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River Mease SSSI/SAC Restoration Plan

Technical Report

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Executive Summary

The River Mease and the lower part of Gilwiskaw Brook are designated as a Special Area of Conservation (SAC) under the European Union (EU) Habitats Directive, and a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act.

A Natural England condition assessment of the SSSI/SAC conducted during 2009, showed that stretches of river that are in unfavourable condition. The reasons cited for unfavourable condition include physical modifications such as dredging and weirs, lack of river bank vegetation; low macrophyte species abundance and composition.

Returning rivers to favourable condition is a requirement of both the EU Habitats Directive and EU Water Framework Directive. For those river SSSIs judged to be in unfavourable condition, Natural England has identified a range of actions and organisations potentially responsible for their delivery, including the Environment Agency.

The aim of this project is to identify river restoration or enhancement actions that can address the physical modifications to the River Mease which are contributing to unfavourable condition. This includes the following specific objectives:

1. Determine the impacts of physical modifications on the geomorphology and ecology of the river.
2. Provide an outline restoration plan for the river on a reach-by-reach basis.
3. Identify potential delivery mechanisms.

The plan is intended to provide a framework for the improvement in the physical habitat condition of the River Mease SSSI/SAC for the next 20 to 30 years. This report outlines the technical aspects of the development of the restoration plan which accompanies this report.

Development of the River Mease SSSI/SAC Restoration Plan involved reviewing information describing the catchment of the River Mease SSSI/SAC, together with a survey of geomorphology and ecology of the River Mease SSSI/SAC (which covered Gilwiskaw Brook downstream of Packington, and the River Mease between the Gilwiskaw Brook and the River Trent).

A range of different pressures were identified which collectively affect the physical shape and behaviour of the Mease, and the associated habitats and species: features which collectively comprise the river:

Riparian zone:

- *Degraded riparian (and floodplain) vegetation*
- *Lack of trees*

Banks:

- *Degraded bank vegetation*
- *Accelerated bank erosion (e.g. poaching of the banks by livestock)*
- *Lack of morphological diversity due to re-sectioning or engineered structures*

Bed:

- *Lack of morphological diversity due to channel re-sectioning, dredging and removal of fallen trees (non-willow)*

Planform:

- *Lack of morphological diversity due to straightening and re-sectioning (large scale)*

Flow (pattern and velocity):

- *Over-deepened (lack of floodplain connectivity)*
- *Informal embankments (lack of floodplain connectivity)*
- *Impounded flows (weirs)*
- *Limited variety in flow velocity/depth (lack of woody debris in the channel)*

Based on these findings a range of different restoration activities were identified. These fall into two broad categories: those which involve restoring the channel, and those which focus on rehabilitating degraded sections of the riparian zone. Therefore restoration actions can be grouped into two categories: rehabilitation and restoration. In some reaches ecological benefits could be realised by implementing one or both types of restoration. In other reaches the study found that natural readjustment of the channel and riparian zone following past modification has allowed the typical characteristics of the channel and riparian zone expected for this type of river to reform. In these reaches conservation should be the main objective.

The restoration actions identified in each reach form a series of ‘components’ which build together to create an overall restoration vision for the SSSI/SAC which describes how the river would look and behave once the restoration plan has been implemented.

Both Natural England and the Environment Agency recognise that implementing the restoration plan requires effective and positive engagement with landowners, land managers and stakeholders. The actions in the restoration plan are required in order to achieve favourable condition in the River Mease SSSI/SAC. As such, the restoration plan will inform future decision making by the Natural England and the Environment Agency. To facilitate the involvement of land owners and other stakeholders, Natural England and the Environment Agency have taken steps to inform and involve the community and other stakeholder groups.

A range of potential constraints on restoration have been identified, including land use, flood risk, development, infrastructure and cultural heritage. These are important considerations, and future implementation of the restoration plan may be constrained at particular locations by these factors. However, overall there is the opportunity to deliver significant improvements to the river at the catchment scale.

Following publication of the final restoration plan, Natural England and the Environment Agency will work with stakeholders to take the plan forward. Whilst some options will be able to be implemented relatively quickly over the next few years, other measures will take longer to develop. This plan is a long term restoration strategy likely to be realised over the next two to three decades.

Contents

1 Introduction

1.1 Background

The River Mease and the lower part of Gilwiskaw Brook are designated as a Special Area of Conservation (SAC) (SAC EU code UK0030258) under the EU Habitats Directive, and a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act. The Mease is an example of a River Community Type II Lowland River, naturally characterised by a meandering channel, range of flow types and depths, soft bed with occasional gravel riffles, and extensive tree lining (Holmes *et al*., 1999). The primary reason for the designation of the SAC is the presence of spined loach and bullhead, which are Habitats Directive Annex II species. Additional qualifying features are white-clawed crayfish and otter (both Annex II species) and the presence of watercourses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.

A Natural England condition assessment of the SSSI/SAC, conducted during 2009, has shown that there are stretches of river that are in unfavourable condition and particular attributes that are not achieving conservation objectives. Reasons cited for unfavourable condition include physical modifications such as dredging and weirs, lack of river bank vegetation, low macrophyte species abundance and composition.

1.2 Rationale for restoration of the River Mease SSSI/SAC

There is no assumption that the River Mease was in Favourable Condition at the time of designation as a SSSI in 2000. Many of the anthropogenic stresses acting on the Mease have been present for considerable periods of time, and the SSSI designation was only made within the last 12 years. The Mease was designated on the basis of being one of the best examples of the river type, with the intention of preventing further deterioration and, over time, addressing existing impacts.

For those river SSSIs judged not to be in favourable condition, Natural England has identified actions to remedy this together with a range of potentially responsible organisations, including the Environment Agency. Returning rivers to favourable condition is a requirement of both the EU Habitats Directive and EU Water Framework Directive.

1.3 Project aim and objectives

The aim of the project is to identify river restoration or enhancement actions that can address previous physical modifications to the River Mease SSSI/SAC which contribute to the unfavourable condition. This includes the following specific objectives:

1. Determine the impacts of physical modifications on the geomorphology and ecology of the river.
2. Provide an outline restoration plan for the river on a reach-by-reach basis.
3. Identify potential delivery mechanisms.

The plan is intended to provide a framework for the improvement of the River Mease SSSI/SAC for the next 20 to 30 years.

1.4 Aims and objectives of the Technical Report

This Technical Report is for use by river managers and regulating bodies (specifically Natural England and the Environment Agency) as supporting information for the accompanying River Mease SSSI/SAC Restoration Plan. The aim of the Technical Report is to present the findings of the geomorphological assessment and ecological interpretation of the physical impacts on the river, and determine the types of restoration measures required to rectify this.

2 Method

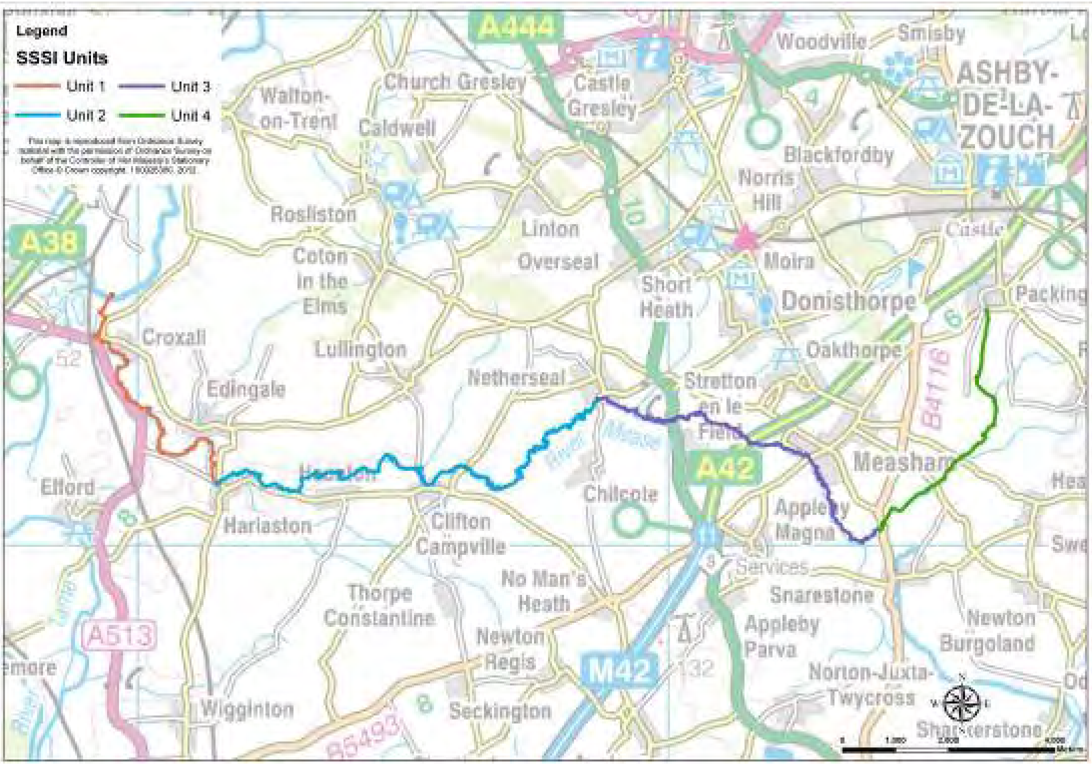
2.1 Overview of method

The geomorphological and ecological study of the River Mease SSSI/SAC was based on the Fluvial Audit method. The Fluvial Audit approach was originally developed in parallel with the DEFRA/Environment Agency Guidebook of Applied Fluvial Geomorphology (Sear, Newson and Thorne, 2003). Fluvial Audit has been applied to a wide range of purposes and the detail of the method tailored to specific project objectives. In this case the method was amended to include the collection of habitat suitability data. As with all Fluvial Audits, the study consisted of desk study followed by field survey components.

2.2 Study area

Development of the River Mease SSSI/SAC Restoration Plan focused on a review of information describing the entire catchment of the river. The field survey focused specifically on the River Mease SSSI/SAC, which encompasses Gilwiskaw Brook downstream of Packington, and the River Mease between the Gilwiskaw Brook and the River Trent (Map 1).

Map 1: River Mease SSSI/SAC extent and management units



2.3 Desk based assessment

The desk study involved reviewing a combination of catchment-scale data sets, such as topographic and geological maps, and the findings of previous studies which describe the characteristics and condition of the River Mease SSSI/SAC and the wider catchment. Previous studies reviewed included:

- *River Mease SSSI and SAC Fish Survey (2010), APEM report for Natural England;*
- *Development of an ecologically based vision for the River Mease SAC and River Eye SSSI (2010), APEM report for Natural England;*
- *River Mease Diffuse Water Pollution Plan (2010), Joint Natural England and Environment Agency report;*
- *Condition Monitoring of Canal, River and Open Water SSSIs in the East Midlands Area Common Standards Monitoring Condition Assessment of River Mease SSSI (2010). Scott Wilson report for Natural England;*
- *The Tame, Anker and Mease Catchment Abstraction Management Strategy (2008). Environment Agency;*
- *Measham and Packington Scenario Modelling, Flood Risk Mapping Study. Interim Hydrology Report. Hyder Consulting UK Ltd for the Environment Agency;*
- *River Mease Diffuse Water Pollution Plan, Joint Natural England and Environment Agency report, and*
- *River Mease SAC Water Quality (Phosphate) Management Plan, Joint Natural England and Environment Agency report.*

2.4 Field survey

2.4.1 Overview

A walk-over survey of the 25km long SSSI/SAC was undertaken between the 7th and 12th November 2012. The survey team comprised an experienced geomorphologist and an experienced ecologist. The walk-over survey focused on recording the following types of information:

- *Sediment sources (erosion) and sinks (deposits);*
- *Woody debris (fallen trees branches etc) within the channel;*
- *Channel modifications (straightening, deepening);*
- *Channel structures (weirs, walls, culverts etc.);*
- *Dominant geomorphological processes, and*
- *Characteristics of the riparian zone.*

Field data was collected using a hand-held mobile mapping device, allowing this to be inputted directly into a Geographical Information System (GIS) for subsequent analysis and comparison with other datasets.

2.4.2 Reach definition

In order to organise the data collected during the field survey and to facilitate the development of outline restoration plans for the SSSI/SAC, the river was sub-divided into ‘reaches’. These reaches represent sections of the river with specific geomorphological and ecological characteristics that differ from adjoining sections of the river. The reaches were defined during the field survey starting a GIL001 or MEA001, a new reach number was allocated where the character of the river and its surroundings changed. Reasons for defining a new reach consisted of a combination of the following:

- *Appreciable change in the morphology of the channel, such as a change in planform, cross-sectional form;*
- *Change in the composition and condition of the riparian zone, and*

- *Change in dominant land use.*

When assigning sections of river to particular reaches, emphasis was placed on the likely need for restoration and the potential nature of this restoration (Appendix 1).

2.4.3 Field based interpretation

A key aspect of the walk-over survey was to use observations to establish the degree of modifications to the channel and its surrounding environment, and the processes up and downstream of that reach affecting it, both of which formed a key determinant as to the need for physical restoration.

2.5 Data analysis and reporting

The findings of the desk study and field survey data are presented in this report. The survey data collected using the mobile mapper is in GIS format, and can be viewed using the interactive map tool on the CD accompanying this report. The photographs taken during the field survey are also included in the interactive map. The restoration plan for the SSSI/SAC developed during this study is outlined in the accompanying River Mease SSSI/SAC Restoration Plan document. This sets out the vision for the long term restoration of the SSSI/SAC and provides a series of reach-by-reach proposals.

2.6 Developing the restoration vision and detailed plans

The restoration plans have been developed using a combination of:

- *Geomorphological and ecological expertise regarding the type of characteristics the river channel and its surrounding environment should ideally have under natural conditions;*
- *Reference to descriptions of the 'reference condition' (essentially a set of characteristics) for the specific river types found within the SSSI/SAC;*
- *Guidance on best practice for management of rivers and their surroundings, and*
- *A review of widely used river restoration techniques including a consideration of their suitability.*

3 River Mease SSSI/SAC

3.1 River Mease SSSI/SAC designation and ecological features

The SSSI/SAC is approximately 25km in length and comprises the lower reaches of the Gilwiskaw Brook downstream of Packington, and the River Mease downstream of its confluence with the Gilwiskaw Brook to its confluence with the River Trent. The SSSI/SAC comprises four management units across three counties; Leicestershire, Derbyshire and Staffordshire (Map 1).

Unit 1: River Trent – Harlaston Bridge
Unit 2: Harlaston Bridge – Netherseal
Unit 3: Netherseal – Snarestone
Unit 4: Snarestone – Packington (Gilwiskaw Brook)

As briefly noted in Section 1.2, at the time of designation the SSSI was considered to be one of best remaining examples in the UK of a lowland river (JNCC Type II). However, although the physical form of the river, especially its planform, is considered to be relatively unmodified, the river has been previously adversely impacted by human activities including physical habitat modifications. As a result of these modifications the river was in unfavourable condition at the time of designation in 2000. The designation of the river was intended to provide a means of conserving the habitat that was present and the important ecology which depended on this. Designation was intended to prevent the river from deteriorating further, and to form the foundation from which efforts to improve the river could be developed. A range of measures have already been implemented to improve the condition of the SSSI/SAC (see Section 4). However it will take time for these to be effective and for the results to be reflected by a measurable improvement in river condition.

3.2 SSSI/SAC condition status

A condition assessment of the SSSI/SAC, conducted during 2009, has shown that each of the four SSSI units is in unfavourable condition (Table 3.1). The condition assessment survey was based on four 500 m long sites (one in each SSSI unit). The failure to meet favourable condition in each of the units reflects that fact that one or more of the particular attributes of the SSSI unit are not achieving the conservation objectives required (Scott Wilson, 2010) (Table 3.2). The further detail describing the reasons for unfavourable condition is provided in Table 3.3.

Many of the reasons for unfavourable condition are also reflected in risks to achieving the Water Framework Directive (WFD) objectives. The Gilwiskaw Brook is currently considered to have poor ecological status, and the River Mease within the SSSI/SAC extent is achieving moderate ecological status. The aim is to reach good ecological status by 2027 (see section 7.1). The measures to achieve this must be operational by 2012.

Of the different aspects of the river considered during the condition assessment, substrate (siltation) and channel structures are of particular relevance to this study. The 2009 condition assessment indicated that the river bed conditions appear to be in favourable condition, as each site examined exhibited a range of sediment types and siltation (fine sediment accumulation) was not deemed to be excessive. While this indicates that substrate conditions are generally in line with target conditions, this is based on observations undertaken along only 8% of the river length, limiting the certainty of the assessment. In contrast, bed conditions along the whole length of the SSSI/SAC have been examined (where visible) in the fluvial audit undertaken as part of this study, to provide a more comprehensive assessment. Similarly, Unit 2 was deemed to be in favourable condition based on the 2009 assessment for the channel and banks. However, as this was based on only a 500m sample of the unit, this study has examined the potential need for restoration of these features along the whole unit.

Table 3.1: Summary of the results of 2009 condition assessment undertaken along the River Mease SSSI/SAC

Unit	Condition	Reason for adverse condition	Assessment comment
1	Unfavourable no change	Drainage, inappropriate weirs, dams and other structures, invasive freshwater species, other (siltation, water abstraction, water pollution - agriculture/run off, water pollution – discharge)	The River Mease fails on the following targets: biological GQA phosphorus - due to point source and diffuse pollution. Physical modifications - over dredging, weir, other impoundments, non native species, lack of river bank vegetation, lack of macrophyte species density and composition. over abstraction - lack of fresh water entering the river, density of the designated fish species
2	Unfavourable no change		
3	Unfavourable no change		
4	Unfavourable no change		

Table 3.2: Summary of the condition of the different aspects of the SSSI Units

Aspect	SSSI Unit and condition			
	1	2	3	4
Water flow	Inconclusive	Inconclusive	Inconclusive	Inconclusive
Water quality	Unfavourable	Unfavourable	Unfavourable	Unfavourable
Substrate (siltation)	Favourable	Favourable	Favourable	Favourable
Channel structure	Unfavourable	Favourable	Unfavourable	Unfavourable
Plant community	Favourable	Unfavourable	Unfavourable	Unfavourable
Biological disturbance	Favourable	Unfavourable	Unfavourable	Favourable
Local distinctiveness	Inconclusive	Inconclusive	Inconclusive	Inconclusive

Table 3.3: Summary of the condition of the different aspects of the SSSI Units (based on Scott Wilson, 2010, p 53)

SSSI Unit No.	River length (km)	Reason for status						
		Water flow	**Water quality**	**Substrate (Siltation)**	**Channel and banks**	**Plant community**	**Negative Indicators (Biological disturbance)**	**Local distinctiveness**
1	7.10	**Inconclusive status:** Lack of information although no problem with water availability.	**Unfavourable no change:** High concentrations of mean soluble reactive phosphorous/orthophosphate concentration.	**Favourable:** The substrate was dominated by gravels and pebbles with lesser amounts of cobbles, sands, silt and clay.	**Unfavourable no change:** Planform not assessed. Favourable for river profile. River bank vegetation and riparian zone unfavourable.	**Favourable:** Vegetation was well developed within the channel.	**Favourable**	**Inconclusive status:** No site-specific aspects have been identified for consideration so the Attribute does not apply.
2	12.86	**Inconclusive status:** Lack of information although no problem with water availability.	**Unfavourable no change:** Non-compliance with biological GQA Class targets; High concentrations of mean soluble reactive phosphorous/orthophosphate concentration.	**Favourable:** The substrate present comprised approximately equal proportions of pebbles, gravels, cobbles and sands. Very locally accumulations of silt could be found in sheltered areas near the bank. Water clarity was excellent throughout the site with negligible turbidity observed.	**Favourable:** Planform not assessed, favourable for river profile, river bank vegetation and riparian zone.	**Unfavourable no change:** Vegetation was well developed within the channel, particularly in the upstream two-thirds of the site. Non-compliance with species composition targets. Does not meet required target for the abundance of frequency IV macrophyte species.	**Unfavourable no change:** Non-compliance with naturalness of macrophytes target. Result of low diversity of native macrophyte species and the presence of *Elodea nuttallii* and *Impatiens glandulifera*.	**Inconclusive status:** No site-specific aspects have been identified for consideration so the Attribute does not apply.
3	9.17	**Inconclusive status:** Lack of information although no problem with water availability.	**Unfavourable no change:** High concentrations of mean soluble reactive phosphorous/orthophosphate concentration.	**Favourable:** Two contrasting substrate types were present in the channel. Large stretches of the site had a clay substrate whilst in other areas a substrate of gravels and pebbles was predominant.	**Unfavourable no change:** Planform not assessed. Favourable for river profile. River bank vegetation and riparian zone unfavourable.	**Unfavourable no change:** Vegetation was well developed within the channel, with the composition varying according to the dominant substrate type and water depth. Non-compliance with species composition targets. Does not meet required target for the abundance of frequency IV macrophyte species.	**Unfavourable no change:** Non-compliance with naturalness of macrophytes target. Result of low diversity of native macrophyte species and the presence of *Elodea nuttallii* and *Impatiens glandulifera*.	**Inconclusive status:** No site-specific aspects have been identified for consideration so the Attribute does not apply.
4	5.81	**Inconclusive status:** Lack of information although no problem with water availability.	**Unfavourable no change:** High concentrations of mean soluble reactive phosphorous/orthophosphate concentration.	**Favourable:** Substrates within the channel were typically dominated by gravels and pebbles with lesser amounts of sand, cobbles and boulder. Water clarity was excellent throughout the site, with negligible turbidity observed.	**Unfavourable no change:** Planform not assessed. River profile, river bank vegetation and riparian zone unfavourable.	**Unfavourable no change:** Vegetation was very poorly developed within the channel due to historic modifications to the channel including over-deepening. Non-compliance with species composition targets.	**Favourable**	**Inconclusive status:** No site-specific aspects have been identified for consideration so the Attribute does not apply.

4 Catchment characteristics

4.1 Geology and topography

The geology of the catchment comprises Mercia mudstone and Sherwood sandstone, which give rise to a reddish clay soil with occasional areas of sandier soils. The upper Mease drains the elevated Charnwood Area whilst the lower catchment is flatter. Ground elevations vary between 160 to 60 mAOD. The clay rich soil and low relief mean the river is a lowland, passively meandering river. The Gilwiskaw Brook is steeper than the River Mease, which results in a slightly different character, in-channel features and vegetation, which adds to the diversity of the SSSI/SAC (see Section 5).

4.2 Hydrology and flood risk

The River Mease catchment drains an area of approximately 167 km^2. The river flows from its source as the Gilwiskaw Brook in Smisby to the north of Ashby-de-la-Zouch, to its confluence with the River Trent near Croxall. The Hooborough Brook rises on the outskirts of Swadlincote and flows south to its confluence with the River Mease near Netherseal.

4.2.1 Hydrology

The Mease catchment receives a relatively low annual average rainfall total of 640 mm (Hyder, 2011), with the highest rainfall total received in the upper catchment of the Gilwiskaw Brook and the lowest average received by the Mease tributaries in the lower catchment toward the Trent confluence (Hyder, 2011).

The hydrology of the River Mease is characterised by pronounced variations between low and high flows (see Figure 4.1). The sandstone provides the base flow but the clay rich geology results in a relatively impermeable soil leading to rapid surface runoff. Urban and road runoff also influences the flow regime; the A42, constructed in the late 1980s, is believed to add a considerable amount to the flow. Sewage Treatment Works (STW) augment the flow and there are also discharges from industry. The hydrology is also influenced by rising mine water in the north of the catchment (Natural England and Environment Agency, 2010).

In 2002 a new gauging station at Clifton Hall was installed on the River Mease which replaced the one at Stones Bridge (which was providing unreliable flow data due to surcharging by the bridge upstream under high flow conditions, and summer weed growth). As a result, there is little historic flow data to enable long term trends to be deduced or to ascertain the significance of the runoff contribution from the A42. Figure 4.1 illustrates the high variation in the flow. The red dotted line indicates the change in gauging data from Stones Bridge site to Clifton Hall; it is clear that the Stones Bridge station overestimated the flow. The high peak in flow in 2007 relates to the June/July flood event when the River Mease inundated the floodplain and flooded several gardens in Packington (Table 4.1).

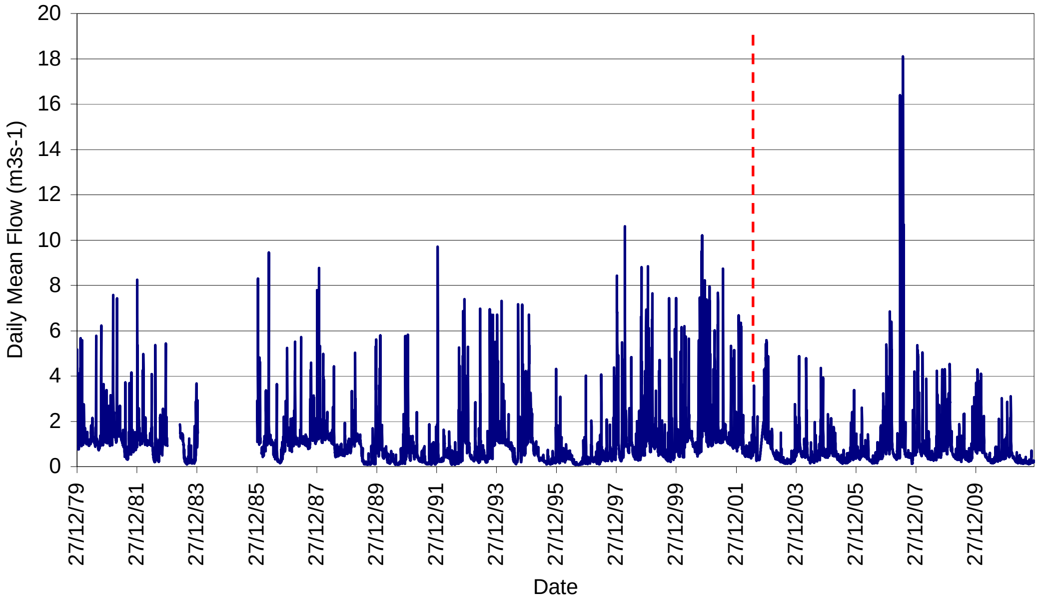


Figure 4.1 Flow record for the River Mease from the Stones Bridge station (left of red dotted line) and Clifton Hall (right of red dotted line) (N.B. The data from Clifton Hall (2002 onwards) is more reliable than that obtained at Stones Bridge which overestimated the flow)

4.2.2 Flood risk

Flooding in the past has been quite localised, and in some cases, has arisen from pluvial sources (flooding from drains through high surface runoff) rather than fluvial sources (flooding from the river overtopping its banks). Both winter and summer flooding occur. Table 4.1 summarises the flood events documented in the recent past (from Hyder, 2011). There is ongoing flood risk mapping work within the Environment Agency to update the 1:100 and 1:1000 year flood zones within the Mease catchment (Hyder, 2011).

Table 4.1 Summary of flood events in the Mease catchment (from Hyder, 2011)

Event	Description	Information source
1987	Main Measham Road between Oakthorpe and Donisthorpe closed several times because of flooding caused by subsidence associated with local mine workings	Leicestershirevillages.com
November 2000	River Mease flooded the quarry at Measham, filling it in less than a day	FRA for Proposed Development at Measham Brickworks (SLR, 2006)
July and November 2000	Flooding from the Gilwiskaw Brook at Packington	Burton Mail
July 2001	Flooding in Packington – 1 property, 6 back gardens and Mill Street. Drainage capacity issues are causative, in addition to flooding from the Gilwiskaw Brook	NW Leicestershire SFRA (Atkins, 2008)
September 2002	Sewer flooding in Packington	NW Leicestershire SFRA

Event	Description	Information source
		(Atkins, 2008)
January 2006	Flooding at Wilkes Avenue in Measham, caused by leaves blocking the drains	Measham Parish Council meeting minutes
June/July 2007	Heavy rainfall caused flooding on roads and gardens in Packington, River Mease over-topped its banks causing floodplain inundation	NW Leicestershire SFRA (Atkins, 2008)
August, September and October 2008	Sewer flooding in Packington	NW Leicestershire SFRA (Atkins, 2008)
July 2010	Flooding of Burton Road, Mill Street, Chapel Street, gardens and one residential property in Coton in the Elms. Surface water runoff and foul sewer overflows attributed as the cause.	EA flood survey questionnaire

The River Mease SSSI/SAC is located in sub area 6, Mid Staffordshire and Lower Tame (Units 1, 2 and 3) and sub-area 8, Rural Leicestershire, (Units 4 and 3) of the River Trent Catchment Flood Management Plan (CFMP) (Environment Agency, 2007).

In sub area 6 the CFMP Policy Option (Policy Option 6) is in areas of low to moderate flood risk where the Environment Agency will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits. The key messages of relevance of this sub area are to:

- *Work with others to sustain and improve the status of environmentally designated areas through appropriately managing the frequency, extent and duration of flooding;*
- *Reduce soil erosion resulting from rapid surface water run-off;*
- *Where appropriate, return watercourses to a more natural state, increasing biodiversity and opening up green river corridors through urban areas;*
- *Sustain and increase the amount of BAP habitat in the catchment, and*
- *Support and encourage land management and drainage practices that will protect and improve water quality.*

Proposed actions for this area include:

- *Carry out a feasibility study to identify and assess locations for river restoration or improvements; and*
- *Identify locations where flood attenuation ponds or wetland areas could be developed with associated habitat improvement or creation.*

In sub area 8 the CFMP Policy Option (Policy Option 6) is in areas of low to moderate flood risk where the Environment Agency will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits. The key messages of relevance of this sub area are to:

- *Sustain and improve the status of environmentally designated areas through appropriate frequency, extent and duration of flooding, including using rivers and floodplains to benefit nature conservation;*

- *Work with land managers and farmers to reduce soil erosion from intensively farmed land;*
- *Support and encourage land management and land use that will reduce run-off rates from upland areas, and*
- *Sustain and increase the amount of BAP habitat in the catchment.*

Proposed actions for this area include:

- *Investigate land use changes which will reduce run-off rates and lessen soil erosion from intensively farmed land in Leicestershire;*
- *Identify locations where flood attenuation ponds or wetland areas could be developed with associated habitat improvement; and*
- *Identify potential sites for BAP habitat creation.*

(Environment Agency, 2007)

The River Mease SSSI/SAC Restoration Plan provides an opportunity to contribute to the implementation of these policies and actions.

4.3 Land use

The river flows through a largely rural and agricultural landscape, with urban development located in the Gilwiskaw catchment (Ashby-de-la-Zouch and Packington), and the middle reaches of the River Mease (Measham). There is also a history of mining within the catchment, with some open cast mines still in operation.

The majority of land adjacent to the river is arable, although there is a proportion of grazed pasture from approximately 25% along the Mease to approximately 40% along Gilwiskaw Brook. Some of the landowners adjacent to the river are in Environmental Stewardship schemes (Entry level and/or Higher level) (Appendix B).

4.4 Water resources

4.4.1 Water abstraction

The largest number of licences for abstraction of water resources in the River Mease catchment is for the purpose of agriculture, although the volumes licensed are relatively small. Only 1% volume of water is abstracted for industrial use (Environment Agency, 2008). The current licensing strategy dictates winter abstraction only (November to March) and a 'hands-off' flow of 19.3 Ml/d based on Clifton Hall gauged flows, to maintain flow variability. There is therefore no water available for abstraction at low flows on the River Mease (including the Measham groundwater unit), and this will remain the case until at least 2014 (Environment Agency, 2008).

Due to the SAC and SSSI designation of the River Mease and the Gilwiskaw Brook up to Packington, the impact of all abstractions on water resources have recently been investigated under the Habitats Directive Review of Consents (RoC) process. The Review of Consents was undertaken by the Environment Agency to assess if any licensed permissions were having an impact on the River Mease SSSI/SAC. The RoC identified that existing licences had the potential to adversely impact on the designated features of the Mease SSSI/SAC. To prevent damage, changes were made to a total of eight abstraction licences, and the existing strategy to close abstraction in the summer and enforce a hands off flow in winter was retained (Environment Agency, pers. comm). The RoC also identified that the River Mease is currently failing to meet the phosphate objectives set for the SSSI/SAC by Natural England (see section 4.5.2.).

4.4.2 Water quality

In recent years all sampling sites within the SSSI/SAC obtained a Class A or B for General Quality Assessment (GQA) Chemistry, and Class B or C for Biology (Scott Wilson, 2010). The concentration of unionised ammonia over the last decade or so has been relatively low (Scott Wilson, 2010). Suspended solids concentrations have been consistently below the 25mgL^{-1} threshold (EC Freshwater Fisheries Directive target value) although there appears to have been a slight increase since 2003 (Scott Wilson, 2010).

(a) Phosphorous levels

One of the main pressures on the water quality of the River Mease SAC/SSSI is the level of phosphorous, and these are generally higher in the upper reaches. Factors such as dilution, sedimentation and uptake are likely to contribute to reduction in nutrient levels from upstream to downstream (Scott Wilson, 2010), however no monitoring sites met even the most lenient target of 0.1 mgL^{-1} between 1998 and 2008 (Scott Wilson). The recent Review of Consents (RoC) confirmed that the River Mease is currently failing to meet the phosphate objectives set for the SAC by Natural England, and that these excessive levels were preventing the achievement of favourable condition for this attribute. Phosphorous removal was recommended for a total of nine water quality discharge permits which were shown to be having the largest impact on the SAC. To date, phosphorus removal has been introduced at some of the nine sewage treatment works, with the remainder to follow by 2014.

(b) Water Quality (Phosphorous) Management Plan (WQ(P)MP)

The RoC and resulting actions implemented from it will not in isolation be enough to meet the conservation objective for phosphate in the SAC, so a water quality phosphate management plan (WQ(P)MP) was developed in 2011 by the Environment Agency in conjunction with Natural England. The plan aims to contribute to achieving the phosphate favourable condition targets by concentrating on diffuse inputs and sources of phosphate, and promoting new technology. The implementation of the plan is a partnership between the Environment Agency, Natural England, Severn Trent Water and the relevant local planning authorities, and will help mitigate the pressures of new development and housing in the catchment and the capacity and quality of effluent from the sewage treatment works. The WQ(P)MP also incorporates and builds on the Diffuse Water Pollution Plan (DWPP) (see section 7) produced by Natural England and the Environment Agency in December 2010, which will help mitigate the impacts of urban (highway and sewer discharges) and agricultural/land runoff. Both these plans will help to achieve both Habitats Directive targets and WFD objectives.

4.5 Fisheries

The River Mease has variable spatial fish populations. The patchy distribution of fish reflects their mobile nature, seasonality, habitat preferences and sensitivity to poor water quality. In February 2010, Natural England commissioned a fish survey which concluded that both spined loach and bullhead populations failed to achieve favourable condition in at least two of the SSSI/SAC units in terms of population size, and in all units in terms of population structure (where the distribution in the ages of fish indicates a healthy population).

The Environment Agency has been surveying fish populations since 2002 in several locations along the River Mease (Appendix C). Chub and roach are the two most common fish, with dace, pike, perch and gudgeon also evident. Since 2007 there appears to have been an overall decline in fish numbers, but this coincides with the time the Environment Agency ceased stocking the river. There have also been several pollution incidents on the River Mease over the past decade.

The most significant decline in fish numbers appears to be around Netherseal, compared to other sites near the A42 road bridge downstream of Measham, and at Stones Bridge near Clifton Campville (Appendix C). The numbers of Chub have generally increased since 2007 around Clifton Campville.

Fish surveys have been less frequent on Gilwiskaw Brook and data has only been collected since 2005. In recent years, the numbers of chub near Stone House Farm near Packington have increased, and in 2011, a few dace and gudgeon were present. There is a greater diversity of fish downstream on Gilwiskaw Brook around Snarestone, with chub, dace, roach, gudgeon and perch recorded in 2011.

4.6 Crayfish

Native white clawed crayfish currently appear to be absent from the SSSI/SAC, other than near the Trent confluence, where very low numbers were recorded. A spot survey undertaken by the Environment Agency and Staffordshire Wildlife Trust in June 2011 recorded a dominant population of non-native American signal crayfish here.

4.7 Historical catchment changes and river modifications

4.7.1 Gilwiskaw Brook

In 1883 the channel of Gilwiskaw Brook downstream of Packington had a straight (modified) planform, which followed exactly the same alignment as the present channel. This infers that channel straightening was undertaken prior to this date. At this time the Gilwiskaw Brook was divided into two channels approximately 700 m upstream of Clock Mill (NGR: 436083 312259). One channel flowed to the unnamed left bank tributary which joins the Gilwiskaw Brook at Clock Mill. This appears to have been an engineered modification designed to supply water to Clock Mill. The natural channel (which generally followed the present course of the Brook) was highly sinuous in 1883 between the point at which it divided and the Clock Mill. This remained the case until the early 1980s, however, by the 1990s the present straight planform had been established and some straightening was also undertaken between Clock Mill and Swepstone Road. The extent of river channelisation works in Britain was investigated in the 1980s (Brookes, 1988). Gilwiskaw Brook was recorded as having undergone comprehensive channel improvements during the early 1980s. It is therefore probable that this channel straightening was undertaken at this time.

Approximately 50 m downstream of Swepstone Road, Gilwskaw Brook divided once more. Here an artificial channel split from the natural channel (which followed the present course of the stream) to the right and flowed parallel to the Brook (roughly 100 and 200 m to the west) passing under Bosworh Road and then dividing and feeding a series of drains. This appears to represent an irrigation system for the fields to the south of Measham Lodge. This system was still operational in the 1960s.

In the 1920s mining began to the left of Gilwiskaw Brook downstream of Swepstone Road. The Brook became increasingly confined by spoil heaps which completely controlled the Brook to a narrow steep sided valley by the 1960s. The Brook remains confined between mining spoil to this day.

Downstream of Swepstone Road, Gilwiskaw Brook has followed its present, straight, modified alignment since the 1880s with channel modifications having been undertaken prior to this date. The planform of the lower section of Gilwiskaw Brook around Snarestone Road has not been significantly modified; however it is likely that this section was improved by dredging during the 1980s channel improvement scheme.

The modifications to Gilwiskaw Brook are shown on Figure 4.2.

4.7.2 River Mease

A comparison of 1888-1889 1:10500 Leicestershire, Derbyshire and Staffordshire County OS Maps against contemporary OS maps and aerial photography indicates that the majority of the course of the River Mease has not significantly changed since 1888 and is generally natural. There are however local areas where site specific channel modifications are known to have occurred (Table 4.2)

Table 4.2 Site specific channel modifications along the River Mease

Location	Details
Measham Reach: MEA003	Anomalously straight section of channel, as compared to surrounding reaches. Straightening occurred prior to the 1880s.
Measham Reach: MEA005	Anomalously straight section of channel, as compared to surrounding reaches. Straightening occurred prior to the 1880s.
Measham: Reach: MEA006	Straightening of the channel during the late 1980s during construction of the A42 trunk road.
Stretton Brdige (Mill) Reach: MEA007	Weir to supply water to mill. Mill was disused by the 1880s and the weir was removed during the 1950s.
Netherseal (Corn Mill) Reach: MEA008	Course of flow altered to feed majority of flow into a mill leat at confluence with Hoobrough Brook (which was also routed into the leat). Natural channel of Mease regulated by a sluice.
Netherseal Reach: MEA008	Secondary channel of River Mease, to left of the existing channel, at Netherseal was cut-off prior to the 1880s.
South of Seal Sands Farm Reach: MEA011	Anomalously straight section of channel, as compared to surrounding reaches. Straightening occurred prior to the 1880s.
Clifton Campville (Clifton Mill) Reach: MEA013	Mill has been present since at least the eighteenth century probably on the site on an earlier (Domesday) mill. The river is still impounded by the mill weir.
Between Clifton Campville and Haunton (NGR 424551	A bend in the river was cut off prior to the 1880s (possibly natural) and a low weir installed, apparently to create a

Location	Details
311407) Reach: MEA014	sheep wash.
Harlaston (Mill) Reach: MEA017	Sluice (weir) to supply water to the mill present in 1880s. Recently removed (2000s).
Croxall Mill Reach: MEA022	Weir present to 1880s to feed mill leat. The weir is no longer present and the leat partially filled in. The downstream portion of the leat remains as a backwater at high flows no longer present
Croxhall Lakes Reach: MEA025	River channel realigned during the 1990s to facilitate sand and gravel extraction.

In addition to these site specific modifications, research by Brookes (1988) indicated that a comprehensive arterial drainage scheme was undertaken along the River Mease (between Measham and its confluence with the River Trent) between 1985 and 1986 (although records are not available to confirm this with certainty). Field evidence in the form of the highly uniform channel cross-section and relatively deep channel (described in Section 5) are consistent with this activity. Since this time, the river has however, readjusted its form through sediment deposition on the bed, bank collapse, narrowing, accumulations of woody debris and vegetation growth (Section 5).

The modifications to the River Mease are shown on Figure 4.2.

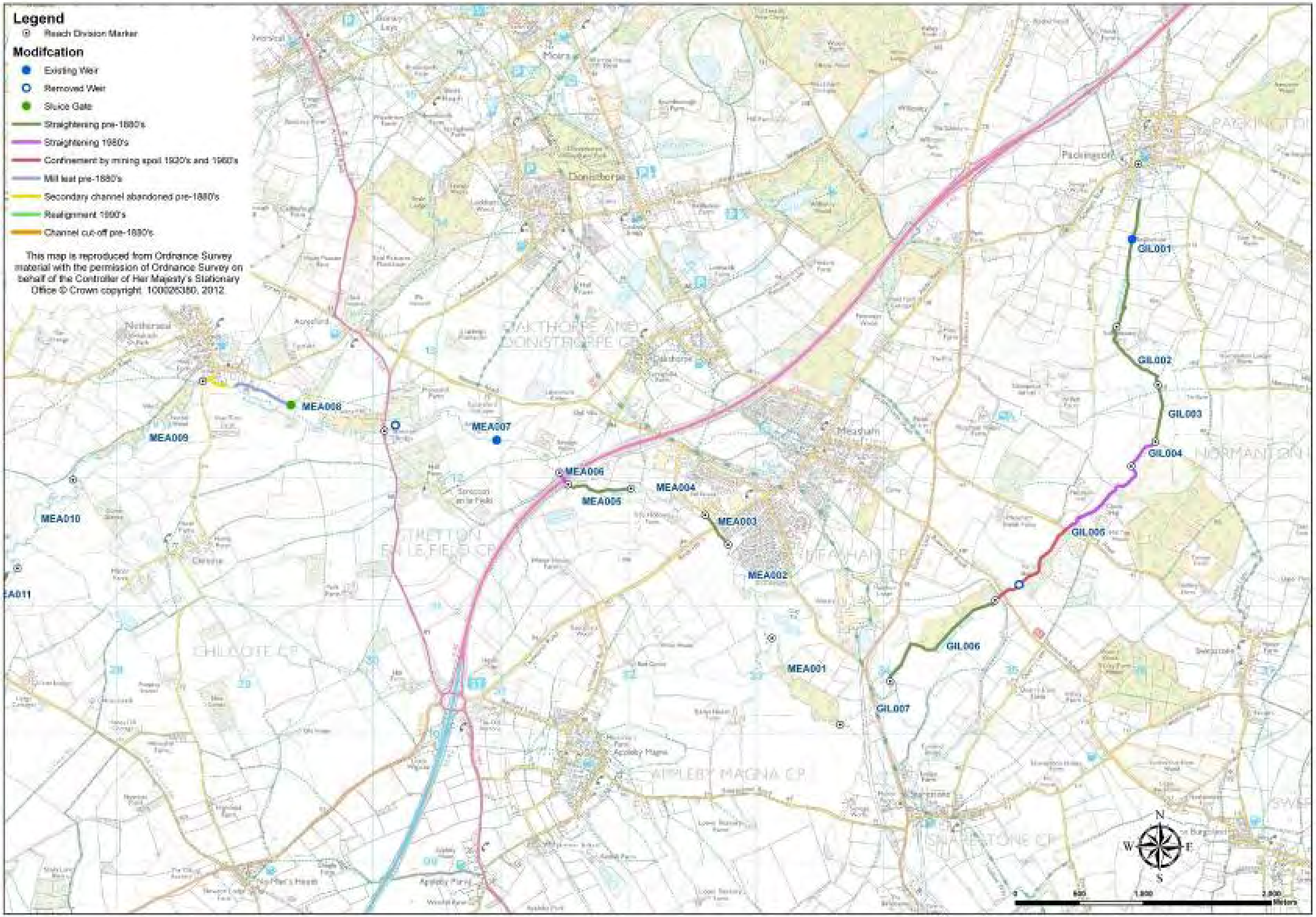


Figure 4.2: (a) Site specific river channel modifications along the upper half of the River Mease SSSI/SAC

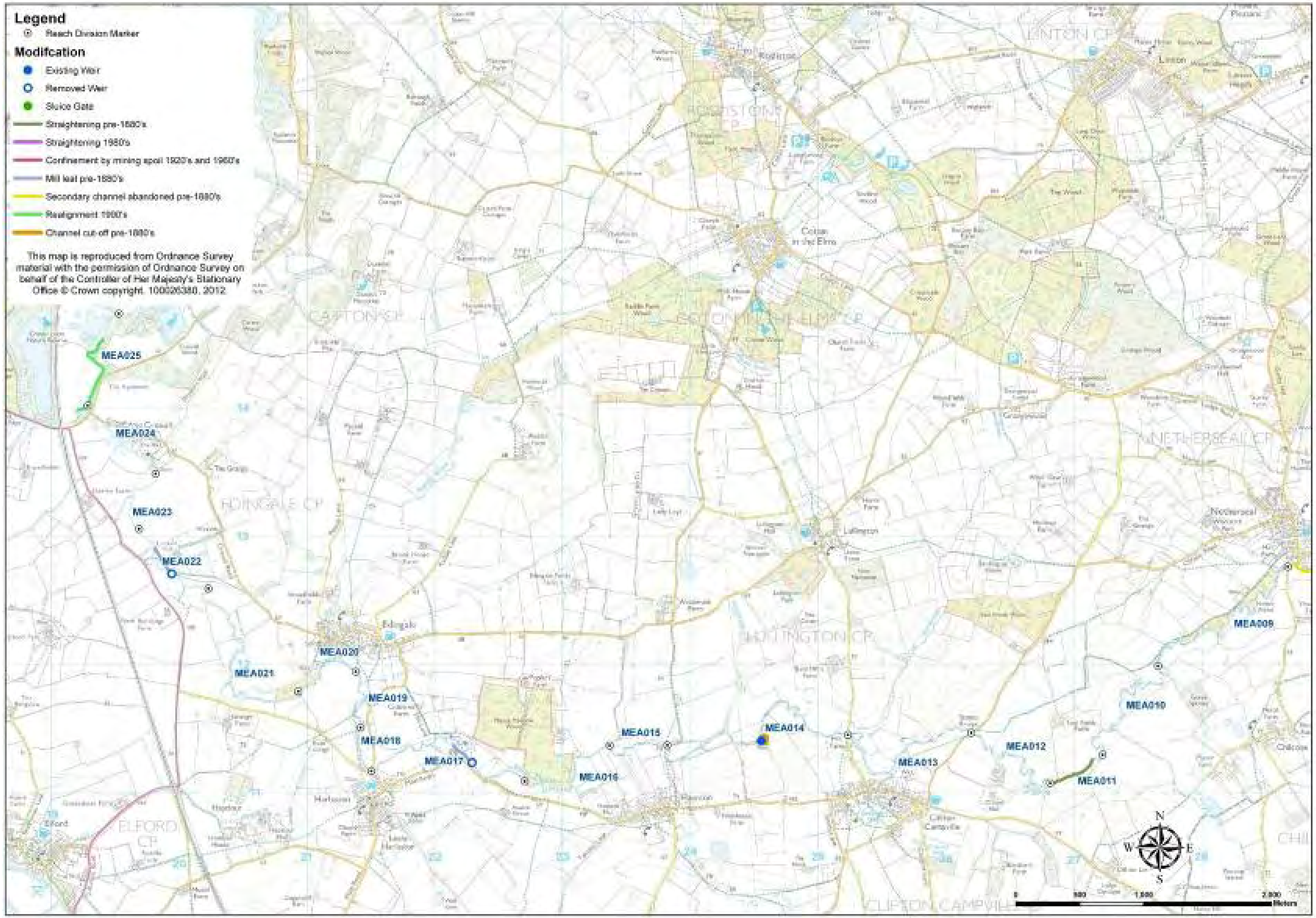


Figure 4.2: (b) Site specific river channel modifications along the lower half of the River Mease SSSI/SAC

5 Geomorphological and ecological condition

5.1 Reference condition

5.1.1 River channel morphology

The geomorphological form of river channels needs to support the ecological features that are characteristic of the river, and for which it has been designated. Table 5.1 describes the typical geomorphological natural lowland rivers and its relationship to the characteristic ecology of these rivers. This provides the reference conditions against which the findings of the Mease field survey can be compared. The field survey results, contained in the interactive map, are summarised in the following sections, which have been structured in accordance with the reference conditions described in Table 5.1.

Table 5.1: The characteristics of natural lowland rivers (based on Mainstone, 2007)

Feature	Description	Ecological significance
Bed	Sands and silts with gravel accumulating at riffles (with the amount of gravel depending on supply of gravel and the energy of the river).	River bed gravels provide an essential, but relatively scarce, habitat for a wide variety of species including caddis-flies, riffle-beetles and mayflies, and fish such as dace, bullheads, stone-loach, brook lamprey, minnow and stickleback. Gravels and faster flows also provide rooting opportunities for species such as water-crowfoot.
Flow types	Dominated by glides and occasional pools with coarse sections creating localised riffles. Occasional log jams (coarse woody debris) creating ponded sections.	Creates habitat variability. Woody debris attracts decomposer species. In ponded sections and backwaters with finer bed sediments, a flora and fauna more associated with stillwaters develops, including unionid mussels and pea-mussels, libellulid dragonflies, agrionid damselflies, burrowing mayflies, water-snails, alder-flies, and various families of caddis-fly and spined loach when present. Where flows are stronger, fish species may include perch, roach and eel, with chub and gudgeon.
Planform and banks	Extensive meandering which, depending on natural sediment supply and hydraulic energy, generates sequences of alternating steep and shallow bank profiles together with point bars on the inside of bends.	On shallow banksides (particularly the insides of meander bends), a significant zone of hydrological transition can be expected, with beds of emergent species such as branched bur-reed and reed canary-grass, and wetland species such as brook-lime, water forget-me-not, water-mint, and water-cress. Vertical cliffs provide nesting opportunities for kingfisher and sand martins, as well as for burrowing bees and wasps and a range of other insects specialising in bare soils. Water voles thrive in banksides of intermediate slopes with tall herb vegetation and an active marginal zone of emergent plants. The insect fauna is heavily dependent on an active marginal and wetland fringe of vegetation for hatching, resting, feeding and mating, and as a flow refuge under spate conditions.

Feature	Description	Ecological significance
Riparian zone	Near continuous lining of the channel by riparian trees.	Submerged exposed root systems that provide in-channel habitat for fish and invertebrates such as white-clawed crayfish, potential holt and resting sites for otters. Trees are a source of woody debris and leaf litter for the river. Tree lining creates variations in within-channel light and temperature regimes that add further habitat diversity. Riparian scrub provides additional important habitat for otter and bird species such as warblers.

5.1.2 Ecology

Along the River Mease, stands of marginal vegetation are typically dominated by common club-rush (*Schoenoplectus lacustris*), reed sweet-grass (*Glyceria maxima*), reed canary-grass (*Phalaris arundinacea*), branched bur-reed (*Sparganium erectum*), greater pond-sedge (*Carex riparia*) and bulrush (*Typha latifolia*). Submerged aquatic vegetation is more varied along the lower reaches of the river and includes river water-crowfoot (*Ranunculus fluitans*), common water-crowfoot (*Ranunculus aquatilis*), blunt-leaved pondweed (*Potamogeton obtusifolius*), fennel pondweed (*Potamogeton pectinatus*), arrowhead (*Sagittaria sagittifolia*) and yellow water-lily (*Nuphar lutea*) (Scott Wilson, 2010).

Bankside tree cover varies, but trees are a vital feature of a fully functioning river corridor and channel, as submerged root systems provide important in-channel cover for fish, crayfish and aquatic insects. Fallen trees are an important source of in-channel woody debris, which plays an important role in helping previously modified parts of the river to recover lost variation in physical habitat. Sections of river that are shaded by trees, not only provide protection from bird predation, they also provide water temperature diversity,both important elements of maintaining a healthy, self-sustaining fish population.

The Gilwiskaw Brook is steeper than the River Mease and the flow velocities in the brook are higher. As a result the bed sediments are coarser, aquatic vegetation is sparser and marginal vegetation is restricted to stands of floating sweet-grass (*Glyceria fluitans*). This marginal vegetation and coarse substrate provide valuable habitat niches for bullhead.

As described in Section 1.1, the River Mease and the lower part of Gilwiskaw Brook are designated as a SAC due to the presence of spined loach and bullhead, which are Annex II species. Additional qualifying features are white-clawed crayfish, otter (both Annex II species) and *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.

The habitat requirement for the species for which the Mease is designated as a SAC are set out in Table 5.2. The species requirements of these interest species reflect the geomorphological characteristics of lowland rivers such as the Mease (Table 2).

In terms of river bed conditions, spined loach require fine substrate comprising at least 20% sand and no more than 40% silt, and bullhead require a clean coarse (gravel) bed with no excessive siltation (maximum of 20% in the upper 10cm of mid-channel gravels) (Natural England and Environment Agency, 2010). Adult white-clawed crayfish utilise tree roots and rocks in the banks to provide shelter, whilst juveniles shelter in vegetation and grass growing out of the river banks.

Table 5.2: The habitat requirements of the qualifying species found within the SSSI/SAC (Sources Scott Wilson, 2010, www[1] and www[2])

Species	Habitat requirements	Implications for River Mease
Spined loach (*Cobitis taenia*)	Small bottom-living fish that has a restricted microhabitat associated with a specialised feeding mechanism. They use a complex branchial apparatus to filter-feed in fine but well-oxygenated sediments. Optimal habitat is patchy cover of submerged (and possibly emergent) macrophytes, which are important for spawning, and a sandy (also silty) substrate, into which juvenile fish tend to bury themselves.	The River Mease is a good example of a riverine population of spined loach *Cobitis taenia*. It has a reasonable degree of channel diversity compared to other similar rivers containing spined loach populations. It has extensive beds of submerged plants along much of its length which, together with its relatively sandy sediments (as opposed to cohesive mud) provides good habitat opportunities for the species.
Bullhead (*Cottus gobio*)	Small bottom-living fish that inhabits a variety of rivers, streams and stony lakes. It appears to favour fast-flowing, clear shallow water with a hard substrate (gravel/cobble/pebble) and is frequently found in the headwaters of upland streams. However, it also occurs in lowland situations on softer substrates so long as the water is well-oxygenated and there is sufficient cover. It is not found in badly polluted rivers.	The Gilwiskaw Brook provides the best opportunity to provide good extensive habitat for a healthy population of bullhead *Cottus gobio*. Although bed sediments are generally not as coarse as other steeper rivers of central England, it does reflect the nature of many rivers in this geographical area. The Mease is also suitable in patches due to the sinuosity of the river expose gravels/cobbles; cover from submerged macrophytes is also important for the species.
White-clawed crayfish (*Austropotamobius pallipes*)	Lives in a diverse variety of clean aquatic habitats but favours hard-water streams and rivers. Non-native species of crayfish are a major threat to the native white-clawed crayfish. White-clawed crayfish make us of crevices in rocks, submerged plants and tree roots or features which provide shelter from predators. They feed on all manner of live and dead organic matter (fallen leaves, vegetation, worms, insect larvae, small fish and other crayfish).	Annex II species present as a qualifying feature, but not a primary reason for site selection.
Otter (*Lutra lutra*)	Semi-aquatic mammal, which occurs in a wide range of freshwater and coastal areas. Inland populations utilise a range of running and standing freshwaters. Suitable habitat includes vegetated river banks, islands, reedbeds and woodland (used for foraging, breeding and resting).	Annex II species present as a qualifying feature, but not a primary reason for selection of this site.
Water-crowfoots (*Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation)	Grows on gravel riffles where flow is in relatively swift and shallow. Requires good light for photosynthesis so is sensitive to siltation and shade and does not occur in deep slow flowing areas. There needs to be at least 5cm of water over riffles in summer (when flows are lower).	Annex I habitat present as a qualifying feature, but not a primary reason for site selection.

In order to maximise the habitat suitability for the qualifying species the following river characteristics are required:

- *varied bed sediments including both areas of soft fine sediment (silt and especially sand) and hard coarse sediment (gravel/pebble/cobble);*
- *a range of flow velocities including both fast and slow flowing areas;*
- *in-channel macrophytes and exposed tree roots;*
- *a supply of organic debris including leaf litter and woody debris,*
- *areas of tree cover (including woodland) along the banks (Oak, Ash, Alder and Black Poplar.*

5.1.3 Geomorphological characteristics of lowland rivers

The designation of SSSI/SAC rivers in England is based on the JNCC classification of vegetation communities in British rivers, which defines nine River Community Types (Holmes et al 1999) types in England (River Community Types). The River Mease SSSI/SAC is regarded as being a relatively unmodified example of a Type II lowland river (see Table 5.1) but with some physical habitat modifications, especially along Gilwiskaw Brook. Whilst described by River Community Type as a lowland, clay dominated river, geomorphologically the River Mease can best be described as a passively meandering river. This reflects that while the river channel has a meandering course (planform) it does not exhibit widespread on-going bed and bank deformation (erosion and deposition) and as a result the meanders of the river are fixed and do not migrate. Such rivers differ from actively meandering rivers (Table 5.3).

Table 5.3: The differences between actively and passively meandering rivers (modified from Thorne, 1997)

Feature	Active meandering	Passive meandering
Bed and banks	Subject to erosion and deposition driving a change in channel morphology and also position.	Insufficient energy (stream power) to deform the channel boundary through erosion. High boundary material resistance may also contribute to this.
Bed topography	Riffle spacing 5 to 10 channel widths (close to half the wavelength). Generally one deep pool on each bed and one distinct riffle on each crossing reach.	Riffle-pool sequence not linked to planform. There may be more pool-riffle units on each bend way. Conversely there may be fewer pools and riffles than would be expected.
Planform dimensions	Meander wavelength typically in the order of 10 to 14 times the channel width.	Meander wavelength often higher than 10 to 14 channel widths. Planform generally determined by topography. For example valley side bluffs defect the channel back and forth across a comparatively narrow floodplain.
Geomorphological behaviour	Actively forming new landscape features.	Not forming new landscape features.

The occurrence of a meandering channel planform (discussed in Section 5.2.3) and the presence of riffles on the bed (discussed in Section 5.2.1) reflects an earlier stage in the river's evolution in the past under different catchment and climate conditions. The morphology of river channels reflects a combination of present day controls and characteristics inherited from the past. When determining the reference conditions for a passive river channel it is important consider the potential significance of past processes, which may no-longer be effective.

The present day morphology of the River Mease is, at least partly, a reflection of the long-term history of the catchment. Research into the evolution of the rivers in the English midlands (see Brown, 1997 for a summary) suggests that changes in the catchment over the past 10,000 years have played an important role in the development of the present day character of the river channel. The River Mease, in common with many other rivers in the English midlands, has relatively cohesive clay-rich river banks (Brown and Keough, 1992) with few gravels (except locally where these occur very close to the bed level). Also in common with other rivers in the area, the floodplain of the River Mease has low relief (Brown and Keough, 1992) which indicates that the river has not recently shifted position in the landscape.

The development of the present form of the River Mease is likely therefore to have much in common with nearby rivers. Brown and Keough (1992) argue that the characteristics of the passive lowland rivers in the midlands can be explained by long-term stability of the river bed, while the floodplain accumulated sediments and river banks gained height (the 'Stable Bed Aggrading Banks' model). The model postulates that around 8000 years BP (before present) the rivers of the midlands had shallow, relatively active gravel-bed channels surrounded by floodplains covered in birch and willow. Increasing wetness of the floodplain (potentially due to climatic changes) led to water-logging, favouring alder trees which gradually out-competed other species (Brown and Keough, 1992). By 6000 years BP the floodplains of the midlands were dominated by alder (Brown, 1997). At some point between 4500 and 2500 years BP, land use in the catchment changed through woodland clearance and the occurrence of arable farming (possibly coinciding with climatic changes). This led to an increase in the rate of fine sediment supply to the river valleys causing vertical accretion of the floodplain. As the floodplain accreted through the deposition of fine sediments, the resistance of the banks to erosion increased and the position of the river channel became increasingly fixed. Over time the increase in the height of the banks led to a reduction in the ratio of the channel width to depth and a gradual (natural) reduction in the connectivity of the river and its floodplain. Some river channels in the midlands appear to have remained in the same location, situated on bed sediment pre-dating the accretion of the floodplain (Brown and Keough, 1992). The planform of the river channel is therefore likely to be inherited from the period of more active channel behaviour prior to 4500 years BP. Where riffles were present these will have remained as areas of faster shallow flow, and elsewhere where the channel was deeper and flow slow, accumulations of fine sediment will have formed on top of the gravel bed. This model of river channel evolution does appear to explain many of the features of the River Mease.

An important consequence of the vertical accretion of the floodplain is that it would tend to lead to a reduction in the frequency of over-bank flooding (Brown and Keough, 1992). A further consequence is that the increased height of the river banks, due to floodplain build-up, is likely to have triggered localised collapses. Steep, high, fine grained, river banks are particularly vulnerable to failure in the form of collapsing blocks. This type of bank collapse is likely to have resulted from water level fluctuations within the channel. Given the low stream power (energy) of the river, many of these blocks are likely to have remained in place in the channel and become colonised by vegetation. Localised bank failures and the reduction in floodplain inundation (and therefore sediment deposition beyond the channel) will have promoted in-channel siltation (Brown and Keough, 1992). The implementation of past drainage schemes (Section 4.4) to lower the bed of the channel during the twentieth century is likely to have been a response to this. These drainage schemes may have resulted in the destruction of some riffles and the creation of a relatively uniform channel, this is considered further in Section 5.2.1.

A conceptual model illustrating the likely long-term evolution of the River Mease is provided in Figure 5.1. This is based on the 'stable bed aggrading banks' model which has been used to describe the long-term development of the rivers in the English midlands (Brown and Keough, 1992; Brown, 1997).

The Gilwiskaw Brook differs from the River Mease as it has a very straight channel planform that reflects past channel engineering. The Gilwiskaw Brook also has a higher channel gradient than the Mease (this is partly a result of straightening and partly natural topography). Field evidence, described in the following sections, indicates that the Gilwiskaw Brook is more dynamic than the River Mease and some sections of the channel are not passive but actively changing. This is likely to be a reflection of the relatively high gradient of the system, which provides higher flow energy. It is possible that prior to channel straightening, the Gilwiskaw Brook was a passive system and evolved in a similar manner to the River Mease (Figure 5.1), but channel straightening caused a threshold in the geomorphological behaviour of the channel linked to gradient to be crossed, resulting in the current channel adjustment.

The passive nature of the main channel of the River Mease, and its long-term history, have a number of potential implications for the degree to which the "reference conditions" can be restored through restoration, namely:

- *The channel is likely to be (naturally) narrower and deeper than actively meandering rivers;*
- *Riffles and pools will not be as numerous as in active river systems;*
- *Lateral stability is a natural feature of the river;*
- *The planform of the river reflects topography in many places and has been inherited from an earlier period in the evolution of the channel, new meanders will not form naturally;*
- *Restoration measures which rely on natural recovery (e.g. expecting riffles to re-form naturally) may be of limited effectiveness along the River Mease (due to lack of coarse sediment supply and energy to transport that sediment), but may be more effective along Gilwiskaw Brook.*

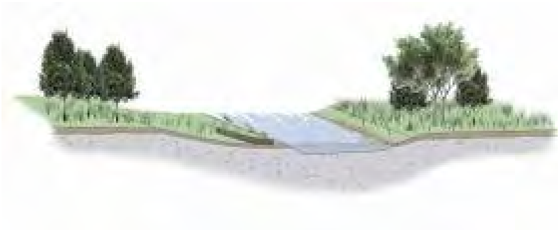
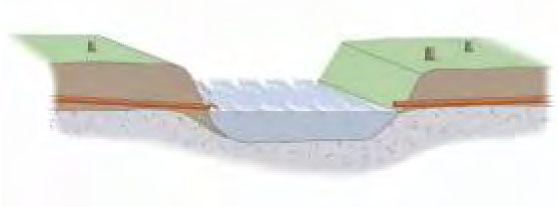
Time	Illustration	Description
8000 to 6000 years BP		Shallow gravel bed river. Floodplain covered by birch and willow. Increase in floodplain wetness.
6000 to 4500 years BP		Floodplain dominated by alder woodland. Woody debris in channel.
4500 to 2500 years BP		Land use change. Arable farming in catchment. Increase in rate of fine sediment supply to river. Increase in rate of fine sediment deposition on the floodplain. Lateral channel migration declines. Woody debris in channel.
1000 years BP		Floodplain composed of a thick accumulation of fine sediment. River channel still located on bed of gravel inherited from earlier times. Passive meandering river. Woody debris in channel.
1000 years to 200 years BP		Passive meandering. High banks subject to local collapse and subsequent stabilisation of failed blocks and growth of vegetation. Local accumulation of silt on bed. Woody debris in channel.
Nineteenth and Twentieth Centuries		Increasing intensification of land use. Tree removal. Coppicing / pollarding. Installation of piped field under-drainage. Channel dredging (deepening). Removal of woody debris.
Present		Reduced maintenance of trees (re-growth). No channel maintenance, allowing localised silt and sand deposition and the accumulation of woody debris in the channel.

Figure 5.1: Conceptual model of the evolution of the channel of the River Mease (note times are approximate)

5.2 Contemporary river characteristics

5.2.1 Bed

The beds of both Gilwiskaw Brook and the River Mease are generally composed of gravel which is covered to varying degrees by fine sediment (sand and silt). Along Gilwiskaw Brook there is evidence that the gravel bed is relatively active and the bed sediments move during high flow events. Where flow is fast, such as in narrow or shallow areas, the gravel bed is not covered by fine sediment, however the voids between gravel particles appear to be filled by fine sediment. Along the upper reaches of the River Mease it is likely that the gravel is also mobilised during high flows. There are gravel bars in reaches MEA001 and MEA005 (Table 5.4) which could only have formed through the transport of gravel along the upper section of the River Mease.

The middle and lower reaches of the River Mease also have a gravel-bed; however this is frequently covered by a layer of fine sediment (Figure 5.2). Deposition of sediment in this area would be expected to occur naturally, due to the lower channel gradient, so fine sediment accumulation on the bed of the channel is consistent with the characteristics of lowland rivers (Table 5.1) and at present is not a reason for unfavourable condition-However, there are localised instances where fine sediment (clay, silt and sand) is being supplied to the channel at an accelerated rate. These point sources, which are primarily associated with small ditch-like tributaries, were observed in reaches GIL005 and MEA001 (Figure 5.3). Occasionally, during flood events, soil from low-lying fields is subject to erosion where flow crosses the floodplain (Figure 5.4). This is a source of fine sediment to the channel, although the amount of sediment and frequency of occurrence is variable.

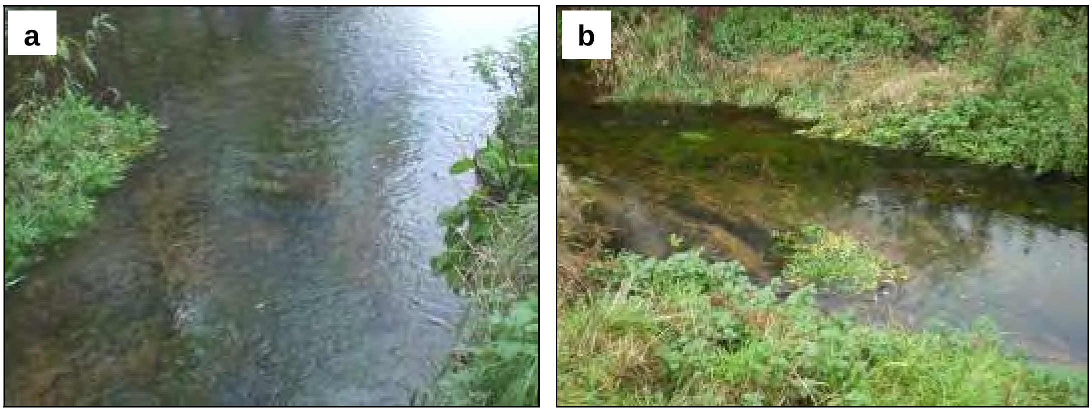


Figure 5.2: Examples of localised instances of fine sediment (sand) accumulation on the bed of the channel (a) MEA012 and (b) MEA014

Figure 5.3: Ditch-like tributaries which act as point sources of fine sediment along reaches (a) GIL005 and (b) MEA002 (Photograph b courtesy of the Environment Agency)

Figure 5.4: Evidence of flow across the floodplain, note the upper layer of the soil appears to be been subject to preferential erosion of fine material leaving gravel particles exposed (Photograph courtesy of the Environment Agency)

The gravel bed of the river channel appears to be generally stable with only minor localised re-distribution of the smaller gravel sizes during flood events. There are few channel deposits along the SSSI/SAC (Table 5.4). Those that are present are concentrated along the Gilwiskaw Brook and upper reaches of the River Mease. The presence or absence of sediment deposits, in particular gravel and cobble bars, is related to the supply of sediment and the ability of the river flow (energy availability) to move this sediment into locations where bars can develop. The concentration of channel deposits along Gilwiskaw Brook and the upper Mease (upstream of reach MEA007) is likely to be a reflection of channel gradient (Figure 5.5).

There are approximately 15 gravel riffles and 14 pools in the middle and lower reaches of the River Mease (Table 5.4). This is a relatively low number of bedforms, even for a lowland river (See Section 5.1.3) and illustrates a high degree of uniformity of the bed topography. The low number of riffles is likely to reflect a combination of their destruction (removal or breakdown due to disturbance) during past river maintenance activities (see Section 4.4) and the absence of significant sources of gravel and adequate flow energy to allow the natural redevelopment of riffles by natural recovery following the cessation of maintenance in the middle and lower reaches of the river. It is likely that the gravel bed of the middle and lower River Mease accumulated over long timescales and a significant proportion of this may reflect an earlier phase in the long-term evolution of the river (Section 5.1.3).

Although it is unlikely that coarse gravel riffles will reform naturally, and there is no evidence that this is occurring, there is evidence that the topography and morphology of the bed is becoming more diverse along the middle and lower reaches of the River Mease. This adjustment is being driven by the deposition of sand (with some silt) and some fine gravels. Reaches showing evidence of recovery include:

- *MEA004*
- *MEA007 – MEA010*
- *MEA012*
- *MEA014 – MEA015*
- *MEA019 – MEA020*
- *MEA023 – MEA025*

The degree of recovery is variable between reaches.

Table 5.4: The distribution of bedforms (pools and riffles) and channel deposits along the River Mease SSSI/SAC (*source APEM, 2010)

Unit	Reach	Riffles*	Pools*	Channel Deposits
4	GIL001	6	3	-
	GIL002	5	2	3 silt bars, cobble side bar
	GIL003	2	-	-
	GIL004	1	-	-
	GIL005	4	-	1 silt bar downstream of road bridge
	GIL006	-	1	-
	GIL007	2	2	1 small silt deposit
3	MEA001	1	2	4 vegetated islands, 1 mid-channel gravel bar, 2 silt deposits, 1 gravel side bar
	MEA002	1	3	2 vegetated islands, 1 silt island, 1 silt side bar
	MEA003	-	-	-
	MEA004	-	3	1 silt side bar
	MEA005	-	-	1 gravel bar
	MEA006	-	-	1 silt side bar
	MEA007	1	2	-
2	MEA008	1	7	-
	MEA009	1	1	-
	MEA010	-	2	-
	MEA011	-	-	-
	MEA012	-	-	-
	MEA013	2	1	-
	MEA014	2	-	-
	MEA015	-	-	-

Unit	Reach	Riffles*	Pools*	Channel Deposits
1	MEA016	-	-	-
	MEA017	-	1	-
	MEA018	1	-	-
	MEA019	-	-	-
	MEA020	-	-	-
	MEA021	-	-	-
	MEA022	3	-	-
	MEA023	-	-	-
	MEA024	-	-	-
	MEA025	4	-	Gravel side bar

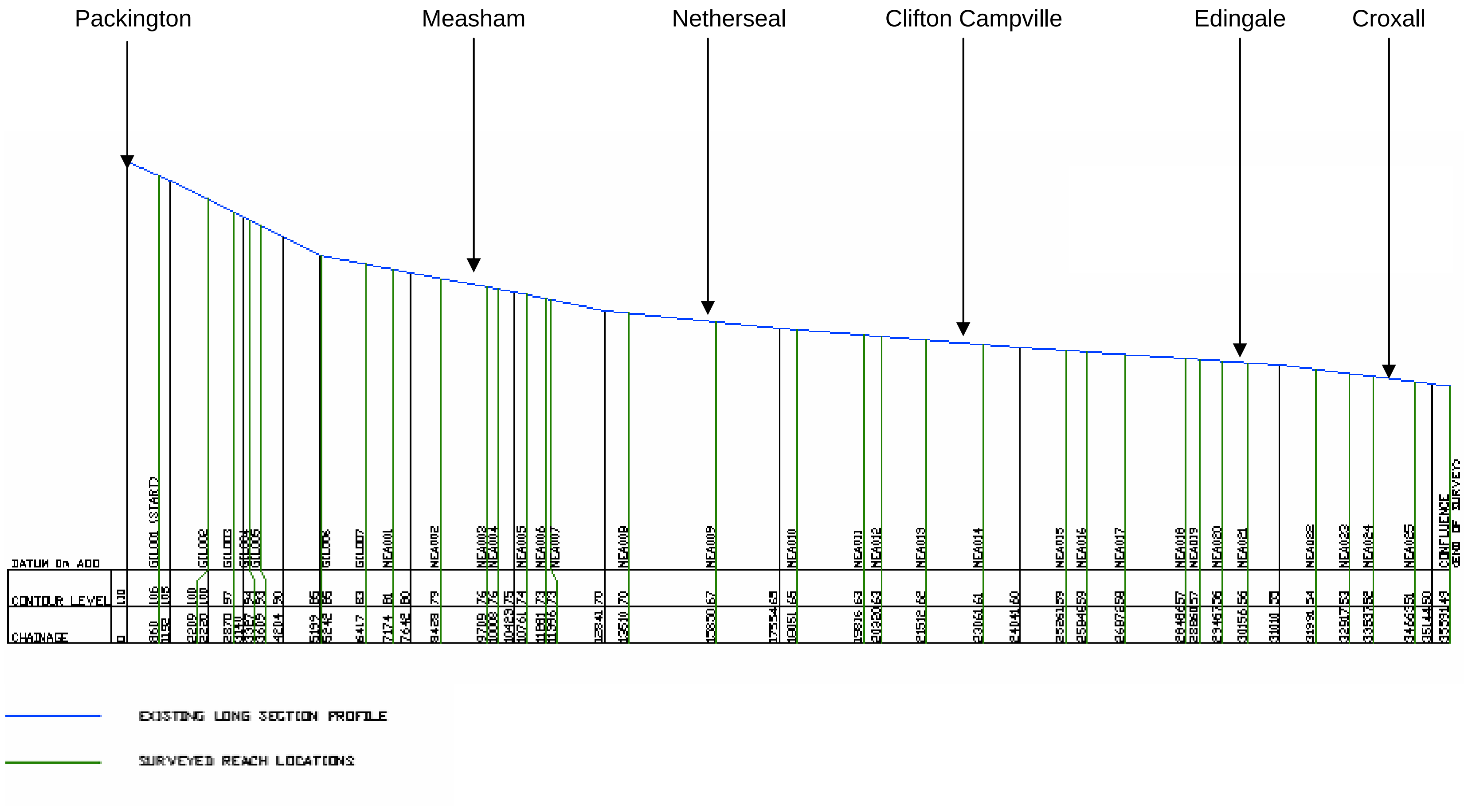


Figure 5.5: Long profile of the River Mease SSSI/SAC (note there is a pronounced vertical exaggeration)

5.2.2 Flow

(a) Flow types

The variation of flow types along the Gilwiskaw Brook and River Mease shows a similar distribution to the variation in bed topography, in that the Gilwiskaw Brook and upper reaches of the River Mease generally show more diversity than the middle and lower reaches (Table 5.5). However, there is considerable variation. Variations in flow type should be treated with some caution as they are strongly influenced by the flow at time of the survey. However, the data recorded provide a snap-shot of flow variability along the river channel. The generally greater variation in flow types as compared to variations in bed topography reflects the importance of other factors in providing variation in flow patterns other than the topography of the bed. This includes variations in channel planform, channel width, channel gradient and the occurrence of woody debris and macrophytes.

Table 5.5: The number and distribution of different flow types along the River Mease SSSI/SAC (source APEM, 2010)

Unit	Reach	Length (m)	Run	Riffle	Glide	Pool	Other	No. Types
4	GIL001	1348	7	6	9	3	1	26
	GIL002	662	2	5	6	2	-	15
	GIL003	457	2	2	-	-	-	4
	GIL004	282	1	1	-	-	1	3
	GIL005	1633	14	4	15	-	1	34
	GIL006	1175	7	-	7	1	-	15
	GIL007	756	10	2	8	2	-	22
3	MEA001	1254	8	1	8	2	-	19
	MEA002	1281	10	1	10	3	-	24
	MEA003	230	1	-	1	-	-	2
	MEA004	752	8	-	8	3	-	19
	MEA005	520	3	-	3	-	-	6
	MEA006	115	-	-	1	-	-	1
	MEA007	2114	13	1	16	2	-	32
2	MEA008	2340	6	1	9	7	-	24
	MEA009	2200	4	1	4	1	-	10
	MEA010	1766	6	-	5	2	-	13
	MEA011	504	2	-	2	-	-	4
	MEA012	1191	4	-	4	-	-	8
	MEA013	1550	6	2	6	1	-	15
	MEA014	2200	5	2	7	-	-	14
	MEA015	587	2	-	3	-	-	5
	MEA016	1024	1	-	1	-	-	2
	MEA017	1614	1	-	2	1	-	3
1	MEA018	374	-	1	1	-	-	2
	MEA019	607	-	-	1	-	-	1
	MEA020	690	-	-	1	-	-	1
	MEA021	1834	3	-	4	-	-	7
	MEA022	926	3	3	5	-	-	11
	MEA023	621	-	-	1	-	-	1
	MEA024	1126	-	-	1	-	-	1
	MEA025	928	2	4	7	-	-	15

Generally, the variations in flow type demonstrate that there are some reaches of the river which show a wide variation in flow types and others with very uniform flow. Those reaches where flow variation is low could be prioritised for restoration.

(b) Woody debris

Woody debris can provide an important source of flow variation in rivers, especially lowland rivers. Observations of the amount of woody debris found in the river channel along the SSSI/SAC were made on two separate occasions (Table 5.6). These surveys recorded accumulations of woody debris as opposed to individual particles of wood. These accumulations represent locations where there is a sufficient quantity of wood in the channel to influence flow both upstream and around the accumulations (Figure 5.6). The results indicate that at the time of survey, relatively few debris accumulations were present along the SSSI (Table 5.6). The amount of woody debris accumulations is likely to reflect a combination of the limited supply of wood in some areas, due to the absence or low density of riparian tree cover, removal of debris accumulations (although it is understood this is not routinely practiced), and the relative absence of flows sufficient to transport wood and promote the formation of accumulations.

Figure 5.6: Example of an accumulation of woody debris within the channel in reach MEA025 (Photograph courtesy of the Environment Agency)

Table 5.6: Number of woody debris accumulations recorded along the River Mease SSSI/SAC

Unit	Reach	Length (m)	APEM 2010	Jacobs November 2011
4	GIL001	1348	2	-
	GIL002	662	-	1
	GIL003	457	-	-
	GIL004	282	1	-
	GIL005	1633	-	2
	GIL006	1175	1	2
	GIL007	756	2	2
3	MEA001	1254	1	2
	MEA002	1281	1	-
	MEA003	230	1	-
	MEA004	752	1	-
	MEA005	520	1	1
	MEA006	115	-	-
	MEA007	2114	7	-
2	MEA008	2340	1	-
	MEA009	2200	-	-
	MEA010	1766	1	1
	MEA011	504	-	-
	MEA012	1191	1	8
	MEA013	1550	2	-
	MEA014	2200	-	3
	MEA015	587	2	2
	MEA016	1024	2	1
	MEA017	1614	1	2
1	MEA018	374	-	1
	MEA019	607	4	1
	MEA020	690	1	-
	MEA021	1834	1	-
	MEA022	926	1	1
	MEA023	621	1	-
	MEA024	1126	1	-
	MEA025	928	-	2

(c) Channel modification

The morphology of the river (together with the river engineering records) indicates that widespread channel re-sectioning (including some deepening) was undertaken in the past to improve land drainage. Channel deepening is likely to have primarily involved the removal of accumulations of fine sediment from the bed, but may have involved some gravel removal also (see Figure 5.1). This channel modification will have contributed to the relatively deep channel in comparison to its width (low width to depth ratio), which also reflects the long-term evolution of the river (Section 5.1.3). The implications of this are discussed further in Section 6.1.5.

This deepening also reduced the connectivity between the channel and the floodplain. The reaches most affected by this are:

- *GIL001*
- *GIL003 – GIL006*
- *MEA004 – MEA007*

There are other reaches which have been affected by deepening, but are now actively recovering, these are:

- *MEA008 – MEA010*
- *MEA012 – MEA016*
- *MEA019 – MEA021*
- *MEA023 – MEA025*

There is widespread evidence of readjustment through the deposition of sediment on the bed (see Section 5.2.1). This is generally leading to a reduction in the depth of the channel, although the degree of sediment deposition is spatially variable. Sediment deposition is most extensive in the middle and lower reaches of the River Mease, where the channel gradient is relatively low (Figure 5.5).

(d) Embankments

Formal flood defence embankments are absent along the River Mease. There is however, one short section of informal embankment along the Gilwiskaw Brook (GIL006) (probably formed from the tipping of material dredged from the channel along the bank top) (Figure 5.7).

Figure 5.7: Low informal embankment along a section of Gilwiskaw Brook in reach GIL006

5.2.3 Planform

The planform of the Gilwiskaw Brook and River Mease is variable and ranges from straight sections of channel to highly (tortuous) meandering sections (Table 5.7). Although straight sections of river can exist naturally, this is relatively unusual and not typical of lowland rivers (Section 5.1.3). Sections of river with a predominantly straight channel (even if occasional bends are present) generally reflect historic channel engineering (Section 4.4). The majority of Gilwiskaw Brook and five reaches of the River Mease show a channel planform which is indicative of past channel engineering (straightening/realignment) (Table 5.7 and Figure 4.2). Elsewhere the planform of the river channel appears to be relatively natural, and the position of the channel (in the floodplain) varies considerably with distance downstream, in some places alternating between valley sides. It is likely that short sections of river channel such as individual bends have been modified by human activity (such as local straightening) (Figure 4.2). However it is difficult to determine the significance of this based on the existing evidence.

Table 5.7: Variation in the planform of Gilwiskaw Brook and the River Mease

Unit	Reach	Length (m)	Planform	Likely influencing factors
4	GIL001	1348	Straight with a single meander	Channel engineering
	GIL002	662	Generally straight with occasional bends	Channel engineering
	GIL003	457	Straight with occasional gentle bends	Channel engineering
	GIL004	282	Straight with occasional gentle bends	Channel engineering
	GIL005	1633	Straight with occasional open bends	Channel engineering
	GIL006	1175	Straight with occasional tight bends	Channel engineering
	GIL007	756	Sinous	Width of valley floor
3	MEA001	1254	Gently sinuous in upper half meandering in lower section	Width of valley floor
	MEA002	1281	Meanders	Width of valley floor
	MEA003	230	Straight	Channel engineering
	MEA004	752	Sinuous	Width of valley floor
	MEA005	520	Straight with occasional open bends	Channel engineering Width of valley floor
	MEA006	115	Straight	Channel engineering
	MEA007	2114	Meanders	Width of valley floor
2	MEA008	2340	Irregular meandering, tortuous meanders in places	Width of valley floor
	MEA009	2200	Irregular meandering, tortuous meanders in places	Width of valley floor
	MEA010	1766	Irregular meandering, tortuous meanders in places	Width of valley floor
	MEA011	504	Straight	Channel engineering
	MEA012	1191	Meanders	Width of valley floor
	MEA013	1550	Sinuous	Width of valley floor
	MEA014	2200	Sinuous with local meanders	Width of valley floor
	MEA015	587	Sinuous	Width of valley floor
	MEA016	1024	Sinuous	Width of valley floor
	MEA017	1614	Sinuous with local meanders	Width of valley floor
1	MEA018	374	Straight	Along valley side
	MEA019	607	Slight meanders	Width of valley floor
	MEA020	690	Sinuous with meanders	Along valley side
	MEA021	1834	Slight meanders	Width of valley floor
	MEA022	926	Sinuous with local meanders	Width of valley floor
	MEA023	621	Sinuous	Width of valley floor
	MEA024	1126	Slight meanders	Width of valley floor

	MEA025	928	Straight with occasional tight bends	Channel engineering

The width and planform of the valley floor, and therefore the extent of the floodplain, is an important control over the nature of the channel planform that can develop (Section 5.1.3). The width (as defined by the extent of a 1 in 100 year return flood) and alignment of the floodplain is variable along the SSSI/SAC.

Where the channel has been subject to straightening, such as along Gilwiskaw Brook, this does not necessarily mean that the channel morphology is uniform and devoid of diversity. As described previously, Gilwiskaw Brook shows considerable morphological diversity, especially when compared to the middle and lower reaches of the River Mease. This reflects variability created by natural channel adjustment (recovery) due to channel gradient. Straightening of the channel of Gilwiskaw Brook will have increased the gradient of the channel and contributed to higher flow energy. There are for example locations on Gilwiskaw Brook (e.g. GIL002) which show active ongoing adjustment through erosion and deposition, which is increasing the morphological diversity of the channel (Figure 5.8). As a result, channel planform restoration is not necessarily required to improve the geomorphology of the channel. Indeed many of the highly meandering sections of channel are relatively uniform in their morphology, which is in part due to the low channel gradient associated with this degree of sinuosity.

Figure 5.8: Active channel adjustment (bank erosion, riffle formation and increased channel sinuosity) along Gilwiskaw Brook (reach GIL002) (Photograph courtesy of the Environment Agency)

5.2.4 Banks

Field observations indicate that in general, the river channel cross-section along the Gilwiskaw Brook and River Mease is relatively symmetrical, even around bends, where more pronounced channel asymmetry might normally be expected. It should be noted that there are exceptions to this, but in general the cross-sectional form of the channel is relatively uniform. This uniformity of channel cross-section is generally characterised by the presence of steep banks along both sides of the channel even around bends (Figure 5.9). This channel shape is likely to primarily reflect extensive past channel engineering during either straightening (Gilwiskaw Brook) or re-sectioning (River Mease) (Section 4.4 and 5.2.2). There is however evidence along the majority of reaches that a degree of recovery in the diversity of the river banks has begun to occur, due primarily to a combination of vegetation colonisation and localised scour associated with variations in flow caused by woody debris.

Figure 5.9: Examples of sections of channel with uniform cross-section indicative of past re-sectioning (a) reach MEA002 and (b) MEA005 (Photograph b courtesy of the Environment Agency)

Bank erosion along the SSSI/SAC is not widespread (Table 5.8). This reflects the passively meandering nature of the river (Section 5.1.3). Where bank erosion is occurring, it is generally concentrated around the outside of bends in the channel (planform is a controlling factor), where flow is concentrated against the bank. However, there are many sections of bank around the outside of bends where erosion is not occurring. The observed bank erosion is not associated with system-wide adjustments in channel morphology in response to flow as would be expected in actively meandering rivers, or upland gravel-bed rivers. Rather bank erosion is initiated by local factors such as land use pressures, past channel modification or woody debris causing flow diversion (Table 5.8). Bank erosion tends to occur in locations where the channel is naturally vulnerable to erosion, such as the outside of bends.

It is important to recognise that bank erosion is not considered to be a negative feature as it is a naturally occurring process. Eroding banks provide a source of sediment to the river channel and flow diversity which can promote the formation of bedforms and channel deposits downstream (Figure 5.8). Eroding banks provide variations in the form of the river banks and can provide important habitat features such as sites for burrows (crayfish, mammals or birds) or areas of overhanging bank which can provide cover for fish, crayfish and mammals. Where bank erosion is accelerated due to factors such as land use pressures it may be of sufficient magnitude to cause adverse impacts due to higher volumes of fine sediment input, which can smother the gravel bed, or due to threatening critical infrastructure. However, only reach MEA008 shows evidence of widespread bank erosion (Table 5.8) and even this is unlikely to be particularly adverse.

Table 5.8: The distribution of bank erosion along the Gilwiskaw Brook and River Mease

Unit	Reach	Length (m)	No of sections	Length of erosion (m)	Potential causal factors
4	GIL001	1348	1	3.7	Scour at weir
	GIL002	662	5	150.9	Adjustment to past channel straightening
	GIL003	457	1	5.2	Past channel deeping
	GIL004	282	2	29.8	Past channel deeping
	GIL005	1633	2	64.8	Past channel deeping
	GIL006	1175	4	100.1	Past channel deeping
	GIL007	756	4	68.4	Planform / grazing of banks
3	MEA001	1254	2	28.4	Planform
	MEA002	1281	5	105.1	Planform / grazing pressures
	MEA003	230	-	-	-
	MEA004	752	3	53.0	Planform / grazing pressures
	MEA005	520	1	-	Past channel deeping
	MEA006	115	-	-	-
	MEA007	2114	Insufficient data	Insufficient data	-
2	MEA008	2340	7	111.1	Planform / ploughing to the bank top
	MEA009	2200	3	102.3	Planform / grazing pressures
	MEA010	1766	1	18.4	Planform
	MEA011	504	-	-	-
	MEA012	1191	-	-	-
	MEA013	1550	Insufficient data	Insufficient data	-
	MEA014	2200	1	-	Grazing pressures
	MEA015	587	1	-	Grazing pressures
	MEA016	1024	-	-	-
	MEA017	1614	-	-	-
1	MEA018	374	-	-	-
	MEA019	607	-	-	-
	MEA020	690	-	-	-
	MEA021	1834	3	56.5	Planform / grazing pressures
	MEA022	926	-	-	-
	MEA023	621	-	-	-
	MEA024	1126	1	6.3	-
	MEA025	928	1	6.0	Planform / grazing pressures

The banks are generally composed of fine sediments. Coarse sediments within the river banks were generally restricted to the Gilwiskaw Brook. Their presence, toward the foot of the river banks, is likely to reflect the occurrence of a phase of channel incision (bed erosion) following channel straightening (see Figure 5.8). The general absence of gravels from the river banks reflects the long-term evolution of the channel (Section 5.1.3). The lack of coarse sediment in the bank means that the natural supply of gravel to the channel to form riffles and discrete deposits will be restricted to the Gilwiskaw Brook and the upper reaches of the River Mease (Section 5.2.1).

Bank face and toe vegetation is generally good along much of the River Mease and Gilwiskaw Brook. This reflects the general stability of the system due to lack of flow energy and relative cohesive (resistant) bank materials. Bank face vegetation is generally only absent where land use pressures are high, principally the ploughing of the floodplain up to the bank top, or where livestock have free access to the channel. This affects the following reaches:

- *GIL002*
- *GIL003*
- *GIL006*
- *MEA002*
- *MEA005 – MEA007*
- *MEA021*
- *MEA025*

5.2.5 Riparian zone and floodplain

The riparian zone along both Gilwiskaw Brook and the River Mease has been extensively modified by land use pressures along its length (Table 5.9). Under natural undisturbed conditions (Table 5.1) the river would be expected to be almost continuously tree lined, although the density of the tree lining would vary. It is likely that, under pre-cultivation land use conditions, tree lining would be associated with wider floodplain woodland. Based on the reconstructed environmental histories from nearby catchments this is likely to have been dominated by alder (Brown, 1997) although other species would also have been present. Some open areas were probably present having been initiated and maintained by grazing animals.

Clearance of floodplain woodland and drainage of the floodplain to provide high quality farm land has resulted in the depletion of the riparian zone to such an extent that where tree lining occurs it is generally restricted to a single line of trees (Table 5.9). There are however numerous sections where the riparian zone is now totally devoid of trees (Table 5.9). It would be expected that under more natural conditions the riparian zone would be characterised by a range of plants from grasses and herbs, to bushes, shrubs and trees, and be continuous with the wider floodplain vegetation assemblage. Grazing by animals, tree death and variations in floodplain water levels would have maintained a mosaic of different types and densities of vegetation.

The draining of the floodplain and use for agriculture has a number of impacts:

- *Drainage increases the efficiency of the movement of water into the river (volume and rate) during rainfall events;*
- *Exposed soil, associated with arable land use, is vulnerable to erosion during flood events, which leads to an increase in the supply of fine sediment to the channel, and*
- *Reduction in the range of habitats on the floodplain such as wet woodland.*

The degradation of the riparian zone, especially the absence of trees, has impacts on both the ecology and geomorphology of the river, including a lack of:

- *Variety of vegetation and habitat types;*
- *Roots to bind banks and resist erosion by flow or water level fluctuations;*
- *Cover (branches, roots or woody debris) for fish and crayfish;*
- *Foraging, breeding and resting areas for otter;*
- *Supply of organic debris which is a food source for invertebrates and crayfish, and*

- *Woody debris which would provide a source of variation in channel form and flow types (woody debris can also help retain water in both channel and floodplain during dry periods).*

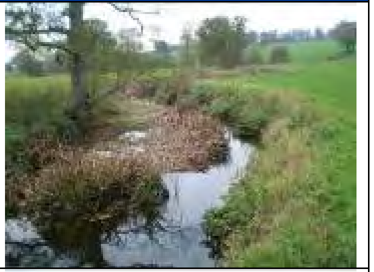
Table 5.9: General characteristics of the riparian zone along the River Mease SSS/SAC

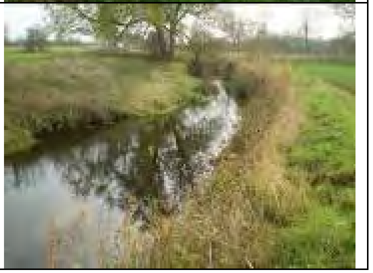
Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
4	GIL001	1348	Single continuous line of trees/shrubs along both banks.	Grazed pasture / arable fields	
	GIL002	662	Single semi-continuous line of trees /shrubs along both banks. Where gaps in trees are present, the land is grazed up to the bank top.	Grazed pasture	
	GIL003	457	Occasional isolated (scattered) trees along both banks. Where gaps in tree cover are present there is strip of scrub between 1 and 3 m in width.	Grazed pasture / arable fields	
	GIL004	282	Single semi-continuous single line of trees /shrubs along both banks.	Grazed pasture / arable fields	

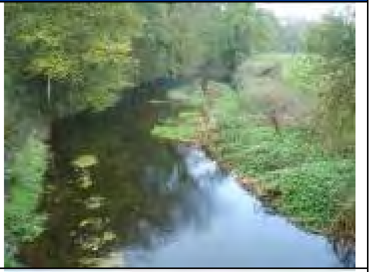
Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
	GIL005	1633	Single generally continuous line of trees /shrubs with some wider areas of woodland along both banks.	Grazed pasture / arable fields Area of woodland along left bank	
	GIL006	1175	Narrow uncultivated margin along left bank generally devoid of trees. Single continuous line of trees /shrubs along right bank.	Grazed pasture / arable fields	
	GIL007	756	Single continuous line of trees /shrubs with some wider areas of woodland along the left banks. Some gaps present.	Grazed pasture	
3	MEA001	1254	Single semi-continuous line of trees /shrubs along left bank. Woodland along right bank.	Arable fields along left bank, woodland to right	

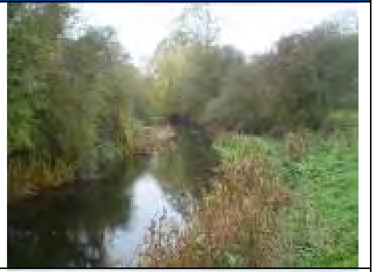
Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
	MEA002	1281	Occasional isolated (scattered) trees along right banks. Uncultivated margin of scrub along left bank of variable thickness	Arable fields along left bank Graze pasture along left	
	MEA003	230	Occasional single lines of trees along both banks. Significant gaps present.	Arable fields and grazed pasture along left bank and recreation land or urban along right bank	
	MEA004	752	Occasional clumps of trees along both banks. Numerous gaps. Narrow (1-3 m) strip of scrub where trees absent.	Grazed pasture along left bank. Industrial estate along right bank.	
	MEA005	520	Occasional clumps of trees however, tree lining is generally absent. Narrow (1-3 m) strip of scrub along both banks.	Grazed pasture along both banks.	

Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
	MEA006	115	Occasional trees along both banks. Strip of scrub 1-2 m wide along both banks.	Access tracks and dual carriageway.	
	MEA007	2114	Occasional trees along both banks. Strip of scrub 1-3 m wide along both banks. One isolated clump of woodland on left bank.	Grazed pasture or arable fields along both banks.	
2	MEA008	2340	Isolated sections of tree lining, primarily along the right bank. Numerous sections devoid of trees with narrow undisturbed strip 0.5-2 m in width along both banks.	Arable fields and occasional grazed pasture along left bank. Grazed pasture along right bank.	
	MEA009	2200	Isolated sections of tree lining along both banks. Gaps present but scrub present along both banks.	Woodland along right bank with some arable fields to right at lower end of reach. Grazed pasture along left.	

Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
	MEA010	1766	Occasional trees along both banks. Strip of scrub 1-3 m wide along both banks. Narrow uncultivated margin where gaps in tree lining present. Gaps in tree lining are extensive.	Arable fields to right and occasional and arable fields grazed pasture along left bank. Grazed pasture along right bank.	
	MEA011	504	Occasional small isolated trees along right but trees generally absent Strip of scrub 1-3 m wide along left bank. Narrow uncultivated margins (1-2 m wide) along right bank.	Arable fields along both banks. Area of wet grass land to left of river at downstream end of reach.	
	MEA012	1191	Occasional tree lining along left bank. Occasional isolated trees along right bank. Strip of scrub 1-3 m wide along both banks. Narrow uncultivated margin where gaps in tree lining present. Gaps in tree lining are extensive along the right bank.	Arable fields along both banks.	
	MEA013	1550	Occasional isolated trees along both banks. Strip of scrub 1-3 m wide along both banks. Narrow uncultivated margin where gaps in tree lining present.	Arable fields and grazed pasture along either side of channel.	

Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
	MEA014	2200	Occasional tree lining along both banks. Strip of scrub along both banks where trees are absent. The width of this strip varies.	Arable fields and grazed pasture along either side of channel. Area of wet grassland in one location along left bank.	
	MEA015	587	Semi-continues tree lining along both banks. Where trees are absent there is a wide margin of scrub.	Arable fields to right and grazed pasture along left side of channel.	
	MEA016	1024	Occasional tree lining along both banks. Strip of scrub along both banks where trees are absent. The width of this strip varies. Gaps in tree lining are more extensive than the tree lined sections.	Grazed pasture along left bank. Arable fields and woodland plantation along right bank.	
	MEA017	1614	Occasional trees along the left bank. Strip of scrub along both banks where trees are absent. The width of this strip varies considerably from up to 6 m along the left bank to 1 m along the right bank.	Grazed pasture along left bank. Arable fields and some grazed pasture along right bank.	

Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
1	MEA018	374	Continuous tree lining along left bank. Occasional clumps of trees along right bank. Where trees are absent along the right bank there is a strip of scrub 1-3 m in width along the right bank.	Sports field to right of river.	
	MEA019	607	Occasional scattered trees along both banks. Strip of scrub along both banks where trees are absent. The width of this strip varies. Some sections of the right bank are grazed to the top of the bank. Gaps in tree cover are more extensive than the tree lined sections.	Arable land to left. Grazed pasture to right.	
	MEA020	690	Trees are absent along the left bank. There is a narrow uncultivated margin (1-2 m wide). The right bank is wooded.	Arable land to left. Woodland to right.	
	MEA021	1834	Occasional scattered trees along both banks. Strip of scrub along both banks where trees are absent. The width of this strip varies. Some sections of the left bank are grazed to the top of the bank. Gaps in tree cover are more extensive than the tree lined sections.	Arable to right of river and grazed pasture to left,	

Unit	Reach	Length (m)	Riparian zone character	Surrounding land use	Photograph
	MEA022	926	Semi-continuous lining of trees scrub and shrubs along both banks.	Grazed pasture	
	MEA023	621	Occasional scattered trees along both banks. Strip of scrub along both banks where trees are absent. The width of this strip varies (1 – 3 m). Gaps in tree cover are more extensive than the tree lined sections.	Grazed pasture and arable fields to left arable fields to right.	
	MEA024	1126	Occasional scattered trees along left banks. Uncultivated margin along top of left bank varies from 1 m to 3 m in width. Gardens/Parkland of Croxall Hall along right bank. Isolated trees along the left bank.	Arable fields to left of river. Garden/Parkland and mown grass land to the right of the river.	
	MEA025	928	Scattered trees along the left bank. Where gaps between trees are present there is a strip of scrub which is generally around 4 m wide. Continuous tree lining associated with woodland along the right bank.	Grazed pasture along left bank. Woodland along right bank.	

5.3 River channel modifications

5.3.1 Weirs

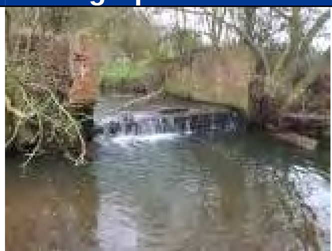
Weirs can have negative effects on the physical character of rivers, which can alter the availability of suitable habitat for the characteristic flora and fauna. Weirs typically have three main effects:

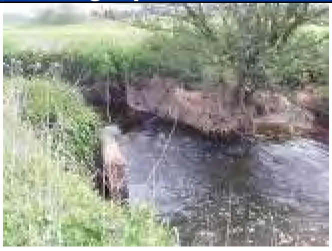
- *Alterations to flow depth and velocities, principally increased water depth and reduced velocities upstream which can profoundly alter the habitat characteristics upstream of the weir;*
- *Disruption to the continuity of sediment transport, this can also alter the habitat characteristics upstream and downstream of the weir, and*
- *Interruption of the biological connectivity (continuity) of the river channel, such as preventing the passage of fish and invertebrates.*

Natural England and the Environment Agency recognise the negative impacts of the artificial in-channel structures on English rivers, and the need to remove as many of these structures as possible (where feasible). The need to do this is heightened by climate change, for which restoring natural river processes, habitats and connectivity are vital adaptation measures. Removal of channel structure is also consistent with the objectives of the WFD.

Flow impoundments are not a widespread issue along the River Mease. There are however, five weirs within the SSSI/SAC (Table 5.10). Of these the weir at Clifton Campville (MEA013) is by far the largest structure, with the most significant impact on flow. Elsewhere the impact of the weirs on flow and channel morphology is relatively localised. However, the weirs in reaches GIL001 are MEA007 are likely to pose a barrier to the movement of fish and invertebrates (Table 5.10).

Table 5.10: The location of weirs along Gilwiskaw Brook and the River Mease

Unit	Reach	Location, description and impact	Photograph
4	GIL001	NGR: 435942 313880 Low stone weir with brick bank protection along either side. Barrier to fish migration. Local ponding upstream Bank scour immediately downstream of weir	
	GIL004	NGR: 435065 311178 Remains of collapsed weir exposed in river bank. – localised hard bank. Limited impact.	

Unit	Reach	Location, description and impact	Photograph
3	MEA007	NGR: 430993 312289 Low weir with concrete walls along each side of the weir. Possible barrier to fish migration at low flow. Local ponding upstream Bank scour immediately downstream of weir	
2	MEA013	NGR: 425296 311397 Narrow weir set within an embankment. Barrier to fish migration. Extensive ponding of flow upstream.	
	MEA014	NGR: 424554 311401 Very low stone weir almost level with the bed. Very localised and minor ponding upstream. Limited impact.	

5.3.2 Bank protection

Bank protection is not widespread along the SSSI/SAC, this reflects the generally passive nature of the river and lack of bank erosion. There are however localised areas where bank protection is present. The main sections of bank protection are located at:

- *Gilwiskaw Brook reaches GIL003 and GIL005*
- *Measham at the downstream end of reach MEA002*
- *Upstream of the A42 in reach MEA005*
- *Under the A42 MEA006*
- *Netrherseal along the right bank at the downstream end of reach MEA008*
- *Croxall Hall along the right bank of reach MEA024.*

In some instances this is to protect property (MEA008, MEA024) or infrastructure (MEA006) that is in close proximity to the channel, and where removal would have adverse impacts on the property / infrastructure.

5.3.3 Maintenance

Maintenance activities along the river are restricted to vegetation management in the form of coppicing or pollarding of trees, or the agreed removal/adjustment of fallen trees. Tree management and any removal of woody debris from the channel are regulated by Natural England (due to the designation of the river), and consent for removal is given on a case by case basis. No sediment maintenance (e.g. dredging) is permitted, as this has adverse impacts on the morphology of the channel and its ability to naturally recover. No in-channel work, dredging, bank reinforcing or crossings are allowed, or structures in the floodplain unless the Environment Agency has provided prior consent to do so.

5.4 Summary of key pressures

A range of different pressures have been identified which affect each of the different features which collectively comprise the river (Table 5.1). The pressures observed on each aspect of the SSSI/SAC are:

Riparian zone:
- *Degraded riparian (and floodplain) vegetation*
- *Lack of trees*

Banks:
- *Degraded bank vegetation*
- *Accelerated bank erosion (e.g. poaching of the banks by livestock)*
- *Lack of morphological diversity due to re-sectioning or engineered structures*

Bed:
- *Lack of morphological diversity due to channel re-sectioning, dredging and removal of fallen trees (non-willow)*

Planform:
- *Lack of morphological diversity due to straightening and re-sectioning (large scale)*

Flow (pattern and velocity):
- *Over-deepened (lack of floodplain connectivity)*
- *Informal embankments (lack of floodplain connectivity)*
- *Impounded flows (weirs)*
- *Limited variety in flow velocity/depth (lack of woody debris in the channel)*

The pressures, and their relative significance, are summarised on a reach by reach basis in Table 5.11 and described in Table 5.12. The reaches most affected by the pressures are also indicated in Table 5.12. The relative significance of these pressures varies across the SSSI/SAC. For example, the extent of some pressures within each reach varies, in some cases ranging from extensive (>60% of reach affected) to localised (<10% affected).

Observations made during the field survey revealed that many of the reaches showed some degree of readjustment of the channel or riparian zone following modification, which is leading to ongoing natural recovery (although this is not complete recovery). Evidence of adjustment to pressures on each attribute, in each reach, is indicated in Table 5.12. The degree of channel adjustment, and therefore ongoing recovery, along the SSSI/SAC is variable. Some reaches only show recovery of a single attribute, while others show recovery to a number of different attributes. The different degree of channel recovery, according to the number of attributes which are adjusting, is summarised in Figure 5.10. This allows a spatial distribution of on-going recovery to be appreciated.

Table 5.11: Summary of the key pressures on the different attributes of the channel recorded during within each reach

	Reach	Key Pressures									
		Bed	Flow			Planform	Banks			Riparian	
		Lack of morphological diversity due to re-sectioning	Over-deepened	Embanked lack of floodplain connectivity	Impounded (weirs)	Lack of morphological diversity due to straightening	Degraded bank face vegetation	Accelerated bank erosion	Lack of morphological diversity due to re-sectioning	Degraded riparian vegetation	Lack of trees
1	GIL001	✓ E A	✓ E A		✓ L	✓ E				✓ A	
	GIL002	✓ A				✓ A	✓	✓	✓ A	✓	✓
	GIL003	✓ A	✓ E			✓ A	✓	✓ L	✓	✓	✓ E
	GIL004	✓ A	✓ E			✓ E		✓ L	✓	✓ E	✓ E
	GIL005	✓ A	✓ E		✓ L	✓ E		✓ L	✓ A	✓ A	
	GIL006	✓ A	✓ E	✓		✓ E	✓	✓ L	✓	✓	✓
	GIL007							✓ L		✓	✓
2	MEA001	✓ A							✓ A	✓	
	MEA002	✓ A					✓	✓	✓ A	✓ E	✓ E
	MEA003	✓				✓ E			✓	✓ E	✓
	MEA004	✓ A	✓					✓	✓	✓ E	✓
	MEA005	✓ E	✓ E			✓ E	✓	✓ L	✓ E	✓ E	✓ E
	MEA006	✓	✓ E			✓ E	✓ A		✓ A	✓ A	✓ A
	MEA007	✓ A	✓ E		✓ L		✓	✓	✓	✓ E	✓ E
3	MEA008	✓ A	✓ A					✓	✓ A	✓ E	✓
	MEA009	✓ A	✓ A					✓ L	✓ A	✓	✓
	MEA010	✓ A	✓ A						✓ A	✓ E	✓ E
	MEA011	✓ E				✓ E			✓ E	✓ E	✓ E
	MEA012	✓ A							✓ A	✓	
	MEA013	✓	✓ A		✓				✓	✓ E	✓ E
	MEA014	✓ A	✓ A		✓ LA			✓ L	✓ A	✓ A	
	MEA015	✓ A	✓ A					✓ L	✓ A	✓ A	
	MEA016	✓	✓ A						✓ A	✓ E	✓ E
	MEA017	✓ A							✓ A	✓	✓
4	MEA018									✓	
	MEA019	✓ A	✓ L			✓ L			✓ A	✓ E	✓ E
	MEA020	✓ A	✓ A						✓ A	✓	
	MEA021	✓	✓ A				✓ L	✓	✓ A	✓ E	✓ E
	MEA022									✓ A	✓ L
	MEA023	✓ A	✓ A						✓ A	✓	✓

Reach	Key Pressures									
	Bed	Flow			Planform	Banks			Riparian	
	Lack of morphological diversity due to re-sectioning	Over-deepened	Embanked lack of floodplain connectivity	Impounded (weirs)	Lack of morphological diversity due to straightening	Degraded bank face vegetation	Accelerated bank erosion	Lack of morphological diversity due to re-sectioning	Degraded riparian vegetation	Lack of trees
MEA024	✓^{A}	✓^{A}						✓^{A}	✓^{E}	✓
MEA025	✓^{A}	✓^{A}			✓^{A}	✓^{L}		✓^{A}	✓^{A}	

Key to symbols:

✓ Present
✓^{L} Localised (<10%)
✓^{E} Extensive (>60%)
✓^{A} Adjusting toward more natural conditions

The pressures summarised in the table above refer to those which have an adverse impact on the geomorphology and therefore provision of associated habitat for typical habitats and species of the River Mease SSSI/SAC. In some instances a pressure may be present (e.g. degraded riparian vegetation) but not impacting adversely on the geomorphology of the channel, in these situations the pressure is not recorded in the table.

Table 5.12: Description of the main issues along the River Mease SSSI/SAC with reaches most affected indicated

Attribute	Description of impact	Consequence	Reaches most affected
Bed	Lack of morphological diversity due to channel re-sectioning. Channel deepening (dredging) and re-shaping associated with re-sectioning to improve water conveyance and land drainage can lead to a uniform bed topography with little variation in composition (sediment type).	Reduces the range of habitats which would be expected to be characteristic of the river type such as those associated with different water depths and flow velocities. For example, shallow areas typical of gravel riffles are often damaged or removed by dredging.	MEA003 MEA005 MEA011 MEA013 MEA016 MEA021
Flow	Uniformity of flow type (including impounded flows)	Lack of habitat variability, increasing sedimentation which increases channel vegetation causing choking during summer low flows and poor oxygenation.	GIL003 GIL004 MEA003 MEA006 MEA011 MEA016 MEA017 MEA019 MEA020 MEA023 MEA024
	Over-deepened channel (lack of floodplain connectivity)	Channel deepening (dredging) to improve land can increase the amount of water that can be contained in the channel before the floodplain is inundated. This leads to reductions in the effectiveness of sediment transfer thus increasing sedimentation, increased channel vegetation causing choking during summer low flows and poor oxygenation.	GIL001 GIL003 GIL004 GIL005 GIL006 MEA004 MEA005 MEA006 MEA007
	The increase in the capacity of the channel to contain water can (but not always) lead to higher flow velocities than would be characteristic of the river type and can increase the risk of excessive erosion.	Reduction in the occurrence of floodplain inundation means that fine sediment, which would otherwise be deposited in the floodplain, is deposited within the channel, this can increase siltation. Higher flows in trapezoidal channels are	

Attribute	Description of impact	Consequence	Reaches most affected
		particularly hostile to fish (especially fry) and invertebrates, causing loss or fragmentation of localised populations, especially where refuges are missing (fallen trees and backwater features).	
	In-formal (often low) embankments (lack of floodplain connectivity)	Creating embankments along the river bank tops can increase the amount of water that can be contained in the channel before the floodplain is inundated. This leads to reductions in the effectiveness of sediment transfer thus increasing sedimentation, increased channel vegetation causing choking during summer low flows and poor oxygenation.	GIL006
Planform	Lack of morphological diversity due to straightening and re-sectioning (large scale).	The realignment of the river channel into a straighter course is often associated with land use or attempts to improve flow conveyance. Higher flows in trapezoidal channels are particularly hostile to fish (especially fry) and invertebrates, causing loss or fragmentation of localised populations, especially where refuges are missing (fallen trees and backwater features).	GIL001 – GIL006 MEA003 MEA005 MEA006 MEA011 MEA025
Banks	Degraded bank face vegetation	Change in the type of bank face vegetation along the river corridor away from that characteristic of the river type, due to land use or channel modification. This may include damage by livestock or modifications such as steepening the banks. Reduces the habitat variability along the banks.	GIL002 GIL003 GIL006 MEA002 MEA005 MEA006 MEA007 MEA021 MEA025
	Lack of diversity due to re-sectioning and therefore lack of cover for fish and otter.	Makes the banks more vulnerable to erosion as good vegetation cover protects and binds (with roots) bank sediments, reducing their vulnerability to	GIL006 MEA003 MEA004 MEA005

Attribute	Description of impact	Consequence	Reaches most affected
		entrainment by river flow (see below).	MEA007 MEA011 MEA013
	Accelerated bank erosion	Increase in bank erosion due to land use or channel modification. This may include damage by livestock or modifications such as steepening the banks. Higher rates of bank erosion occur than would be characteristic of the river type increases the supply of sediment to the channel. Can lead to increased siltation downstream.	GIL002 MEA002 MEA004 MEA007 MEA008 MEA021
Riparian zone	Degraded riparian vegetation	Change in the type of terrestrial vegetation along the river corridor away from that characteristic of the river type, due to land use. This may include complete removal due to ploughing or reduction in variety and density of vegetation due to grazing by livestock. Increases the amount of surface runoff reaching the channel which may supply high loads of fine sediment or dissolved nutrients. Increases the vulnerability of the river corridor to erosion (soil loss) during floods where the ground is bare.	All reaches show some degree of riparian vegetation which could be improved. Some reaches however show evidence of adjustment (recovery) where almost continuous tree lining is present.
	Lack of trees	Makes the banks more vulnerable to erosion (e.g. lack of roots binding the banks). Lack of a supply of woody debris which would, if present, vary flow and sediment deposition patterns and associated habitat benefits.	GIL002 GIL006 MEA002 MEA004 MEA007 MEA008 MEA021

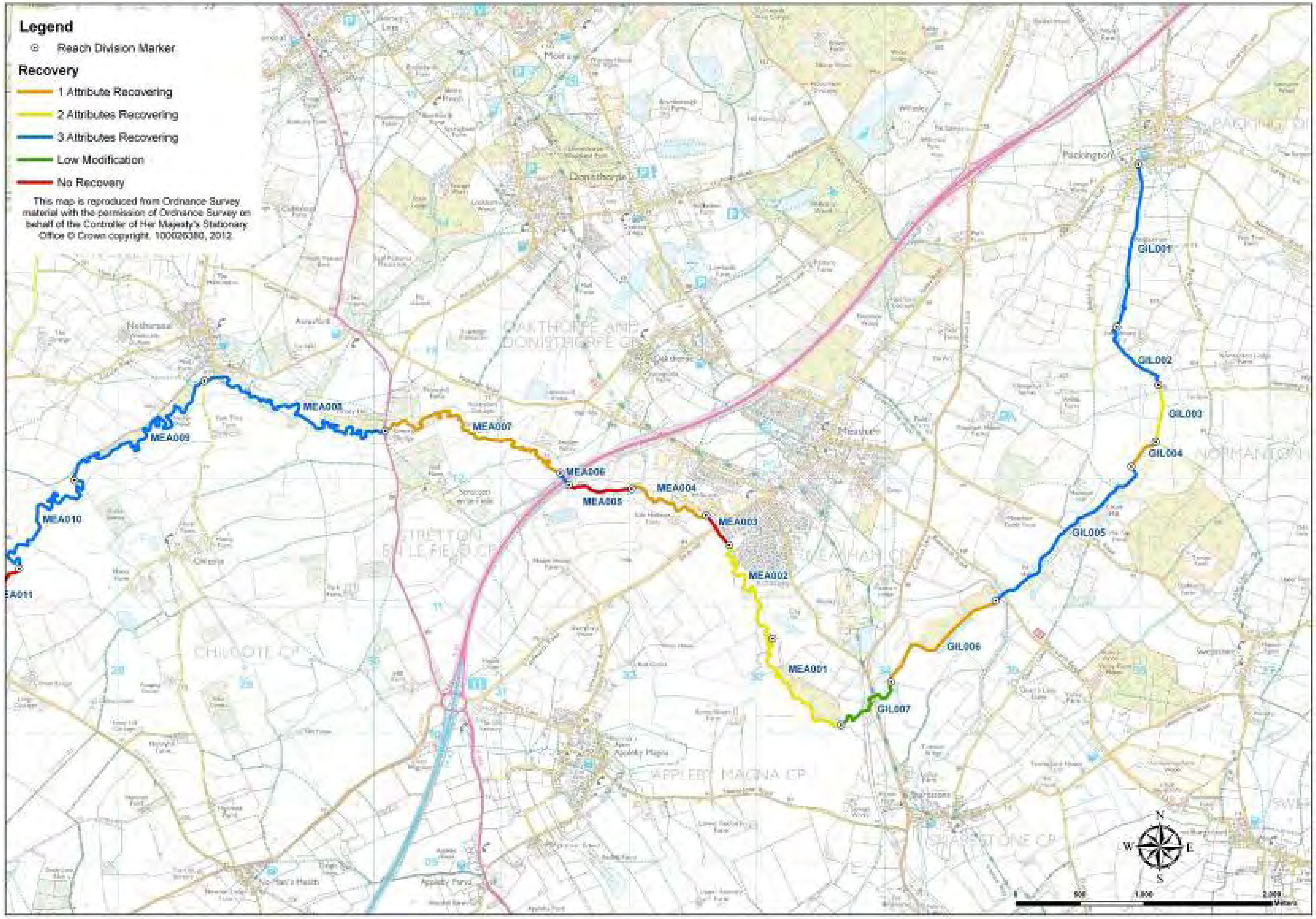


Figure: 5.10: (a) Map showing the number of different attributes that are recovering within each reach in the upper half of the SSSI/SAC; the more attributes showing recover the greater the overall degree of recovery.

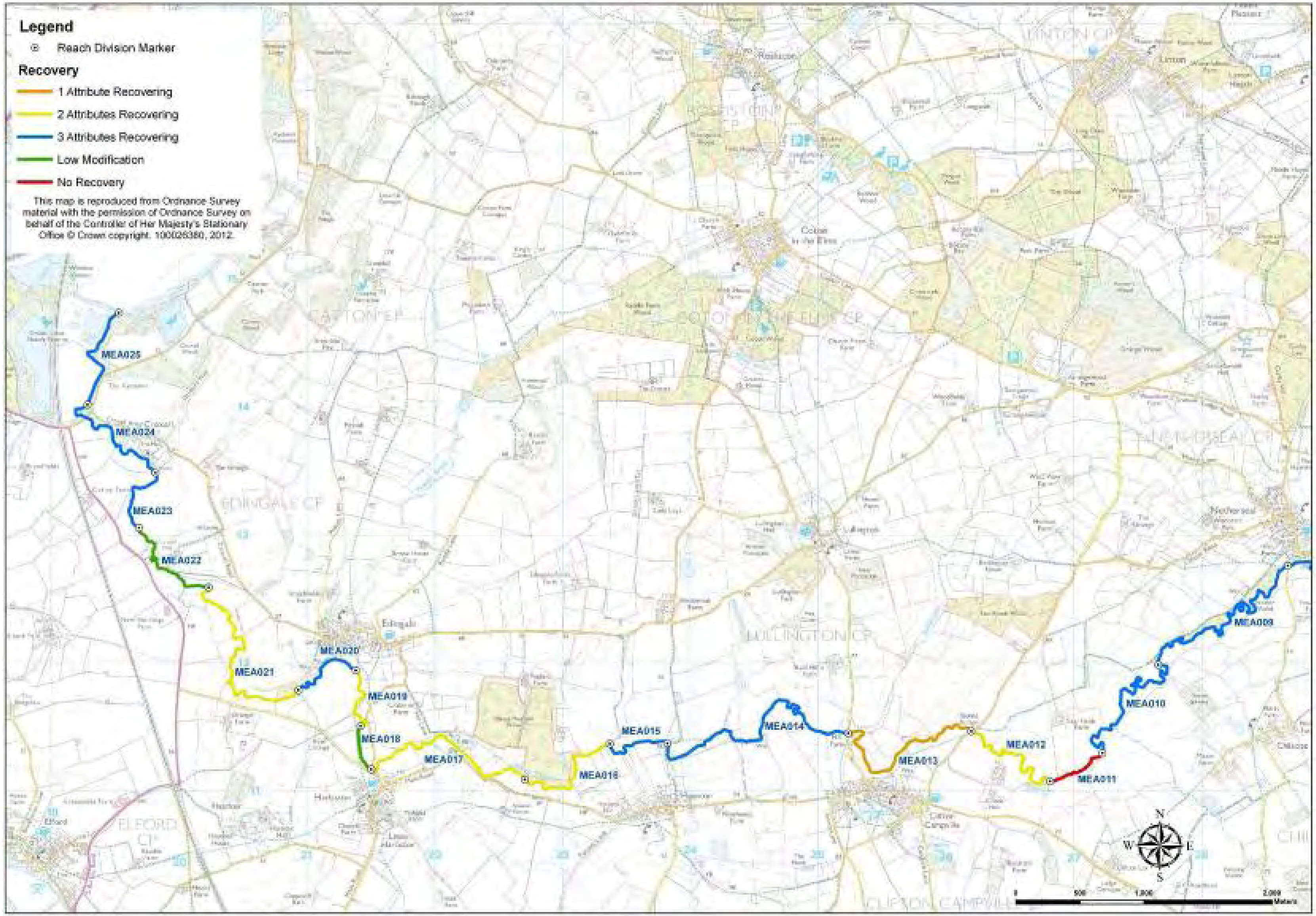


Figure: 5.10: (b) Map showing the number of different attributes that are recovering within each reach in the lower half of the SSSI/SAC; the more attributes showing recover the greater the overall degree of recovery.

6 Restoration potential

6.1 Summary of restoration potential

The majority of pressures identified along the Gilwiskaw Brook and River Mease which are contributing to the unfavourable status of the SSSI/SAC reflect the impact of land use on the river. River channels and their surrounding floodplains are linked systems and, as identified in Section 5, floodplain land use practices have had a range of impacts on the river channel (Section 5).

The River Mease SSSI is situated in a section of the catchment which is dominated by a mixture of arable and grazed land. The floodplain, which is used for both arable and grazed land, has been subject to past land improvement practices including woodland clearance, under drainage, deepening and straightening of tributary streams, deepening and localised straightening of the River Mease and Gilwiskaw Brook. The floodplain is now highly managed and intensively farmed.

In order to deliver optimal river channel processes and forms, it would be necessary to both improve the morphology of the river channel and address the impact of land use pressures on the floodplain. Ideally this would include ending the drainage of the floodplain for agricultural purposes, establishing a mosaic of wet grassland and wet woodland habitats on the entire floodplain, and preventing livestock from accessing the river channel. However, it is recognised that the floodplain is regarded as an important part of the farmed landscape, containing productive agricultural land, and other habitats, which are highly valued. Full restoration of the floodplain, while a highly desirable aspiration from a habitat restoration perspective, would require significant changes to land use practices, which may not be feasible in the short-term, but should not be ruled out in the long term

In recognition of this, when assessing river restoration potential, emphasis has been placed on the identification of short to medium term measures that would improve the river through channel restoration and/or improvements to the river corridor. Restoration of the river corridor (the riparian zone), although a compromise, would bring benefits by providing a buffer, separating agricultural land from the river channel, providing a source of woody debris to the channel and providing cover, shelter and shade for mammals, fish, crayfish and insects. The river channel and riparian zone restoration potential of each reach is summarised in Table 6.1 and outlined in more detail in the River Mease Restoration Plan. Key considerations arising from the geomorphological and ecological appraisal are outlined below.

6.1.1 Riparian zone

The riparian zone has been degraded throughout the SSSI/SAC due to land use pressures and there are potential opportunities for improvements in every reach. However, there is pronounced variation in the degree to which degradation has occurred. Generally, riparian (non-agricultural) vegetation is restricted to a narrow corridor along the top of each bank of the river. The range of vegetation varies, depending on land use pressures, from a mixture of trees and shrubs (best) to grass and herb dominated areas with isolated trees and /or shrubs, to a thin grass strip (worst case). The degree of riparian zone improvement required is therefore variable.

6.1.2 Banks

The structure of the river banks is generally uniform and appears to reflect past re-profiling, associated with channel re-sectioning and deepening. In some instances bank protection has been installed, however this is relatively localised and reflects the general lack of erosion associated with the passive nature of the river channel. Bank face vegetation is generally recovering with a mixture of vegetation types occurring, often merging with marginal aquatic macrophytes. However in some specific areas the bank face vegetation is uniform or absent, and in some instances this has led to increased bank erosion. Occasionally, bank erosion is accelerated by livestock access.

6.1.3 Bed

The bed of the river channel is often relatively uniform and covered by a layer of soft fine sediment. Riffles and pools, while generally uncommon, are most numerous in the upper reaches of the SSSI in Units 1 and 2. This reflects the steeper channel gradient and therefore more active geomorphological processes that have occurred in this are of the catchment. Lower in the catchment the absence of pools and riffles is likely to reflect the naturally infrequent occurrence of these features due to the passively meandering character of the river (Section 5.1.3), and the removal of some of these features by channel modifications associated with land drainage activities (deepening and re-sectioning). The natural infrequency of riffles and pools, especially in the lower reaches, means that there is no need for widespread riffle creation, as this would not be characteristic of the river.

6.1.4 Planform

The planform of the river is generally natural with evidence of deliberate channel straightening in 10 reaches, half of which are located on Gilwiskaw Brook. Often planform modification has been undertaken when the river channel has experienced some re-adjustment (e.g. along Gilwiskaw Brook). Along the River Mease straight sections of channel are relatively short and not perfectly straight. The limited impact of channel planform modification means that channel planform restoration (e.g. re-meandering) is not required along the SSSI/SAC. The range of alternative ways to improve in morphology eliminates the need for large scale planform restoration and the associated costly and disruptive earthworks.

6.1.5 Flow

Flow patterns and velocity have been influenced by a combination of channel deepening (reduced floodplain connectivity), informal embankments and weirs. The most widespread of these impacts is apparent channel deepening. There is evidence that the river channel has been deepened in the past to facilitate land drainage activities, with the unnaturally uniform cross-section of the channel, and river maintenance records which refer to arterial drainage works (Section 4.7). However, artificial deepening is, on the basis of research into the long-term history of rivers in the English midlands (Section 5.1), unlikely to be the only explanation of the relatively narrow and deep channel form (low width to depth ratio). This, together with evidence of recovery i.e. ongoing sand and silt deposition on the bed of the channel (promoting a reduction in depth over time), means that widespread bed raising is unnecessary for the restoration of favourable condition.

Table 6.1: Summary of the restoration potential of each reach (for locations refer to the maps in Appendix A)

Unit	Reach	Restoration potential – issues to address	Restoration actions
1	GIL001	Straightened section of channel which shows evidence of adjustment (varied bed, scattered woody debris, exposed tree roots) following past channel modification, and so does not require channel planform restoration. Weir should be removed. Tree lining is present, consider if there is a need to replace trees if they are removed in any great number during weir removal and associated access work.	Remove Weir. Rehabilitate the riparian zone.
	GIL002	Shows evidence of adjustment following past channel modification and so does not require channel restoration. Riparian zone and bank face vegetation are degraded and this is leading to accelerated bank erosion.	Rehabilitate the riparian zone.
	GIL003	Straightened section of channel which shows evidence of adjustment (varied bed) following past channel modification, and so does not require channel planform restoration. However, the banks are generally uniform and these could be improved. Section of bank protection should be removed to allow natural recovery of bank face morphology and vegetation. Riparian zone and bank face vegetation are degraded, tree lining is absent with only occasional scattered trees.	Remove bank protection. Re-profile the banks. Rehabilitate the riparian zone.
	GIL004	Straightened section of channel which shows evidence of adjustment (varied bed) following past channel modification, and so does not require channel planform restoration. However, the banks are uniform and these could be improved. Riparian zone and bank face vegetation are degraded; tree lining is generally absent with only occasional clumps of trees.	Re-profile the banks. Rehabilitate the riparian zone.
	GIL005	Relatively straight, incised section of channel. Channel shows evidence of natural recovery including a varied bed, a range of flow types and a supply of woody debris. The riparian zone shows evidence of recovery along much of this reach. Pressures are localised and include a culvert outlet, localised sediment extraction from the channel and the recent excavation of a field drain which is delivering fine sediment to the channel.	Remove culvert if no longer functional. Review sediment management. Address fine sediment supply from drain.
	GIL006	Straight section of channel with generally uniform banks. There is a section of embankment along the left bank.	Re-profile the left bank. Remove embankment.

Unit	Reach	Restoration potential – issues to address	Restoration actions
		Arable land use extends to the top of the left bank along this reach, with a very narrow uncultivated margin.	Create a riparian corridor along the left bank.
	GIL007	Sinuous section of channel which does not appear to have been subject to planform modification. Evidence of active geomorphological processes which are creating varied channel morphology. Tree lining of the channel is present, although there are some gaps.	Conserve this reach and seek opportunities to enhance the riparian zone.
2	MEA001	Sinuous section of channel which does not appear to have been subject to planform modification. Recent woodland creation along the right bank has brought benefits including a supply of woody debris. The channel has a relatively diverse morphology. The main pressure is the degradation of the riparian zone along the left bank (especially a lack of trees) associated with arable farming. Two ditch-like tributaries join the channel in the middle of this reach, these appear to be a source of fine sediment.	Create a riparian corridor along the left bank. Address fine sediment supply from tributaries.
	MEA002	Meandering section of channel, which shows adjustment to past modification. Despite this recovery however, the inside of bends in the channel are steeper than would be expected under more natural conditions. There is a section of bank protection that could be removed. Riparian zone and bank face vegetation are degraded; tree lining is generally absent with only occasional clumps of trees.	Re-profile banks on the inside of bends. Remove bank protection. Create a riparian corridor along the river channel.
	MEA003	Straightened section of channel with uniform banks and highly degraded riparian zone. Although the bed is generally uniform there is evidence from elsewhere in this part of the catchment that natural recovery of the bed may occur over time. To aid this process woody debris could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition.	Re-profile the banks. Rehabilitate the riparian zone. Introduce woody debris.
	MEA004	A relatively sinuous section of channel, which shows some adjustment to past modification. The main pressure is the degradation of the riparian zone, especially along the left bank which generally lacks trees.	Rehabilitate the riparian zone.
	MEA005	A straightened section of channel which shows evidence of deepening. The channel has steep uniform banks, which has caused erosion in some places. The bed is uniform and there is little variation in flow types. There is a short section of bank protection which should be removed. The riparian zone is very uniform and lacks trees.	Re-profile the banks. Remove bank protection. Introduce woody debris and gravel. Rehabilitate the riparian zone.
	MEA006	A straightened section of channel which has been heavily impacted by the crossing of the	Focus on preventing further

Unit	Reach	Restoration potential – issues to address	Restoration actions
		A42 trunk road. The channel shows readjustment to this modification such as narrowing and the establishment of riparian vegetation, which given the context of the reach is unlikely to be enhanced by intervention.	modification of the channel. Seek opportunities to improve riparian and in-channel vegetation.
	MEA007	A sinuous to meandering section of channel with steep uniform banks, which has caused erosion in some places. This reach receives water from the A42 drainage network and a Sewage Treatment Works. There is a small weir which could be removed. The riparian zone is very uniform and generally lacks trees.	Re-profile the banks. Remove weir. Address water discharges. Enhance the riparian zone.
3	MEA008	A highly meandering section of channel, there is some evidence of recovery including the formation of pools, however there is only a single riffle. The insides of bends in the channel are steeper than would be expected under more natural conditions. Woody debris and gravel could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition. Arable land use extends to the top of the left bank along this reach, with a very narrow uncultivated margin.	Re-profile the banks. Introduce woody debris and gravel. Rehabilitate the riparian zone.
	MEA009	A meandering section of channel which shows evidence of natural recovery. While the riparian zone has been impacted by the surrounding land use, the river bank vegetation is generally good and there are areas with tree cover, which are introducing woody debris to the channel.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA010	A meandering section of channel. Despite the natural planform, the insides of bends in the channel are steeper than would be expected under more natural conditions. Agricultural land use extends to the bank tops with only a very narrow uncultivated margin as a result the riparian zone is relatively uniform, with few trees.	Re-profile the banks. Introduce woody debris and gravel. Rehabilitate the riparian zone.
	MEA011	Straightened section of channel with uniform banks and highly degraded riparian zone. The bed is relatively uniform and there is little habitat or flow variation. Woody debris and gravel could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition.	Re-profile the banks. Introduce woody debris and gravel. Enhance the riparian zone.
	MEA012	A meandering section of channel which shows evidence of natural recovery. While the riparian zone has been impacted by the surrounding land use, the river bank vegetation is generally good and there are areas with tree cover, which are introducing woody debris to the channel.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA013	Gently sinuous section of channel with uniform banks and highly degraded riparian zone. There is a large weir toward the lower end of the reach. Ponding from the weir creates	Remove weir. Introduce woody debris and

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Unit	Reach	Restoration potential – issues to address	Restoration actions
		highly uniform flow conditions upstream. The weir should ideally be removed. Woody debris and gravel could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition.	gravel. Rehabilitate the riparian zone.
	MEA014	A meandering section of channel which shows evidence of natural recovery. While the riparian zone has been impacted by the surrounding land use, the river bank vegetation is generally good and there are areas with tree cover, which are introducing woody debris to the channel. There is a very low weir in this section, however, this does not appear to be off sufficient size to cause any adverse impacts and as such removal is not warranted.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA015	A slightly sinuous section of channel which shows evidence of natural recovery. While the riparian zone has been impacted by the surrounding land use, the river bank vegetation is generally good and there are areas with tree cover, which are introducing woody debris to the channel.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA016	Slightly sinuous section of channel with steep uniform banks. The bed is uniform and there is little variation in flow types. Agricultural land use extends to the bank tops with only a very narrow uncultivated margin as a result the riparian zone is relatively uniform, with few trees. Woody debris and gravel could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition. Gravel could also be used to create one or two riffles.	Re-profile the banks. Introduce woody debris and gravel. Create one or two riffles. Rehabilitate the riparian zone.
	MEA017	Slightly sinuous section of channel with steep uniform banks. The bed is uniform and there is little variation in flow types although some recovery has occurred in places, through channel narrowing. Agricultural land use extends to the bank tops with only a very narrow uncultivated margin in some locations, in these areas riparian zone is relatively uniform, with few trees. Woody debris could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition. Gravel could also be used to create one or two riffles.	Re-profile the banks. Introduce woody debris. Create one or two riffles. Rehabilitate the riparian zone.
4	MEA018	A relatively straight section of channel located along the foot of the left valley side. The straight planform of this reach appears to be natural, reflecting the control imposed by the valley side. The channel is extensively tree lined in this section, this creates a supply of woody debris which provides habitat and flow diversity. The presence of gaps associated with the surrounding land use allows light to reach the channel and provides variation in habitat.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA019	A slightly meandering section of channel which shows evidence of past deepening and widening. The banks are generally uniform in morphology; however, some recovery has occurred through vegetation growth and channel narrowing. Agricultural land use extends to the bank tops with only a very narrow uncultivated margin, as a result the riparian zone is relatively uniform, with few trees.	Rehabilitate the riparian zone.

Unit	Reach	Restoration potential – issues to address	Restoration actions
	MEA020	A sinuous to meandering section which also shows evidence of past deepening and widening. The banks, despite having a uniform morphology show some recovery through vegetation growth which has lead to channel narrowing. Agricultural land use extends to the bank top along the left bank with only a very narrow uncultivated margin as a result the riparian zone is relatively uniform, with few trees. The right bank is covered by trees associated with a woodland plantation.	Rehabilitate the riparian zone along the left bank.
	MEA021	A sinuous to meandering section which also shows evidence of past deepening and widening. The banks are relatively uniform and there is little variation in flow patterns. Woody debris could be installed in the channel to add habitat and flow variation and encourage localised sediment deposition. Agricultural land use extends to the bank tops with only a very narrow uncultivated margin, as a result the riparian zone is relatively uniform, with few trees, although occasional clumps are present.	Re-profile the banks. Introduce woody debris. Create one or two riffles. Rehabilitate the riparian zone.
	MEA022	A slightly sinuous section of channel which shows evidence of natural recovery. While the riparian zone has been impacted by the surrounding land use, the river bank vegetation is generally good and there are areas with tree cover, which are introducing woody debris to the channel.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA023	A slightly sinuous section of channel which shows evidence of natural recovery. While the riparian zone has been impacted by the surrounding land use, the river bank vegetation is generally good and there are areas with tree cover, which are introducing woody debris to the channel.	Conserve this reach and seek opportunities to enhance the riparian zone.
	MEA024	A meandering section of channel which shows some evidence of recovery following past modification, primarily through vegetation growth along the banks and within the channel. Trees are present along parts of the right bank, associated with the grounds of Croxall Hall, this provides a source of woody debris. The main pressure is the degradation of the riparian zone along the left bank (especially a lack of trees) associated with arable farming.	Rehabilitate the riparian zone.
	MEA025	A straight and relatively deep section of channel which was realigned in the past. Despite this past modification the channel the channel morphology has undergone adjustment which has created varied channel morphology. Tree lining is extensive along this reach and although there are some gaps along the left bank, this provides a source of woody debris to the channel.	Conserve this reach and seek opportunities to enhance the riparian zone.

6.2 Reach-scale restoration plans

The restoration potential of each reach (Table 6.1) forms the basis of the reach-by-reach restoration plans which are provided in the accompanying River Mease SSSI/SAC Restoration Plan document. The potential restoration activities identified fall into two broad categories: those which involve restoring the channel, and those which focus on rehabilitating degraded sections of the riparian zone. Therefore restoration actions can be grouped into two categories: rehabilitation and restoration. In some reaches the ecological benefits could be realised by implementing one or both types of restoration. In other reaches the study found that readjustment of the channel and riparian zone following past modification has allowed the typical characteristics of the channel and riparian zone expected for this type of river to reform. In these reaches conservation should be the main objective. In view of this the reach-scale plans were categorised according to the types of restoration measures required in that reach, as either:

- *Conserve and enhance;*
- *Rehabilitate, and*
- *Restore.*

A map showing the restoration category for each reach is provided in Appendix A)

Where both rehabilitation of the riparian zone and restoration of the channel are required, the reach has been categorised as ‘restore’. This categorisation scheme reflects the degree of effort required to deliver improvements to the river and its corridor. It should be recognised that as these activities would not restore the floodplain they represent the starting point from which more ambitious floodplain restoration initiatives could be developed in the future. If opportunities arise that allow wider restoration of the floodplain it would no longer be necessary to concentrate rehabilitation works within the riparian zone (to provide a buffer between the river and the surrounding agricultural land), instead the rehabilitation of the river corridor would be undertaken as part of the wider floodplain restoration. In some instances, due to land use change, this could alter the type of riparian rehabilitation that would be necessary.

The restoration plan categories, and the measures they entail, are discussed below.

6.2.1 Conserve and enhance

This category reflects locations where proposed river restoration activities will be the least intensive. These sites were selected on the basis that the river channel already exhibits good channel morphology because either:

- *No pressures adversely affect the channel form (bed or banks) or the flow of water within the channel, or*
- *Reaches previously impacted by pressures, such as channel engineering, have since undergone adjustment towards a more natural form.*

In these locations actions to physically restore the channel were deemed to be unnecessary. Typically these sections were also characterised by less degradation of the riparian zone than other sections of the SSSI/SAC.

However, despite the good channel morphology in these sections of river, there are opportunities to further improve the riparian zone in these reaches. This is because while the riparian zone quality is relativity good, compared to other reaches it could be improved further.

6.2.2 Rehabilitate (assist natural recovery)

This category of restoration encompasses those reaches where the channel shows evidence of active adjustment of the channel morphology towards a more natural form, following past modification. However there are pressures affecting the riparian zone which, without intervention, will prevent the channel from fully recovering to support favourable condition. Typically riparian vegetation is sparse or absent along these reaches. Therefore in order to improve the river in these reaches, efforts should focus on the riparian zone rather than the channel. Improving the condition of the riparian zone will enhance channel adjustment (recovery) to occur in the medium-long term by providing a natural supply of woody debris to the channel, which will create variations in flow patterns, which will in turn influence patterns of erosion and sediment deposition and create more varied channel morphology. Rehabilitation techniques would include:

- *Filling gaps in the existing riparian vegetation;*
- *Restoring a riparian zone parallel to the channel, and*
- *Creating a riparian corridor along the river.*

These actions are described in more detail in the accompanying River Mease Restoration Plan.

6.2.3 Restore

This category encompasses those reaches that have been degraded by pressures affecting both the riparian zone and the channel, and are not showing evidence of naturally re-adjusting towards a more typical form. Restoring the river in these reaches will require both enhancements to the riparian zone and channel restoration measures to improve the morphology of the channel, helping it to support favourable condition. River channel restoration measures which could be implemented include:

- *Introducing woody debris;*
- *Removing bank structures (bank protection or embankments);*
- *Re-profiling the river banks;*
- *Adding gravel to provide bed habitat variation and/or riffles;*
- *Removing weirs, and*
- *Creating areas of wetland or wet woodland to intercept flow and sediment discharge into the channel.*

These actions are described in more detail in the accompanying River Mease Restoration Plan.

6.3 Stakeholder involvement

The actions in the restoration plan are required in order to achieve favourable condition in the River Mease SSSI/SAC. As such, the restoration plan will inform future decision making by the Natural England and the Environment Agency. Natural England and the Environment Agency recognise that implementing the restoration plan will require effective and positive engagement with landowners, land managers and stakeholders. To facilitate the involvement of land owners and other stakeholders, Natural England and the Environment Agency have taken steps to inform and involve the community and other stakeholder groups by:

- *Holding a meeting with key stakeholders, to gather their views, on 17th October 2011;*
- *Distributing a newsletter introducing the project to all land owners along the river in late October 2011;*
- *Publishing the restoration plan on the internet (OnTrent website) in January 2012;*
- *Running a consultation event for land owners and mangers in the catchment in January 2012.*

The consultation event, designed to engage land owners and managers in the restoration process, was held on the 10th January 2012 at Chilcote Village Hall. This provided an opportunity for those who would potentially be affected by the proposals to speak with representatives from Natural England and the Environment Agency to seek clarifications on the proposals, where necessary, and to provide feedback on the suggested restoration activities. In addition, feedback forms were also made available to allow comments to be submitted in writing for up to three weeks after the event. A deadline of 31 January 2012 was set for feedback. Forms were handed out at the event and were included at the back of the draft River Mease SSSI/SAC Restoration Plan.

General suggestions and concerns were considered and where these were compatible with the objective to restore favourable condition they were included in an update of the Plan. The final Plan will be published at the end of March 2012. From then on, Natural England and the Environment Agency will work with stakeholders to agree how best to deliver the River Mease Restoration Plan. Whilst some options will be able to be implemented over the next few years through agri-environment schemes (e.g. Higher Level Stewardship (HLS)), other measures will take longer to organise with the landowners and interested parties. It is envisaged that one-to-one discussions with landowners will be required to develop the options on a reach by reach basis.

6.4 Restoration vision

The restoration measures identified collectively set out a restoration vision for the SSSI/SAC, which describes how the river will look and behave once the restoration plan has been implemented. As the Gilwiskaw Brook and River Mease have different geomorphological characteristics due to their catchment context, two visions have been developed (section 6.4.1). Despite, the extent of modifications to the River Mease and Gilwiskaw Brook, there are sections along both waterbodies that provide morphological and/or habitat diversity consistent with a judgment of favorable condition. These locations provide 'templates' or 'reference sites' which can be used to help visualize the desired outcomes of the restoration measures. The sections which follow (6.4.1 and 6.4.2) use the reference site features to create illustrated visions of the character of the restored River Mease and Gilwiskaw Brook. The vision focuses on increasing the extent of the reference site so that they become the dominant characteristic of the river. In doing so this will increase the availability of habitats, providing space to allow populations of the characteristic wildlife species to grow and become more widespread. The larger and more widespread the populations are, the more resilient they become to pressures such as pollution incidents, low flows, predation and climate change.

6.4.1 Gilwiskaw Brook

Gilwiskaw Brook is a lowland river which has been extensively modified (at some point prior to the late nineteenth century), by milling (GIL001/5), land drainage (GIL001-5) and mineral extraction (GIL005/6) activities, to such an extent that it has a predominantly straight planform. Under more natural conditions the Gilwiskaw Brook would have a sinuous or meandering planform and be similar in form to (although smaller than) the River Mease. The desired features of the Gilwiskaw Brook which would contribute to favorable condition are summarised in Table 6.2.

The Gilwiskaw Brook is steeper than the River Mease, partly due to straightening, and so has higher energy flow energy. The Gilwiskaw Brook is therefore more geomorphologically active than the River Mease, which has enabled the channel to start to recover (where it is not constrained by stone bank reinforcing) towards a more typical diverse morphology. As such it is not considered to be necessary to actively restore a meandering planform; the focus is on assisting the natural recovery that is already underway.

The flow of the Gilwiskaw Brook, like all rivers, fluctuates over time. This means there are contrasts between periods of low or base flow and times when the river is in flood and inundates the surrounding floodplain. Floodplain inundation is a natural and important part of the functioning of the river. Ideally, river restoration would also include floodplain restoration, through the elimination of artificial drainage and establishing a mosaic of wet grassland and wet woodland habitats on the entire floodplain. Floodplain restoration would bring significant benefits in potentially reducing high flow peaks (benefiting places such as Packington), and for water quality by eliminating the floodplain as a source of diffuse pollution in terms of both nutrients and fine sediment. Where this is not possible (due to land use constraints), enhancement and rehabilitation of the riparian zone could bring limited flood risk benefits, and will help to reduce the supply of diffuse pollution in terms of both nutrients and fine sediment from land surface runoff.

Example of a good corridor of varied and floodplain vegetation (viewed from the air) including a) woodland (b) tree lining with good marginal vegetation (c) grassland (d) wet grassland.

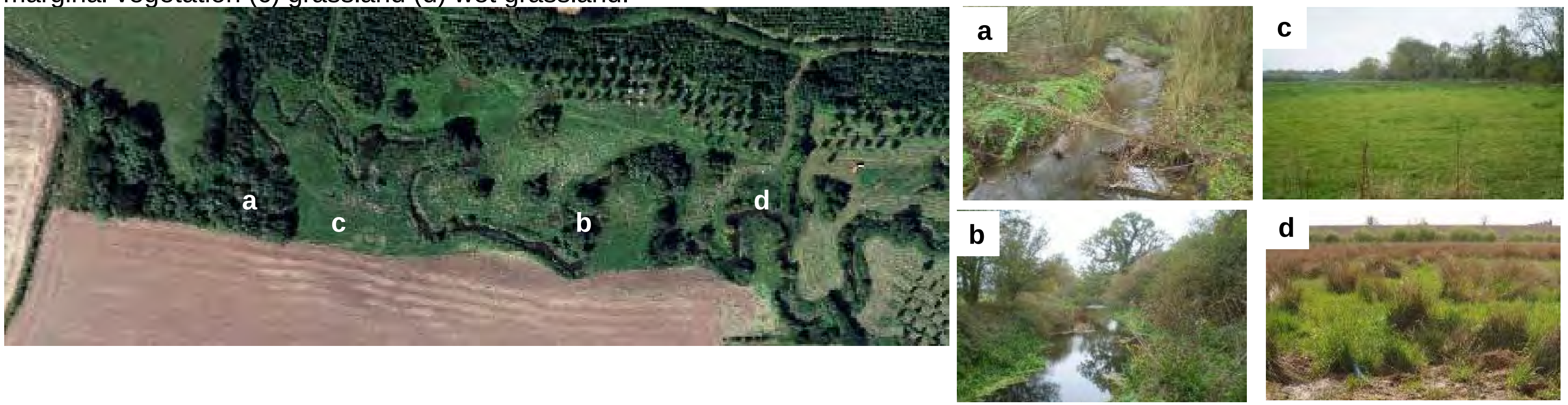


Table 6.2: Characteristics of the different features of the Gilwiskaw Brook which would contribute to favourable condition

Feature and its characteristics	Ecological benefit	Illustration
Planform Active channel recovery (adjustment) leading to the development of a sinuous channel planform.	Variations in channel cross-section associated planform recovery provide a range of habitats.	
Diverse bed and flow types Varied bed alternating frequently between shallow fast flowing sections (riffles) with turbulent flow where the bed is composed of gravel, pebbles and cobbles and deep flow flowing sections (pools and glides) where the bed is covered by a layer of soft, fine grained sediments (sand and some silt). Exposed gravel and cobble deposits occur at bends in the channel.	In short ponded sections and backwaters with finer bed sediments, a flora and fauna more associated with stillwaters develops, including unionid mussels and pea-mussels, libellulid dragonflies, agrionid damselflies, burrowing mayflies, water-snails, alder-flies, and various families of caddis-fly. Diverse velocities, depths and substrate ensure that there is suitable habitat present for all life stages of the characteristic species. In particular: **Spined loach** filter-feed in fine but well-oxygenated sediments. Juvenile spined loach bury themselves in sandy (also silty) bed sediments. **Bullhead** favour fast-flowing, clear shallow water with a hard substrate (gravel/cobble/pebble) or softer substrates so long as the water is well-oxygenated and there is sufficient cover. **White-clawed crayfish** make use of crevices in rocks. Where flows are stronger fish species may include perch, roach and eel, with chub and gudgeon.	

Feature and its characteristics	Ecological benefit	Illustration
Varied bank profiles would be expected under natural circumstances but these are currently restricted to those areas where a sinuous planform has developed. Typically the banks of the channel are high; however sections where adjustment has occurred where the banks are lower.	On shallow bank sides (particularly the insides of meander bends), a significant zone of hydrological transition can be expected, with beds of emergent species such as branched bur-reed and reed canary-grass, and wetland species such as brook-lime, water forget-me-not, water-mint, and water-cress. Water voles thrive in bank sides of intermediate slopes.	
Bank materials are generally composed of relatively fine grained sediment (clay, silt and fine sand). In some areas a layer of gravel and pebbles occurs at the base of the bank. This represents incision (bed lowering) of the channel through old river bed sediments.	Vertical cliffs of soft sediment provide nesting burrowing opportunities for kingfisher and sand martins, **white-clawed crayfish** and water voles. Vertical cliffs provide nesting opportunities for, as well as for burrowing bees and wasps and a range of other insects specialising in bare soils.	
Undisturbed bank and riparian vegetation comprising a range of different vegetation types from grass to mature trees. Trees are important as their root systems exposed in the river banks provide cover for fish and otter, and fallen trees and branches provide a source of woody debris which creates variation in flow, particularly areas of slack water.	Submerged exposed root systems that provide in-channel habitat for fish and invertebrates such as bullhead, **white-clawed crayfish**, potential holt and resting sites for otters. Trees are a source of woody debris and leaf litter for the river. Tree lining creates variations in within-channel light and temperature regimes that add further habitat diversity. Water voles thrive in tall herb vegetation. Riparian scrub provides additional important habitat for otter and bird species such as warblers. **Otter** utilise vegetated river banks, islands and woodland	

Feature and its characteristics	Ecological benefit	Illustration
	for foraging, breeding and resting. **White-clawed crayfish** make use of tree roots or woody debris which provide shelter from predators. They feed on all manner of live and dead organic matter (fallen leaves, vegetation). Tree roots are also a preferred habitat of bullhead.	
In-channel vegetation is relatively scarce; this reflects the relatively fast flowing nature of Gilwiskaw Brook.	The insect fauna is heavily dependent on an active marginal and wetland fringe of vegetation for hatching, resting, feeding and mating, and as a flow refuge under flood conditions. Water voles thrive in an active marginal zone of emergent plants. **Otter** utilise reed beds for foraging, breeding and resting. **White-clawed crayfish** make use of submerged plants for provide shelter from predators.	

6.4.2 River Mease

The River Mease is a passively meandering lowland river, which means the channel does not change its position over time (migrate). Passively meandering rivers have a varied bed morphology with alternating shallow (riffles and runs) and deep sections (pools and glides). These features do not change appreciably over time, and their position does not necessarily match the planform of the river This is a natural consequence of its low gradient (low energy) and relatively high, fine grained cohesive banks which are fairly resistant to erosion by flow. The desired characteristics of the different features of the River Mease channel which would contribute to favorable condition are summarised in Table 6.3.

The flow of the River Mease, like all rivers, fluctuates over time. This means there are contrasts between periods of low or base flow and times when the river is in flood and inundates the surrounding floodplain. Floodplain inundation is a natural and important part of the functioning of the river.

Ideally river restoration would also include floodplain restoration through the elimination of artificial drainage and establishing a mosaic of wet grassland and wet woodland habitats on the entire floodplain. Floodplain restoration would bring significant benefits

in potentially reducing high flow peaks, and for water quality by eliminating the floodplain as a source of diffuse pollution in terms of both nutrients and fine sediment. Where this is not possible (due to land use constraints), enhancement and rehabilitation of the riparian zone could bring limited flood risk benefits, and will help to reduce the supply of diffuse pollution in terms of both nutrients and fine sediment from land surface runoff.

Example of a good corridor of varied and floodplain vegetation (viewed from the air) including a) woodland (b) tree lining with good marginal vegetation (c) grassland (d) wet grassland.

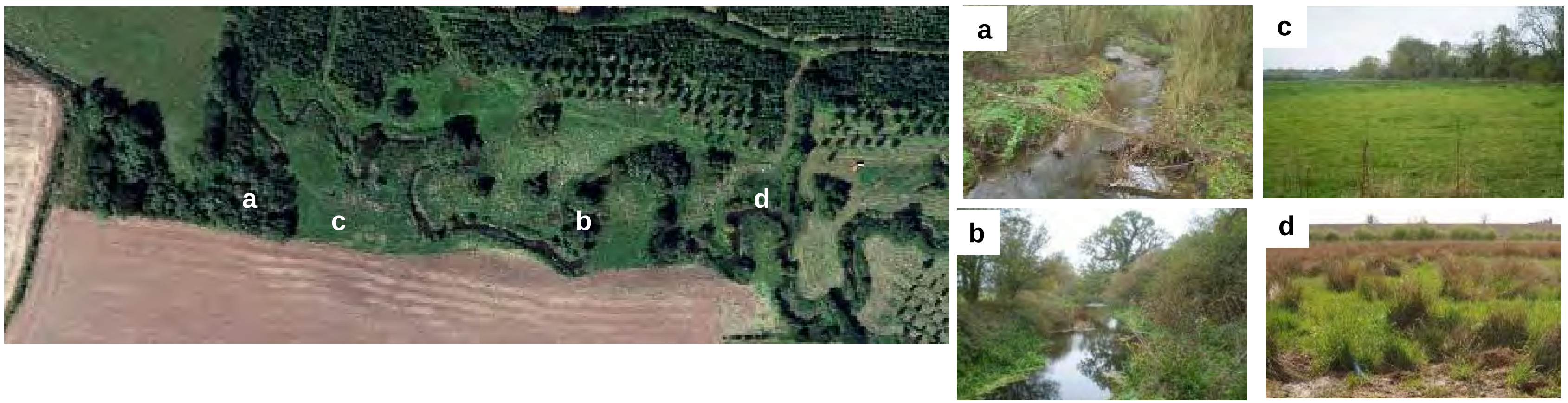
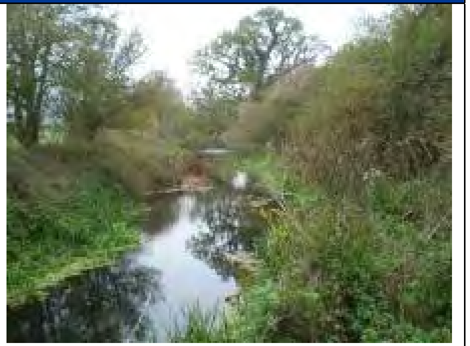


Table 6.3: Characteristics of the different features of the River Mease channel which would contribute to favorable condition

Feature	Ecological benefits	Illustration
Planform – the river has a meandering planform except locally where it has been modified by straightening.	Variations in channel cross-section associated with planform recovery provide a range of habitats.	
Diverse bed and flow types – alternating between shallow fast flowing sections (riffles and runs) with turbulent flow where the bed is composed of gravel, pebbles and cobbles, and deep slow flowing sections (pools and glides) where the bed is covered by a layer of soft, fine grained sediments (sand and some silt). In lowland rivers, deeper sections are more extensive than shallow areas, due to the low channel gradient. Riffles would be more numerous in the upper reaches (Unit 2) compared to the middle and lower reaches (Units 3 and 4). Only occasional riffles would be expected in the middle and lower reaches.	In ponded sections and backwaters with finer bed sediments, a flora and fauna more associated with stillwaters develops, including unionid mussels and pea-mussels, libellulid dragonflies, agrionid damselflies, burrowing mayflies, water-snails, alder-flies, and various families of caddis-fly. Diverse velocities, depths and substrate ensure that there is suitable habitat present for all life stages of the characteristic species. In particular: **Spined loach** filter-feed in fine but well-oxygenated sediments. Juvenile spined loach bury themselves in sandy (also silty) bed sediments. **Bullhead** favours fast-flowing, clear shallow water with a hard substrate (gravel/cobble/pebble). However, will live on softer substrates so long as the water is well-oxygenated and there is sufficient cover. **White-clawed crayfish** make us of crevices in rocks. Where flows are stronger fish species may include perch, roach and eel, with chub and gudgeon.	

Feature	Ecological benefits	Illustration
	Water-crowfoots favor gravel riffles where flow is in relatively swift and shallow. Restoration will bring benefits as this requires good light for photosynthesis (low siltation) and there needs to be at least 5cm of water over riffles in summer (when flows are lower).	
Varied bank profiles with areas of steep banks where the channel is straight or around the outside of bends, to gentle banks on the inside of bends. Bank heights are variable but should be relatively low (¼ or less of the channel width), however naturally high banks can also occur.	On shallow bank sides (particularly the insides of meander bends), a significant zone of hydrological transition can be expected, with beds of emergent species such as branched bur-reed and reed canary-grass, and wetland species such as brook-lime, water forget-me-not, water-mint, and water-cress. Water voles thrive in bank sides of intermediate slopes.	
Bank materials are generally composed of relatively fine grained cohesive sediment (clay, silt and fine sand). These banks have built-up over time as successive floods have deposited sediment onto the floodplain.	Vertical cliffs of soft sediment provide nesting burrowing opportunities for kingfisher and sand martins, **white-clawed crayfish** and water voles. Vertical cliffs provide nesting opportunities for burrowing bees and wasps and a range of other insects specialising in bare soils.	

Feature	Ecological benefits	Illustration
Undisturbed bank and riparian vegetation comprising a range of different vegetation types from grass to mature trees. Trees are important as their root systems exposed in the river banks provide cover for fish and otter, and fallen branches provide a source of coarse woody debris which creates variation in flow, particularly areas of slack water, and bed composition.	Submerged exposed root systems that provide in-channel habitat for fish and invertebrates such as **white-clawed crayfish**, potential holt and resting sites for otters. Trees are a source of woody debris and leaf litter for the river. Tree lining creates variations in within-channel light and temperature regimes that add further habitat diversity. Water voles thrive in tall herb vegetation. Riparian scrub provides additional important habitat for otter and bird species such as warblers. **Otter** utilise vegetated river banks, islands and woodland for foraging, breeding and resting. **White-clawed crayfish** make use of tree roots or woody debris which provide shelter from predators. They feed on all manner of live and dead organic matter (fallen leaves, vegetation).	
In-channel vegetation including reeds and rushes along the margins, where the channel is relatively deep and the flow slow, and water-crowfoot where flow is shallow and fast.	The insect fauna is heavily dependent on an active marginal and wetland fringe of vegetation for hatching, resting, feeding and mating, and as a flow refuge under flood conditions. Water voles thrive in an active marginal zone of emergent plants. **Otter** utilise reed beds for foraging, breeding and resting. **White-clawed crayfish** make use of submerged plants for provide shelter from predators.	

6.5 Restoration constraints

6.5.1 Land use

Land use is likely to be the main constraint on restoration. As described in Section 6.1, the SSSI/SAC is located in an area of high quality, productive agricultural land. The main impact of the restoration plan on the surrounding land use will be through land use change. Widespread land use change would be required to deliver floodplain restoration (a long-term aspiration), while more modest land use change will be required to deliver improvements to the riparian zone. Taking land out of arable production or reducing the intensity of grazing, will have financial implications for farmers. As a result many farmers are either sceptical of or in opposition to the restoration proposals. As implementation of the restoration plan will require co-operation and consent from land owners this is a significant potential barrier to implementation.

Farmers currently utilising the floodplain for arable farming or livestock grazing are faced with a number of challenges, this includes:

- *Crop damage and/or soil loss associated due to flood events (which are natural and due to climatic change likely to increase in frequency and magnitude in the future);*
- *Managing nutrient runoff in accordance with the catchment diffuse water pollution plan;*
- *Maintaining land drainage in areas where the river is re-adjusting following the cessation of land drainage work (no-longer permitted), and*
- *Limits on water availability for abstraction, especially during the summer (which is likely to increase in severity due to climatic change).*

Natural England and the Environment Agency recognise these pressures and want to work with farmers to help them adjust their farming practices to address these issues while protecting the internationally important wildlife within the river. The River Mease SSSI/SAC Restoration Plan offers a means by which farmers can be supported to meet the future challenges of farming the floodplain. The plan which is designed to be a strategic high level guide will assist in the uptake of agri-environment schemes, and provide farmers with an opportunity to seek financial assistance to adapt river and riparian management practices, if they so wish. For example, financial support (through Environmental Stewardship) could be given to farmers to change land management practices where land is subject to repeated flood impacts (crop damage or soil loss) and/or land drainage issues. Similarly the plan can be used as a means to support farmers who wish to apply for grants or other funding streams, to fund adaptations to floodplain land management challenges. For example woodland planting can be funded through grants from Natural England, the National Forest or the Forestry Commission

Some of the actions identified in the plans may actually deliver indirect benefits for farming. For example, retaining more woody debris in the channel will help to slow the flow of water through the river and lead to short-term local retention of water. This offers the potential to increase water levels and prolong water retention at times when flows would otherwise be low. This may reduce the duration that abstraction is prevented or limited (by hands-off flow). Measures to remove woody debris and maximise downstream flow rates will accentuate summer low flows and reduce water availability for abstraction. A more diverse, in some areas wooded, riparian zone will help to slow the passage of flood water and increase the retention of flood waters along the channel corridor. This could reduce the potential for overland flow across the floodplain which can cause soil erosion (Figure 5.4). As a result the degree to which land use is a constraint on restoration will depend on local circumstances.

6.5.2 Flood risk

The restoration plan is designed to provide a means of adapting to and working with natural processes. Flooding is a natural and essential part of river behaviour. Periodic inundation of the floodplain has a range of benefits:

- *It dissipates flow energy and thereby helps to reduce the likelihood of bed and bank erosion;*
- *It deposits sediment on the floodplain which is a source of nutrients and material for soils, and*
- *It stores water and helps to reduce flood risk downstream by reducing the volume and rate of downstream flood propagation.*

The majority of the land in the catchment which is vulnerable to flooding (within the 100 year floodplain) is agricultural land. Preventing or limiting flooding of this land is not possible due a number of factors including:

- *Funding constraints (the relatively high cost of the work, as compared to the benefits realised);*
- *The ecological sensitivity of the river precludes dredging, and*
- *Cost and space requirements preclude embankment construction along the river (and they can trap water behind them, increasing the time to drain land).*

It is recognised however that floodplain inundation does present challenges for farmers such as crop damage and soil loss (described above). These challenges can be addressed by taking actions such as avoiding planting crops in high risk areas, especially the inside of meanders where flood water velocities are likely to be greatest, and avoiding actions which might channel or confine flood water flows into narrow pathways.

The restoration does not introduce any new activities or constraints which will make flood risk worse. Sediment and vegetation management is already regulated, due in part to the designation of the river, to ensure the river channel is allowed to function in a way that is as natural as possible. Localised accumulation of sediment within the channel and the growth of aquatic vegetation are unlikely to have a significant impact on flood risk. During flood events aquatic vegetation tends to be flattened by flood waters and does not lead to appreciable increases in water level. Localised accumulations of sediment in the channel do not necessarily increase flood risk as the reduction in channel capacity leads to an increase in flow velocity, which maintains the rate of flow discharge.

However, where particular risks are identified, such as the build-up of blockages composed of woody debris within the channel or on structures, then work could be undertaken to remove material to reduce the risk. This type of activity, which is subject to consent from Natural England and the Environment Agency, is included for within the restoration plan. As the restoration measures are developed in more detail (on a site by site basis) measures will be taken to ensure that the plan does not increase flood risk to property or infrastructure.

6.5.3 Cultural heritage

River restoration activities may be constrained in some locations where they may impact on cultural heritage interests. Weirs, most of which are recommended for removal, may have important ongoing functions or historic/cultural associations, which need to be considered carefully when planning and designing restoration work. Changes to landscape character may be a constraint. For example, increased tree cover may be inappropriate in some locations, such as close to historic buildings or areas of parkland. Consideration will be given to potential impacts on landscape character, however it is envisaged that this is likely to be a relatively localised issue. Reaches where this may be a consideration are GIL005, MEA013 and MEA024.

6.5.4 Development and infrastructure

Properties (buildings), infrastructure (roads and services) and development (e.g. mining) are likely to present immovable constraints on restoration. However, in the context of the River Mease SSSI/SAC, where development on the floodplain is limited, this is not a widespread constraint. Impacts of development on restoration and are likely to be restricted to a few specific locations such as reaches GIL005 and MEA006. GIL005 is likely to be impacted by the planned extraction of coal and fireclay by surface mining methods and subsequent restoration to agriculture, woodland and nature conservation by UK Coal Ltd at Minorca Colliery, Measham. MEA006 is located beneath the A42 trunk road and this limits the scope for restoration.

7 Other plans and delivery mechanisms

7.1 River Basin Management Plan

The River Mease is formed of two, waterbodies, divided at the confluence of Hooborough Brook. Both are currently at Moderate Ecological Status and neither is classified as an artificial or heavily modified waterbody (A/HMWB) (Table 7.1). All three waterbodies have the objective to be at Good Ecological Status (GES) by 2027.

All measures in the relevant river basin plan must be 'operational' by Dec 2012. Since the River is designated as an SAC ('Protected Area') the measures necessary to achieve both GES and the Natura site conservation objectives must therefore be in operation by Dec 2012. This equates to the River Mease SSSI units underpinning the SAC having their relevant SSSI/SAC remedies 'underway'.

Whilst the target to achieve GES has been extended to 2027, the SAC conservation objectives should be met by December 2015 (since no extension has been applied on this site). Where objectives for GES and Natura sites apply to the same body of water, the most stringent apply. Any elements that are necessary to achieve the SAC conservation objectives should be improved to enable these objectives to be achieved by December 2015; and all elements should be improved to enable GES to be achieved by December 2027 (Table 7.2).

If it becomes apparent that it is not possible to achieve the conservation objectives for the site by December 2015 (e.g. due to time taken for the ecology of the site to recover), then it must be demonstrated that every effort has been made to ensure that the necessary measures to achieve the protected area conservation objectives are in place.

Table 7.1: Hydromorphological status of the waterbodies along the SSSI/SAC (www[4])

Waterbody ID	Name	Hydromorphological status
GB104028046590	Gilwiskaw Brook from Source to River Mease	Not Designated A/HMWB
GB104028046570	River Mease from Gilwiskaw Brook to Hooborough Brook	Not Designated A/HMWB
GB104028046560	River Mease from Hooborough Brook to Trent	Not Designated A/HMWB

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Table 7.2: Ecological status of the quality elements for the waterbodies along the SSSI/SAC (www[4])

Element	Waterbody		
	Gilwiskaw Brook from Source to River Mease	River Mease from Gilwiskaw Brook to Hooborough Brook	River Mease from Hooborough Brook to Trent
Fish	Poor (very certain)	High	High
Invertebrates	Moderate (very certain)	Good	Moderate (uncertain)
Phosphate (water quality)	Moderate (very certain)	Bad	Poor (very certain)
Quantity and dynamic of flow	Supports good	Supports good	Supports good
Morphology	Supports good	Supports good	Supports good

Implementation of the River Mease Restoration Plan would help to deliver improvements required by the WFD by increasing the availability of suitable habitat for fish and invertebrates, which, assuming water quantity improvements also occur, will help to increase numbers and species diversity. Implementation of the plan will also help to deliver water quality improvements via reductions in land use pressures and enhancements to the riparian zone, which can help to reduce volumes and rates of nutrient supply to the channel. While the quantity and dynamics of flow and morphology quality elements supported GES, the favourable condition targets for the SSSI/SAC are more stringent.

7.2 Diffuse Water Pollution Plan

A range of measures are being implemented to reduce diffuse water pollution in the catchment, these include:

- *Reducing sediment supply to the river by enhancing riparian habitats along the river corridor;*
- *Reduced sediment runoff from fields;*
- *Reduced sediment runoff from livestock poaching, and*
- *Reduction of unconsented pollution incidents.*

The measures, which are described in more detail in the River Mease Diffuse Water Pollution Plan (www[3]) will complement the River Mease Restoration Plan. Indeed some of the actions included in the restoration plan associated with reducing land use pressures and improving the riparian zone will help to deliver the objectives of the DWPP. The Water Quality (Phosphorous) Management Plan (see section 4.4.2) builds on the DWPP and is specific to addressing the high levels of phosphorous in the river. Measures have been assigned to Natural England, Environment Agency, Local Authorities, the Highways Agency and Severn-Trent Water. Mechanisms to deliver these improvements include the Environmental Stewardship schemes (ELS, HLS), Catchment Sensitive Farming (CSF), Catchment Restoration Fund (CRF) and Severn-Trent Water's environmental improvement programme associated with Asset Management Period 5 (2010-2015).

7.3 River Trust initiatives

The Trent Rivers Trust is an independent environmental charity established to promote the preservation, protection and improvement of the rivers and streams in the Trent catchment and the habitats they support, increasing awareness and understanding of the management of water bodies and the wider environment (see: http://www.trentriverstrust.co.uk). Rivers Trusts generally rely on public funding, but many have successfully applied for European Union structural funds such as Interreg and Objectives One, Two and 5b or Lottery funds. They deliver major programs of physical works and practical river improvements in partnership with the Environment Agency and Natural England. At present the Trent Rivers Trust is undertaking work on the River Trent near the confluence of the River Mease and they are currently running a programme to eradicate Himalayan Balsam from the area.

7.4 Delivery mechanisms

Whole river restoration plans are based on multi-partner working, time horizons suited to the nature and scale of each site's problems and solutions (typically 20-50 year time horizons), a negotiated settlement to any disagreements, and a best endeavours approach to implementation. Funds need to be secured to maintain best endeavours over time, including rolling bids to obvious budgets such as EA Flood and Coastal Risk Management (FCRM) capital works, Catchment Restoration Funds, and Environmental Stewardship, but also opportunistic bids to a range of other funding sources including European programmes. Work in-kind from third parties, including 'third sector' partners such as the Rivers Trusts has a vital part to play.

A number of potential delivery mechanisms for the River Mease SSSI/SAC Restoration Plan, these are:

- *Trent Rivers Trust contribution in kind*
- *Catchment Restoration Fund*
- *Nutrient Management Plan funded actions*
- *European funding*
- *Environmental Stewardship*
- *Catchment Sensitive Farming*
- *Forestry Commission England Woodland Grant Scheme*
- *National Forest*

Further details on each of these mechanisms are provided in the accompanying River Mease SSSI/SAC Restoration Plan. Restoration costs have been estimated but these are very rough cost bandings currently to guide future funding and resources, and will be revised over time.

7.5 Prioritisation and costs

7.5.1 Prioritising

The order in which the proposals recommended in this plan are implemented is likely to be influenced by opportunities which arise such as landowner cooperation and funding. However, in order to maximise the degree of improvement to the SSSI/SAC that can be realised in the short-term, those actions which will deliver the greatest benefits should be prioritised. Maximising short-term gains will be essential for meeting the SAC conservation objectives by 2015 (Section 7.1). Short-term actions, have therefore been assigned a target delivery date of 2015. Restoration actions that will deliver maximum benefits are those which involve:

- *Removing redundant structures within the channel (which have a high impact on channel morphology), and*
- *Restoring reaches most adversely affected by pressures.*

Removing redundant structures, including weirs, will provide the greatest benefit at an early stage, allowing free movement of aquatic fauna and flora, and natural river dynamics to re-establish within the SSSI/SAC and logically need to occur before other actions in that reach.

Those reaches which are most adversely affected by pressures are generally those which show the least evidence of natural recovery (Figure 5.10). While pressures on the different attributes are widespread within the SSSI/SAC, many reaches show evidence of natural readjustment and therefore ongoing natural recovery (Section.5.4). Those reaches where no natural recovery is occurring should be prioritised, as these are the least favourable sections of river. Restoring these reaches will bring greater benefits than resorting to those which have already begun to recover. In addition, the fact that many of the reaches are recovering (albeit to varying degrees and rates) means that while restoration effort is focused elsewhere improvements will occur naturally in other reaches.

While many of the reaches along the SSSI/SAC show evidence of ongoing natural recovery (Figure 5.10), this process will take time. In order maximise the rate and degree of recovery restoration measures will need to be implemented. Those reaches where readjustment is restricted to one or two attributes should be prioritised over those where three or more attributes are recovering (Figure 5.10). These reaches have therefore been selected as medium term objectives. A target date of 2027 has been selected, as this is consistent with the WFD target date for GES (Section 7.1). Those reaches which show the strongest degree of adjustment (recovery), by virtue of three of more attributes showing recovery have been selected as long-term objectives with a target date of 2050. Similarly those reaches which already show a low degree of modification have also been selected as long-term objectives. This reflects the fact that these reaches will, assuming no adverse new pressures occur, continue to improve through natural processes during the short and medium terms when effort is focused elsewhere.

The prioritisation of actions outlined above, does not preclude, opportunities which arise to rehabilitate or restore those reaches at an earlier time than that envisaged. For example, opportunities presented by the participation of farmers and land owners in agri-environmental schemes, successful funding applications or other third party activities (e.g. utility companies, UK coal) should be explored wherever possible, irrespective of the previously envisaged prioritisation.

The prioritisation of the restoration options are summarised in Table 7.3 to 7.5 in the following section.

7.5.2 Costs

Costs to carry out this restoration work have been estimated based on similar measures on other projects and on past experience. Minimum and maximum costs have been provided for each type of restoration measure suggested in the Plan which gives a price range for restoring each reach. Costs will be site specific and will vary according to a number of factors including, for example, the need for further investigations, external contractors, access, reuse or disposal of materials, local gravel import. There are also a number of assumptions attached to the costs which relate to the percentage of reach length that needs to be restored, for example, 10% of channel length requiring bank reprofiling and 50% for riparian improvement) (Table 7.6). The likely annual HLS costs have also been calculated per hectare but are based on the 12m buffer width for riparian improvement (but this could be more or less).

A delivery lead has been indicated, however there are a number of actions that are suitable for implementation by angling clubs, the river and wildlife trusts. The Environment Agency and Natural England will seek to work in partnership with a range of external parties to deliver the actions.

Table 7.3: Short-term restoration actions (by 2015) with broad indicative costs- note these are subject to change

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
4	GIL001	Remove minor weir	EA	£5,000	£19,000	
	GIL001	Re-profile banks	EA	£1,348	£18,601	
	GIL003	Remove bank reinforcement	EA	£750	£1,380	
	GIL005	Remove culvert	EA	£850	£1,380	
		Wet woodland	NE	£571	£571	£39
		Review sediment management	EA	£5,000	£5,000	
	GIL006	Remove embankment	EA	£400	£27,600	
3	MEA002	Remove bank reinforcement	EA	£750	£1,380	
	MEA003	Re-profile banks	EA	£300	£4,136	
		Install gravel	EA	£749	£1,948	
		Introduce woody debris	EA	£60	£108	
		Improve riparian zone (including fencing and field gates)	NE	£2,098 (£2,769)	£2,098 (£4,940)	£212
	MEA005	Remove bank reinforcement	EA	£750	£1,380	
		Re-profile banks	EA	£520	£7,177	
		Install woody debris	EA	£104	£187	

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
		Install gravel	EA	£1,300	£3,380	
		Improve riparian zone (including fencing and field gates)	NE	£3,640 (£4,588)	£3,640 (£7,914)	£500
	MEA007	Remove minor weir	EA	£5,000	£19,000	
2	MEA011	Re-profile banks	EA	£504	£6,954	
		Install woody debris	EA	£101	£181	
		Install gravel	EA	£1,260	£3,276	
		Improve riparian zone (including fencing and field gates)	NE	£3,528 (£4,456)	£3,528 (£7,698)	£617
	MEA013	Remove major weir	EA	£36,000	£60,000	
		Short-term Total (including fencing and field gates)		**£73,130**	**£203,191**	**£1,368**

Table 7.4: Medium-term restoration actions (by 2027) with broad indicative costs- note these are subject to change

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
4	GIL003	Improve riparian zone (including fencing and field gates)	NE	£3,197 (£4,066)	£3,197 (£7,060)	£440
	GIL004	Improve riparian zone (including fencing and field gates)	NE	£1,976 (£2,627)	£1,976 (£4,705)	£271
	GIL006	Re-profile banks	EA	£1,175	£16,218	
		Improve riparian zone (including fencing and field gates)	NE	£8,227 (£9,994)	£8,227 (£16,760)	£1,045
3	MEA001	Improve riparian zone (including fencing and field gates)	NE	£8,780 (£10,646)	£8,780 (£17,827)	£1,126

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
		Create wetland	NE	£439	£439	£3
	MEA002	Re-profile banks	EA	£1,281	£17,671	
		Improve riparian zone (including fencing and field gates)	NE	£8,964 (£10,863)	£8,964 (£18,181)	£1,290
	MEA004	Improve riparian zone (including fencing and field gates)	NE	£5,267 (£5,940)	£5,267 (£8,109)	£790
	MEA007	Re-profile banks	EA	£2,114	£29,180	
		Install woody debris	EA	£423	£761	
		Install gravel	EA	£5,286	£13,744	
		Create wetland	NE	£1,057	£1,057	£541
		Improve riparian zone (including fencing and field gates)	NE	£14,801 (£17,742)	£14,801 (£29,439)	£3,219
2	MEA012	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£572
	MEA013	Install woody debris	EA	£310	£558	
		Install gravel	EA	£3,874	£10,073	
		Improve riparian zone (including fencing and field gates)	NE	£10,848 (£13,083)	£10,848 (£21,815)	£1,671
	MEA016	Re-profile banks	EA	£1,024	£14,127	
		Install woody debris	EA	£205	£369	
		Install gravel	EA	£2,559	£6,654	
		Improve riparian zone (including fencing and field gates)	NE	£7,166 (£8,744)	£7,166 (£14,714)	£1,096
	MEA017	Re-profile banks	EA	£1,614	£22,273	
		Install woody debris	EA	£323	£581	
		Install gravel	EA	£4,035	£10,491	
		Improve riparian zone (including fencing	NE	£11,298 (£13,614)	£11,298 (£22,683)	£698

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
		and field gates)				
1	MEA019	Improve riparian zone (including fencing and field gates)	NE	£4,249 (£5,306)	£4,249 (£9,089)	£356
	MEA021	Re-profile banks	EA	£1,834	£25,315	
		Install woody debris	EA	£917	£1,651	
		Install gravel	EA	£4,586	£11,924	
		Improve riparian zone (including fencing and field gates)	NE	£12,841 (£15,432)	£12,841 (£25,659)	£2,379
		Medium-term Total (including fencing and field gates)		**£151,113**	**£379,127**	**£15,497**

Table 7.5: Long-term restoration actions (by 2050) with broad indicative costs- note these are subject to change

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
4	GIL002	Improve riparian zone (including fencing and field gates)	NE	£4,630 (£5,755)	£4,630 (£9,823)	£367
4	GIL007	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£363
3	MEA006	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£55
2	MEA008	Re-profile banks	EA	£2,340	£32,295	
		Install woody debris	EA	£468	£842	
		Install gravel	EA	£5,851	£15,211	
		Improve riparian zone (including fencing and field gates)	NE	£16,381 (£19,604)	£16,381 (£32,486)	£2,779
	MEA009	Improve riparian zone	NE	This would be delivered	This would be delivered	£1,056

Unit	Reach	Action	Delivery Lead	Minimum Cost	Maximum Cost	Annual HLS Cost
				under HLS	under HLS	
	MEA010	Re-profile banks	EA	£1,766	£24,365	
		Install woody debris	EA	£353	£636	
		Install gravel	EA	£4,414	£11,476	
		Improve riparian zone (including fencing and field gates)	NE	£12,359 (£15,007)	£12,359 (£24,729)	£2,279
	MEA014	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£1,056
	MEA015	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£282
1	MEA018	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£179
	MEA020	Improve riparian zone (including fencing and field gates)	NE	£4,828 (£5,988)	£4,828 (£10,205)	£315
	MEA022	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£444
	MEA023	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£298
	MEA024	Improve riparian zone (including fencing and field gates)	NE	£7,882 (£9,588)	£7,882 (£16,095)	£939
	MEA025	Improve riparian zone	NE	This would be delivered under HLS	This would be delivered under HLS	£445
		Long-term Total (including fencing and field gates)		**£71,134**	**£178,163**	**£10,857**

Table 7.6: Assumptions made when calculating costs note HLS costs based on 2012 rates, and subject to change and acceptance into scheme

Action	Min Cost	Max Cost	Assumptions	HLS cost
Review sediment management	£5,000	£5,000	Sediment management study	
Add woody debris to channel	£10/m	£18/m	Assume 2% of reach length	
Add gravels / riffle creation	£50/sqm	£130/sqm	Assume 50% of reach length	
Remove bank reinforcement	£75/m	£138/m	Cost based on length of reinforced bank	
Remove culvert	£85/m	£138/m	Assumes same cost as removing bank reinforcement	
Remove embankment	£2/m	£138/m	Cost based on length of reinforced bank	
Remove minor weir	£5,000	£19,000	Minor weir, landowner or local contractor to undertake work. No detailed assessment likely to be necessary	
Remove major weir (and associated walls)	£36,000	£60,000	Feasibility and detailed design necessary and included in costs.	
Reprofile or lower banks	£10/m	£138/m	Assume 10% of channel length	
Create sinuous low flow channel	£45/m	£138/m	Assume 30% of channel length	
Create an area of wetland	£10/sqm	£10/sqm	Costs based on area requiring action	£285/hectare for wet grassland
Create wet woodland	£7/sqm	£7/sqm	Costs based on area requiring action	£315/hectare for wet woodland
Fill gaps in riparian vegetation by planting	£7/m	£7/m	Assume 50% of channel length (between both banks).	Based on 12m riparian width and £400/hectare
Improve riparian corridor (including trees)	£7/m	£7/m	Assume 100% of channel length (divided between both banks).	Based on 12m riparian width £400/hectare.
Fencing (both banks)	£2.50/m	£13/m	Assume 50% of reach (divided between left and right bank)	
Field gate (£149 each)	£298	£894	Assumes 2 as minimum and 6 as maximum	

7.6 Implementation – next steps

A consultation event with landowners was held on the 10th January 2012 at Chilcote Village Hall. Feedback from land owners was taken on board and used, where applicable, to refine the proposals included in the River Mease SSSI/SAC Restoration Plan. Following publication of the final plan, Natural England and the Environment Agency will work with stakeholders to take forward the actions within the plan, and will refer back to relevant specific comments provided by landowners during the consultation period. Whilst some restoration options will be able to be implemented relatively quickly over the next few years, other measures will take longer to develop. This plan is a long term restoration strategy likely to be realised over the next two to three decades by working in partnership with interested parties, and using a range of delivery mechanisms.

8 Conclusion

This geomorphological and ecological assessment of the River Mease SSSI/SAC has identified a range of different pressures which affect each of the different features of the river. These are:

Riparian zone:

- *Degraded riparian (and floodplain vegetation*
- *Lack of trees*

Banks:

- *Degraded bank vegetation*
- *Accelerated bank erosion (e.g. poaching of the banks by livestock)*
- *Lack of morphological diversity due to re-sectioning or engineered structures*

Bed:

- *Lack of morphological diversity due to channel re-sectioning, dredging and removal of fallen trees (non-willow)*

Planform:

- *Lack of morphological diversity due to straightening and re-sectioning (large scale)*

Flow (pattern and velocity):

- *Over-deepened (lack of floodplain connectivity)*
- *Informal embankments (lack of floodplain connectivity)*
- *Impounded flows (weirs)*
- *Limited variety in flow velocity/depth (lack of woody debris in the channel)*

Based on these findings, a range of different potential restoration activities have been identified. The restoration potential of each river reach forms the basis of the reach-by-reach restoration plans which are provided in the accompanying River Mease SSSI/SAC Restoration Plan. The reach-scale plans are categorised according to the types of restoration measures required in that reach, as either:

- *Conserve and enhance;*
- *Rehabilitate, and*
- *Restore*

Reaches identified for conservation and enhancement exhibit good channel morphology. However, while the riparian zone is relativity good, compared to other reaches, the quality of the riparian zone could be improved further.

Rehabilitation techniques would include:

- *Filling gaps in the existing riparian vegetation;*
- *Resorting a riparian zone parallel to the channel, and*
- *Creating a riparian corridor along the river.*

River channel restoration measures which could be implemented include:

- *Introducing woody debris;*
- *Removing bank structures (bank protection or embankments;*
- *Re-profiling the river banks;*
- *Adding gravel to create bed habitat variation and/or riffles;*
- *Removing weirs, and*
- *Creating areas of wetland or wet woodland to intercept discharge into the channel.*

These actions are described in more detail in the accompanying River Mease Restoration Plan.

The restoration actions identified in each reach form components which build together to create a restoration vision for the SSSI/SAC which describes how the river will look and behave once the restoration plan has been implemented.

Natural England and the Environment Agency recognise that implementing the restoration plan will require effective and positive engagement with landowners, land managers and stakeholders. The actions in the restoration plan are required in order to achieve favourable condition in the River Mease SSSI/SAC. As such, the restoration plan will inform future decision making by the Natural England and the Environment Agency. To facilitate the involvement of land owners and other stakeholders, Natural England and the Environment Agency have taken steps to inform and involve the community and other stakeholder groups.

A range of potential constraints on restoration have been identified, including land use, flood risk, development, infrastructure and cultural heritage. However, they do not represent obstacles to delivering significant improvements to the river at the catchment scale.

Following publication of the final plan, Natural England and the Environment Agency will work with stakeholders to take forward the actions within the plan. Whilst some options will be able to be implemented relatively quickly over the next few years, other measures will take longer to develop. This plan is a long term restoration strategy likely to be realised over the next two to three decades.

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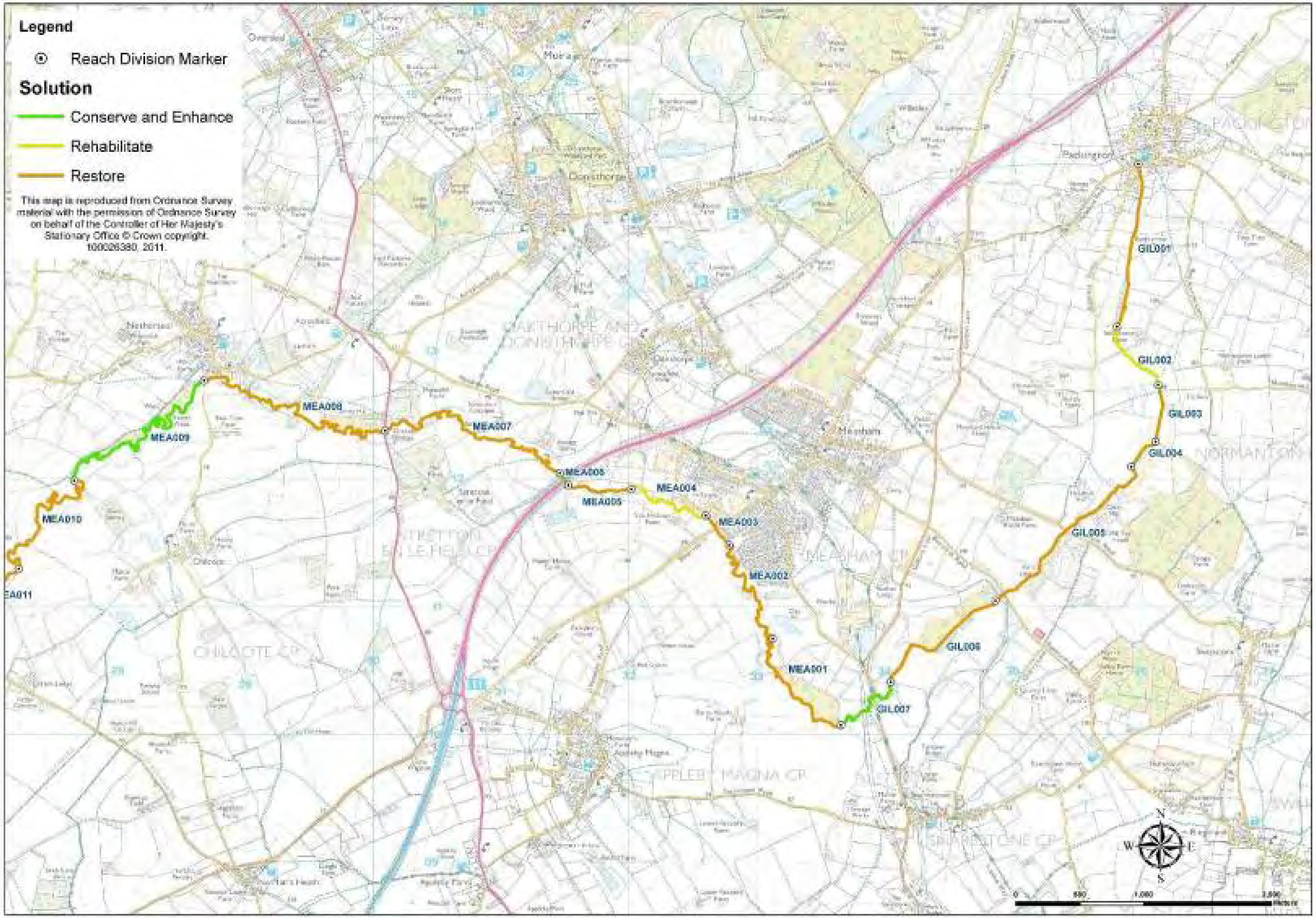
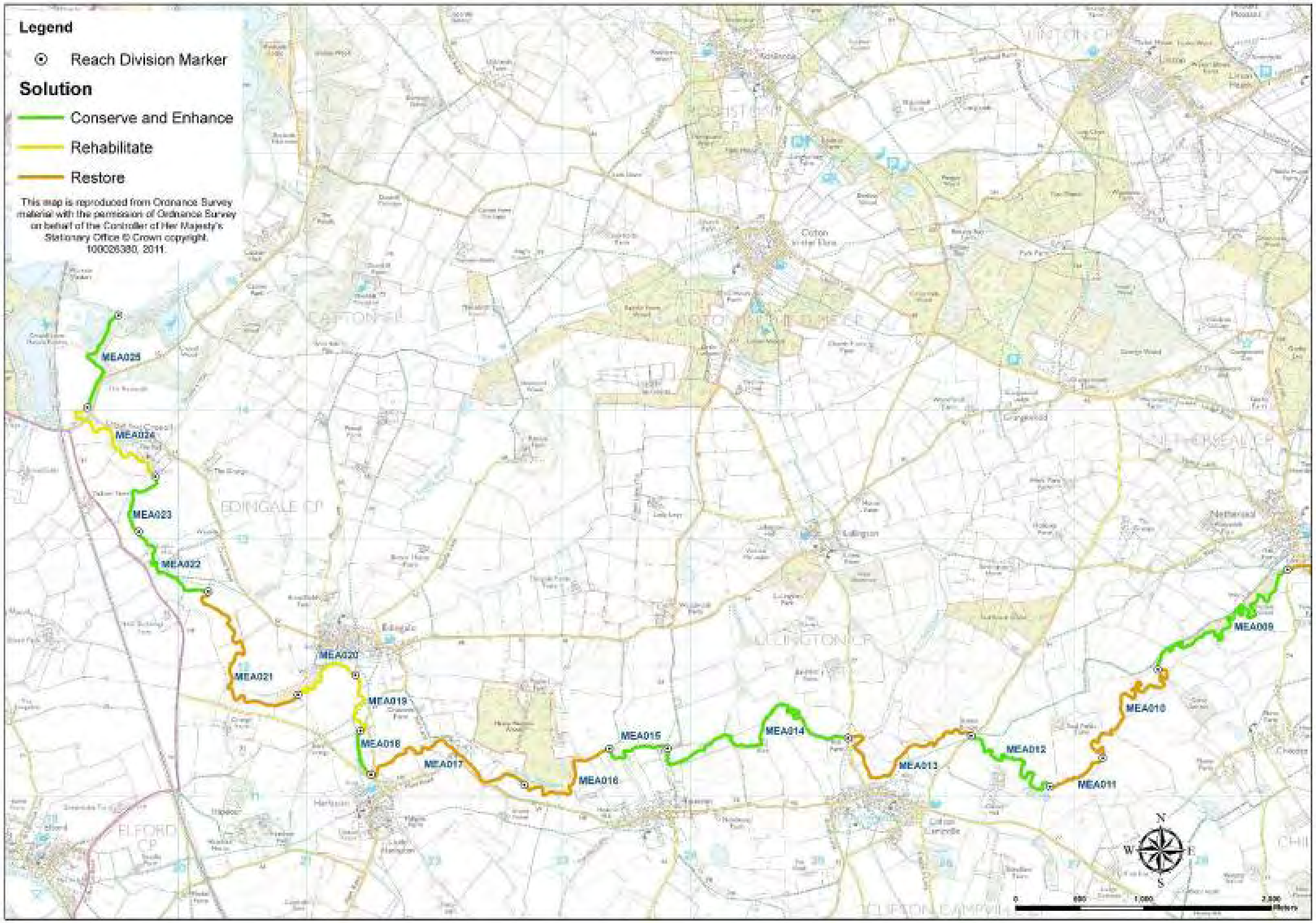
Appendix A Maps of river restoration category in each reach



JACOBS



Legend
Reach Division Marker
Solution
Conserve and Enhance
Rehabilitate
Restore
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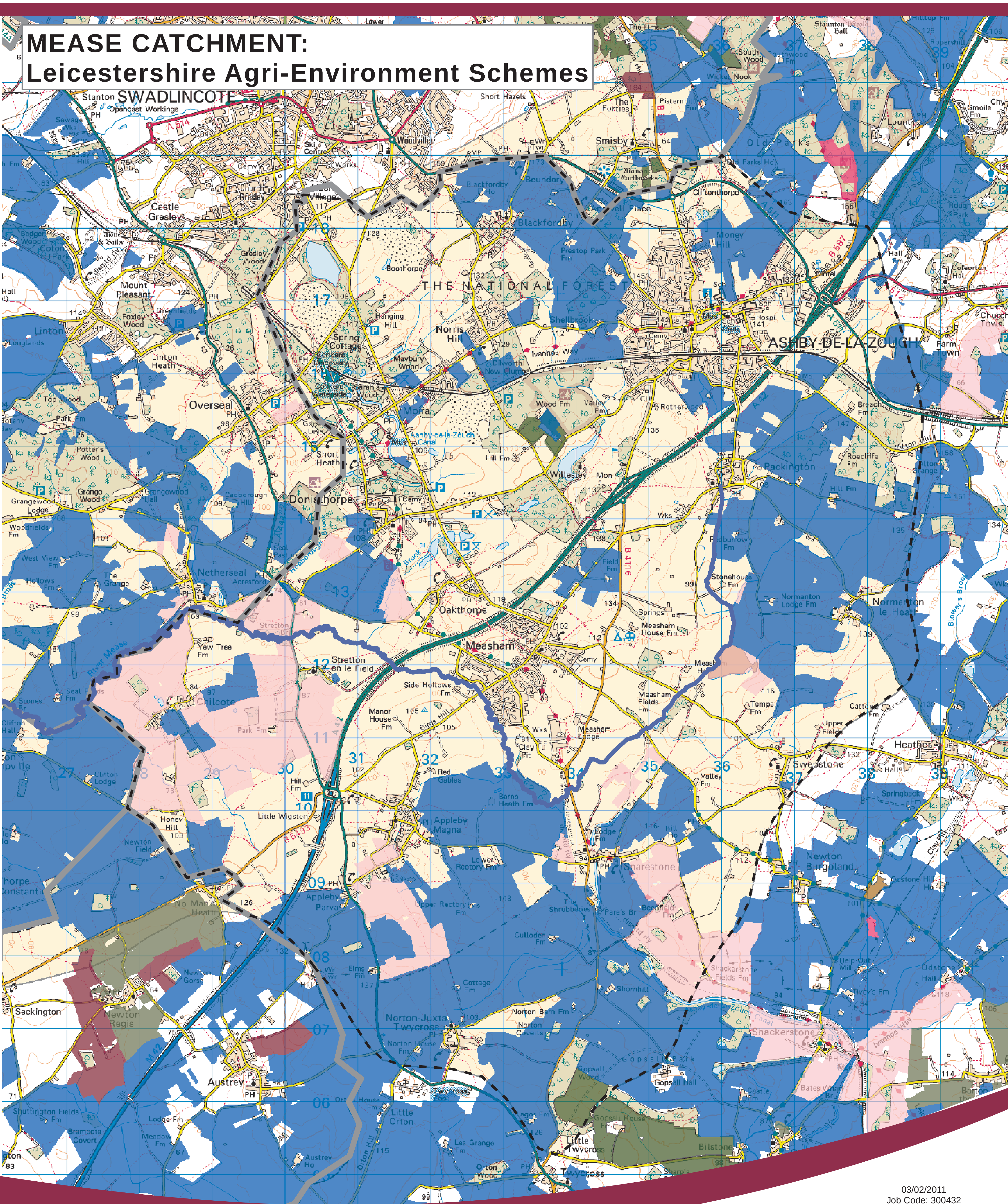
MEA025
MEA024
MEA023
MEA022
MEA021
MEA020
MEA019
MEA018
MEA017
MEA016
MEA015
MEA014
MEA013
MEA012
MEA011
MEA010
MEA009
EDINGALE CP
CLIFTON CAMPVILLE
Metres

Appendix B Agri-Environment Schemes in the catchment

MEASE CATCHMENT:
Leicestershire Agri-Environment Schemes



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Graham Murray

ES Scheme

- ELS
- ELS plus HLS
- HLS
- OELS
- OELS plus HLS
- CSS
- WES
- River Mease SAC
- Leicestershire Mease Catchment
- Mease Catchment
- CSS
- Counties

0 0.5 1 km

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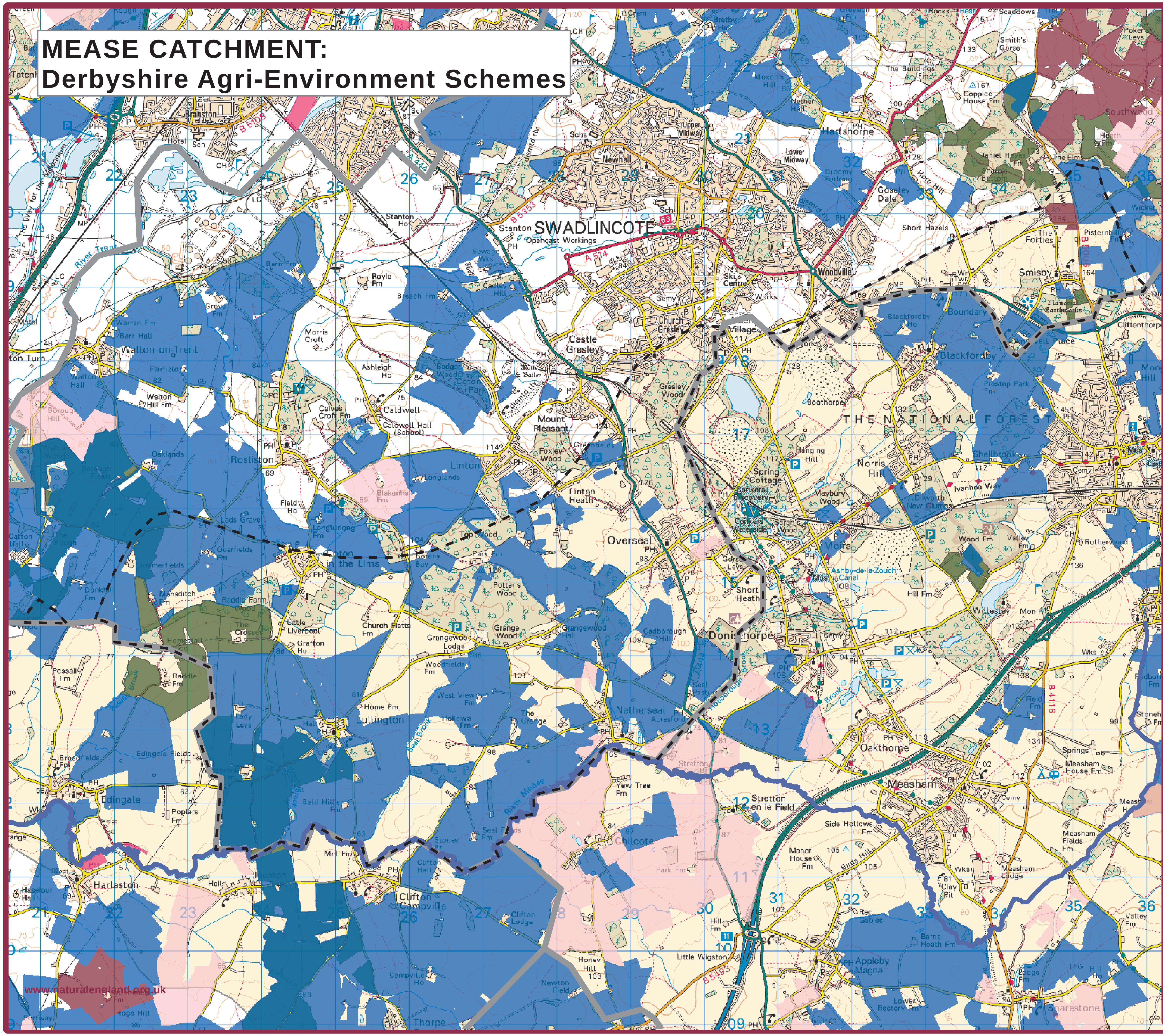
MEASE CATCHMENT:
Derbyshire Agri-Environment Schemes



ES Scheme
- ELS
- ELS plus HLS
- HLS
- OELS
- OELS plus HLS

CSS

WES

River Mease SAC

Derbyshire Mease Catchment

Mease Catchment

Counties

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0 0.5 1 km

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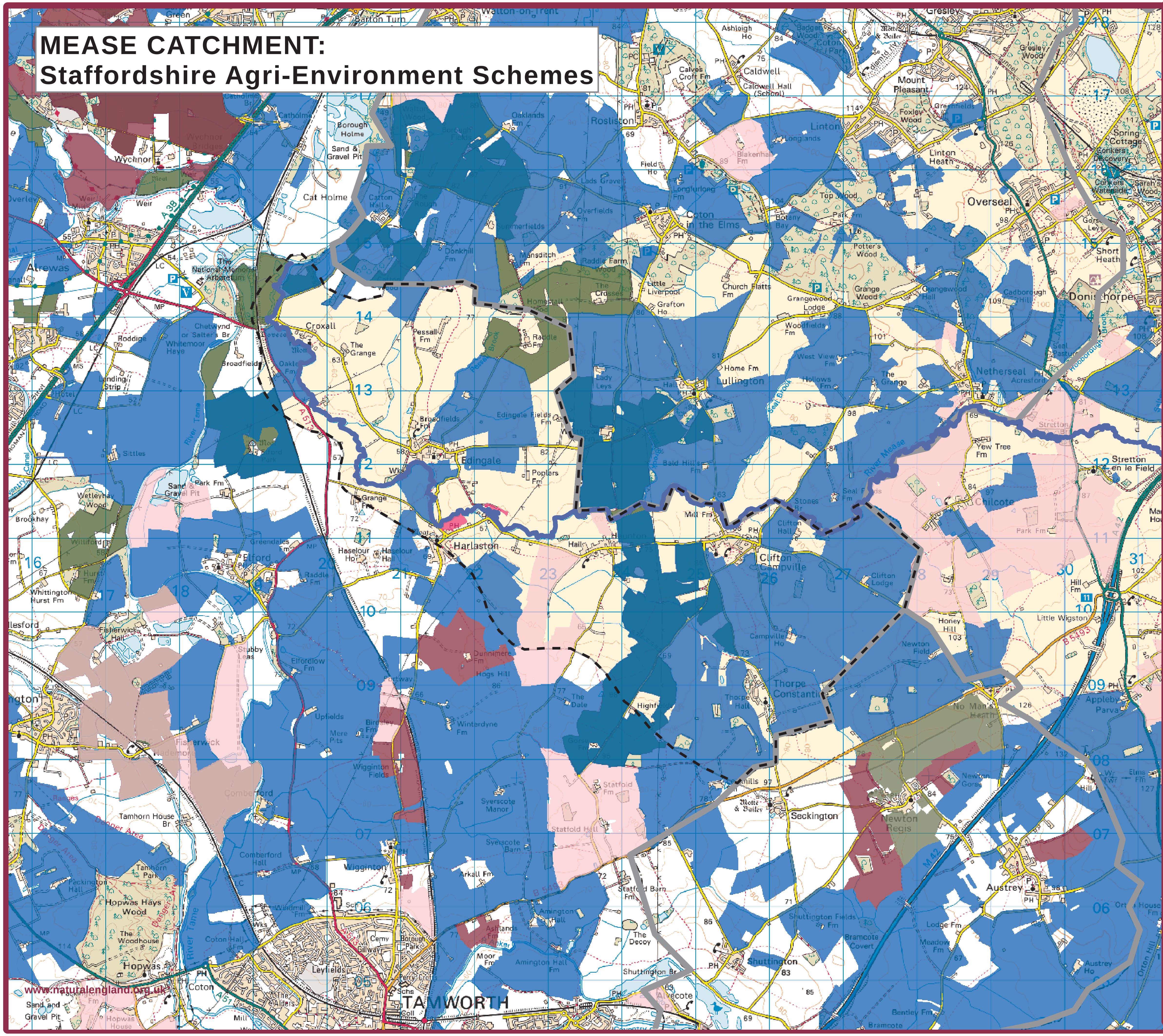
MEASE CATCHMENT:
Staffordshire Agri-Environment Schemes



ES Scheme

- ELS
- ELS plus HLS
- HLS
- OELS
- OELS plus HLS

CSS

WES

River Mease SAC

Staffordshire Mease Catchment

Mease Catchment

Counties

0 0.5 1 km

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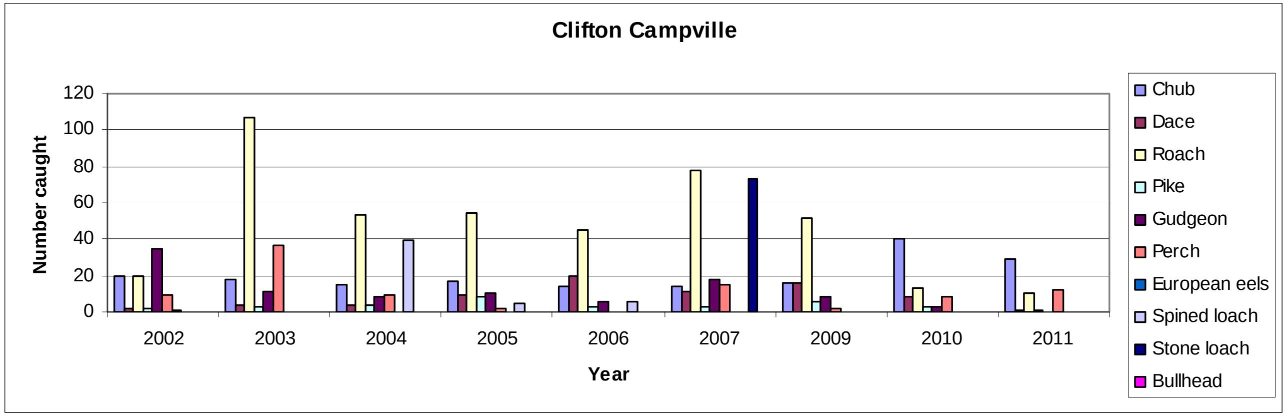
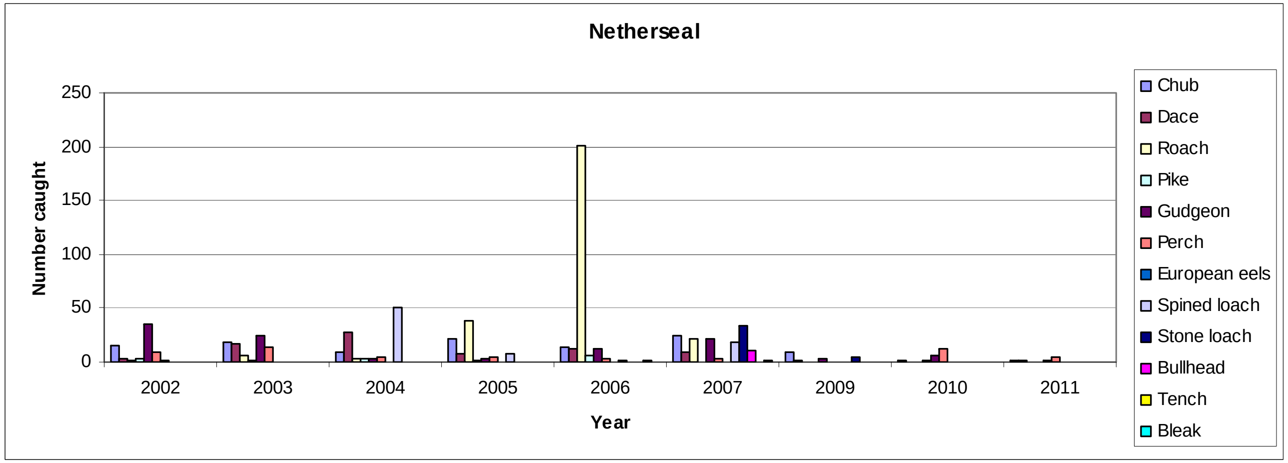
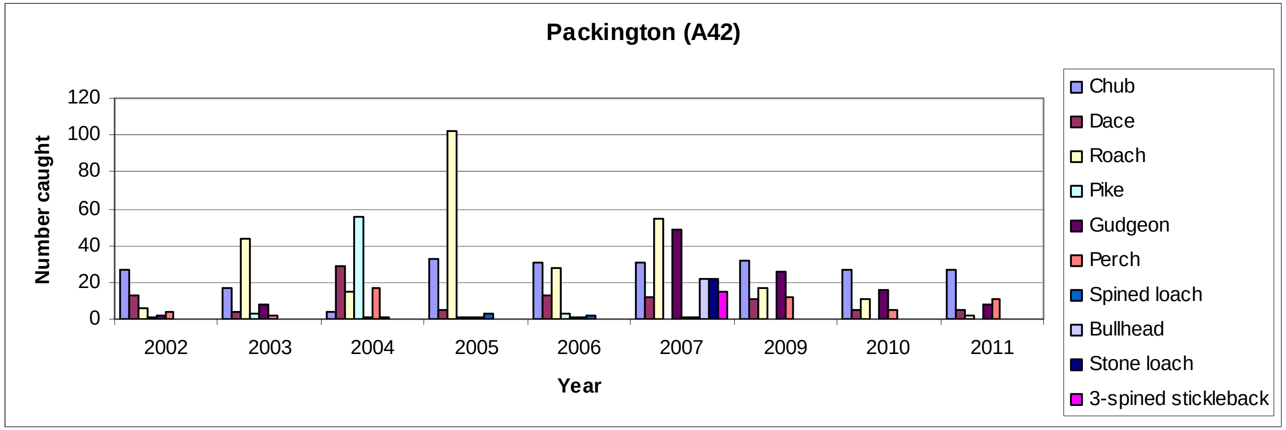
Appendix C Fish Survey Data

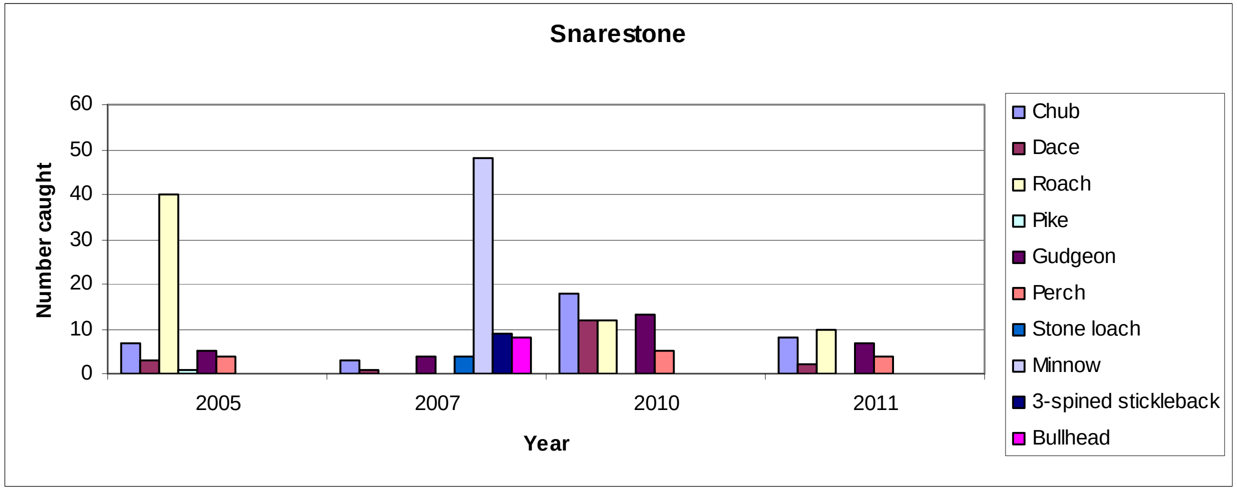
Fish survey data at sites on the River Mease, including Clifton Campville (Stones Bridge), Netherseal, Packington (upstream of A42) and on Gilwiskaw Brook including Snarestone (near confluence with the River Mease) and at Stone House Farm (Environment Agency)



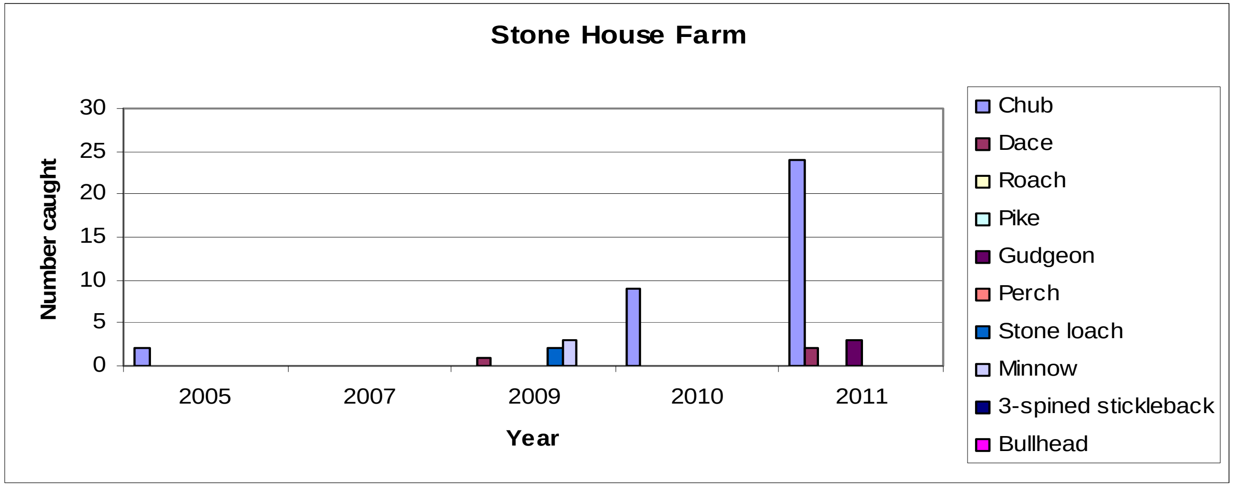




Packington (A42)
Number caught
120
100
80
60
40
20
0
2002
2003
2004
2005
2006
2007
2009
2010
2011
Year
Chub
Dace
Roach
Pike
Gudgeon
Perch
Spined loach
Bullhead
Stone loach
3-spined stickleback



Snarestone
Number caught
60
50
40
30
20
10
0
2005
2007
2010
2011
Year
Chub
Dace
Roach
Pike
Gudgeon
Perch
Stone loach
Minnow
3-spined stickleback
Bullhead



Stone House Farm
Number caught
30
25
20
15
10
5
0
2005
2007
2009
2010
2011
Year
Chub
Dace
Roach
Pike
Gudgeon
Perch
Stone loach
Minnow
3-spined stickleback
Bullhead