, particularly adjacent to the road bridge (see photographs). This reach could be improved through the reprofiling of the steep banks, which would allow marginal and riparian habitats to develop. It may also be possible to remove the Kexby House embankment, and create an area of wetland in the low, wet ground behind it.

The banks are generally steep, and do not provide the opportunity for marginal habitats to develop

The A1079 road bridge, showing some tree cover

Potential restoration measures

Measure		Issues addressed	Description
B.1	**Investigate the potential to modify the Kexby House embankment to encourage the development of wetland and riparian habitats**	Fine sedimentation Lack of shelter and shading	The Kexby House embankment is located on the left bank of the river, immediately upstream of the A1079 trunk road. The embankment is 0.4 km long, and is 0.7 m high. The embankment could potentially be removed to allow improved bank habitats to develop, and for a wetland area to become established on the floodplain, which is frequently wet.
C.1 **C.2**	**Investigate the potential to reprofile the banks and establish riparian and marginal habitats**	Lack of shelter and shading Channelisation	The banks in this reach are relatively steep, and have limited potential for the establishment of marginal habitats. With the exception of areas where mature trees are present, the banks upstream of the road bridge could potentially be reprofiled. Low benches and shallow areas could be created at the base of the banks, which would allow marginal and emergent habitats for plants, mammals, insects and birds to develop along the reach. More trees could be planted to provide shelter and shading in exposed areas, particularly on the left bank upstream of the bridge. This option is only likely to be feasible if combined with the removal or modification of the flood embankment.


D15
Arnull Goit
Manage sediment input from Arnull Goit and introduce buffer strips next to the watercourse
Reprofile the banks and encourage the development of marginal habitats
Investigate the potential to modify Newton Mask embankment to enhance floodplain and riparian habitats and promote overbank sedimentation
Meters
0
50
100
200

Reach D15 – Downstream limit of Kexby to Upstream of Sutton Wood

Opportunities for enhancement

The River Derwent follows a gently meandering course in this reach. The channel has been deepened to increase its capacity, resulting in a deep, uniform channel with little diversity and steep banks. Parts of the banks, particularly on the outside of the meanders, are topped by riparian trees. The left bank is topped by some embankments which limit the growth of riparian vegetation, leaving parts of the reach exposed (see photograph). Some of the area behind these embankments consists of Newton Mask SSSI, part of the Lower Derwent Valley SA and SPA. This reach could be improved through targeted works on the banks to create more varied habitats and the development of bank-top tree cover. This could potentially be combined with modifications to the embankments, which could help to improve bank and floodplain habitats and remove sediment from the channel. In addition, actions as part of a catchment-wide initiative to reduce sediment supply from tributaries and field drains could be taken in this reach.

The embankment on the left-hand bank of the river

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from Arnull Goit and introduce buffer strips next to the watercourse**	Fine sedimentation	The maintenance regime of Arnull Goit should be reviewed in order to reduce fine sediment input to the system. This should aim to retain more sediment within the watercourse, and could include reducing the frequency of drain clearance and encouraging vegetation growth. Riparian buffer strips could also be established along both banks of the watercourse to help reduce sediment supply
B.1	**Investigate the potential to modify Newton Mask embankments to enhance floodplain and riparian habitats and promote overbank sedimentation**	Lack of shelter and shading Fine sedimentation	The Newton Mask embankment, which is 0.65 km long and with a height of 1.2 m, could potentially be removed to increase the frequency of overbank flooding and allow riparian vegetation cover to develop. Modifications would allow the natural removal of sediment from the main river channel. However, any proposed works undertaken at this site will need to consider the potential impact on the Newton Mask SSSI and also the Lower Derwent Valley SAC and SPA, which is located behind the embankment. Newton Mask SSSI supports lowland hay meadow and most of the site is unfavourable due to recent wet summers. Proposed works would also need to take account of Low Catton Ings which is known to support wading birds.
C.1 C.2	**Reprofile the banks and encourage the development of marginal habitats**	Lack of shelter and shading Channelisation	Parts of the steep banks on the left of the channel could be reprofiled to reduce their gradient and aquatic ledges could be created at the base of the bank. This would produce areas for marginal and emergent plants to colonise the area by the edge of the channel, and create improved habitats for mammals, invertebrates and birds. This option would be most effective if combined with measures to alter the embankments.


D16
N
Enhance riparian habitats through tree planting
Meters
0 50 100 200

Reach D16 – Upstream of Sutton Wood to Upstream limit of Elvington

Opportunities for enhancement

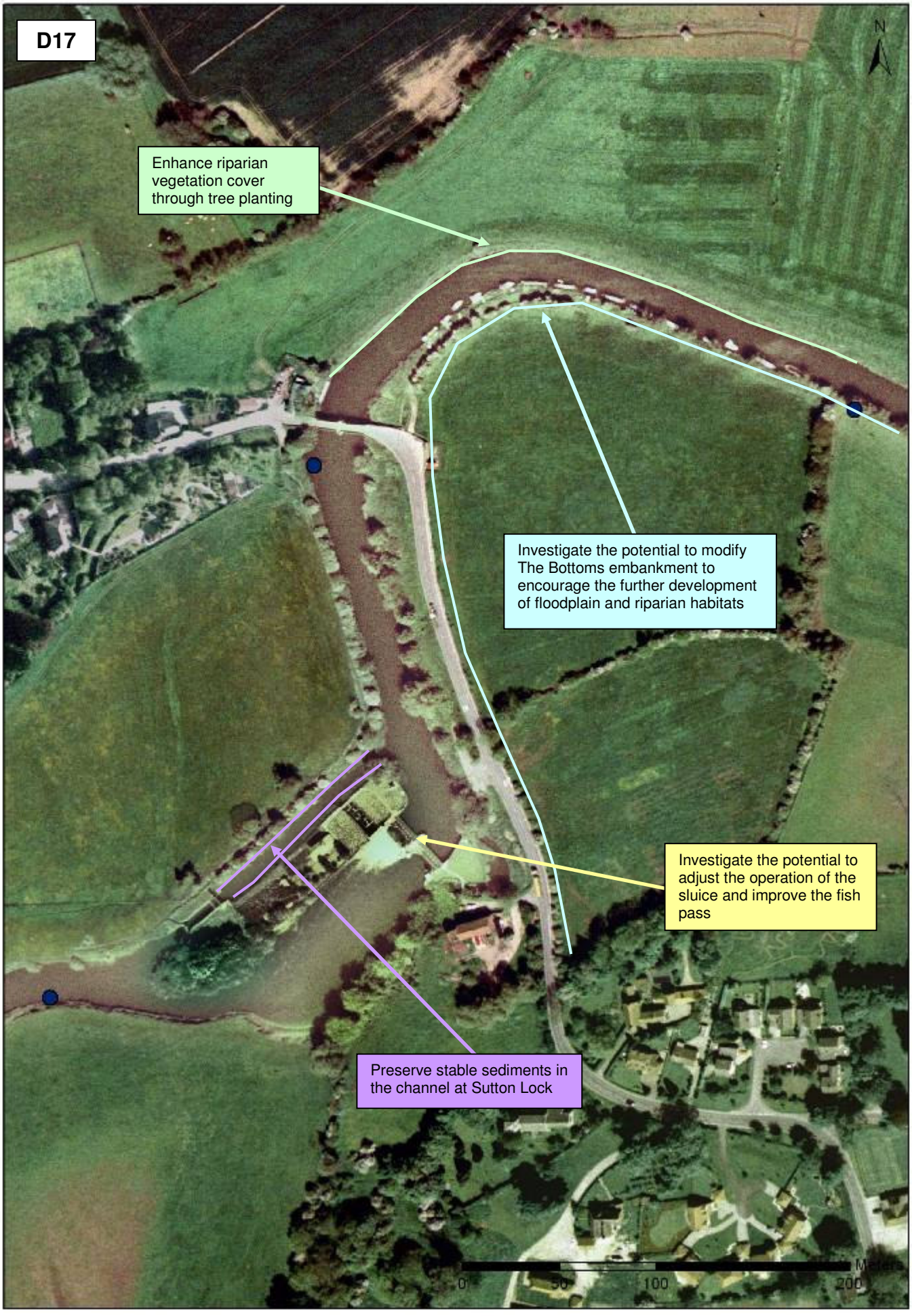
This reach is comprised of several large meanders. The channel has been deepened, resulting in uniform flow conditions and steep banks. Cattle trampling and bank collapse have helped to reduce the gradient of the banks in places, which is encouraging the development of marginal habitats. Although parts of the bank are tree lined, large areas have very little tree cover and do not support any significant riparian habitats (see photograph). Elvington Water Treatment Works is located in this reach, abstracting water from the River Derwent (see photograph). This reach could be enhanced through increasing tree cover on the exposed banks, although existing planting will need to be taken into account to avoid the possibility of overshading.

The banks downstream of the water treatment works, which have very little tree cover

The intake at Elvington Water Treatment Works

Potential restoration measures

Measure		Issues addressed	Description
C.1	**Enhance riparian habitats through tree planting**	Lack of shelter and shading	Large areas of the banks in this reach have very little cover, particularly on the right bank downstream of the water treatment works. These banks have a length of approximately 0.8 km, and could be enhanced through the targeted planting of native trees and shrubs. This would provide in-channel cover for lamprey and other fish species, and provide bankside shelter for mammals and birds. Planting would need to be undertaken carefully, to ensure that the channel does not become overshaded.


D17
N
Enhance riparian vegetation cover through tree planting
Investigate the potential to modify The Bottoms embankment to encourage the further development of floodplain and riparian habitats
Investigate the potential to adjust the operation of the sluice and improve the fish pass
Preserve stable sediments in the channel at Sutton Lock
0
50
100
200
Metres

Reach D17 – Upstream limit of Elvington to Downstream limit of Elvington

Opportunities for enhancement

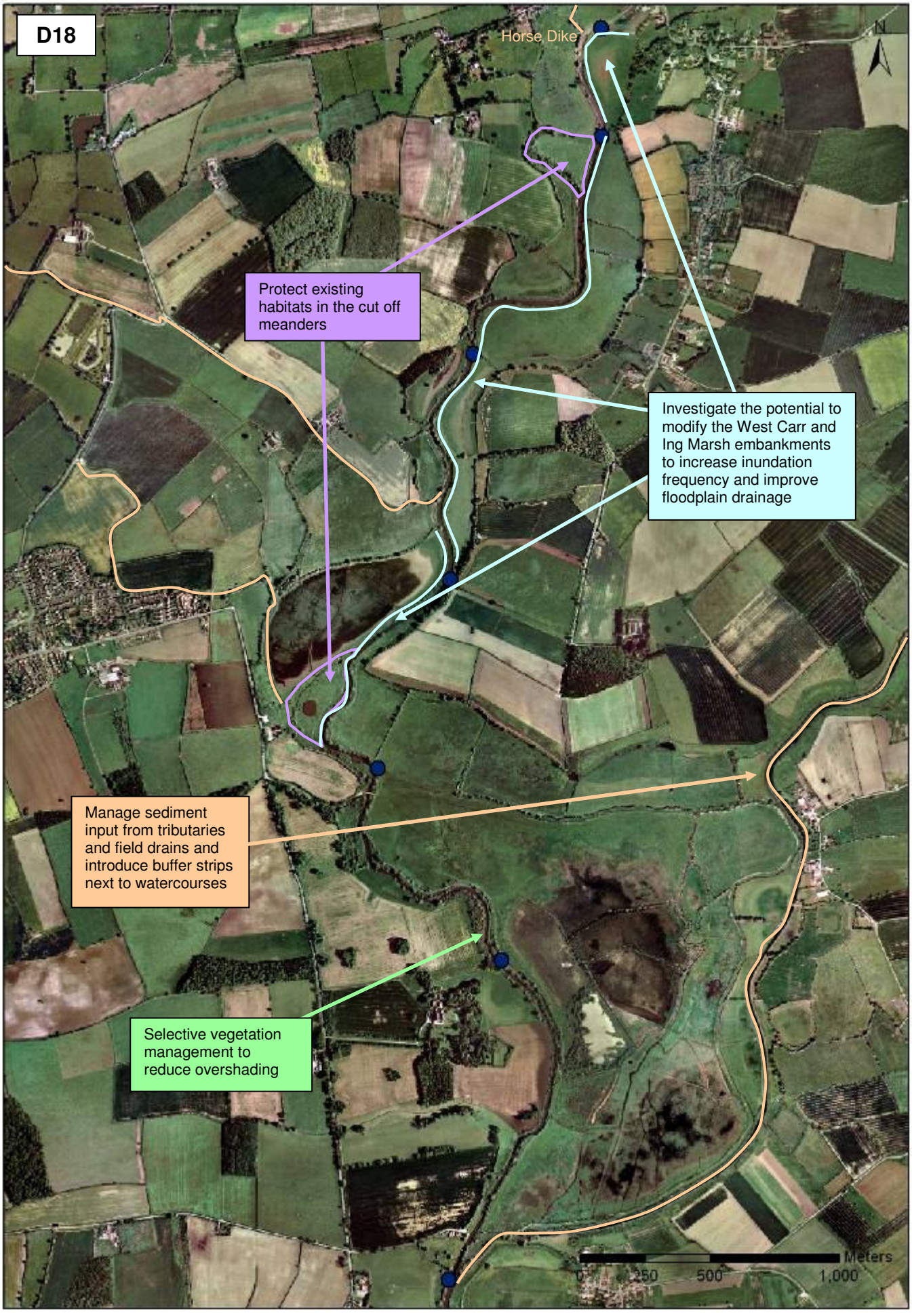
The River Derwent flows through two relatively tight meanders in this reach. This reach includes two major structures: Elvington Sluice and Sutton Lock. Elvington Sluice is located on the main channel, and consists of two counter-balanced steel gates which are operated to maintain water levels for abstraction at the water treatment works upstream (see photograph). This structure includes a working fish pass. Sutton Lock is located on the bypass channel, and allows boat passage upstream of the sluices. The channel contains relatively undisturbed sediments that provide excellent habitat for lamprey (see photograph). Parts of the river banks are very exposed, and could be enhanced through tree planting. In addition, it may be possible to remove the embankment at the upstream end of the reach to allow the further development of wetland habitats on the floodplain.

One of the gates at Elvington Sluice

The channel at Sutton Lock, which provides good nursery habitat for lamprey

Potential restoration measures

Measure		Issues addressed	Description
B.1	**Investigate the potential to modify The Bottoms embankment to encourage the further development of floodplain and riparian habitats**	Lack of shelter and shading Fine sedimentation	The Bottoms is an area of low-lying ground upstream of Elvington, fronted by a 0.9 km-long embankment. The embankment could potentially be removed to increase the frequency of overbank flooding. This would encourage wetland habitats to develop on the floodplain, and allow sediment to be removed from the main river. In addition, removal of the embankments could help to encourage the development of improved riparian habitats.
C.1	**Enhance riparian vegetation cover through tree planting**	Lack of shelter and shading	The right bank upstream of Sutton Bridge is very exposed. The bank could be enhanced through the targeted planting of native trees, which would provide in-channel shelter and shading for fish and bank-top cover for mammals, invertebrates and birds. Planting would need to be undertaken carefully, in order to ensure that the channel does not become overshaded.
D.3 **D.4**	**Investigate the potential to adjust the operation of the sluice and improve the fish pass**	In-channel structures	Elvington sluice has an important strategic water level control function in maintaining water levels to allow continuous abstraction for public water supply. It is therefore not possible to remove the structure. However, it may be possible to alter its operating protocol to reduce impoundment. The opportunity to modify the operating protocol of the sluice gates and make small improvements to the entrance and exit of the fish pass should therefore be investigated.
E.1	**Preserve stable sediments in the channel at Sutton Lock**	Lack of shelter and shading	The channel at Sutton Lock contains relatively stable fine sediments that provide excellent nursery habitat for lamprey. The current maintenance regime of the channel should be retained, to ensure that these sediments are preserved in the lock channel. However, these should not be preserved at the expense of creating larger areas of valuable habitat by altering the operating protocol of the sluice.


D18
Horse Dike
N
Protect existing habitats in the cut off meanders
Investigate the potential to modify the West Carr and Ing Marsh embankments to increase inundation frequency and improve floodplain drainage
Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses
Selective vegetation management to reduce overshading
0
250
500
1,000
Meters

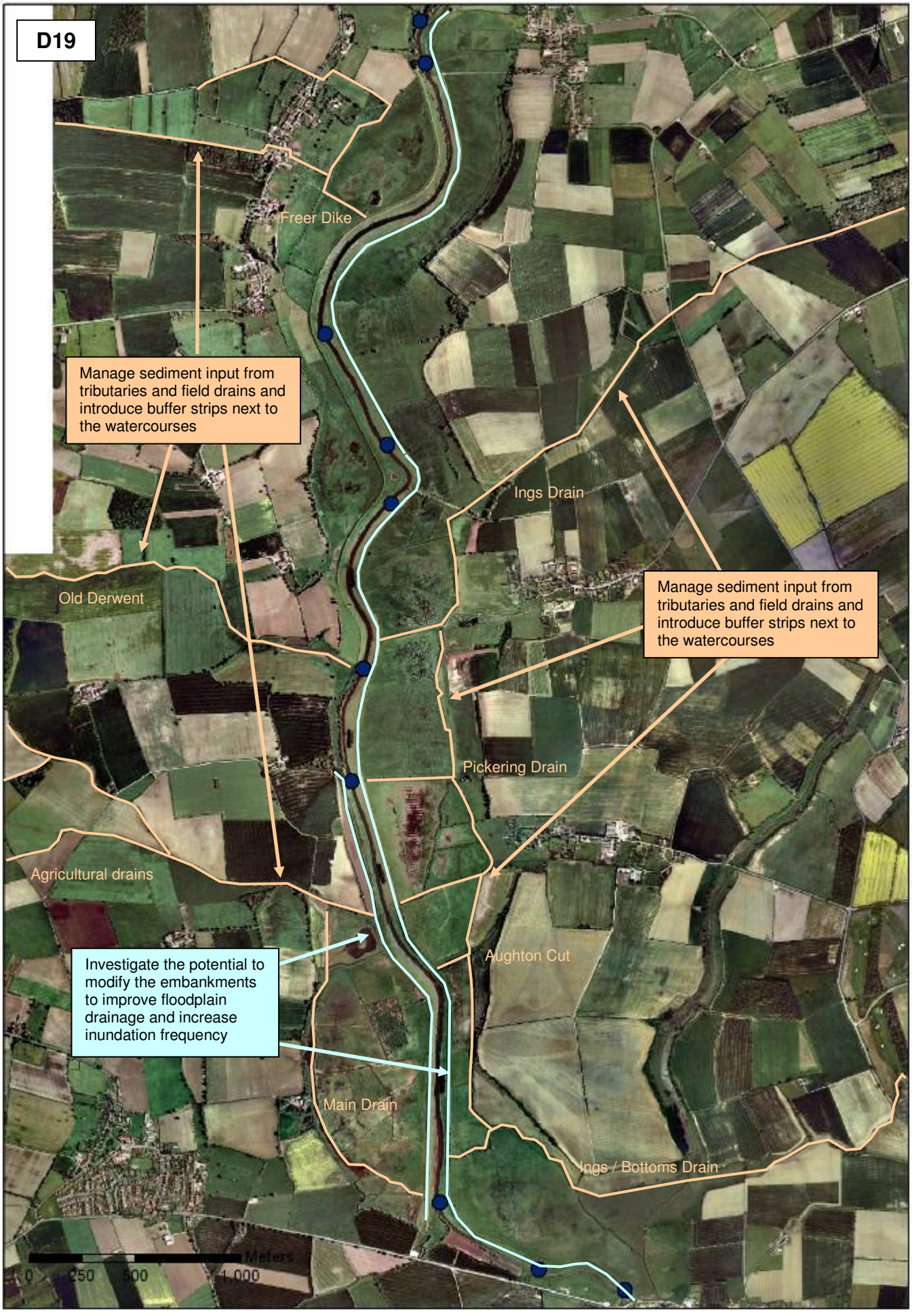
Reach D18 – Downstream limit of Elvington to Pocklington Canal confluence

Opportunities for enhancement

The River Derwent follows an irregular meandering course in this reach. Historical dredging to increase the capacity of the river has resulted in a deep channel with steep banks and uniform flow conditions. The river has also been extensively straightened, with two cut off meanders and a major diversion at the downstream end of the reach. The channel is bounded by embankments along much of the reach. These structures control inundation of the low meadows, or ings, that are located on the floodplain. West Carr and Ing Marsh SSSIs are located in the upper and middle parts of the reach, and Wheldrake Ings nature reserve is located at the downstream end. The ings flood regularly, but take a long time to drain. This can damage the grassland habitats, particularly during the spring and summer. A large area of land drains into the river at the downstream end of Wheldrake Ings SSSI. This reach could be enhanced by protecting the habitat provided in the cut off meanders, and actions to reduce sediment supply as part of a catchment-wide initiative. In addition, the ings may benefit from modifications to the embankments, which could allow them to drain more freely.

Potential restoration measures

Measure		Description	
A.1 **A.2**	**Manage sediment input from tributaries and field drains and introduce buffer strips next to watercourses**	Fine sedimentation	A large number of watercourses, with a total combined length of approximately 190 km, feed into the River Derwent in this reach. These watercourses include a large number of field drains, plus Horse Dike and Pocklington Canal. These watercourses drain a large catchment area, and supply large quantities of sediment to the main river. In order to reduce sediment supply, the maintenance regime of the smaller tributaries and field drains could be reviewed, and measures to retain sediment within the channels could be implemented. In addition, riparian buffer strips could be established next to the banks of the watercourses to prevent sediment from entering them. These could be most useful in areas where cultivation continues right next to the water, and in areas that are heavily grazed.
B.1 **B.2**	**Investigate the potential to modify the West Carr and Ing Marsh embankments to improve floodplain drainage and inundation frequency**	Fine sedimentation Lack of shelter and shading	West Carr ings, which are located on the left bank at the upstream end of the reach, are protected by a 2.6 km-long embankment with a height of between 1 and 2 m. The embankment could potentially be removed to increase floodplain inundation and improve subsequent drainage after periods of flooding. This could help to implement the 2005 Lower Derwent Valley Management Plan, which states that the improved drainage would benefit the ing. Alternatively, the embankment could be breached at the cloughs to improve drainage, although this will not restore full connectivity with the river channel. Ing Marsh embankment is approximately 1 km long and 1 m high, and is located on the right bank downstream of West Carr. The embankment could potentially be removed or breached at the clough to improve drainage. It could also increase inundation frequency and help to remove sediment from the channel. This could help to implement the 2005 Lower Derwent Valley Management Plan, which states that the improved drainage would benefit the ing SSSI. Alternatively, the embankments could potentially be lowered to increase the frequency of overtopping and provide flood storage during smaller floods. Any works undertaken on the embankments will need to consider the potential impacts on the SSSI and SAC which are located behind them. These units support a range of grassland and wetland habitats, and are in favourable or unfavourable recovering condition. Any alterations to the current drainage regime will need to ensure that the SSSI/SAC/SPA habitats are not compromised by increased flood frequency although it is recognised that improved drainage after flooding will be beneficial. Consequently If modifications to the embankments are not feasible, improvements to existing cloughs to improve floodplain drainage may be required. The embankments themselves also provide important habitats for wintering waterfowl and are important for maintaining SPA interest of the Lower Derwent Valley SPA and this needs to be taken into account when considering any options.
C.1	**Undertake selective vegetation management to prevent overshading**	Lack of shelter and shading	Undertake selective vegetation management (e.g. thinning or removal of selected trees and shrubs) on both banks at the downstream end of the reach to allow more light to reach the channel and combat the effects of overshading.
E.1	**Protect existing habitats in the cut off meanders**	Lack of shelter and shading	The two cut off meander loops in this reach provide good quality habitats that should be protected to ensure that habitat diversity for SSSI invertebrate and bird populations is maintained.


D19
Freer Dike
Manage sediment input from tributaries and field drains and introduce buffer strips next to the watercourses
Ings Drain
Old Derwent
Manage sediment input from tributaries and field drains and introduce buffer strips next to the watercourses
Pickering Drain
Agricultural drains
Aughton Cut
Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency
Main Drain
Ings / Bottoms Drain
Meters
0
250
500
1,000

Reach D19 – Pocklington Canal confluence to Bubwith

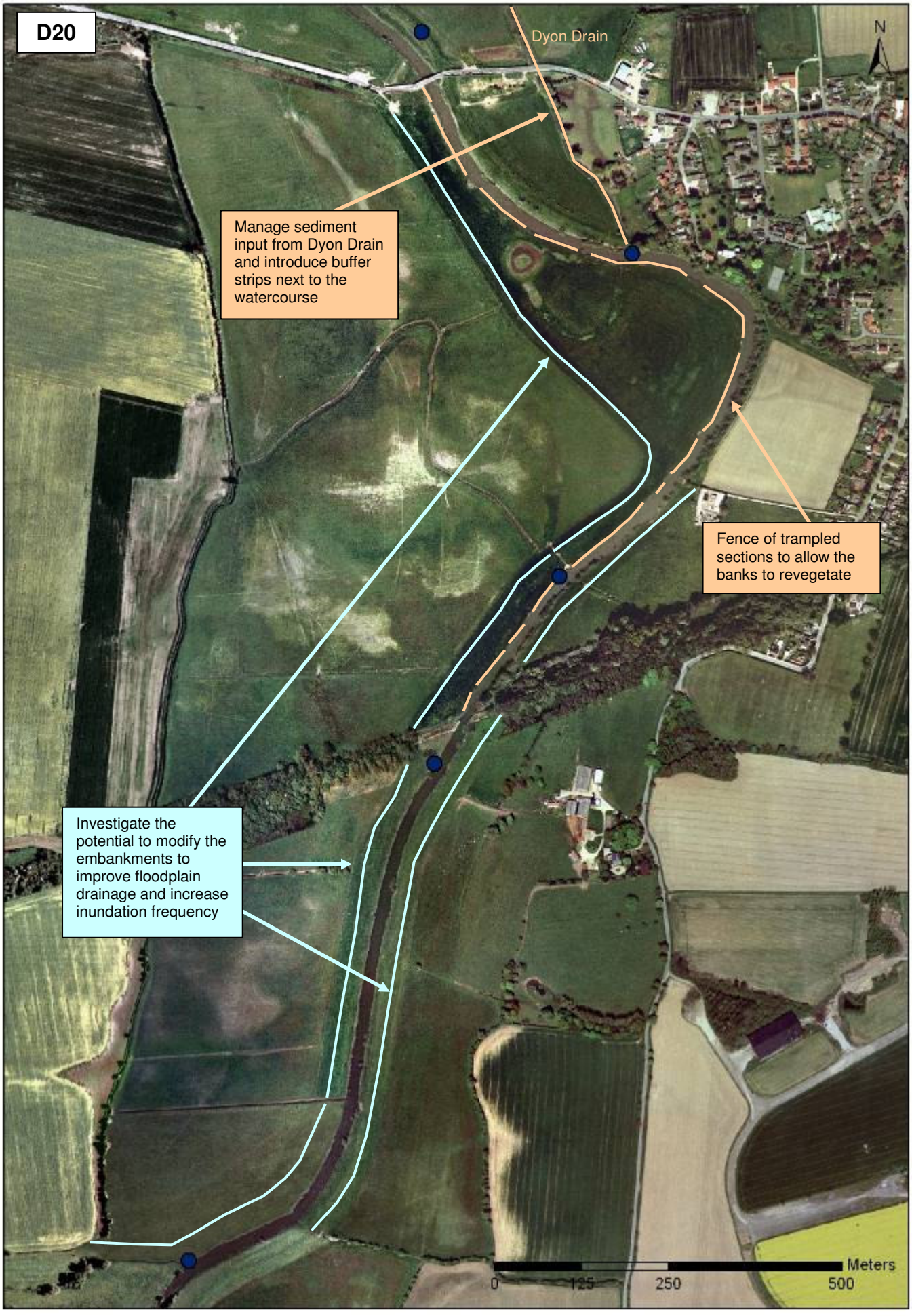
Opportunities for enhancement

Although the River Derwent meanders slightly in this reach, it has been straightened and deepened as a result of historical dredging to increase the conveyance of flood waters and improve land drainage. This has resulted in a deep, uniform channel with steep banks and little flow diversity. A large proportion of the reach has been embanked, and there is little tree cover due to the construction of the embankments (see photograph). The structures control the inundation of the ings, which are located between the river and the valley sides. The ings flood regularly, but the cloughs through which the field drains pass can impede subsequent drying out. Field drains from a large area enter the channel in this reach, supplying large quantities of sediment. In addition, actions to reduce the input of sediment from the field drains could be implemented as part of a catchment-wide management scheme. Although a high proportion of this reach has very little shelter, increased planting may adversely affect the SPA-designated bird communities which use the area,

A large embankment, viewed from the opposite side of the river

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from tributaries and field drains and introduce buffer strips next to the watercourses**	Fine sedimentation	Approximately 40 km of watercourse drain into the River Derwent in this reach, including Freer Dike, Old Derwent, Pickering Drain, Aughton Cut and Main Drain. These supply the river with large quantities of sediment. The maintenance regime of the main watercourses that drain into this reach could be reviewed to help reduce this sediment input. Sediment could be retained in the drains by reducing the frequency of clearance, encouraging vegetation growth, and installing sediment traps. In addition, riparian buffer strips could be established next to the watercourses, to reduce the amount of sediment entering the drainage network.
B.1 B.2	**Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency**	Fine sedimentation Lack of shelter and shading	The left bank of the river is fringed by a large embankment, with a total length of 7.3 km and a height of between 2 and 2.5 m. Approximately 5.8 km of the right bank are also embanked. The embankments on both sides of the river are set back approximately 30 m from the bank top, and are punctuated by drainage cloughs. A series of floodplain meadow SSSIs (Thorganby Ings, East Cottingwith ings, Ellerton Ings, Aughton Ings, Bubwith Ings and North Duffield Carrs) are located behind the embankments. The embankments could potentially be removed to improve drainage, increase inundation frequency, and remove sediment from the main channel. Alternatively, the embankments could potentially be lowered to increase the frequency of overtopping and provide flood storage during smaller floods. If modifications to the embankments are not feasible, it may be possible to de-silt and enlarge the cloughs to improve floodplain drainage. Any works undertaken on the embankments will need to consider the potential impacts on the SSSI and SAC which are located behind them. These units support a range of grassland and wetland habitats, and are in favourable or unfavourable recovering condition. Any alterations to the current drainage regime will need to ensure that the SSSI/SAC/SPA habitats are not compromised by increased flood frequency although it is recognised that improved drainage after flooding will be beneficial. Consequently If modifications to the embankments are not feasible, improvements to existing cloughs may be required to improve floodplain drainage. The embankments themselves also provide important habitats for wintering waterfowl and are important for maintaining SPA interest of the Lower Derwent Valley SPA and this needs to be taken into account when considering any options. Since the embankments are set back from the river along much of this reach, the benefits obtained from their removal or modification may be less significant than those gained from other reaches where the embankments abut the channel.


D20
Dyon Drain
N
Manage sediment input from Dyon Drain and introduce buffer strips next to the watercourse
Fence of trampled sections to allow the banks to revegetate
Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency
Meters
0
125
250
500

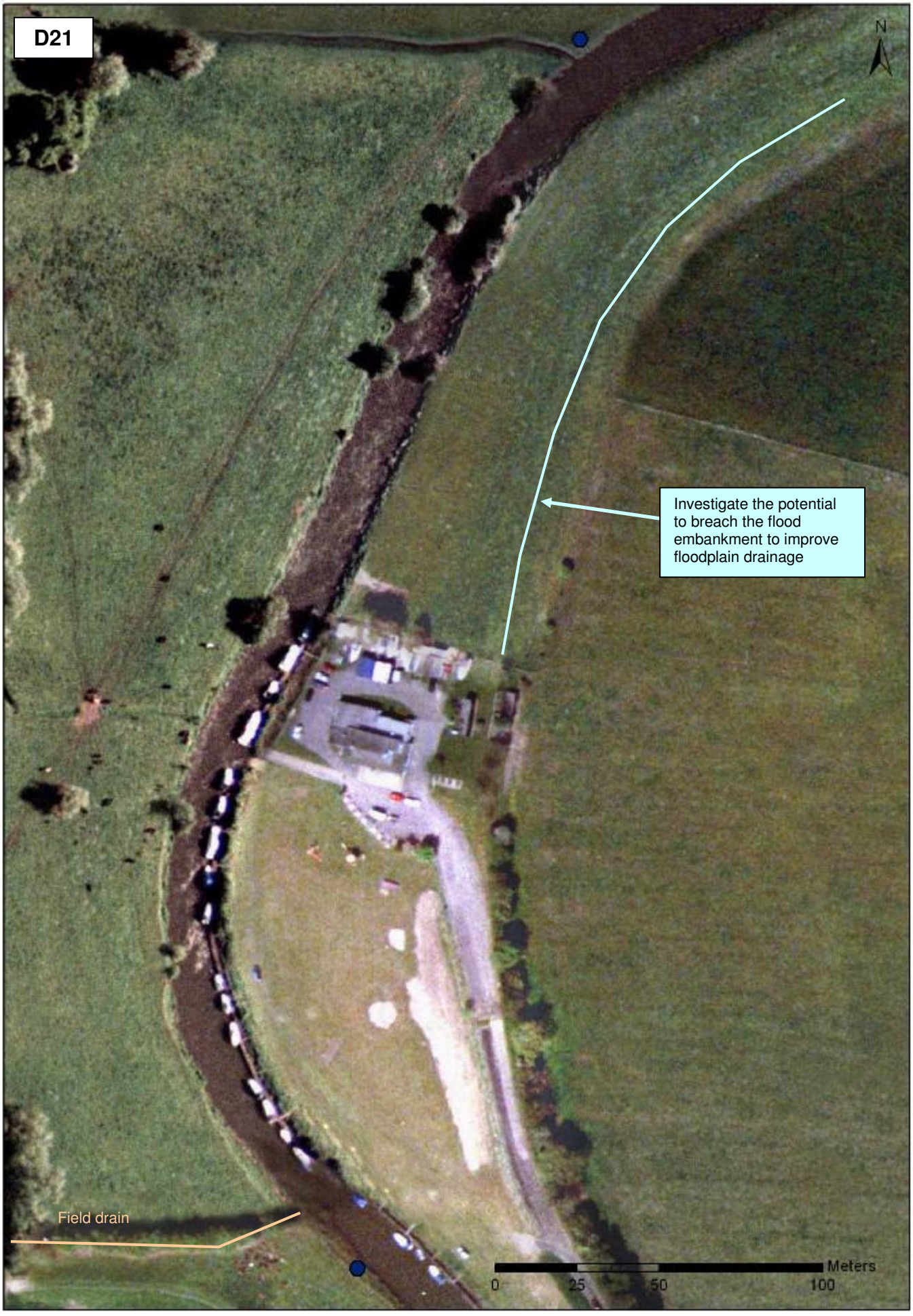
Reach D20 – Bubwith to Upstream limit of Menthorpe

Opportunities for enhancement

The River Derwent follows a large meander at the upstream end of the reach, and becomes considerably straighter further downstream. The river has historically been dredged and straightened to increase its capacity to convey flood waters, which has resulted in a deep, uniform channel with steep banks and little diversity. North Duffield, Menthorpe and Gunby Ings are all embanked, and drainage channels pass through the embankments in a series of cloughs. These do not work effectively in all conditions, and as a result the ings can take a long time to drain after flooding. The reach has very little tree cover due to the presence of the embankments. Livestock trampling in the upstream end of the reach has started to create a more gentle bank profile in places. This reach could be enhanced through the management of trampling and targeted planting to improve bank habitats, and the embankments could potentially be modified to improve the drainage of the ings. In addition, measures to reduce sediment supply as part of a catchment-wide initiative could be implemented in this reach.

Potential restoration measures

Measure		Issues addressed	Description
A.1 A.2	**Manage sediment input from Dyon Drain and introduce buffer strips next to the watercourse**	Fine sedimentation	Approximately 8.6 km of watercourse enter the main channel and supply sediment in this reach, principally Dyon Drain. In order to reduce the amount of sediment that enters the river, the maintenance regime of the watercourses could be reviewed and actions to retain sediment in the drains could be implemented. Riparian buffer strips could also be established along the banks of the main drains, particularly in areas where intense grazing or cultivation occur.
A.2	**Fence off trampled sections to allow the banks to revegetate**	Lack of shelter and shading	Trampling occurs along a 0.7 km long reach on the right bank adjacent to Bubwith. Individual areas of trampling vary between 2 m and 10 m in size. Some of these areas could be fenced off to allow them to revegetate, and riparian habitats to develop. Livestock could be given access to water through the provision of reinforced drinking points, or by leaving some areas unfenced on a rotational basis.
B.1 B.2	**Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency**	Lack of shelter and shading Fine sedimentation	North Duffield Ings, at the upstream end of the reach, are protected by an embankment with a length of 1.2 km and a height of approximately 1.8 m. Menthorpe Ings, on the right bank at the downstream end of the reach, are protected by a 1 km long embankment, with a height of 2.5 m. On the opposite bank, the upstream end of Gunby Ings are also embanked. The embankments could potentially be removed or breached at the cloughs to improve drainage, increase inundation frequency, and help to remove sediment from the main channel. This could help to implement the 2005 Lower Derwent Valley Management Plan for North Duffield Ings, which would benefit from improved drainage. The embankments could be breached at the cloughs to improve floodplain drainage. However, this is unlikely to offer significant benefits for the river channel. Alternatively, the embankments could potentially be lowered to increase the frequency of overtopping and provide flood storage during smaller floods. If modifications to the embankments are not feasible, it may be possible to de-silt and enlarge the cloughs to improve floodplain drainage. Any works undertaken on the embankments will need to consider the potential impacts on the SSSI and SAC which are located behind them. These units support a range of grassland and wetland habitats, and are in favourable or unfavourable recovering condition. Any alterations to the current drainage regime will need to ensure that the SSSI/SAC/SPA habitats are not compromised by increased flood frequency although it is recognised that improved drainage after flooding will be beneficial. Consequently If modifications to the embankments are not feasible, improvements to existing cloughs may be required to improve floodplain drainage. The embankments themselves also provide important habitats for wintering waterfowl and are important for maintaining SPA interest of the Lower Derwent Valley SPA and this needs to be taken into account when considering any options.


D21
N
Investigate the potential to breach the flood embankment to improve floodplain drainage
Field drain
Meters
0
25
50
100

Reach D21 – Upstream limit of Menthorpe to Downstream limit of Menthorpe

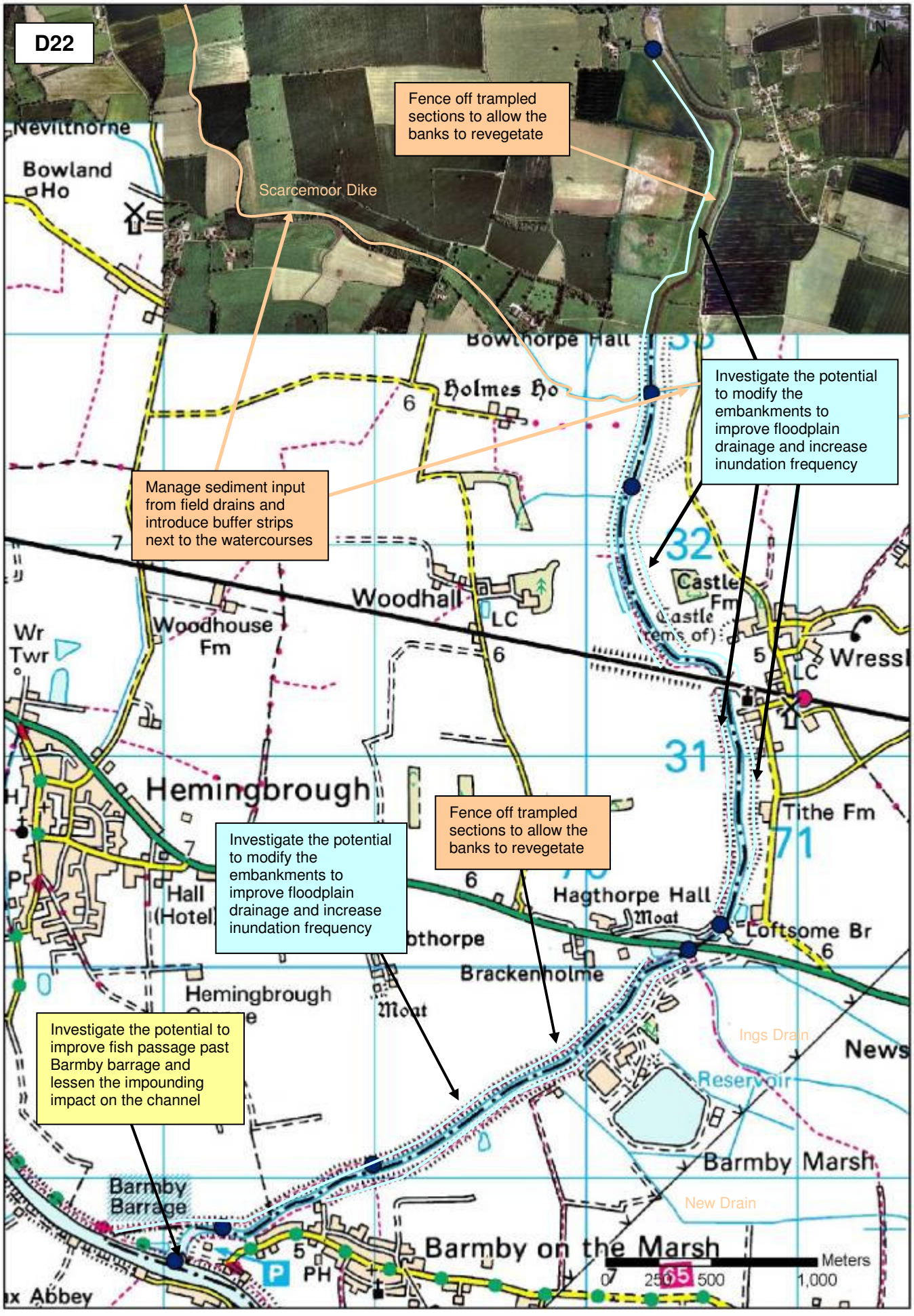
Opportunities for enhancement

This reach is located on a large meander, which has been historically dredged and straightened to increase its capacity to convey water downstream. As a result, the channel is deep and uniform, with steep banks and little habitat diversity. Recreation boats are moored along the left bank (see photograph). Both banks are relatively exposed, although there are some isolated areas of tree cover. Several straight, well maintained field drains enter the river on the right bank. Gunby Ings, which is located on the left bank, is protected by an embankment that is set back from the channel. An area of higher ground, on which a public house is situated, is located between the river and the embankments. There may be potential to modify the embankment to improve this reach.

The upstream end of the embankment at Gunby Ings, with recreational boats moored along the river bank

Potential restoration measures

Measure		Issues addressed	Description
B.1 **B.2**	**Investigate the potential to breach the flood embankment to improve floodplain drainage**	Fine sedimentation	Gunby Ings are fronted by a 2.5 m-high embankment, which is set behind an area of higher ground adjacent to the channel. The Lower Derwent Valley Management Plan indicates that increased wetness is having a detrimental effect on Gunby Ings. The embankment could potentially be removed to allow the floodplain to drain more naturally. Any works undertaken on the embankments will need to consider the potential impacts on the SSSI and SAC which are located behind them. These units support a range of grassland and wetland habitats, and are in favourable or unfavourable recovering condition. Any alterations to the current drainage regime will need to ensure that the SSSI/SAC/SPA habitats are not compromised by increased flood frequency although it is recognised that improved drainage after flooding will be beneficial. Consequently If modifications to the embankments are not feasible, improvements to existing cloughs may be required to improve floodplain drainage.. The embankments themselves also provide important habitats for wintering waterfowl and are important for maintaining SPA interest of the Lower Derwent Valley SPA and this needs to be taken into account when considering any options.


D22
Fence off trampled sections to allow the banks to revegetate
Scarcemoor Dike
Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency
Manage sediment input from field drains and introduce buffer strips next to the watercourses
Fence off trampled sections to allow the banks to revegetate
Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency
Investigate the potential to improve fish passage past Barmby barrage and lessen the impounding impact on the channel
Nevilthorne
Bowland Ho
Holmes Ho
Woodhall
Woodhouse Fm
Wr Twr
Hemingbrough
Hall (Hotel)
Hagthorpe Hall
Moat
Loftsome Br
Brackenholme
Tithe Fm
Castle Fm
Wressl
Ings Drain
Reservoir
Barmby Marsh
New Drain
Barmby Barrage
Barmby on the Marsh
PH
Abbey
Meters
0
250
500
1,000

Reach D22 – Downstream limit of Menthorpe to Barmby Barrage

Opportunities for enhancement

This reach has been historically straightened and dredged to increase the size of the channel. As a result, it is very deep and uniform, with little diversity and steep banks. The channel is bounded by embankments for the majority of the reach, behind which several urban areas and the Loftsome Bridge Water Treatment Works are located. Barmby Barrage, which has a significant impounding effect on the river, is located at the downstream end of the reach, where the Derwent flows into the tidal River Ouse. The banks are very exposed and heavily trampled in areas. This reach could be enhanced through measures to encourage the stabilisation of trampled banks, and reduce the amount of sediment supplied from tributaries and field drains. The embankments could potentially be modified, and the operating regime of Barmby Barrage could be reviewed to allow more natural flow conditions to develop.

The Barmby Barage, at the confluence between the River Derwent and the River Ouse

Potential restoration measures

Measure		Issues addressed	Description
A.1 **A.2**	**Manage sediment input from field drains and introduce buffer strips next to the watercourses**	Fine sedimentation	Several tributaries and field drains feed into this reach, including Scarcemoor Dike (Dyon Drain), Fleet Dike, Ings Dike and New Drain. These supply sediment from the surrounding catchment into the main river. The maintenance regime of the watercourses could be reviewed to help retain sediment in the drainage channels. For example, they could be cleared less frequently, or sediment could be trapped by in-channel vegetation and/or sediment traps. In addition, riparian buffer strips could be established next to the drains in areas where grazing or cultivation is intense. This could help to reduce the amount of sediment that enters the drainage network.
A.2	**Fence of trampled sections to allow the banks to revegetate**	Channelisation Lack of shelter and shading	Livestock trampling occurs along the right-hand bank from the top of the reach downstream to the main drain at Bowthorpe Ings, for approximately 1 km, and also along the right-hand bank downstream of Loftsome Bridge, for approximately 2 km. Some of these areas could be fenced off to allow them to revegetate, and riparian habitats could develop. Planting could also help to provide additional shelter in places. Livestock access to water could be retained through the provision of reinforced drinking points, or by leaving some areas unfenced on a rotational basis.
B.1 **B.2**	**Investigate the potential to modify the embankments to improve floodplain drainage and increase inundation frequency**	Fine sedimentation Lack of shelter and shading	The entire right bank is topped by embankments, with a combined length of 8.5 km and a height of approximately 2.5 m. The left bank downstream of Breighton is also embanked, with a total length of 5.8 km and a height of between 2 and 2.5 m. The embankments could potentially be removed to improve drainage, increase inundation frequency, and help to remove sediment from the main channel. The embankments could be breached at the cloughs to improve floodplain drainage, but this would only offer limited opportunities for increased sediment removal and improved riparian habitats. The embankments on the right bank near Bowthorpe Hall currently protect wet grassland, which may benefit from their removal or modification. The embankment on the left bank at the downstream end of the reach should not be removed, however. The land behind this structure is very low lying, and contains the Loftsome Bridge Water Treatment Works. Removal of the embankment is likely to compromise this area. Furthermore, the left bank near Wressle may need to be maintained for flood protection purposes. If modifications to the embankments are not feasible, it may be possible to

			de-silt and enlarge the cloughs to improve floodplain drainage. Any works undertaken on the embankments will need to consider the potential impacts on the SSSI and SAC which are located behind them. These units support a range of grassland and wetland habitats, and are in favourable or unfavourable recovering condition. Any alterations to the current drainage regime will need to ensure that the SSSI/SAC/SPA habitats are not compromised by increased flood frequency although it is recognised that improved drainage after flooding will be beneficial. Consequently If modifications to the embankments are not feasible, improvements to existing cloughs may be required to improve floodplain drainage. The embankments themselves also provide important habitats for wintering waterfowl and are important for maintaining SPA interest of the Lower Derwent Valley SPA and this needs to be taken into account when considering any options.
D.3 **D.4**	**Investigate the potential to improve fish passage past Barmby Barrage and lessen the impounding impact on the channel**	In-channel structures	Although the Barrage is passable to some fish species, additional measures to ease the passage of lamprey species and salmonids could be investigated. The Environment Agency is trialling measures to ease the passage of river and sea lamprey and salmon, including the installation of a temporary lamprey ramp and navigation lock operation. Depending on the results of these trials, these measures could be implemented on a permanent basis.

5. ACTION PLAN

Purpose of this section

The purpose of this section is to set out a plan of action for the implementation of the reach-based solutions outlined in **Section 4**. These solutions are proposed to restore the ecological health of the River Derwent SSSI and deliver the conservation objectives for the catchment. In order to implement the solutions, it is important to develop a plan of actions to:

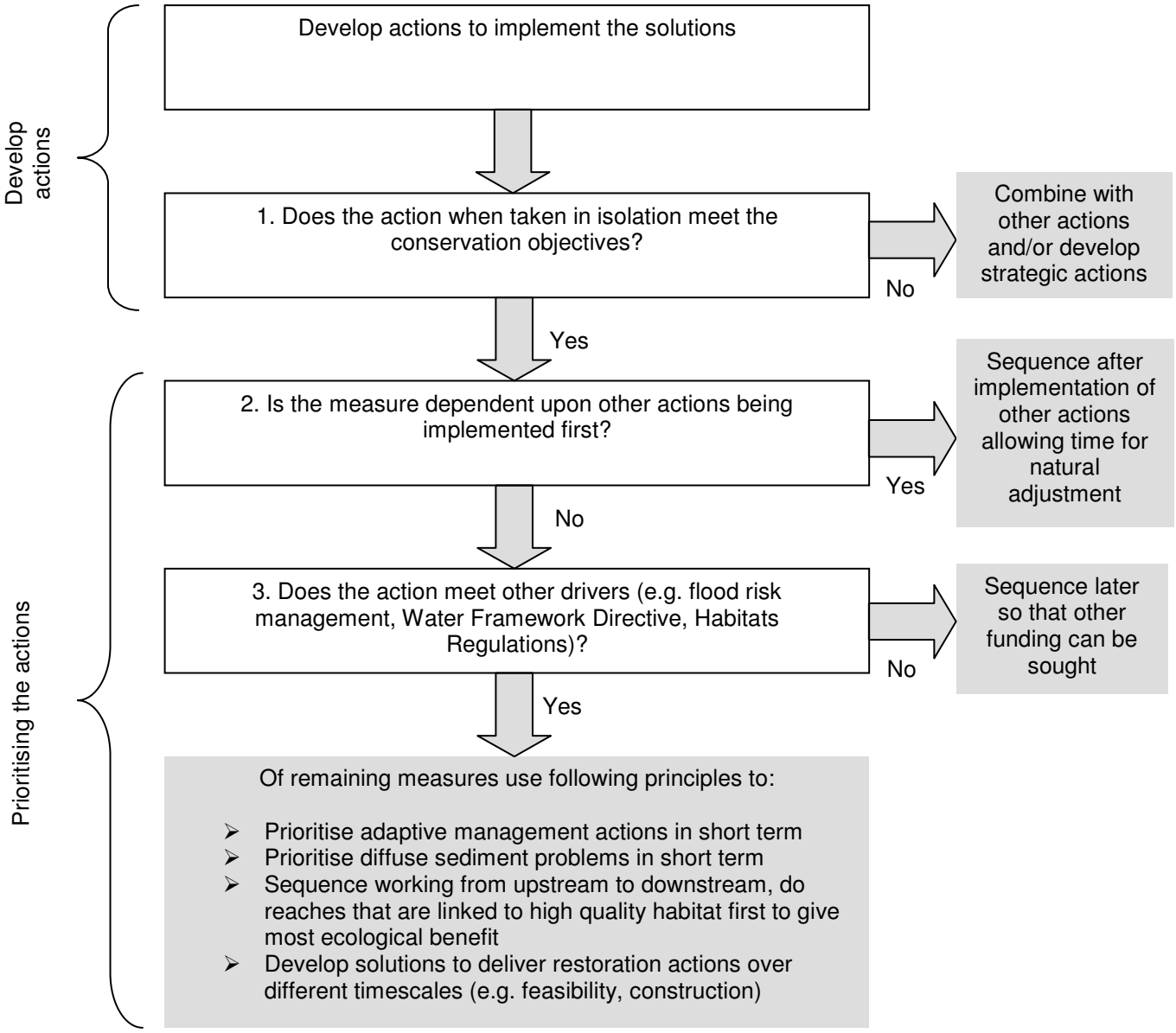
- Develop the list of actions needed to implement the solution.
- Identify which actions need to be taken in combination in order to be most effective.
- Prioritise which actions need to be taken forward first (for example, some require planning and pre-feasibility).
- Review key drivers and mechanisms that could be used to fund or co-deliver actions.
- Estimate indicative costs to allow forward planning for funding.

Impacts upon the SPA, SAC and Ramsar interests of the Lower Derwent

It is recognised that many of the proposed actions have the potential to impact upon the existing SPA, SAC and Ramsar interests of both the River Derwent and Lower Derwent Valley. Consequently any actions likely to have a significant effect upon these sites both alone and in combination with other plans and projects will be subject to Appropriate Assessment prior to commencement of any works or consents being granted. Proposals shown to have an adverse impact upon these sites will not be undertaken unless suitable mitigation alleviating these impacts is able to be incorporated into a proposal and the requirements of the Conservation of Habitats and Species Regulations 2010 (the “Habitats Regulations”) satisfied.

Figure 5.1 summarises how the reach based actions have been taken forward into an action plan based on short, medium and long term phases. The subsequent sections provide more detail on each element of the flow chart.

Figure 5.1 Flow chart explaining steps to prioritisation of actions to deliver



Develop actions to implement the solutions

The initial stage of the process is to identify the actions which can be taken to implement the solutions within the catchment. In many cases the solutions have been identified on a reach by reach basis, and are individually tailored to meet the specific requirements of each part of the river and are therefore actions that can be taken forward for prioritisation.

In some circumstances it will be important to investigate the feasibility of a solution prior to implementation and the first action is therefore to undertake a feasibility study. Feasibility studies, which may include detailed design and planning applications, could be potentially time consuming, and it is therefore important that they are undertaken at a suitably early stage in the process. Any actions arising from these studies can then be incorporated into the prioritisation system at a later date (e.g. a feasibility study can be prioritised in the short term, and delivery of the outcomes of the study can be prioritised over the medium to long term). Feasibility studies would address three key questions:

1. Will the solution successfully deliver the required objectives?

2. What are the potential constraints and benefits for:
- water quality and morphology (these are key constraints on the current condition of the SSSI)
- biodiversity
- fisheries
- flood risk
- landscape
- recreation
- cultural heritage and archaeological value
- agriculture

3. Is the solution sustainable? (this takes into account the function of the river for both wildlife and those who use the river now and into the future)

Does the action when taken in isolation meet the conservation objectives?
Conservation objectives are set for all SSSIs, and are the main driver for improving the physical, biological and chemical status of the habitats they contain. For river SSSIs morphological objectives are set to help support and deliver ecological health. A copy of the conservation objectives for the River Derwent can be found in **Appendix B** of the plan. It is important that all actions undertaken in the catchment are aimed at delivering these objectives, setting challenging targets to achieve the overall vision for the River Derwent SSSI (as described at the beginning of this report). These targets will need active support from key stakeholders and funding bodies if they are to be delivered successfully.

Some actions may be capable of delivering the conservation objectives without the need to combine them with other actions. Others may need to be taken in combination with others and a strategic action may be required to combine these together.

Prioritisation of actions

Not all actions can be taken immediately and it is important to prioritise actions in order to make the plan more achievable. The actions are split into short, medium and long term after the prioritisation shown in **Figure 5.1**:

Short term actions: by 2015
Medium term actions: by 2021
Long term actions: by 2050

Is the measure dependent on other actions being implemented first?
Some options may only be effective once other options have been implemented. It is therefore important to sequence the implementation of all actions to take these inter-dependencies into account. Actions on which other actions are dependent should be given a higher priority than actions which are dependent on others.

Does the action meet other drivers?
There are other initiatives which are targeting morphological improvements to meet other legislation; to assist in sensitive catchment management for ecology or to manage flood risk working with natural processes. **Appendices A**, **C** and **D** provide details on different drivers.

Appendix A Environmental Stewardship is an environmental scheme for landowner participation which aims, among other objectives, to help conserve wildlife through changing land management. Appendix A gives more information on the scheme.

Appendix C The England Catchment Sensitive Farming Delivery Initiative is a joint venture between the Environment Agency and Natural England funded by Defra working in 50 priority catchments of which the River Derwent is one. Delivering strategic objectives aimed at tackling diffuse pollution could work in partnership with this existing initiative.

Appendix D The Water Framework Directive is European Legislation aimed at improving the management of rivers, coasts and estuaries to achieve good ecological status or good ecological potential. Geomorphological changes from river management are recognised as contributing to degradation of habitat and all rivers (waterbodies) have had objectives set for improvement. The measures identified for improvement in the River Derwent are included in Appendix D. These measures may have funding associated with them.

Flood risk management is progressed strategically through Catchment Flood Management Planning and implementation of the strategy should identify ways of working with flood risk management to ensure policies set down in the strategic planning documents are adhered to and local works do not impact upon the river SSSI.

Any actions which could potentially meet other drivers, and therefore delivered using other funding streams, should be sequenced later in the prioritisation to give sufficient time for funding applications to be prepared and submitted.

Estimate costs to allow forward planning for funding
Approximate cost estimates (including a lower and upper boundary) have been provided for each action. These costs are aggregated to provide total costs for each unit, and summed to provide an estimate of likely total expenditure over short, medium and long timescales.

In addition, an estimate of the likely proportion of funding which can be apportioned to different funding streams has also been made, using the upper and lower estimates described above. These are presented as a potential lower and upper limit for each funding stream. Where funding could potentially be derived from more than one source, the lower limit is assumed to be zero and the upper limit is assumed to be the maximum cost of the measure.

What will happen to the plan?
The plan will be freely available to all and can be accessed from either the Environment Agency or Natural England. Progress on the plan will be reported on through delivery processes against funding and where possible more widely. The plan shows the options that have been identified as desirable to meet the conservation objectives for each reach. These options will need to be developed in the future through detailed consultation with key stakeholders (including landowners, land managers, riparian users, conservation bodies and recreational groups). The plan will be updated and revised to take account of this consultation process.

The implementation of the actions described in this plan is dependent on funding and landowner agreement and subject to the requirements of The Conservation of Habitats and Species Regulations 2010 (the “Habitats Regulations”).

SHORT TERM ACTIONS

SSSI Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Strategic	Sympathetic tree management and non-native invasive plant management.	Flood Risk Management; WFD measures	-	£50,000		
	Reduce sediment input from tributaries in all units through CSF and Environmental Stewardship	Catchment Sensitive Farming, Environmental Stewardship, WFD Measures	£50,000	£100,000		
	Manage the clough drainage system to improve drainage of the lower Derwent floodplain	WFD Measures: Increase floodplain connectivity	£50,000	£100,000	**£100,000**	**£250,000**
Unit 1	Investigate the feasibility of removing or modifying the East Wykeham embankment and restoring the relict channel to promote floodplain sedimentation and development of riparian habitats to outline design stage. Feasibility should consider tree planting on right hand bank to increase shading. As part of this develop a better understanding of sediment build up and transport in SSSI units 1 and 2. (D01)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity	£10,000	£50,000		
	Undertake targeted vegetation management to reduce overshading (D02)	Environmental Stewardship (HLS special project), WFD Measure: Sensitive vegetation management	£1,000	£10,000	**£11,000**	**£60,000**
Unit 2	Fence off sections or install reinforced cattle access points at the downstream end of D04.	Environmental Stewardship	£1,000	£10,000		
	Fence off sections or installed reinforced cattle access points on the right bank downstream of Menthorpe beck (D05)	Catchment Sensitive Farming, Environmental Stewardship	£1,000	£10,000		
	Plant trees along bank top at downstream end of D05.	Catchment Sensitive Farming, Environmental Stewardship	£1,000	£10,000		
	Fence off sections/reinforced cattle access points, RHB at u/s end of reach D06.	Catchment Sensitive Farming, Environmental Stewardship	£1,000	£10,000		
	Undertake targeted vegetation management to reduce overshading (D06 and D07)	Environmental Stewardship (HLS special project), WFD Measure: Sensitive vegetation management	£1,000	£10,000		
	Investigate the feasibility of removing or modifying Kirkham weir and sluices or modifying the fish pass. Modify sluice operation if weir removal is not an option (D07)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc	£10,000	£50,000		
	Fence off sections/reinforce cattle access points along left hand bank upstream and downstream of Braisthwaites Beck (D08)	Catchment Sensitive Farming, Environmental Stewardship	£1,000	£10,000	**£16,000**	**£110,000**
Unit 3	Install fish pass at Buttercrambe weir (D09)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	£300,000	£500,000	**£327,000**	**£670,000**
	Fence off sections/reinforced cattle access points, along left hand bank upstream of Barlam Beck (D10)	Catchment Sensitive Farming, Environmental Stewardship, WFD Measure: Preserve and where	£1,000	£10,000		

SSSI Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
		possible enhance ecological value of marginal aquatic habitat, banks and riparian zone				
	Investigate the potential to remove or modify Stamford Bridge Weir, alter the sluice operation or improve the fish pass (D11)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	£10,000	£50,000		
	Fence off sections/reinforced cattle access points, along right hand bank opposite Low Catton (D12)	Catchment Sensitive Farming, Environmental Stewardship, WFD Measures: Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone	£1,000	£10,000		
	Enhance riparian habitats through planting (D13)	Environmental Stewardship (HLS special project), WFD Measure: restore riparian zone	£1,000	£10,000		
	Undertake targeted vegetation management to reduce overshading (D13)	Environmental Stewardship (HLS special project), WFD Measure: Sensitive vegetation management	£1,000	£10,000		
	Enhance riparian habitats through planting (D16)	Environmental Stewardship (HLS special project), WFD Measure: restore riparian zone	£1,000	£10,000		
	Enhance riparian habitats through planting (D17)	Environmental Stewardship (HLS special project), WFD Measure: restore riparian zone	£1,000	£10,000		
	Investigate the potential to adjust the sluice gate operation, and if feasible adjust the operation. Improve the fish pass at Elvington Sluice (D17)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	£10,000	£50,000		
	Undertake targeted vegetation management to reduce overshading (D18)	Environmental Stewardship (HLS special project), WFD Measure: Sensitive vegetation management	£1,000	£10,000		
Unit 4	Fence off sections/reinforced cattle access points along RHB at Bubwith (D20)	Environmental Stewardship, WFD Measures: Restore riparian habitats	£1,000	£10,000		
	Fence off sections/reinforced cattle access points along the right bank at Bowthorpe and Brackenholme (D22)	Environmental Stewardship, WFD Measures: Restore riparian habitats	£1,000	£10,000		
	Lamprey ramp and navigation lock trials at Barmby Barrage and permanent implementation if successful (D22)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	£50,000	£70,000		
					£52,000	**£90,000**
		Potential costs: Environmental Stewardship			*£76,000*	*£310,000*
		Potential costs: WFD implementation			*£430,000*	*£820,000*
		Potential costs: Other funding sources			*-*	*£50,000*
		Total			**£506,000**	**£1,180,000**

MEDIUM TERM ACTIONS

Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Strategic	Sympathetic tree management and non-native invasive plant management.	Flood Risk Management;WFD measures	-	£50,000		
	Reduce sediment input from tributaries in all units through Environmental Stewardship	Catchment Sensitive Farming. Environmental Stewardship	£50,000	£100,000		
	Manage the clough drainage system to improve drainage of the lower Derwent floodplain	WFD Measures: Increase floodplain connectivity	£50,000	£100,000	**£100,000**	**£250,000**
Unit 1	Detailed design and construction of the East Wykeham restoration scheme (D01)	WFD Measures: Increase floodplain connectivity, Higher Level Stewardship special project	-	£1,000,000		
	Investigate the feasibility of removing the Old Malton embankment to allow more regular floodplain inundation and reprofiling of both banks to outline design stage (D02)	WFD Measures: Increase floodplain connectivity, Higher Level Stewardship special project	£10,000	£50,000	**£10,000**	**£1,050,000**
Unit 2	Subject to findings of investigations, removal or modification of Kirkham weir and sluice structures or modify/replace fish pass (D07)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	-	£1,000,000		
	Investigate the potential to modify the Bridge End Field embankments to outline design stage (D08)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity In line with CFMP policies	£10,000	£50,000		
	Subject to the findings of investigations at Kirkham, investigate the feasibility of removing or modifying Howsham weir (D08)	WFD Measure: Removal of obsolete structures	£10,000	£50,000	**£20,000**	**£1,100,000**
Unit 3	Subject to findings of investigations, remove or modify Stamford Bridge Weir, alter the sluice operation or improve the fish pass (D11)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	£100,000	£1,000,000		
	Improvement of the fish pass at Elvington Sluice (D17)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc; Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works	£10,000	£100,000	**£110,000**	**£1,100,000**

Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Unit 4	Investigate the feasibility of removing or modifying the embankment on the right bank at Menthorpe Ings (D20)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore aquatic habitats	£10,000	£50,000		
	Investigate the potential to alter the operation of Barmby Barrage to reduce impacts on the river SSSI (D22)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc;	£50,000	£100,000	**£60,000**	**£150,000**
				Potential costs: Environmental Stewardship	*£65,000*	*£1,175,000*
				Potential costs: WFD implementation	*£235,000*	*£2,425,000*
				Potential costs: Other funding sources	*-*	*£50,000*
				Total	**£300,000**	**£3,650,000**

LONG TERM ACTIONS

Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
Strategic	Sympathetic tree management and non-native invasive plant management.	Flood risk management; WFD measures	-	£50,000		
	Manage the clough drainage system to improve drainage of the lower Derwent floodplain	WFD Measures: Increase floodplain connectivity	£50,000	£100,000	**£50,000**	**£150,000**
Unit 1	Subject to findings of investigations, detailed design and construction of Old Malton embankment realignment (D02)	WFD Measures: Increase floodplain connectivity	-	£1,000,000	**-**	**£1,000,000**
Unit 2	Subject to findings of investigations, detailed design and construction of the Bridge End Field embankments realignment (D08)	WFD Measures: Increase floodplain connectivity	-	£1,000,000		
	Subject to findings of investigations, remove or modify Howsham Weir (D08)	WFD Measure: Operational and structural changes to locks, sluices, weirs, beach control, etc	£10,000	£50,000	**£10,000**	**£1,050,000**
Unit 3	Over long timescales, investigate the potential to remove Buttercrambe weir and replace it with a hydro-acoustic flow gauging station (D09)	WFD Measure: Removal of obsolete structures	£10,000	£50,000	**£60,000**	**£5,300,000**
	Investigate the feasibility of removing or modifying embankments for whole length of D13 on RHB and reprofiling channel bank; realigning channel	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore aquatic habitats	£10,000	£50,000		
	Subject to findings of investigations, detailed design and construction of bank realignment of D13 on RHB and reprofiling channel bank	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore aquatic habitats	-	£1,000,000		
	Investigate the feasibility of removing or modifying the Kexby House embankment and reprofiling the channel banks (D14)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore aquatic habitats	£10,000	£50,000		
	Subject to findings of investigations, detailed design and construction of bank realignment at Kexby House (D14)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore aquatic habitats	-	£1,000,000		
	Investigate the feasibility for modifying the Ings and Mask embankments and bank reprofiling (D15)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000		
	Subject to findings of investigations, detailed design and construction of bank realignment of the Ings and Mask embankments and bank reprofiling (D15)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats	-	£1,000,000		

Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
		In line with CFMP policy to increase flood storage; where possible restore lowland floodplain				
	Investigate the feasibility for modifying The Bottoms embankment and bank reprofiling (D17)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000		
	Subject to findings of investigations, detailed design and construction of bank realignment of The Bottoms embankment and bank reprofiling (D17)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		
	Investigate the potential to modify the West Carr and Ing Marsh embankments to improve floodplain drainage and inundation frequency (D18)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000		
	Subject to findings of investigations, detailed design and construction of bank realignment of the West Carr and Ing Marsh embankments (D18)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		
Unit 4	Investigate the feasibility to remove/lower embankments on left hand bank (Thorganby Ings and North Duffield Carrs) (D19)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000	**£40,000**	**£5,200,000**
	Subject to findings of investigations, detailed design and construction of bank lowering/realignment of left hand bank (Thorganby Ings and North Duffield Carrs (D19)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		
	Subject to the findings of investigations, remove or modify the embankment on the right bank at Menthorpe Ings (D20)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		

Unit	Action	Other drivers and delivery mechanisms	Costs		Cumulative costs	
			Lower	Upper	Lower	Upper
	Investigate the feasibility of removing embankments on North Duffield Ings (D20)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000		
	Subject to findings of investigations, remove or modify the embankments on North Duffield Ings (D20)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		
	Investigate the feasibility of removing embankments on Gunby Ings (D21)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000		
	Subject to the findings of investigations, remove or modify the embankment at Gunby Ings (D21)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		
	Investigate the feasibility of removing or modifying the embankments downstream of Breighton (D22)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	£10,000	£50,000		
	Subject to findings of investigations, remove or modify the embankment downstream of Breighton (D22)	Environmental Stewardship (HLS special project), WFD Measures: Increase floodplain connectivity; restore riparian habitats In line with CFMP policy to increase flood storage; where possible restore lowland floodplain	-	£1,000,000		
				Potential costs: Environmental Stewardship	*£45,000*	*£6,725,000-*
				Potential costs: WFD implementation	*£105,000*	*£6,875,000*
				Potential costs: Other funding sources	*-*	*£50,000*
				Total	**£150,000**	**£13,650,000**

Further information sources

SSSIs, SACs and their management
Introduction to Sites of Special Scientific Interest
http://www.naturalengland.org.uk/ourwork/conservation/designatedareas/sssi/default.aspx

Introduction to Special Areas of Conservation
http://www.naturalengland.org.uk/ourwork/conservation/designatedareas/sac/default.aspx

Information relating to the Government's Public Service Agreement Target for SSSIs
http://www.defra.gov.uk/wildlife-countryside/protected-areas/sssi/psa.htm

The River Derwent
River Derwent SSSI citation
http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003398.pdf

Current Condition Assessment for the River Derwent SSSI
http://www.sssi.naturalengland.org.uk/Special/sssi/sssi_details.cfm?sssi_id=1003398

River Derwent SAC site details
http://www.jncc.gov.uk/ProtectedSites/SACselection/sac.asp?EUCode=UK0030253

Lower Derwent Project (2005) Lower Derwent Valley Management Plan, 2005-2010.

River restoration and management
River Restoration Centre (2000) Manual of River Restoration Techniques, RRC, Silsoe
http://www.therrc.co.uk/rrc_manual_pdf.php

RSPB, NRA and RSNC (1994) The New Rivers and Wildlife Handbook. RSPB, Sandy, Bedfordshire.

Stephenson R.L. (2000) Watercourses in the Community; A guide to sustainable watercourse management in the urban environment, Scottish Environment Protection Agency
http://www.sepa.org.uk/water/habitat_enhancement/best_practice_guidance.aspx

Environment Agency (1999) Waterway Bank Protection Guide, R&D Project W5-635, Cranfield.

Soulsby (2002) Managing River Habitats for Fisheries, Scottish Environment Protection Agency
http://www.sepa.org.uk/water/habitat_enhancement/best_practice_guidance.aspx

Changing agricultural and land drainage management practices
Defra (2005) Controlling soil erosion: A manual for the assessment and management of agricultural land at risk of water erosion in lowland England
http://www.defra.gov.uk/erdp/pdfs/es/guidance/soilerosion-lowlandmanual.pdf

Environment Agency (1997) Understanding Buffer Strips, Environment Agency, Bristol.

Association of Drainage Authorities and Natural England (2008) The Drainage Channel Biodiversity Manual: Integrating Wildlife and Flood Risk Management
http://naturalengland.etraderstores.com/NaturalEnglandShop/product.aspx?ProductID=e2dae3b7-f789-40e8-b0f6-8cf8a1637032

WWF (Scotland) (2000) Farming and Watercourse Management Handbook.
http://www.sepa.org.uk/water/habitat_enhancement/best_practice_guidance.aspx

Environment Agency/BDB Associates (2001) Best Farming Practices: Profiting from a good environment.
http://www.environment-agency.gov.uk/business/sectors/bestfarmingpractices.aspx

Appendix A: Environmental Stewardship

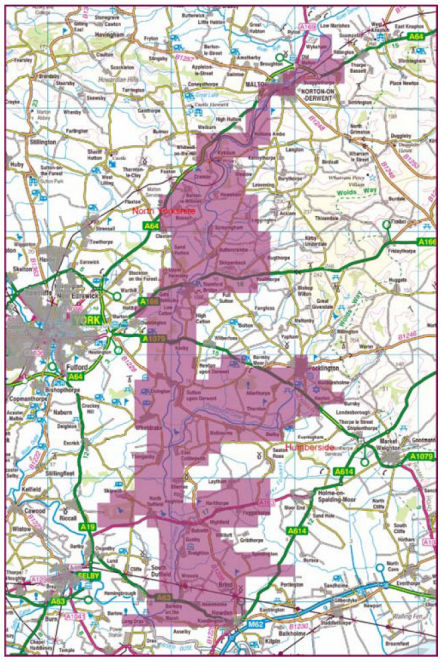
Environmental Stewardship

Natural England currently works with landowners through Environmental Stewardship, an agri-environmental scheme which aims, among other objectives, to help conserve wildlife. Environmental Stewardship has three elements:

- Entry Level Stewardship (ELS) provides a straightforward approach to supporting the good stewardship of the countryside through simple and effective land management that goes beyond the Single Payment Scheme requirement to maintain land in good agricultural and environmental condition. It is open to all farmers and landowners.
- Organic Entry Level Stewardship (OELS) is the organic strand of ELS. It is geared to organic and organic/conventional mixed farming systems and is open to all farmers not receiving Organic Farming Scheme aid.
- Higher Level Stewardship (HLS) concentrates on the more complex types of management where land managers need advice and support and where agreements will be tailored to local circumstances. HLS applications will assessed against specific local targets and agreements will be offered where they meet these targets and represent good value for money.

The River Derwent is one of Natural England's Target Areas for Higher Level Stewardship. The target area covers the length of river between Ryemouth and its confluence with the River Ouse at Barmby and aims to help protect the SSSI. In order to qualify for HLS in the River Derwent Target Area, land managers must perform one or more specific land management activities, which include:

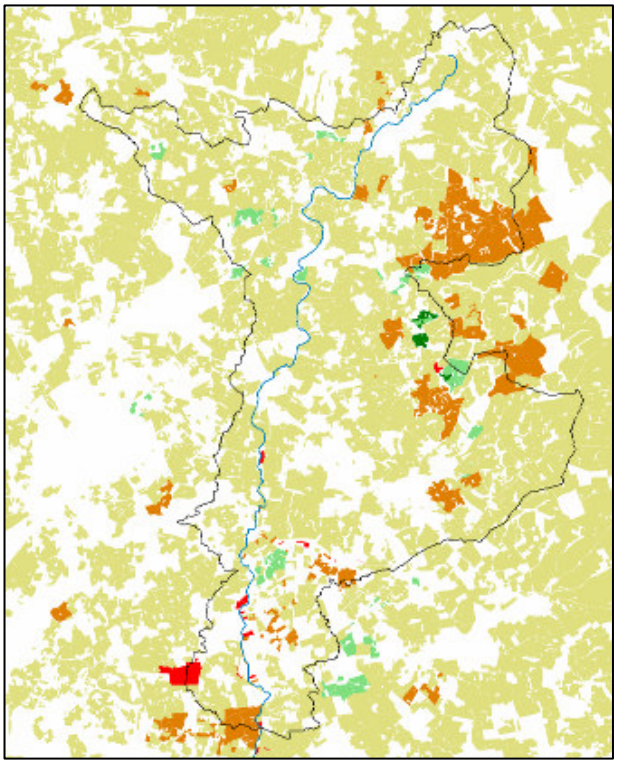
- Maintaining, restoring or creating important areas of species-rich meadows and pastures, wetlands and lowland heathland.
- Providing habitat for wet grassland birds, including nesting habitats and summer food sources, where three or more wet grassland species breed (lapwing, snipe, redshank, curlew and yellow wagtail). The scheme may also be applicable if there is strong supporting evidence for a regionally important breeding colony of one of the species.
- Implementing land management practices and capital works to minimise soil erosion and run-off from land at risk of generating diffuse pollution within the catchment of the River Derwent.
- Restoring characteristic field boundary patterns and systems.



The River Derwent HLS Target Area

The requirements of HLS are likely to be particularly useful in the implementation of actions to reduce sediment input from agricultural land (e.g. **Solutions A.1** and **A.2**). In addition, HLS could also be used as a mechanism to implement solutions that aim to improve floodplain and riparian habitats (e.g. **Solutions C.1**, **C.3** and **E.1**).

Currently, whilst there has been extensive uptake of Entry Level Stewardship throughout the catchment, Higher Level Stewardship is very limited in extent. By working closely together, landowners and Natural England could increase the extent of land under HLS agreement, leading to decreased soil erosion and fine sediment input to the river.



Uptake of Environmental Stewardship in the Derwent catchment

Yellow = ELS,
Orange = ELS+HLS,
Red = HLS,
Light Green = OELS and
Dark Green = OELS+HLS

Several specific measures to reduce sediment input could potentially be delivered under the terms of an Environmental Stewardship agreement, including:

- Reversion from arable land to unfertilised grassland or grassland with low fertiliser use;
- In-field grass areas to reduce erosion and runoff;
- Preventing erosion

Entry Level Stewardship could potentially be used as a mechanism to encourage landowners to establish riparian buffer strips, since the scheme includes payments for the creation of 2 m, 4 m and 6 m-wide strips. In addition to these solutions, Higher Level Stewardship also offers payments for the following practices that are all intended to reduce the production of sediment from agricultural land:

- Reversion from arable land to unfertilised grassland or grassland with low fertiliser use;
- In-field grass areas to reduce erosion and runoff;
- Preventing erosion or runoff from intensively managed, improved grassland; and
- Seasonal livestock removal on grassland.

Steps to encourage the uptake of Environmental Stewardship within the Derwent catchment are therefore likely to be important in reducing sediment supply at a catchment scale.

Appendix B: Conservation objectives

Species	Ecological targets
Otter	Population maintained or increasing
	Fish biomass stays within expected natural fluctuations
Bullhead (adult population)	No reduction in densities from existing levels
Bullhead (distribution within SAC)	Bullheads should be present in all suitable reaches. As a minimum, no decline in distribution from current
Bullhead (reproduction age structure)	Young-of-year fish should occur at densities at least equal to adults
River and sea lamprey (age structure)	For samples of 50 or less, at least two distinct size classes should normally be present. If more than 50 ammocoetes are collected, at least three size classes should be present
River and sea lamprey (distribution within catchment)	Lampreys should be present at not less than 2/3 of sites surveyed. As a minimum, there should be no reduction in the distribution of ammocoetes within the catchment. Where barriers to migration or pollution issues are thought to be a problem, the population should be classed as being in unfavourable condition and targets for an appropriate increase should be set
River and sea lamprey (ammocoete density)	Ammocoetes should be present in at least four sampling sites, each not less than 5km apart
Breeding birds	Maintain assemblage diversity. If the number of breeding species falls by 25% or more, the feature is in unfavourable condition
Non-breeding birds	Maintain assemblage diversity. If the number of wintering species falls by 25% or more, the feature is in unfavourable condition (November – February). If the number of passage species falls by 25% or more then the feature is in unfavourable condition (August – October and March – April)
Invertebrates (Odonata species assemblage)	Monitor the assemblage once in every 6 year monitoring cycle. The following thresholds to be met are: W11 fast flowing water: SQI score 150 W111 shingle bank: WSS 9 W112 stony river margin: WSS 4
Invertebrates (surface topography of vegetation types)	Single surface present in no more than 5 out of 10 Structural Recording Surveys. >3 different surfaces present in at least 20% SRSs. Preferred surfaces are: Water Marginal bare muds Medium layer Taller graminoid layer

Appendix C: Catchment Sensitive Farming

Catchment Sensitive Farming (CSF)

CSF Programme

Catchment Sensitive Farming is land management that keeps diffuse emissions of pollutants to levels consistent with the ecological sensitivity and uses of rivers, groundwaters and other aquatic habitats, both in the immediate catchment and further downstream. It includes managing appropriately the use of fertilisers, manures and pesticides; promoting good soil structure and rain infiltration to avoid run-off and erosion; protecting watercourses from faecal contamination, sedimentation and pesticides; reducing stocking density; managing stock on farms to avoid compaction and poaching of land; and separating clean and dirty water on farms.

The England Catchment Sensitive Farming Delivery Initiative

The England Catchment Sensitive Farming Delivery Initiative is a joint venture between the Environment Agency and Natural England funded by Defra working in 50 priority catchments. It delivers practical solutions and targeted advice to enable farmers and land managers to take action to protect water bodies and the wider environment. The initiative was initially rolled out in April 2006 in forty priority catchments in England, and will continue to at least 2010-11. In October 2008 an additional 10 priority catchments were added to the existing 40, and extensions were made to 7 of the existing catchments.

Engagement with farmers will remain the main objective of the Initiative and there will continue to be an extensive programme of farmer events and farm visits. In its first two years of operation the ECSFDI delivered advice to over 6000 farmers representing 15% of farm holdings (23% by area) within the original forty priority catchments.

Source: http://www.defra.gov.uk/foodfarm/landmanage/water/csf/index.htm

Appendix D: Measures to be undertaken to reach Environmental Objectives under WFD

Map code	Waterbody ID	Waterbody name	SSSI Units	Status	Measures to be applied to improve ecological status
R71	GB104027068313	River Derwent from Rye to Kirkham	Units 1 & 2	Moderate	Appropriate channel maintenance strategies and techniques - wood debris
					Appropriate channel maintenance strategies and techniques - minimise disturbance to channel
					Appropriate timing (vegetation control)
					Appropriate vegetation control technique
					Selective vegetation control regime
					Educate landowners on sensitive management practices (urbanisation)
					Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)
					Appropriate techniques (invasive species)
					Improve floodplain connectivity
					Set-back embankments
					Flood bunds (earth banks, in place of floodwalls)
R84	GB104027068312	River Derwent from Kirkham to Elvington Beck	Units 2 & 3	Moderate	Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)
					Provide flows to move sediment downstream
					Ensure there is an appropriate baseline flow regime downstream of the impoundment
					Appropriate techniques (invasive species)
					Maintain sediment management regime to avoid degradation of the natural habitat characteristics of the downstream river
					Operational and structural changes to locks, sluices, weirs, beach control, etc
					Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone
					Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works
					Improve floodplain connectivity
					Set-back embankments
					Flood bunds (earth banks, in place of floodwalls)
					Preserve and, where possible, restore historic aquatic habitats
					Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution
					Re-engineering of the river where the flow regime cannot be modified
					Remove obsolete structure
R79	GB104027068311	River Derwent from Elvington Beck to River Ouse	Units 3 & 4	Moderate	Selective vegetation control regime
					Ensure that good status of dissolved oxygen levels is being achieved downstream of the impounding works
					Appropriate channel maintenance strategies and techniques - woody debris
					Appropriate channel maintenance strategies and techniques - minimise disturbance to channel bed and margins
					Appropriate timing (vegetation control)
					Appropriate vegetation control technique
					Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution

Map code	Waterbody ID	Waterbody name	SSSI Units	Status	Measures to be applied to improve ecological status
					Preserve and, where possible, restore historic aquatic habitats
					Flood bunds (earth banks, in place of floodwalls)
					Set-back embankments
					Improve floodplain connectivity
					Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works
					Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone
					Re-engineering of the river where the flow regime cannot be modified
					Maintain sediment management regime to avoid degradation of the natural habitat characteristics of the downstream river
					Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)
					Ensure there is an appropriate baseline flow regime downstream of the impoundment
					Provide flows to move sediment downstream
					Operational and structural changes to locks, sluices, weirs, beach control, etc