River Misbourne Appraisal

December 2023

Environment Agency

CHILTERNS CHALK STREAMS PROJECT

Affinity Water
Taking care of your water

Glossary of Terms

Abstraction – taking water from a natural source (rivers, groundwater aquifers) to provide water for homes, farms and industry. When referring to Affinity Water abstraction in the Misbourne catchment, this means taking water from the chalk aquifer for supply.

Alluvium – sediments deposited by rivers in the floodplain.

Aquatic plants – plants that grow in or near water.

Aquifer – a body of permeable rock which can contain or transmit groundwater.

BAP – (UK) Biodiversity Action Plan was published in 1994, and was the UK Government's response to the Convention on Biological Diversity (CBD), which the UK signed up to in 1992 in Rio de Janeiro. The CBD called for the development and enforcement of national strategies and associated action plans to identify, conserve and protect existing biological diversity, and to enhance it wherever possible.

CaBA – Catchment Based Approach is an inclusive, civil society-led initiative that works in partnership with government, local authorities, water companies, businesses and more, to maximise the natural value of our environment.

Catchment – the area of land that feeds rainwater to a river.

CCSP – Chilterns Chalk Streams Project.

Culverting - routing the river through a concrete pipe.

EA – The Environment Agency.

Ephemeral river – a river that drys out periodically.

Eutrophic – the excess accumulation of nutrients in a water body.

Geology - the bedrock and overlying deposits that are present in the catchment.

Groundwater – water in the chalk aquifer, which feeds the chalk stream.

Hydrology - the characterisation and quantification of the flow of water in the catchment as influenced by the catchment properties.

Hydrogeology – the characterisation and quantification of the flow of water in the groundwater catchment.

Perennial river – a river that has continuous flow of surface water throughout the year.

INNS - invasive non-native species.

Impoundment – the backing up / ponding of flow upstream of a weir or other impounding structure.

Lateral connectivity – the connection between the river, its riparian margins and the floodplain.

Longitudinal connectivity – the connectedness along the linear length of the river, interrupted by artificial structures and barriers to fish migration, such as weirs.

Macrophytes – aquatic plants / plants that grow in or near water.

Macroinvertebrates – small creatures such as snails, worms, crayfish, clams and insects in their nymph and larval stages.

Ml/d – megalitres per day. 1 Ml = 1 million litres. A standard measure of water volume for example as river flow or abstracted water.

Nofence collars – a product where the animals wear GPS-enabled collars and invisible boundaries can be defined through an app.

Planform – The shape of the river when viewed from above.

Riparian – the area that forms the transition from the aquatic area to the floodplain - often pictured as the top of the river bank.

WFD – Water Framework Directive.

Winterbourne – the ephemeral part of the chalk stream that routinely and naturally dries for a short period each summer.

River Misbourne | Appraisal

Contents

The River Misbourne is a chalk stream, an internationally rare and irreplaceable habitat. England is home to 85% of the world's chalk streams and they form an important element of our nation's natural heritage.

They provide habitat for a diverse group of wildlife from specialist invertebrates that thrive in the winterbournes, to water crowfoot and the brown trout that rely upon the good water quality found in chalk streams.

Summary

The River Misbourne

The River Misbourne is a chalk stream that rises from the chalk aquifer of the Chiltern Hills in Buckinghamshire.

The winterbourne source of the river is at Mobwell Pond at the northern edge of the village of Great Missenden. It then flows in a south easterly direction within a shallow, rural valley. It becomes more influenced by suburban settlements in its lower reaches, including Old Amersham, Chalfont St Giles, Chalfont St Peter, Gerrard's Cross, Higher Denham and Denham. It meets the River Colne approximately 0.5km to the north of Uxbridge, Greater London.

Unique Geology and Hydrology

The River Misbourne has a unique hydrogeology influenced by the differing permeability of the chalk bedrock layers. Between Amersham Old Town and Gerrards Cross Golf Course a change in the chalk geology results in the river losing water to the underlying bedrock (through water percolating through the river bed) before springs at Gerrards Cross once more return flow to the river.

Chalk streams naturally have seasonal flow patterns with headwater winterbourne sections that flow intermittently. However, the unique hydrogeology of the River Misbourne results an intermittently flowing middle reach and means that the river is particularly sensitive to historic and current pressures on water quality, hydrology and river habitat. Groundwater abstraction for public water supply has contributed to these pressures since 1900. However, abstraction reductions in the Misbourne catchment by Affinity Water, totaling 11 Ml/d were implemented between 1998 and 2018. With further reductions to take place by December 2024 to support increased flows and ecological health.

Historic Pressures

The habitat of the River Misbourne has been significantly influenced by a history of milling, fisheries, watercress production, and urban development.

These modifications prevent the natural processes that create a dynamic, biodiverse ecosystem and support the unique chalk stream species. Relieving these pressures on the River Misbourne will help to restore natural processes and the chalk stream ecosystem.

Environmental Protection

Chalk streams were originally identified in 1999 as priority habitat under the Biodiversity Action Plan (BAP), and were identified as threatened and requiring conservation action. They have been subsequently included as a Priority Habitat under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (England).

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 also provides protection for the water environment, setting an aim for waterbodies to achieve at least good ecological status or potential.

The River Misbourne is classified as having 'Poor Ecological Status' based on an assessment in 2022. The reasons for not achieving 'Good Ecological Status' are given as flow and physical modification (Environment Agency, 2023). These impact WFD classification elements relating to fish, the hydrological regime, macrophytes and phytobenthos assessed by the Environment Agency.

Scope and Objectives

The aim of the River Misbourne Appraisal is to appraise the river health, set out the key challenges on the river and provide a tool kit of measures that can be used to address these challenges.

This work supports the wider 'Mending the Misbourne' initiative which seeks to develop an evidence based, coordinated and integrated catchment plan for the River Misbourne. Development of the plan is in its early stages, and representatives of local community groups, conservation charities, town, parish and county councils, water companies and the Environment Agency undertook a workshop during December 2023 to discuss the priority issues impacting the catchment as part of the first stage in developing the catchment plan.

Next Steps

Building on the workshop undertaken to support the Mending the Misbourne Catchment Plan, and in coordination with the project partners, the next steps will be to identify opportunities to address the pressures identified in this document and restore the River Misbourne. Landowner support will be critical to achieve the stated aims to restore the river to its best possible state and achieve 'Good Ecological Status'.

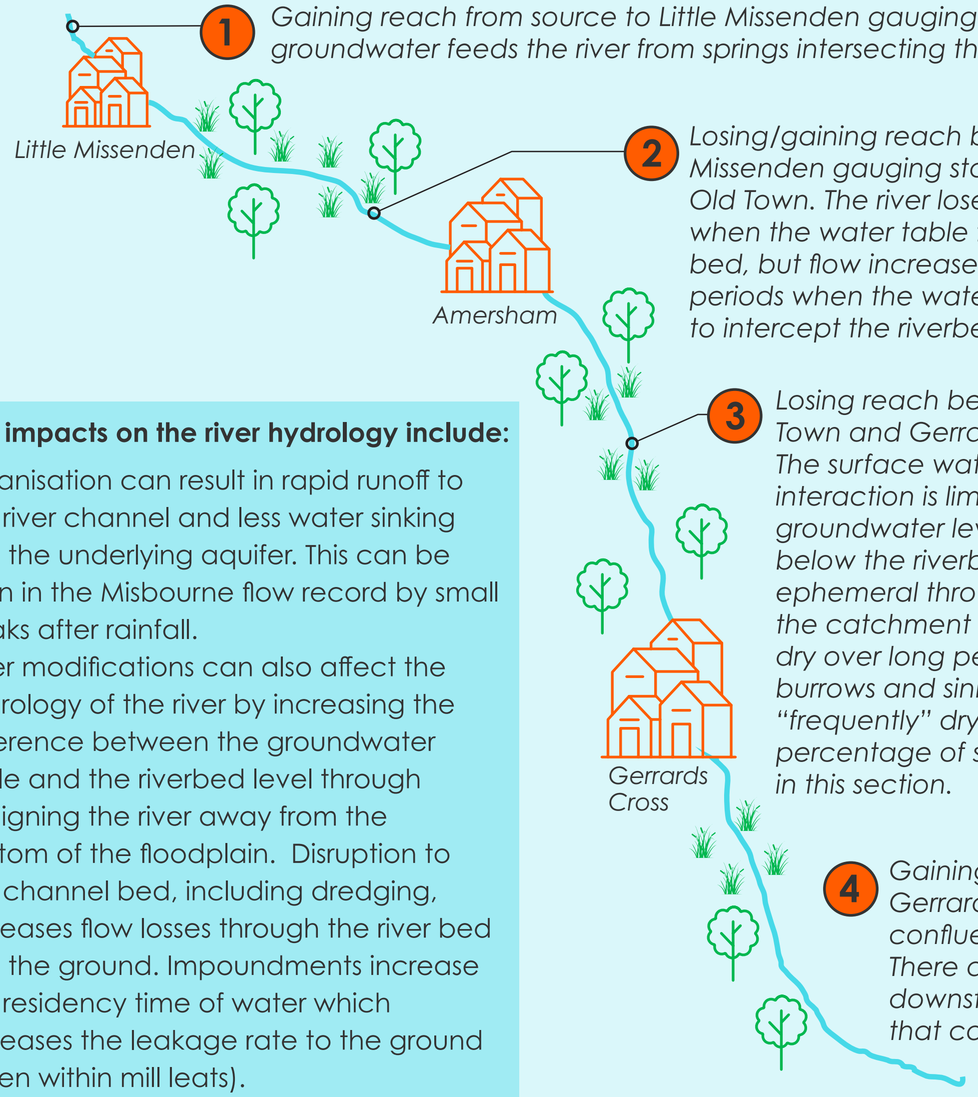
River Misbourne Hydrology and Hydrogeology

The River Misbourne is a chalk stream with a catchment area of 94 km². The hydrology is dominated by the underlying chalk geology. A large proportion of the rain falling on the catchment sinks into the ground and percolates through the rock to form the saturated zone of the chalk aquifer.

It can therefore take some time for groundwater levels to respond to rainfall. Typically, the groundwater level rises from December through to April. Generally, chalk stream flows are at their lowest in the early autumn.

The floodplain of the River Misbourne is underlain with alluvium deposits consisting of clay, silt, sand and gravel, overlying the chalk bedrock.

The chalk bedrock comprises different layers or formations with different permeability characteristics. Where these intersect the valley surface, they can have a significant effect on the flow in the river and therefore whether the river is ephemeral or perennial. In addition, the bedrock between Amersham and Chalfont St. Peter has been heavily eroded and disaggregated by the proto-Thames which flowed across the valley circa 450,000 years ago (Bailey, 2008). Due to these geological variations, the river can be divided into four reaches as shown below.



1. *Gaining reach from source to Little Missenden gauging station where groundwater feeds the river from springs intersecting the riverbed.*

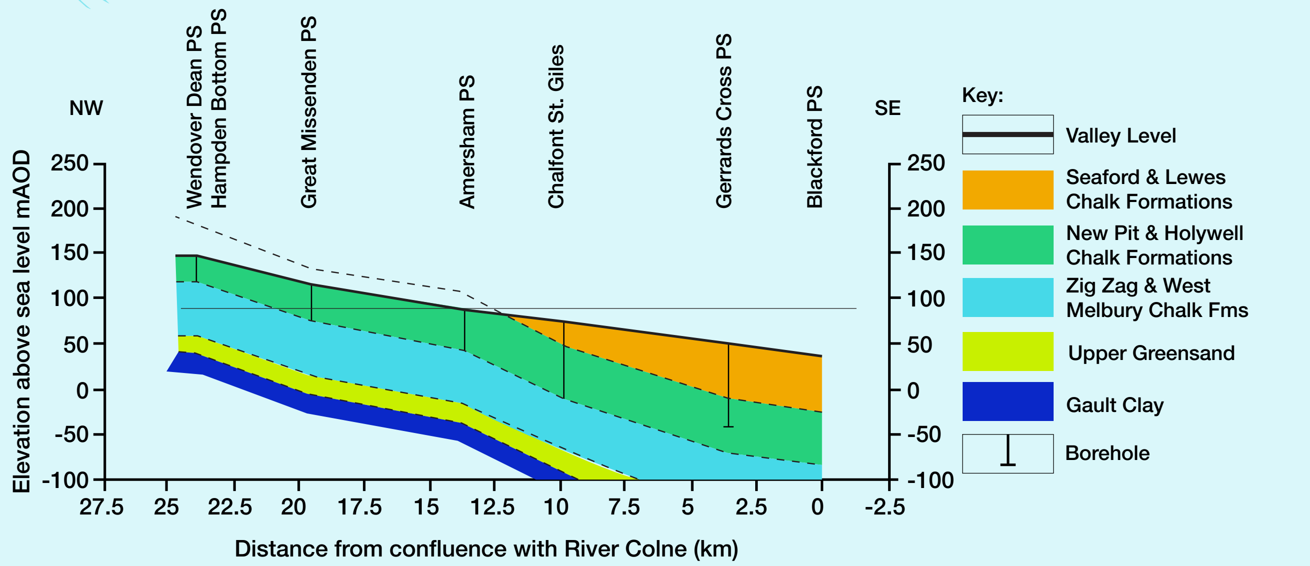
2. *Losing/gaining reach between Little Missenden gauging station and Amersham Old Town. The river loses flow in dry seasons, when the water table falls below the river bed, but flow increases during the wetter periods when the water table is high enough to intercept the riverbed.*

3. *Losing reach between Amersham Old Town and Gerrards Cross Golf Course. The surface water/groundwater interaction is limited because groundwater levels are consistently below the riverbed. River flows are ephemeral through this section of the catchment and the channel is dry over long periods of time. Animal burrows and sinkholes along this "frequently" dry riverbed increase the percentage of surface water leakage in this section.*

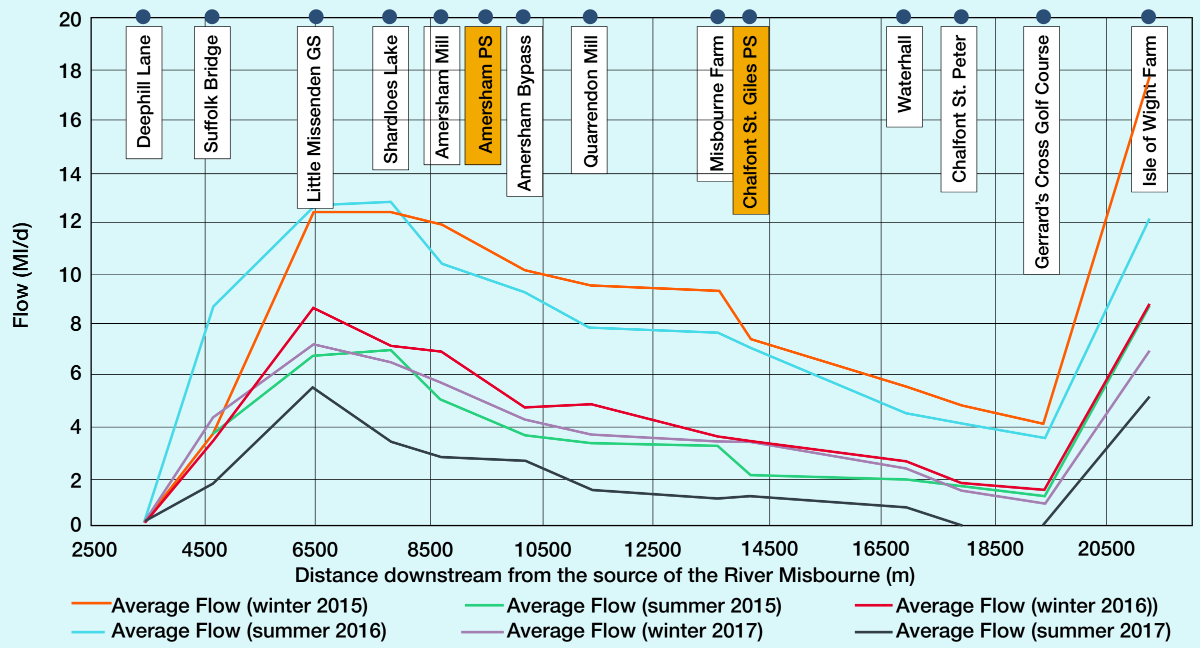
4. *Gaining reach downstream of Gerrards Cross Golf Course to the confluence with the River Colne. There are a number of springs downstream of Gerrards Cross that constantly feed the river.*

Other impacts on the river hydrology include:

- Urbanisation can result in rapid runoff to the river channel and less water sinking into the underlying aquifer. This can be seen in the Misbourne flow record by small peaks after rainfall.
- River modifications can also affect the hydrology of the river by increasing the difference between the groundwater table and the riverbed level through realigning the river away from the bottom of the floodplain. Disruption to the channel bed, including dredging, increases flow losses through the river bed into the ground. Impoundments increase the residency time of water which increases the leakage rate to the ground (often within mill leats).
- Groundwater abstraction locally lowers the water table and may delay the response of the river to rainfall.



Geological section along the Misbourne valley showing the different geological formations.



Note: The winter half-year (October 2016–March 2017) was particularly dry in southern England with below average rainfall which continued to affect groundwater levels during the summer 2017 despite persistent and heavy rainfall. Groundwater levels continued to decline until November 2017 resulting in notably low groundwater levels (Turner et al. 2021).

Flow in the river along the Misbourne valley as monitored during 2015-2017 showing flows increasing and decreasing.

Winterbournes

Chalk streams can dry quite naturally in their upper reaches when groundwater levels fall through the summer and into early autumn. Reaches that do this are called winterbournes and are ecologically important. The River Misbourne flows intermittently in the upper reaches, but also within the naturally losing middle reaches due to its geology. The middle reach functions in a similar way to headwater winterbournes, albeit exacerbated by human activity. Alongside abstraction reductions, restoring the river geomorphology and managing habitats sensitively within these reaches will help to support a high biodiversity and provide resilience to climate change (extreme changes in rainfall, flow, and temperature).

Natural winterbournes are dynamic habitats in which the shifts between wet and dry states support high biodiversity and communities of plants and invertebrates which are uniquely adapted to these conditions (CaBA, 2021).

Ecology, Heritage and Historic Changes

Designated Sites and Ecology

The River Misbourne is situated within the Chilterns National Landscape from Mobwell Pond in Great Missenden to Amersham Old Town and downstream of Amersham Old Town to Chalfont St Giles.

The River Misbourne qualifies as a habitat of principal importance under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (England) due to being a chalk river. Habitats of principle importance are identified as being of importance for biodiversity. They should be protected and enhanced, where local authorities and statutory bodies must have regard for and review actions it can take to conserve and enhance biodiversity.

Shardeloes Lake within the study area boundary is designated as a Local Wildlife Site for its standing open water and wetland birds. Between 2003 and 2011, the site supported wintering gadwall *(Anas strepera)*, green sandpiper *(Tringa ochropus)*, shoveler *(Anas clypeata)*, snipe *(Gallinago gallinago)*, teal *(Anas crecca)*, whooper swan *(Cygnus cygnus)* and wigeon *(Anas penelope)*.

The river is known to support a population of water vole *(Arvicola amphibius)* at the downstream end and also otter *(Lutra lutra)* where suitable habitat exists.

Shardeloes Lake

Shardeloes Lake is designated as a Local Wildlife Site for its standing open water and wetland birds.

Macroinvertebrates

Macroinvertebrate surveys can be used to provide information on the river health, particularly about whether there is sufficient flow, water quality and river habitat. Macroinvertebrate monitoring on the River Misbourne has been taking place since the 1990s. Currently there are 21 sites on the River Misbourne where surveys are carried out by the Environment Agency and Queen Mary University London on behalf of Affinity Water.

The results have shown that generally the macroinvertebrate communities are at 'Good Ecological Status', with the scores around or above the good threshold apart from during drought periods.

The majority of the monitoring sites are modified in some way and not natural, for example containing unnaturally steep banks, which has disconnected the river from the floodplain, and limited in-channel vegetation. Other sites are severely affected by grazing animals poaching the banks and eating the marginal vegetation. Results show that this has an impact on the abundance and diversity of the macroinvertebrate community across the River Misbourne and make the macroinvertebrate communities less resilient to low flows.

Macrophytes

Macrophyte surveys were conducted on an annual basis in summer at eight sites on the River Misbourne on behalf of Affinity Water. Results show that plant communities are negatively affected by low flows and their composition changes from aquatic species to wetland and terrestrial species during times of drought. This trend is not unique to the River Misbourne and is reflected in monitoring on other chalk streams although the rate of change on the River Misbourne appears to be faster.

At species level, the decline in abundance of the important water crowfoot (notably *Ranunculus penicillatus subsp. pseudofluitans)* has continued the negative trend identified regionally for the period 1992-2013. At the same time, wetland and terrestrial plants have increased substantially and have been steadily encroaching into the river channel.

While flow is still the most important variable, the results show that the most biodiverse communities have tended to occupy sites with low, gently sloping banks, some shade (30-50%), predominantly gravel/pebble substrates and a wide variety of flow types. The least biodiverse sites are those with deeply incised channels, a lack of shade and periods of intermittent flow.

Fish

Fish are not widely monitored on the river however surveys on the River Misbourne have found typical chalk stream species including brown trout *(Salmo trutta)* and bullhead *(Cottus gobio)*, with stone loach *(Barbatula barbatula)* and minnow *(Phoxinus phoxinus)* recorded downstream of Gerrad's Cross Golf Club. Lake species are also present associated with the online ponding of the river. For example rudd *(Scardinius erythrophthalmus)* have been found in surveys downstream of Shardeloes Lake.

Invasive Species

Invasive species are present on the river including Japanese knotweed *(Fallopia japonica)*, giant hogweed *(Heracleum mantegazzianum)*, orange balsam *(Impatiens capensis)* and signal crayfish *(Pacifastacus leniusculus)*. Invasive species negatively impact biodiversity in a number of ways by outcompeting native species through direct predation, monopolising resources, locally changing habitat conditions and taking over large areas. Invasive plants prevent the growth of native plants which aid bank stability in the winter when the invasive species die back.

Water Framework Directive Status

The River Misbourne is currently not meeting its target objective of 'Good Ecological Status' as defined under The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

Based on the latest 2022 assessment, the River Misbourne Water Body is classified as 'Poor Ecological Status'.

Reasons for not achieving 'Good Ecological Status' are attributed to flow, and the modified nature of the river including barriers to fish passage.

Heritage and Historic Changes

The effect of human settlement on the River Misbourne dates back to pre-Saxon times. The online Domesday record identifies that two mills were present in Amersham in 1086. The river and floodplain includes over 100 listed buildings, parks and structures. The effects of human settlement are strongly reflected in the form of the current river.

Classification item	2022 Classification Summary
Ecological	Poor
Biological quality elements	Poor
Fish	Poor
Invertebrates	High
Macrophytes and Phytobenthos Combined	Moderate
Macrophytes Sub Element	Moderate
Physico-chemical quality elements	High
Hydromorphological Supporting Elements	Supports good
Hydrological Regime	Does not support good
Specific pollutants	High

Misbourne Water Body Water Framework Directive Classification for 2022.

The River's Journey

Great Missenden to Little Missenden

The winterbourne source of the river is at Mobwell Pond at the northern edge of the village of Great Missenden. The river passes through grazed fields before flowing through a culvert under Buryfield Recreation Ground, and then above ground between residential properties.

The channel passes through the grounds of the Grade II listed Missenden Abbey, where weirs create the online features of Warren Water and Banks Pond. Downstream, the river flows through three more ponds in short succession. From Deep Mill the channel flows through disused watercress beds and into a further online pond at Suffolk Bridge. Upstream of Taylors Lane the channel becomes formalised as part of the landscaping within the Manor Lodge Estate before it passes under Taylors Lane.

Little Missenden to Amersham

Through Little Missenden residential properties and their grounds line the right bank with agricultural land also present. There are several historic channels present which are a legacy of the historic milling. The perennial source can be found at Mill End. From Mill End the channel is wide and straight associated with historic watercress beds and ornamental landscaping.

There is also a large weir at Mop End Lane which is an Environment Agency Flow Gauging Station. Downstream, the channel flows through wet woodland into Shardeloes Lake. The river then passes through the cricket ground, under a series of roads including the A413, as it approaches the outskirts of Old Amersham. A bathing place is noted on historic maps upstream of the Mill Lane.

Amersham to Chalfont St Giles

Through Amersham Old Town the channel follows the back of properties along High Street, through Town Mill, to Flint Barn Court.

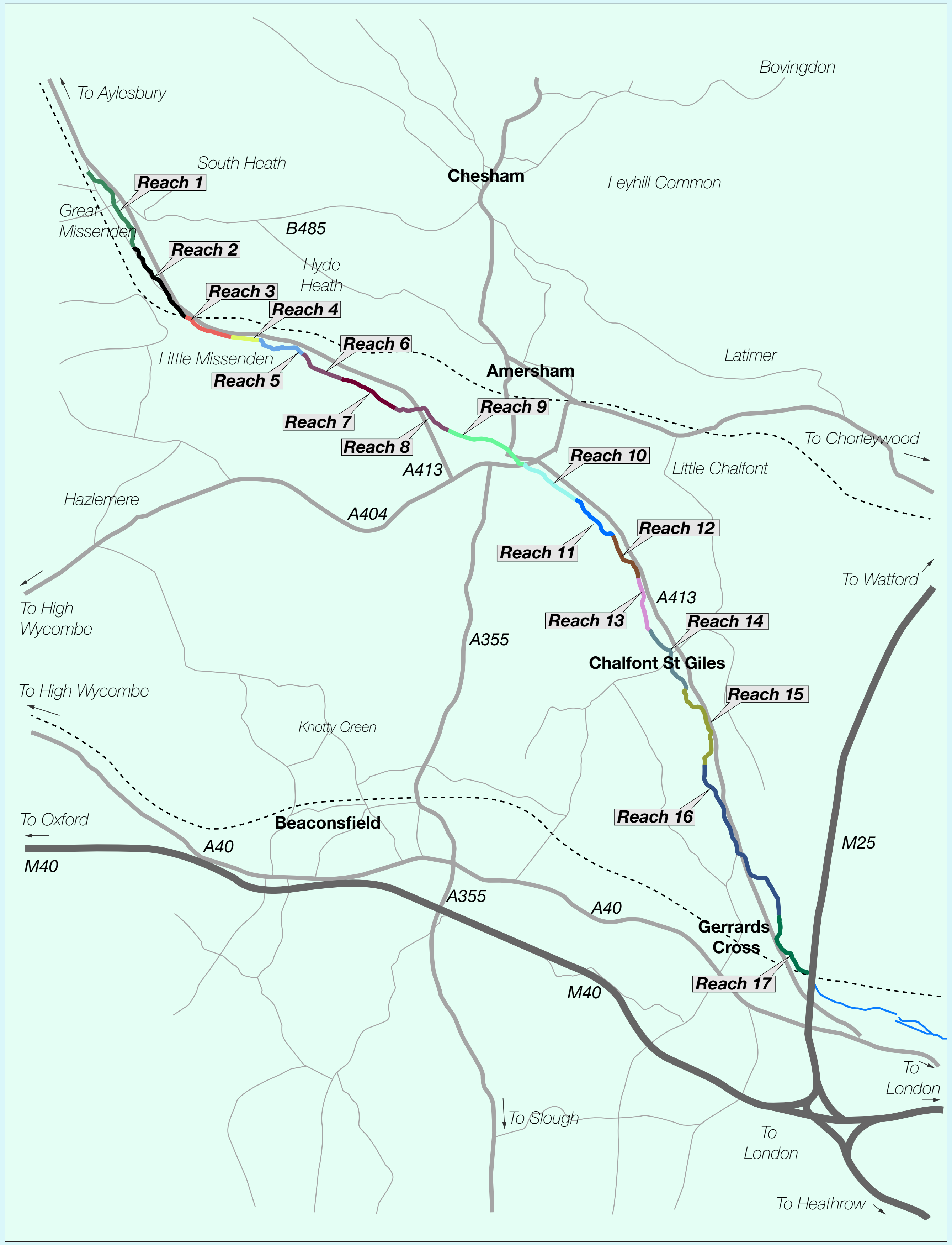
At Barn Meadows Affinity Water carried out enhancement works in 2023 to improve river habitat. From Flint Barn Court, the channel is culverted under several buildings and Church Street then travels through St Mary's Church grounds. Downstream of St Mary's Cemetery, where the right bank is flanked by the supermarket grounds, the channel is culverted under Ambers of Amersham (formerly Bury Mill) and the A355. From downstream of the A413 to Chalfont St Giles, the majority of the reach lies within agricultural land. Here, river restoration work by Affinity Water has been carried out to reconnect the river to its floodplain.

The channel then flows through agricultural land, passing Quarrendon Mill, and is culverted at several places including under Bottom House Farm Lane and the temporarily installed HS2 vent shaft access road. At Mill Lane the channel splits at Chalfont Mill, before flowing through pasture to the High Street at Chalfont St Giles.

Chalfont St Giles to Gerrards Cross

Downstream of the High Street village pond in Chalfont St Giles, the river flows around the edge of the suburban area of Chalfont St Giles before flowing for some distance through pasture with patches of woodland. Through Chalfont St Peter the river flows through suburban land and is culverted under major roads.

Downstream of the A413 roundabout, the channel passes the cricket club grounds and golf course. The channel then enters a short section of wet woodland which provides a glimpse of the river before the valley was deforested, before flowing into Chalfont Park Lake. Downstream the river flows through agricultural land towards the M25 culvert, which marks the end of the study area.



Study area map showing a breakdown of (colour coded) reaches along the River Misbourne.

What Does Good Look Like on the River Misbourne?

Chalk Stream History

Chalk stream valleys were carved by much more energetic forces than are present today, during multiple phases of glaciation which ended with the Pleistocene glaciation, 70,000 to 9,000 BC. Meltwater flows rushed south over semi-frozen chalk hills, carving out the distinctive chalk downland found in the Chilterns. When the glaciers finally retreated about 10,000 years ago, the open grassland of a frigid and chilly post-glacial climate will have made way for the early colonisers of pine, dogwood, juniper, then finally the oak, alder and willow of a deciduous and temperate wet woodland (CaBA, 2021). Fallen trees and beaver dams will have caused chalk streams to break out of their banks and find new pathways across the floodplain.

Untouched meandering chalk streams with broad and shallow, gravelly channels, flowing under and around fallen trees, in semi-drowned meadows are rare if not absent in Southern England. Possible evidence for multiple channels on the Misbourne can be seen in aerial derived ground surveys. The channel within the wet woodland upstream of Chalfont Park Lake may also provide a glimpse of a pre-deforestation natural state.

Studies (for example Sear, 2006) have shown that the following are key features of a natural chalk stream:

- Long duration of bank-full flows, supporting an open wet-woodland / herbaceous riparian zone.
- Low bank heights and relatively wide shallow channel.
- In-stream plant communities which are important in shaping complex dynamics of flow and scour.
- The presence of fallen trees which shape the mosaic of habitats in the river channel and floodplain.

Clearly it would be impossible to restore the Misbourne back to its pre-Neolithic, wild state. Restoration should therefore focus not on 'state' but on 'process'. In restoring process we let the river do most of the work, concentrating primarily on relieving the pressure of whatever it is that is inhibiting process. Flow and water quality, gradient and hydrological connectivity are all key to ecology. A healthy ecology then starts to shape its own physical habitat.

The Chalk Stream Strategy (CaBA, 2022) sets out the key principles for chalk stream restoration of natural processes:

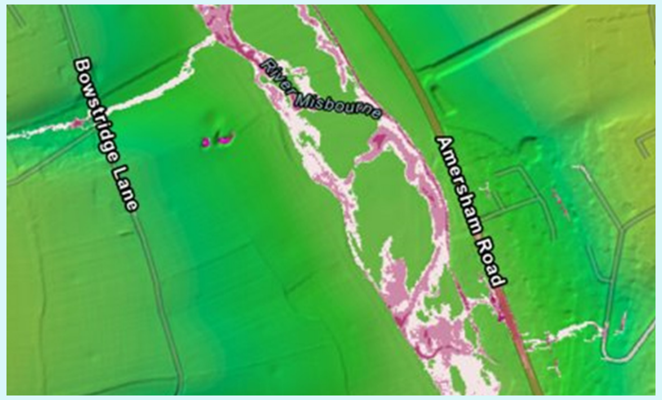
- The restoration of stream slope (longitudinal connectivity).
- The restoration of an intact gravel-bed (by returning gravel to the existing channel or by restoring, or reconstructing the original one).
- The restoration of a dynamic interaction with fallen trees and living riparian trees.
- The restoration of a dynamic interaction with the floodplain (lateral connectivity), and
- Through all the above, the restoration of the ecological processes and the habitat requirements of the ecosystem engineers (fish, invertebrates, mammals and plants).

These 5 principles provide a starting point for consideration of site restoration. Restoring high quality physical habitat to the chalk stream is fundamental to realising the full potential of any other improvements made in flow and water quality.

Scale is key. Even if projects are carried out on an opportunistic basis, they should contribute to an overall strategy to restore the river.

River Misbourne in the Future

Natural flow levels, clean water and good quality habitat are required to support a healthy chalk stream ecosystem. Climate change and increasing population are likely to impact these three key components of the River Misbourne. For example, the modified nature of the channel will limit the river's ability to adjust and respond to drought and flood events, particularly where the channel is less connected with the floodplain and water table. Increasing temperatures may lead to algal blooms in impounded sections and adversely impact temperature sensitive species such as brown trout, whilst population changes may increase pressures on water availability. It is for these reasons that an evidence based, coordinated and integrated catchment plan for the River Misbourne is needed which seeks to address the pressures facing the river now and in the future. The following section of the report focuses on identifying the pressures on river processes and habitats and provides a tool kit of measures to address these pressures.



Evidence of multiple floodplain channels from aerial survey and surface water flood mapping.

Example of the restoration of an intact gravel bed.

Problems and Solutions - Summary of key issues within each reach

Overview

Ecological monitoring suggests that the reasons for not achieving 'Good Ecological Status' is attributed to flow, and poor river habitat associated with river modifications. These issues are inter-related: for instance ecological indicators suggest that macrophyte communities in areas with poor river habitat are less drought tolerant.

Great Missenden to Little Missenden

- **Impounding structures** - artificial ponds and lakes within the reach.
- **Over-deep and over-wide** – modified channel cross-section, including past dredging.
- **Straightened planform**
- **Culverting -** through Buryfield Recreation Ground
- **Overshading** – in some sections.
- **Lack of shade-** no refuge/resilience to high temperatures.
- **Lack of riparian habitat-** no natural floodplain habitat to support in channel species foraging, breeding and migrating opportunities.
- **Disconnected floodplain** – in some sections.

Little Missenden to Amersham

- **Impounding structures –** holding back water to form Shardeloes Lake, and ponding smaller sections upstream.
- **Weirs and sluices** – throughout reach.
- **Bank modification** – embankments, bank protection, re-profiled banks.
- **Over-deep and over-wide** - modified channel cross-section, including past dredging.
- **Channel realignment** – modifications from historic milling, including straightening.
- **Lack of shade-** no refuge/resilience to high temperatures.
- **Lack of riparian habitat-** no natural floodplain habitat to support in channel species foraging, breeding and migrating opportunities.
- **Disconnected floodplain**
- **Invasive species**

Amersham to Chalfont St Giles

- **Channel realignment** – modifications from historic milling.
- **Bank modification** – artificial banks throughout Amersham, embankments, bank protection.
- **Weirs and sluices** – throughout reach.
- **Past dredging**
- **Lack of shade-** no refuge/resilience to high temperatures.
- **Lack of riparian habitat-** no natural floodplain habitat to support in channel species foraging, breeding and migrating opportunities.
- **Disconnected floodplain**
- **Culverting -** underneath roads and buildings in Old Amersham.
- **Perched channel and flow loss**

Chalfont St Giles to Gerrards Cross

- **Channel realignment**
- **Disconnected floodplain**
- **Bank modification** – embankments, bank protection.
- **Over-deep and over-wide** – modified channel cross-section.
- **Weirs** – impoundment for Chalfont Park Lake.
- **Lack of shade-** no refuge/resilience to high temperatures.
- **Lack of riparian habitat-** no natural floodplain habitat to support in channel species foraging, breeding and migrating opportunities.
- **Invasive species**

Weirs and Online Ponds

Weirs and online ponds are widespread on the River Misbourne associated with historic milling and the creation of landscape features. They have a large negative impact on chalk stream processes and ecology specifically:

- Slowing the flow, reducing stream energy and increasing depth of flow, promoting deposition of silt on the gravels and reducing light to the bed.
- Increasing the residence time of water in impounded channels: this drives up water temperature and nutrient levels through the accumulation of sediments, leading to more eutrophic conditions. Increased leakage to the ground may also occur.
- The impoundment structure interrupts the passage of migratory fish like brown trout and eel and prevents recolonisation of coarse fish following extreme drought events.
- Altering the balance of the plant community: some of the key chalk stream macrophytes need swift flows to grow.
- Altering the balance of fish and invertebrate communities: many key chalk stream invertebrates and fish species thrive in cool, swift, well oxygenated water. Impounded channels accumulate sediment and favour a limited range of plants and invertebrates. A naturally flowing chalk stream is far more bio-diverse than an impounded chalk stream.
- Online ponds act as sediment traps and are unsustainable requiring repeated dredging and silt disposal to maintain their appearance.

Restoration Actions: Structure Removal

Removing weirs and restoring the natural river bed gradient restores a key driver to natural ecological process. Due to the low gradient of chalk streams, such weir removal can be the most effective tool in restoring very large lengths of river.

Removing the structure and locally regrading the natural gravel bed will restore the natural channel gradient allowing silt to be scoured from the gravels and water depths to be returned to a natural range.

Where there has been an online pond, removing a structure will expose the accumulated silt upstream of the impoundment which is subject to rapid erosion and can pollute downstream waterbodies. It therefore requires careful management. Silt tends to rapidly vegetate up with wetland vegetation, closely followed by willow and alder.

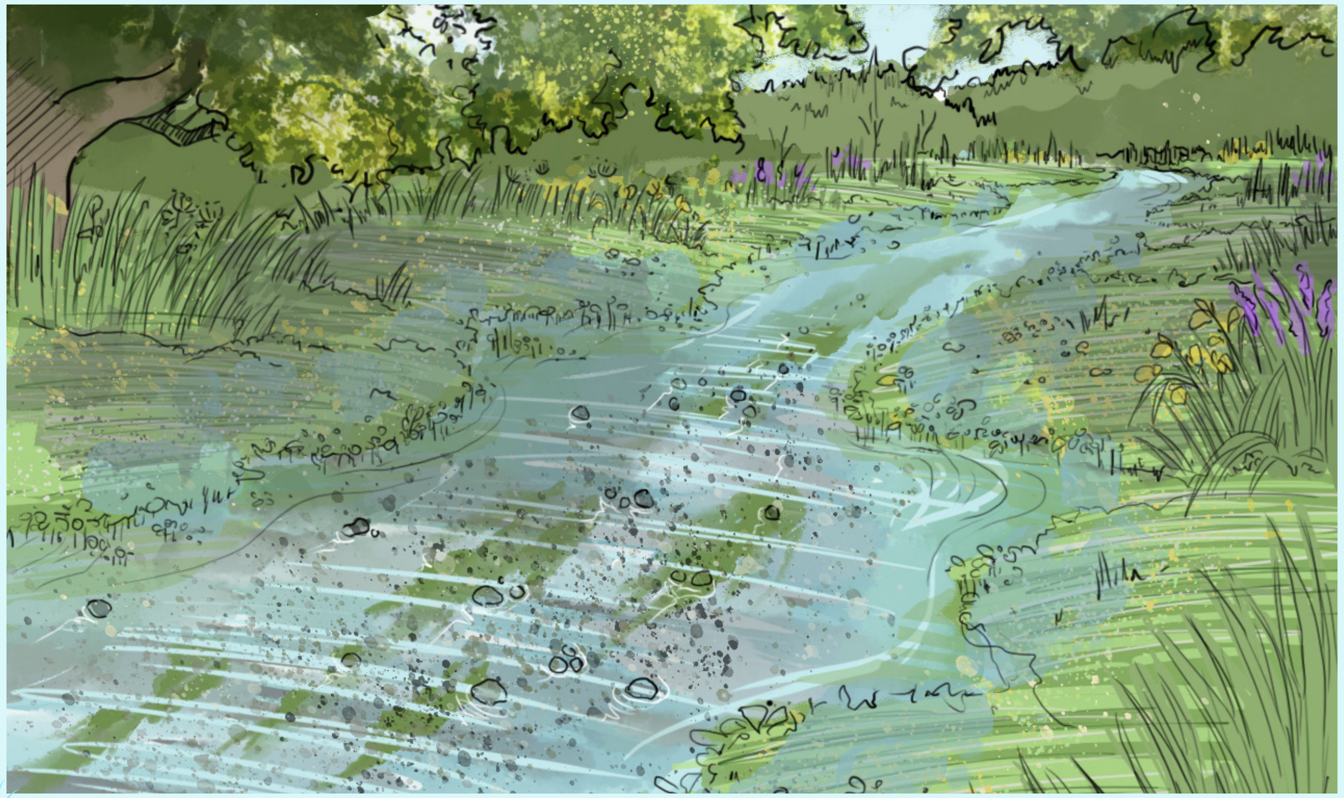
Different management approaches can be taken to this silt. It can be removed or stabilised through either a gradual lowering of the water levels, allowing vegetation to establish over the silt, locking it in place. Alternatively soft engineering techniques can be used to create a formal edge to the river to hold back the silt allowing the weir to be removed in one go.

It should be noted that online ponds may have an intrinsic habitat value, and the benefit of any restoration action needs to be carefully assessed against the value of the lake. For example Shardeloes lake is known to provide a refuge for fish and other species during drought periods, provide overwintering habitat for wildfowl, and also support the largest area of wet woodland carr to be found anywhere in the Chilterns.

Restoration Actions: River Channel Bypassing

An alternative action, where it is desirable to retain the standing waterbody, is to separate the river from the pond or lake. This solution can provide the additional benefit of reducing the fine sediment which enters the lake. Problems can be encountered restoring a natural gradient as the original channel would often have flowed where the pond or lake lies.

Online pond caused by the weir in the foreground.



Visualisation of a restored channel through a pond or lake once the weir is removed.

Canalisation and Connectivity

Chalk streams have a naturally shallow dish-like channel shape, which creates a gradual transition from water to dry land through a wetted margin blurring the boundary between the river and floodplain. Due to the low gentle banks and high density of vegetation growth, chalk stream water levels are naturally near to the top of the bank. The river will therefore routinely spill over its banks into the floodplain wetting up multiple channels, supporting a range of wetland environments which are a haven for wildlife.

Canalisation is the straightening and deepening of the channel and movement of the channel away from its natural position at the bottom of the floodplain. These modifications are commonplace throughout the River Misbourne associated with historic milling, land drainage activities, agricultural productivity improvements and development within the floodplain.

The canalisation results in:

- Removal of river bed gravels, meander bends, pools and riffles that are key to supporting the macrophyte and macroinvertebrate communities and providing resilience during times of drought.
- Removal of marginal vegetation and gentle banks that slope gradually from river to meadow which support a high diversity of wetland plant species, replaced by a steep bank on which little can grow.
- Lowering of the water table, disconnecting the river from the floodplain. The canalisation reduces water levels due to the increased channel size and gradient.
- Where the river is moved to the edge of the floodplain the base of the river can become disconnected from the underlying water table.

Restoration Actions

Where land use allows, restoring the channel to its original course provides the most effective means for restoring the natural channel position in the floodplain and restoring the natural channel bed and bank profiles. Old maps with parish boundaries often show the original course of the river, and aerial topographic data sets routinely collected by the Environment Agency provide historic evidence of where the old channels lie. Often soil auguring can be used to show the old channel position through detection of the gravel layer.

There are however some specific risks and constraints. Often major utilities such as sewer pipes follow the river corridor and can limit the full restoration of the channel. A key risk which is relatively unique to the River Misbourne is associated with the naturally low water table downstream of Amersham where the river will lose water over its length for much of the time to the underlying water table. Careful design is therefore needed to ensure that the bed of the river does not increase the amount of flow lost to groundwater.

Rewilding and Stage Zero

Rewilding the river landscape provides the greatest opportunities for restoring the river. A hands off approach to managing the floodplain paired with rewetting the floodplain and allowing the stream to decide on its natural course is being trialled at multiple locations around the UK. An approach called 'stage zero' has been developed which infills the straight, canalised channel and allows the river to spill out into the floodplain and inundate the historic channels and wetlands. Typically this is paired with tree planting to kickstart the development of wet woodland.

River Misbourne | Appraisal

Straightened, over deep channel with steep banks. The channel is disconnected from the floodplain.

Restoration work near Quarrendon Mill. The channel has been restored back to the valley bottom. Note wide channel and shallow banks.

Enhancing Disconnected Channels

Historically dredging was widespread on chalk streams and caused huge ecological damage by removing gravel, river plants and animals, and disconnecting the river from the floodplain. Typically dredged material was placed on the bank top, forming embankments that further disconnected river from floodplain.

Dredging however is unsustainable and often ineffective. Dredging in rural areas may locally increase channel capacity but at the expense of increasing flood risk downstream. In urban environments where culverts and weirs back up the water during high flows, dredging does not increase channel capacity or reduce flood risk.

Reversing the impacts of dredging, particularly in urban environments can drive considerable improvements to the channel habitat and ecology and allow restoration of some natural processes. It can also be achieved through relatively simple low cost measures as demonstrated on the Misbourne at Barn Meadows.

Addition of gravel: Where the channel is over deep and the river gravels have been removed, bed raising can be implemented through the addition of locally sourced river gravels to the channel. These gravels tend to become naturally sorted by the river into bars, pools and riffles helping to restore the resilience of the river to low flows.

Reinstatement of gentle river margin:
Where the channel is overwide, and banks over steep, gentle river margins known as berms can be reintroduced by reprofiling the banks to slacken their gradient. The bank material is pushed into the channel margins with bundles of brushwood staked in and used as edging to prevent soil washing into the river.

These created berms narrow the river and provide wetted margins for wetland plants to establish. They can also provide food and habitat for species such as water vole.

Removal of hard bank protection: Concrete bank protection removes a key part of the chalk stream ecosystem, the river margin. Not only does it remove the wetland transition that supports the high diversity of wetland plant species, but it also removes the habitats relied upon by bank inhabiting animals such as otter, water vole and kingfisher *(Alcedo atthi)*. Long stretches of bank reinforcement can be a significant barrier to water vole colonisation.

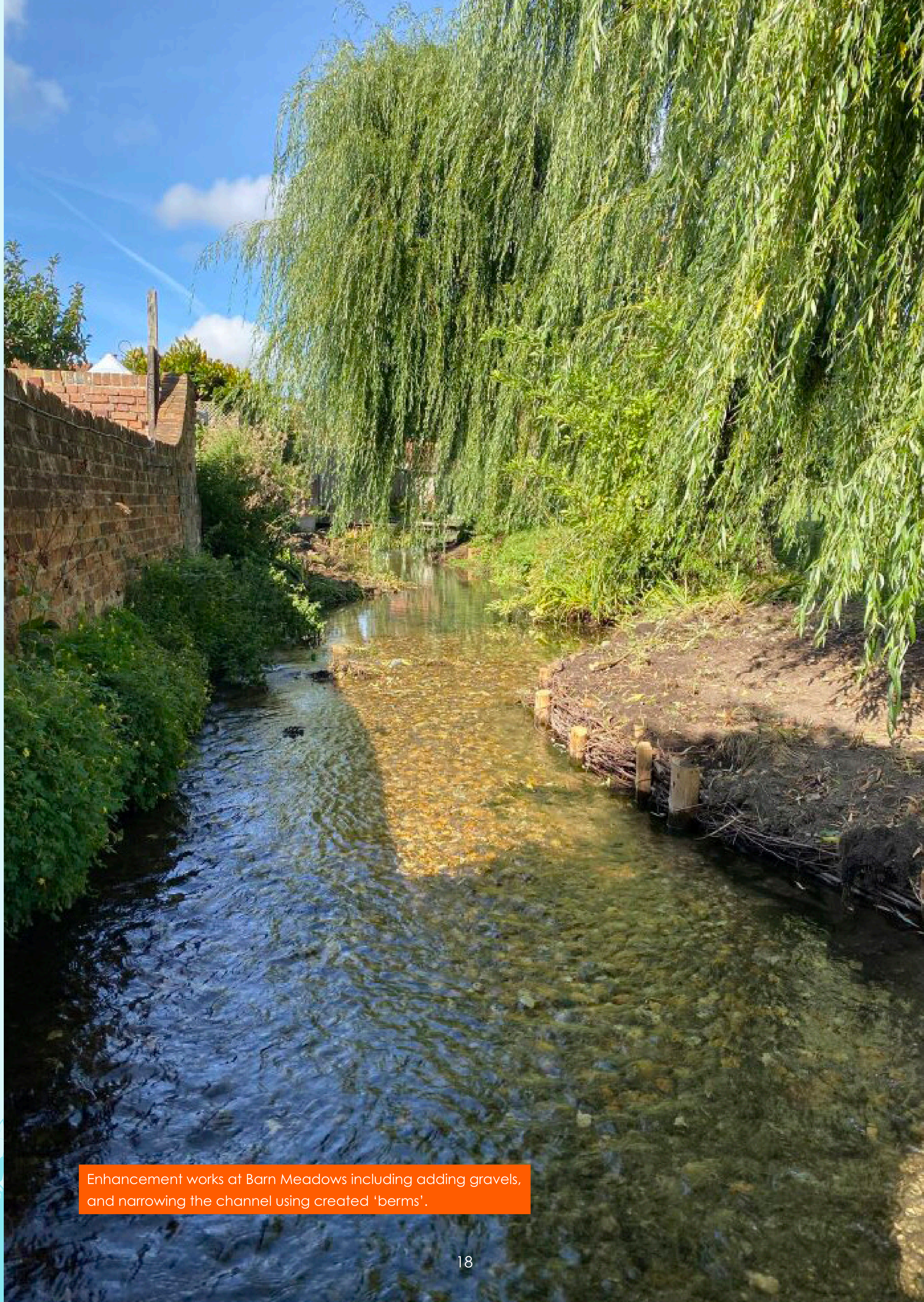
Chalk streams are low energy environments and generally do not erode their banks to any degree unless the energy is artificially increased, such as downstream of a weir. Bank protection from channel erosion is rarely needed unless used to support development that has extended up to the bank edge.

Hard engineered bank protection can often be removed. Where over steep, bank reprofiling as described above would be required.

Where hard revetments cannot be removed, marginal shelves can still be installed in front of hard banks to soften their appearance and provide valuable habitat.

Flood Risk

The techniques described here typically interact at low flows and have a minimal impact on flood levels. However any works would require a Flood Risk Activity Permit which is granted by the Environment Agency. In flood risk sensitive areas, such a permit would be supported by computational hydraulic modelling to determine whether the proposals have an impact on flood risk to property. Works that increase flood risk would not be approved.



Enhancement works at Barn Meadows including adding gravels, and narrowing the channel using created 'berms'.

Trees and Chalk Streams

Trees provide a complex variety of habitats for chalk stream species to thrive.

Natural tree fall into chalk streams creates food for invertebrates, places for fish to seek shelter and generates patches of faster flowing water that scours the silt from the river bed gravels and also patches of slower flowing water where silt can deposit and vegetation establish. Tree fall therefore drives variations in habitats for plants, fish and invertebrates and is a significant component of the biodiversity value of a chalk stream. Fallen trees will also improve floodplain connectivity, promoting overbank flow, and wetting of floodplain wetland habitats. Unfortunately for this reason, tree fall is often removed from the river, even in places where there are no properties at risk of flooding.

The shade trees provide is also important for controlling river temperatures. Riparian shade has been shown to lower river temperatures. In small rivers shade from trees can reduce temperatures by 2-4°C on average (compared to unshaded streams). Adequate shade will therefore become an important climate change adaptation measure.

Tree shade also plays an important role in macrophyte diversity with patches of shade allowing different shade tolerant macrophyte species to thrive. However overshading can prevent growth of vegetation along the river margin or within the stream. It is likely that beavers will have once played an intrinsic role in thinning the tree canopy and creating a mosaic of patches of daylight and shade, however this role must now be carried out by the riparian owner. Conversely, as part of historic land drainage and agricultural improvement schemes, many of the riparian trees along the River Misbourne have been removed leaving bare banks with closely grazed improved grassland lacking the diversity of riparian vegetation and increasing river temperatures.

Vegetation management

There is a need to manage river channel vegetation to produce a diverse riparian corridor which provides habitat and food sources for birds, mammals and invertebrates whilst restoring the dynamic interaction between trees and the river.

Where trees are present but overshading is identified, an effective restoration measure is to selectively thin the tree canopy to create a mosaic of tree cover producing dappled shade that covers around 50% of a reach. Techniques such as tree hinging mimic the natural tree fall by felling and pinning the trees in the river creating both patches of light and shade, and providing the benefits of producing food for invertebrates, shelter for fish and the variation in flow velocities across the channel.

Where trees have been removed and the bank top is closely grazed, livestock management may be required to allow the riparian vegetation to naturally recover. This may include tree planting and fencing off a buffer zone either side of the river. Fencing is not in itself a perfect solution as over time, the natural succession will require active management.

However, the provision of gates in riverside fence lines can be used to allow grazing animals access to the bankside vegetation to ensure it is managed appropriately.

Tree hinging, providing a mosaic of shade and daylight.

Invasive Species

A number of invasive, non-native species (INNS) are present on the River Misbourne, most notably – because of the damage they do – Japanese knotweed, Himalayan balsam *(Impatiens glandulifera)*, giant hogweed and signal crayfish.

Japanese knotweed has extensive, deep rhizomes and can spread from the smallest cutting. It is very challenging to control. Along with Himalayam balsam it forms dense, tall clumps which swamp out other plants, reducing riparian macrophyte diversity and is a rapid coloniser of bare banks.

Signal crayfish out compete and spread crayfish plague to our native white-clawed crayfish *(Austropotamobius pallipes)* which are now extinct on the River Misbourne. Signal crayfish will eat juvenile fish, invertebrates, amphibians and plants. They also burrow into soft riverbanks which causes the riverbank to collapse and the stream to progressively widen. As more and more sediment is released into a widening channel the macrophyte and invertebrate communities spiral downhill.

Control

Misbourne River Action routinely run 'balsam bashes' to hand pull Himalayan balsam. Chilterns Chalk Streams Project (CCSP) are trained to treat giant hogweed and Japanese knotweed, the latter by stem injecting pesticides (to prevent spread).

Signal crayfish are extremely difficult to control once established. They thrive in canalised sections of rivers and online ponds (such as Shardeloes Lake where they are found). They are less prevalent where there are gently sloping margins. Intensive trapping efforts and river restoration currently provides the greatest hope for controlling the spread of this species.

Signal crayfish

Himalayan balsam

Next Steps

Conclusions

This document presents the findings of a project to collate an understanding of the current condition of the River Misbourne, and map out the key challenges facing the river now and in the future with climate change. It is intended as a resource for engaging with landowners, residents, interest groups, parish councils and local authorities. It should also act as a focal point for a coordinated effort by delivery partners to restore and enhance the River Misbourne.

There is a mixed picture in regard to the river health in the River Misbourne catchment. Much has been done to reduce abstraction in the catchment since 1997 and efforts to reduce abstraction are ongoing. Furthermore, the WFD assessment results show that macroinvertebrate populations are in places thriving and water voles are returning to the lower catchment.

The work has however highlighted significant challenges which are likely to be made worse by climate change. Invasive species also represent a significant threat for the future. The key challenges to restoring the river processes and habitat have been mapped out in the next section of this report. This also includes a summary of work done to date to improve the river.

Timescales for restoration

The techniques set out in this report provide a tool kit of measures that can be used to address these challenges however a strategic plan is now needed. A catchment-wide plan (Mending the River Misbourne) is currently in the early stages of development and involves the key River Misbourne stakeholders. Landowner support will be critical to achieve the stated aims to restore the river to its best possible state and achieve 'Good Ecological Status'.

The project partners (CCSP, EA and AW) have been working for many years in the catchment, delivering river improvements with partners including the Berks, Bucks and Oxon Wildlife Trust and Misbourne River Action. CCSP and the Environment Agency have a number of projects that they are investigating with land owners for delivery within the near future. Affinity Water under the Water Industry National Environment Programme have committed to continuing their investment in The River Misbourne over the next Asset Management Plan cycle (2025-2030) and will be exploring with landowners opportunities to address the challenges outlined in this document over this period.

If you are interested in finding out more about the information presented here, or would like to investigate opportunities for river restoration on your land, Please email river.restoration@affinitywater.co.uk

Key references

Affinity Water (2021). Quarrendon Mill Re-meandering Project. Available at: https://www.affinitywater.co.uk/sustainability/restoration/river-misbourne-restoration [Accessed 12/10/2023].

Catchment Based Approach (2021). Catchment Based Approach - Chalk Stream Strategy. Available at: https://catchmentbasedapproach. org/learn/chalk-stream-strategy-3/ [Accessed 31/10/2023].

Cluer, B. and Thorne, C. (2018). Geomorphic and Ecological Basis for Restoring Stage 0. Restoration Symposium February 6, 2018.

Environment Agency (2023). Catchment Data Explorer. Available at: https://environment. data.gov.uk/catchment-planning [Accessed 31/10/2023].

Environment Agency (2012). Keeping Rivers Cool. Getting ready for climate change by creating riparian shade.

Misbourne River Action (2023). Misbourne River Action Data Repository. Available at: https://www.misbourneriveraction.org/data-repository/ [Accessed 12/10/2023].

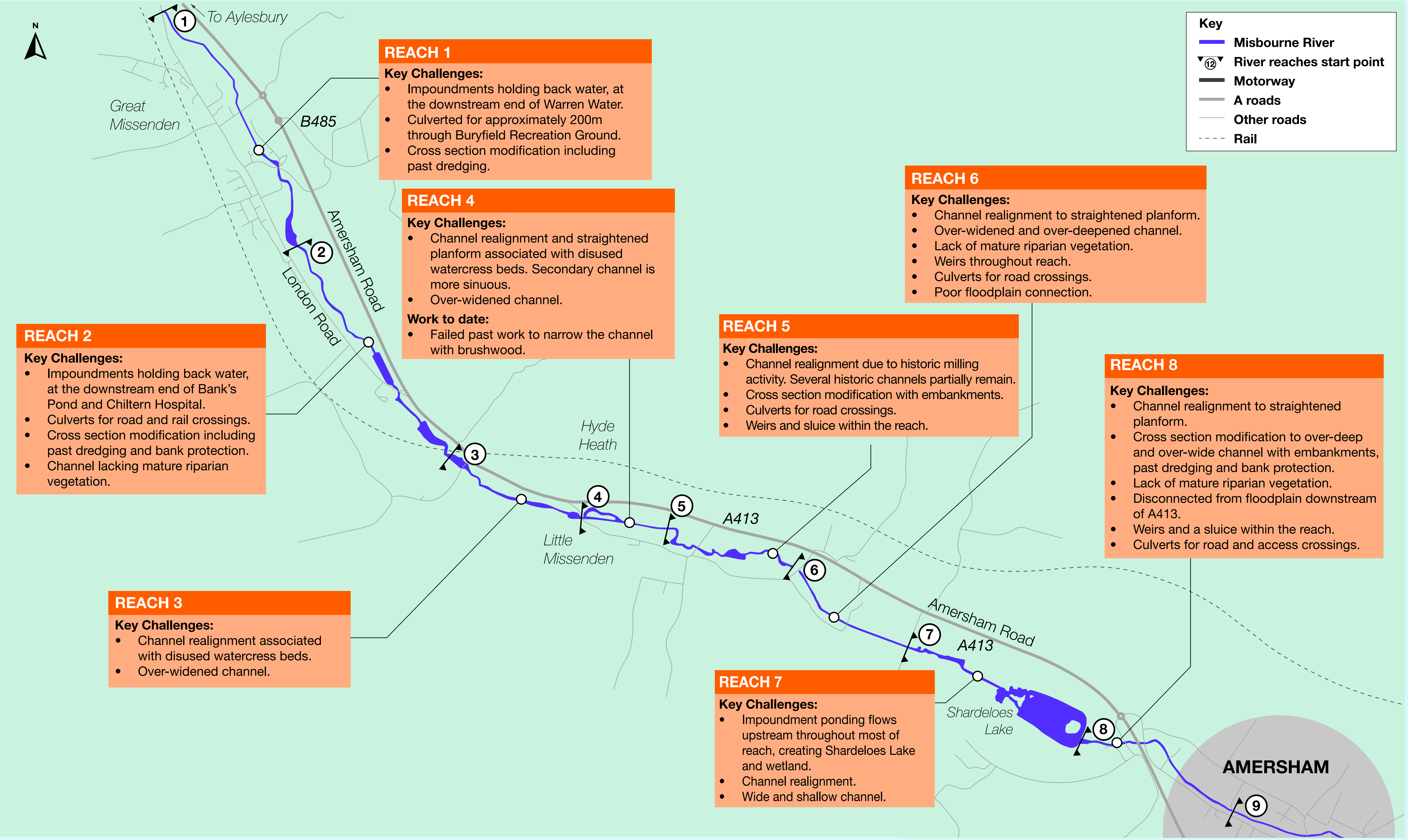
The Norfolk Rivers Trust (2014) The River Nar Catchment Plan.

Sear, D.A. Newson, M. Old, J.C. and Hill, C. (2006). Geomorphological appraisal of the River Nar Site of Special Scientific Interest, Appendix 5. Defining reference conditions for chalk stream and Fenland natural channels.

Turner, S., Barker, L.J., Hannaford, J., Muchan, K., Parry, S. and Sefton, C. (2021), The 2018/2019 drought in the UK: a hydrological appraisal. Weather, 76: 248-253.

River Misbourne | Appraisal

Summary of Key Challenges and Works to Date - Great Missenden to Amersham



REACH 1

Key Challenges:

- Impoundments holding back water, at the downstream end of Warren Water.
- Culverted for approximately 200m through Buryfield Recreation Ground.
- Cross section modification including past dredging.

REACH 2

Key Challenges:

- Impoundments holding back water, at the downstream end of Bank's Pond and Chiltern Hospital.
- Culverts for road and rail crossings.
- Cross section modification including past dredging and bank protection.
- Channel lacking mature riparian vegetation.

REACH 3

Key Challenges:

- Channel realignment associated with disused watercress beds.
- Over-widened channel.

REACH 4

Key Challenges:

- Channel realignment and straightened planform associated with disused watercress beds. Secondary channel is more sinuous.
- Over-widened channel.

Work to date:

- Failed past work to narrow the channel with brushwood.

REACH 5

Key Challenges:

- Channel realignment due to historic milling activity. Several historic channels partially remain.
- Cross section modification with embankments.
- Culverts for road crossings.
- Weirs and sluice within the reach.

REACH 6

Key Challenges:

- Channel realignment to straightened planform.
- Over-widened and over-deepened channel.
- Lack of mature riparian vegetation.
- Weirs throughout reach.
- Culverts for road crossings.
- Poor floodplain connection.

REACH 7

Key Challenges:

- Impoundment ponding flows upstream throughout most of reach, creating Shardeloes Lake and wetland.
- Channel realignment.
- Wide and shallow channel.

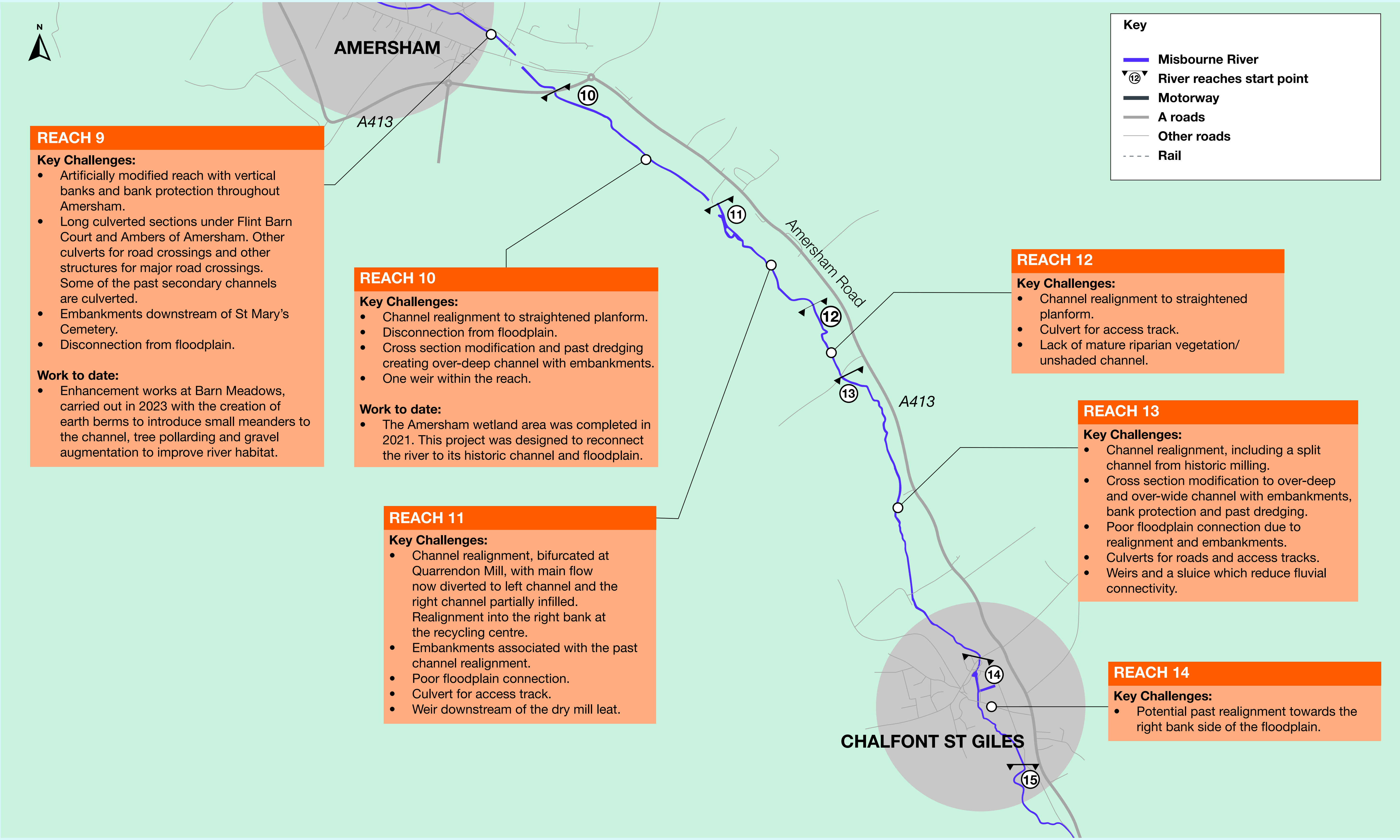
REACH 8

Key Challenges:

- Channel realignment to straightened planform.
- Cross section modification to over-deep and over-wide channel with embankments, past dredging and bank protection.
- Lack of mature riparian vegetation.
- Disconnected from floodplain downstream of A413.
- Weirs and a sluice within the reach.
- Culverts for road and access crossings.

River Misbourne | Appraisal

Summary of Key Challenges and Works to Date - Amersham to Chalfont St. Giles



REACH 9

Key Challenges:

- Artificially modified reach with vertical banks and bank protection throughout Amersham.
- Long culverted sections under Flint Barn Court and Ambers of Amersham. Other culverts for road crossings and other structures for major road crossings. Some of the past secondary channels are culverted.
- Embankments downstream of St Mary's Cemetery.
- Disconnection from floodplain.

Work to date:

- Enhancement works at Barn Meadows, carried out in 2023 with the creation of earth berms to introduce small meanders to the channel, tree pollarding and gravel augmentation to improve river habitat.

REACH 10

Key Challenges:

- Channel realignment to straightened planform.
- Disconnection from floodplain.
- Cross section modification and past dredging creating over-deep channel with embankments.
- One weir within the reach.

Work to date:

- The Amersham wetland area was completed in 2021. This project was designed to reconnect the river to its historic channel and floodplain.

REACH 11

Key Challenges:

- Channel realignment, bifurcated at Quarrendon Mill, with main flow now diverted to left channel and the right channel partially infilled. Realignment into the right bank at the recycling centre.
- Embankments associated with the past channel realignment.
- Poor floodplain connection.
- Culvert for access track.
- Weir downstream of the dry mill leat.

REACH 12

Key Challenges:

- Channel realignment to straightened planform.
- Culvert for access track.
- Lack of mature riparian vegetation/ unshaded channel.

REACH 13

Key Challenges:

- Channel realignment, including a split channel from historic milling.
- Cross section modification to over-deep and over-wide channel with embankments, bank protection and past dredging.
- Poor floodplain connection due to realignment and embankments.
- Culverts for roads and access tracks.
- Weirs and a sluice which reduce fluvial connectivity.

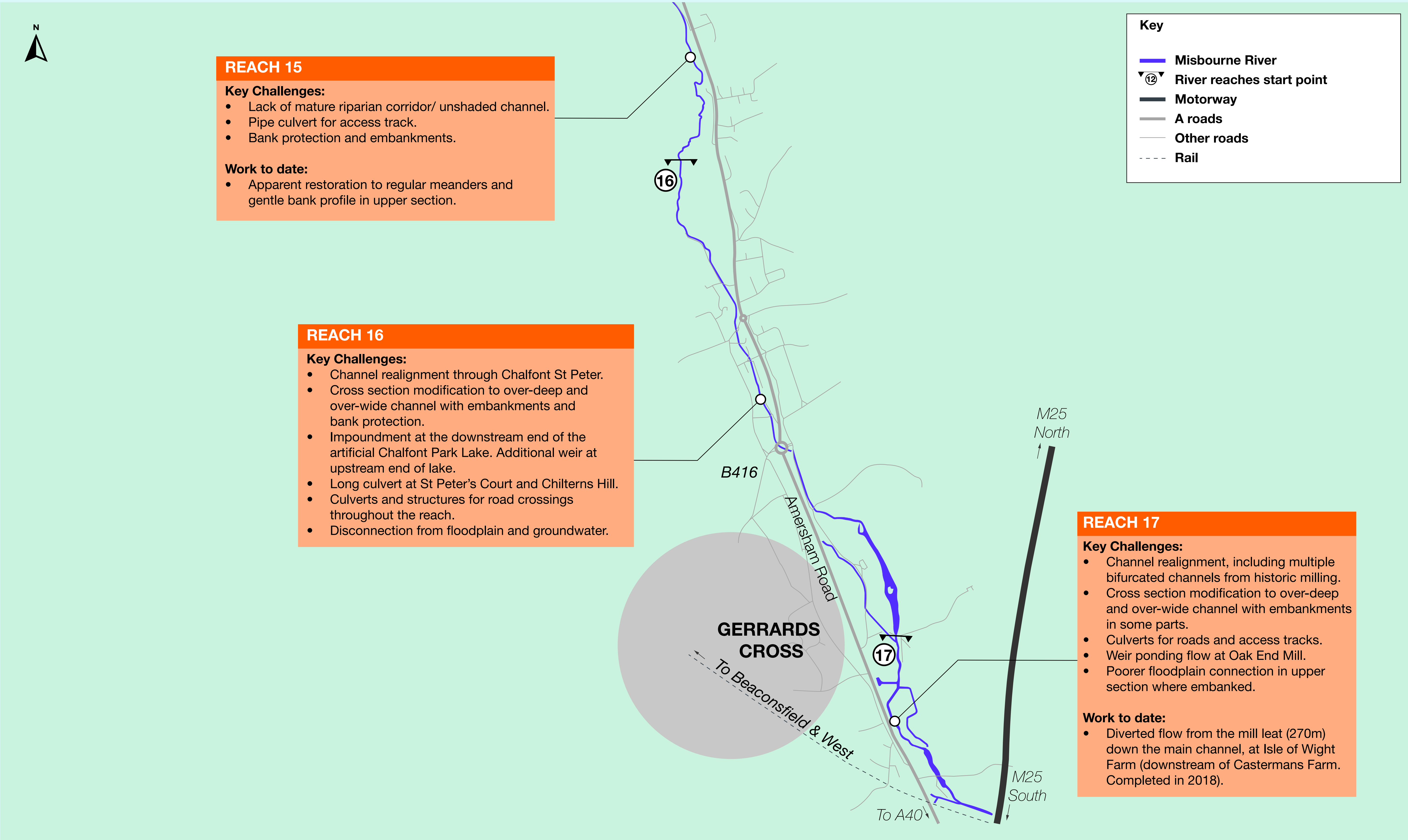
REACH 14

Key Challenges:

- Potential past realignment towards the right bank side of the floodplain.

River Misbourne | Action Plan

Summary of Key Challenges and Works to Date - Chalfont St. Giles to Gerrards Cross



REACH 15

Key Challenges:

- Lack of mature riparian corridor/ unshaded channel.
- Pipe culvert for access track.
- Bank protection and embankments.

Work to date:

- Apparent restoration to regular meanders and gentle bank profile in upper section.

REACH 16

Key Challenges:

- Channel realignment through Chalfont St Peter.
- Cross section modification to over-deep and over-wide channel with embankments and bank protection.
- Impoundment at the downstream end of the artificial Chalfont Park Lake. Additional weir at upstream end of lake.
- Long culvert at St Peter's Court and Chilterns Hill.
- Culverts and structures for road crossings throughout the reach.
- Disconnection from floodplain and groundwater.

REACH 17

Key Challenges:

- Channel realignment, including multiple bifurcated channels from historic milling.
- Cross section modification to over-deep and over-wide channel with embankments in some parts.
- Culverts for roads and access tracks.
- Weir ponding flow at Oak End Mill.
- Poorer floodplain connection in upper section where embanked.

Work to date:

- Diverted flow from the mill leat (270m) down the main channel, at Isle of Wight Farm (downstream of Castermans Farm. Completed in 2018).

This page is intentionally left blank

This page is intentionally left blank

Jacobs

Challenging today.
Reinventing tomorrow.

Environment Agency

CHILTERNS CHALK STREAMS PROJECT

Affinity Water
Taking care of your water