THE NORFOLK RIVERS TRUST

RESTORING NORFOLK'S RIVERS

THE RIVER BURN

A WATER FRAMEWORK DIRECTIVE LOCAL CATCHMENT PLAN

DEVELOPED IN PARTNERSHIP WITH

Environment Agency

CONTENTS

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INTRODUCTION

This plan has been produced by Norfolk Rivers Trust in consultation with relevant agencies, landowners, farmers and local people in the Burn Catchment. The aim of the plan is to provide a framework for improvement of the ecological status of the Burn River, guided by the Water Framework Directive. Delivery of the actions outlined in the plan will lead to improvements in water quality and habitats throughout the catchment, providing benefits to the river wildlife and the community.

The plan begins by providing an audit of the current state of the catchment. Solutions to ecological problems are then are identified, costed and prioritised.

THE WATER FRAMEWORK DIRECTIVE

The Water Framework Directive (WFD) was introduced in 2000 and commits European Union member states to improving the chemical, physical and ecological quality of their streams, groundwater areas, rivers and lakes. The quality of these waters is measured using a range of indicators which combine to give a picture of a river's health. Using this combination of indicators a river (or groundwater unit or lake) is then graded on its overall "ecological status", and designated as either bad, poor, moderate, good or high. Each member state is required to bring its water bodies to good status by 2015. Where this is not possible, good status must be achieved by 2021 or 2027, depending on the severity of the barrier to good status. The majority of Britain's rivers currently fail to attain good status due to a wide variety of pressures. In England, the Environment Agency are responsible for WFD delivery.

Water Framework Directive Status	Current river Status (2009)	Predicted by 2015
Bad		
Poor	**Fish**	
Moderate	**Ecological Potential Phosphate Dissolved Oxygen Overall Status**	**Fish Phosphate Dissolved Oxygen Overall status**
Good	**Invertebrates Hydrology supports good**	**Invertebrates Hydrology supports good**
High	**Ammonia Temperature Copper Zinc Ammonia pH**	**Ammonia Temperature Copper Zinc Ammonia pH**
	The Burn is classified as a Heavily Modified Waterbody	**Heavily Modified Waterbody**

Table 1. Results of detailed water body investigations undertaken by the Environment Agency to determine the status of the River Burn. A prediction about the status at the next "waypoint" in the WFD schedule (2015) is also shown.

A CHOICE FOR THE FUTURE OF OUR RIVERS…

RIVER BURN STATISTICS

Approximate river length:	12.1 km (Sluice to primary source near Southgate Road)
Catchment area:	99.6 km2
Discharge at named point:	Burn at Burnham Overy Base Flow Index: 0.96 Mean Flow: 0.317 m³/s
Legal designations:	Nitrates Directive
County Wildlife Sites:	Fakenham Road Meadow, Grove meadow (near source at Southgate), South of Abbey farm; Thorpe Common and Fen
Protected area designations:	Holkam National Nature Reserve SSSI, NNR, SAC, SPA, Biosphere Reserve
Other areas of conservation importance	40 ha of land managed for conservation close to National Trust Mill

WHY RESTORE RIVERS?

Britain's rivers generally fail to reach "good" ecological quality. This is both a problem in itself and a sentinel of trouble.

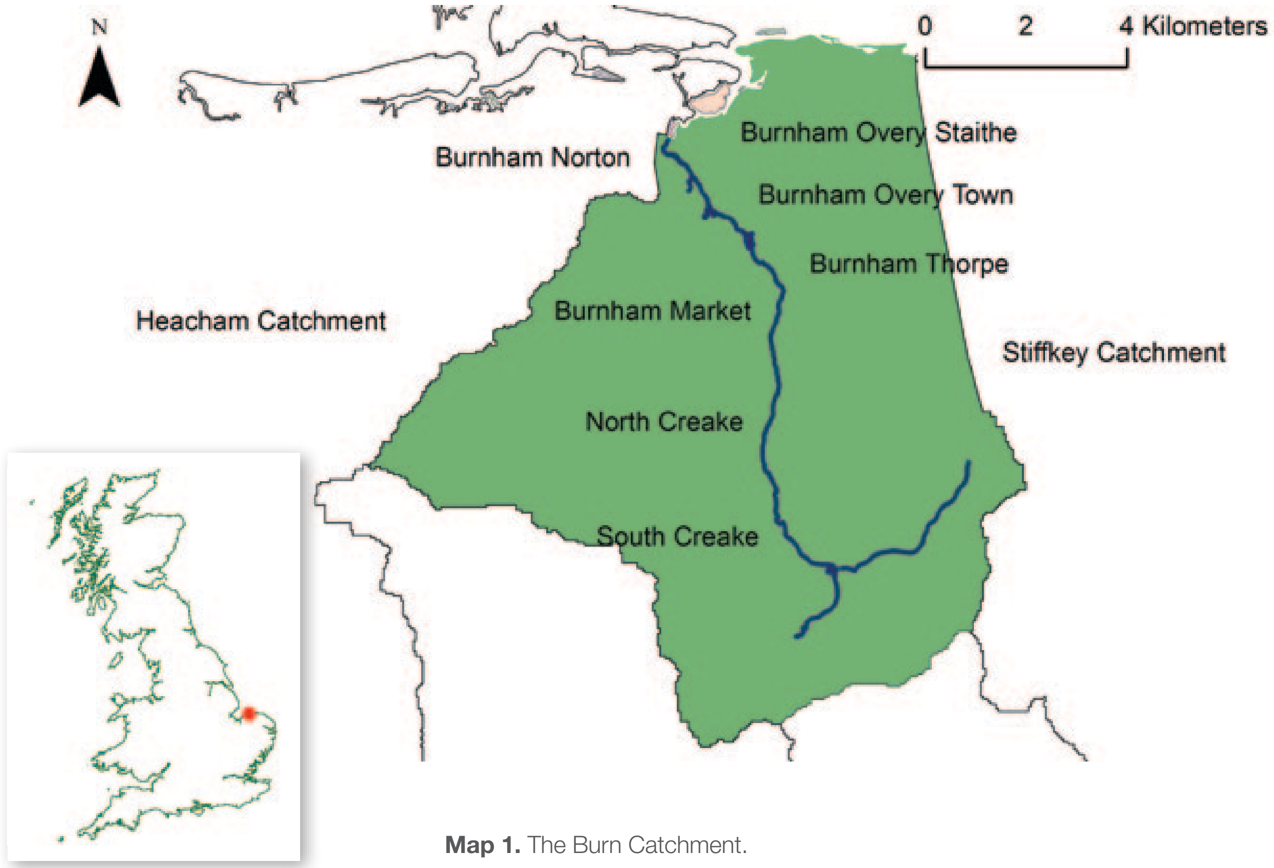
A well-functioning river system is an inseparable combination of good water quality, distinctive physical processes and diverse wildlife. These factors interact to provide benefits. A naturally functioning river has a floodplain with sufficient capacity to absorb inundation and to act as a store for silt carried by high flows. The river channel would also be naturally self-scouring. This reduces flood risk and the need for expensive management. Headwater forests reduce surges of water into the system by increasing drainage and removal of water. Moreover, the vegetation, microbes and invertebrates in the river corridor also absorb and process pollutants. This enhances water quality within limits. However, very polluted rivers have less wildlife and in turn they a reduced capacity to provide such benefits. This leads to a downward spiral. Wildlife itself has an intrinsic value as well as being enjoyed by interest groups such as fishermen, ramblers and bird watchers.

If any of the three pillars of the river system is damaged (water quality, physical processes, ecosystem), then the value of the entire interconnected system is reduced. Arguably, we also have a responsibility to repair our damaged natural heritage for future generations. Thus, ecological restoration aims to enhance the functioning, as well as the intrinsic value of our beautiful rivers.

SECTION 1 THE CATCHMENT

The River Burn is a chalk stream which flows through a low-lying catchment and discharges into salt marshes. These salt marshes are adjacent to the biologically rich freshwater grazing marshes of Holkam National Nature Reserve. The River is classified by the Environment Agency as a Heavily Modified Waterbody, a designation which recognises the long history of modifications to the Burn over several centuries. The upper Burn is a winterbourne, which means that some headwater sections dry out naturally as the level of water in the underlying chalk aquifer drops. However, there is debate about the degree to which flows in the sections which lie above Burnham Thorpe are affected by abstraction. Substantial flow joins the Burn at Burnham Thorpe from a system of springs surrounded by sedge beds. Below this point the remaining 2.5 km of the river has reliable flows, and has not dried out in the last 50 years for which data is available.

Most of the course of the river has been altered by diverting it into straightened sections. Impoundments reduce the potential for fish movement and migration along the river.



Map 1. The Burn Catchment.

THE COMMUNITY

It is part of the Norfolk Rivers Trust's mission to gain the active participation of the community. Stakeholders help us to set objectives, keep us informed about issues on the ground such as pollution and actively volunteer to make many more worthwhile projects possible.

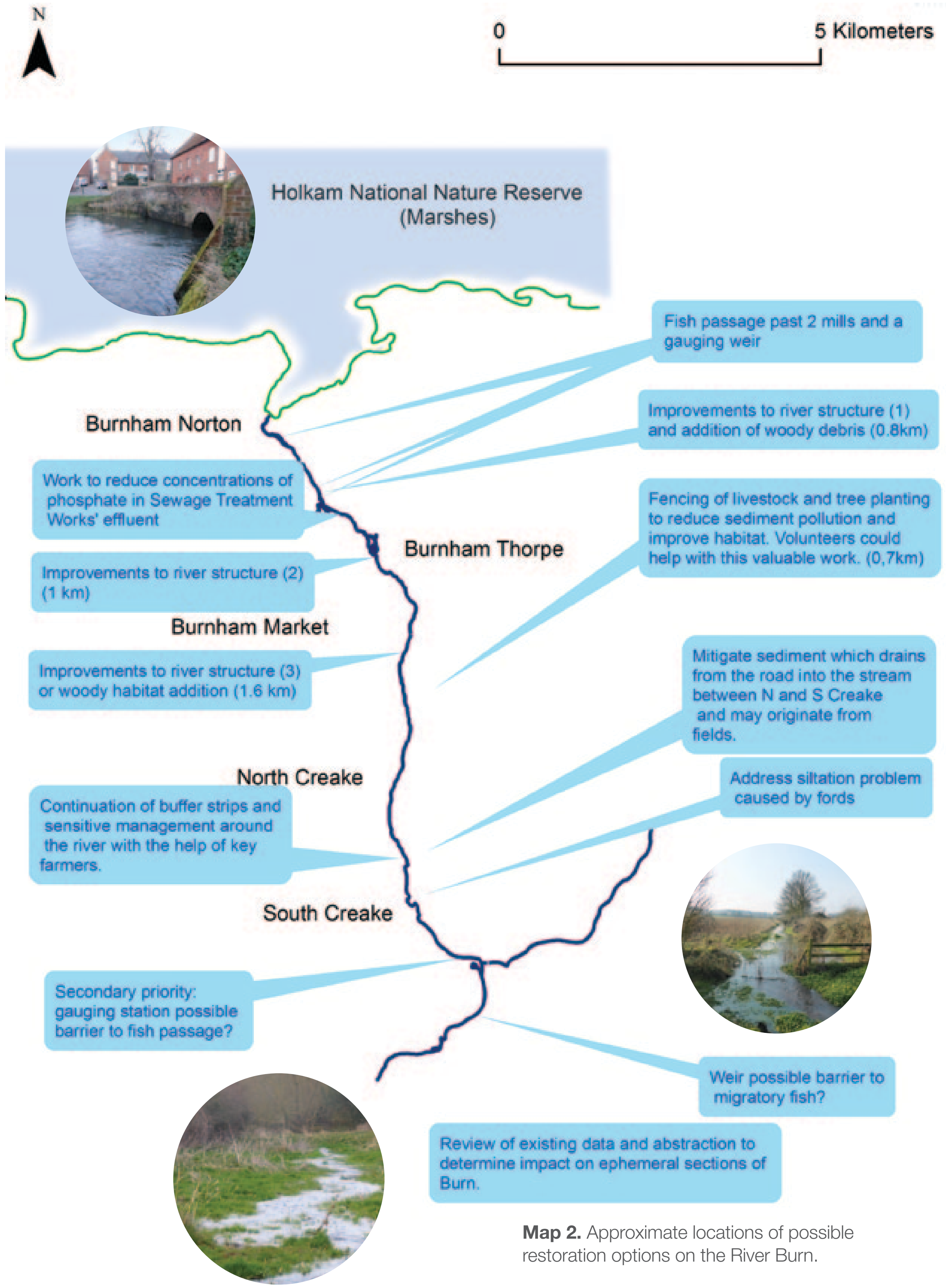
Norfolk Rivers Trust have recently started to work in the Burn Catchment, and we were very pleased to receive over 80 people at our latest event at North Creake Village Hall. The River Burn is a rural catchment, with 10 villages positioned close to the river, including: Waterden, South Creake, North Creake, Burnham Deepdale, Burnham Westgate, Burnham Sutton, Burnham Ulph, Burnham Overy, Burnham Thorpe and Burnham Norton.

An opportunity to restore a section of the River Burn by fencing off livestock and tree planting has already been identified with the aid of the landowner, and this project will be greatly aided by the help of volunteers. Norfolk Rivers Trust are grateful for the help which The Brocklebank Trust has given to make this project happen, and hope that more projects will be initiated in the near future.

Photos. A Norfolk Rivers Trust event in North Creake in February 2014 which was attended around 85 people.

OVERVIEW OF RESTORATION OPTIONS

Summary of possible restoration options on the river Burn. These proposals would greatly enhance the value, water quality and wildlife value of the river. It is stressed that these are subject to consultation and are only outline ideas at this stage.



Map 2. Approximate locations of possible restoration options on the River Burn.

WILDLIFE

Despite the many challenges which the wildlife in the Burn valley faces, the catchment supports a diversity of organisms which benefit from the river.

Photo 3. Riffle beetle and larvae (Elmis aenea),

Photograph: © JAPEMO

Species profile: Riffle Beetle

The riffle beetles (family Elmidae) are small beetles between 1.25-4.75 mm in length, have long legs and claws relative to their body size and are generally dark brown to black in colour. The long claws help them to keep hold of the substrate and plants on the river bed to stop them from getting washed downstream. This is very important as they are not able to swim. There are a small number of species in the family, some of which are very common and some that are Red Data Book species. Most common in the North West Norfolk rivers are *Elmis aenea* which are found in rivers and streams where 'riffle' features are present. One of the regionally notable species found is *Riolus subviolaceus* which inhabits base-rich streams and rivers with good flow velocities.

Contribution: Nina Birkby, Environment Agency

Photo 3. Kingfisher

Photograph: © Jonathan Lewis.

Species profile: River Kingfisher, *Alcedo atthis*

When walking down a gurgling river, one is sometimes lucky enough to be graced by the teal blue flash of a kingfisher speeding busily past. This incredible little bird feeds on small fish and invertebrates at a voracious rate, consuming its entire body weight each day. During the mating season, the kingfisher will catch 5,000 small fish to sustain itself and its young. Kingfishers do not have a beautiful song to match their striking colours, but they do have a variety of calls with different meanings. In fact, one call signifies to their mate and young: "I'm home!"

In the winter, when some of the kingfishers' feeding spots freeze over, the birds migrates towards coastal estuaries where the warming effect of the sea, and the salt water prevent freezing. Most of the time, however, kingfishers stick to a particular territory and will routinely be seen in the same spot.

Species profile: The Eurasian Otter, *Lutra lutra*

The otter is a predatory mammal which uses its excellent swimming ability and specialised teeth to feed on a variety of prey such as fish but also amphibians and occasionally birds. They have even been shown to be capable of eating toads despite their poisoned skins. They corral the amphibians into groups before proceeding to skin them and eat the nutritious innards. Otters hold territories against the same sex, and this stops their numbers building up into high densities, especially when food is scarce. This beautiful and reclusive animal is wide ranging and can be seen around ponds, lakes, rivers and marine habitats.

Photo 2. Otter

Photograph: © Jack Perks

A possible good news story for the future? Could a native species be introduced to the River Burn?

Britain's only native crayfish requires clean, well oxygenated, mineral-rich water and was once common throughout southern and eastern England, but is now on the verge of extinction following the introduction of the American signal crayfish. If the water quality and habitat were sufficiently improved, this species could be introduced to the Burn one day. However, this would rely on the absence of invasive crayfish such as the American signal crayfish.

Native and endangered crustacean: The white clawed crayfish, *Austropotamobius pallipes*

Wildlife profile: River plants

The benefits of aquatic plants for lowland river systems are threefold: they reduce pollution, they improve river structure and they are a vital habitat for other wildlife.

Scientific studies have shown that plants remove excess nutrients caused by sewage effluent or agriculture. Their sinuous fronds create a large surface area for colonisation by algae, bacteria and invertebrates which process nutrients and organic matter within the river. Their roots directly remove nutrients. They also stabilise sediment and thus prevent movement of toxins which may be bound to sediment particles. Water plants' physical role is also vital. They narrow the channel in places and cause water to accelerate, as well as holding water up in other places. This allows differential scour and deposition of sediment, which helps river channels to remove and store sediment. Together with trees, they are nature's architects of channel structure, helping rivers which have been artificially straightened to recover to a more meandering form. Water plants are also a rich habitat for invertebrates which feed the larger animals in the river system. Last, but not least, their delicate greens and subtle white flowers are also one of the wonders of the British countryside.

Ten years ago this section of stream was absolutely straight and featureless. Growth of plants and sediment deposition around dead plants has caused a return to a more natural meandering form, which in turn has started to cause pools and riffles to develop. (Photo: Olly van Biervliet, Fox's Beck, Norfolk. With thanks to John Dowland)

Water crowfoot in flower.

Water plants cause flow variation which also encourages sediment storage and scour.

Varied water plants represent shelter and food for a diversity of other wildlife.

GEOLOGY AND GEODIVERSITY

Introducing Chalk Rivers

Chalk rivers are a distinctive part of England's landscape. There are more found here than anywhere else in the world. They are located wherever rivers flow across chalk bedrock or chalk-rich superficial deposits, in a tract of land stretching from East Yorkshire, Norfolk and the Chilterns to Wiltshire and Dorset. There are 12 such rivers in Norfolk.

They are fed principally from groundwater rather than surface water, and flow is gradually released through springs or directly up through the river bed. Chalk rivers have a distinctive flow regime: their springheads tend to have steady flow, although some headwater valleys may be dry in summer when groundwater levels fall. They tend to have more stable temperature regimes than other rivers due to a constant baseflow component. Their waters are highly alkaline, which gives rise to a distinctive ecology and suite of plants and animals. High quality chalk streams are prized by anglers because they support abundant brown trout populations, which shelter and feed amongst characteristic water plants such as water crowfoot.

The Heacham River: a Norfolk chalk stream, having clear, lime-rich water flowing over flint and chalk gravel.

Chalk underlies most of Norfolk, but only reaches the surface in the western and northern parts of the county, as well as in valleys where rivers have incised down to bedrock. Chalk is also found in the glacial deposits which form a superficial layer across much of Norfolk, as it was readily eroded and redeposited by ice sheets during the Pleistocene period (2.6 million to 10,000 years ago); these chalk-rich glacial deposits are known colloquially as Marly Drift. Thus the chalk rivers of Norfolk have a mixed geological origin, which subtly alters the chemical composition of their waters. A Norfolk chalk river will typically flow through several geological zones and soil types on its way to the sea, but will still retain its characteristic 'chalk river' flow regime and basic alkaline chemistry.

Wildlife in chalk rivers is vulnerable to changes in river structure and processes. Over-abstraction can lead to lowered flows and siltation. Flood defence and drainage work may lead to an alteration of the channel shape by deepening and straightening, with knock-on effects on river flow and biodiversity.

The headwaters

The Burn has its headwaters in the uplands around South Creake, Syderstone and Sculthorpe. Groundwater flows converge on the valley through chalk bedrock and thick layers of Marly Drift and associated sands and gravels of Anglian age. Sandy deposits, resulting from slope erosion in Pleistocene and more recent times, have accumulated on the valley floor. The permeable nature of such superficial deposits means that water percolates downwards to emerge as springs, wet flushes and winterbournes where the valley floor intercepts the water table. Flows may dry up seasonally if water levels fall in the aquifer. There is an important permanent spring near Grove Cottage at Southgate, and several intermittent sources, for example a pond near Leicester Meadow and land round Waterden (literally 'water-valley') and South Creake Common. These sources converge on the wet meadows at Fakenham Road, parts of which are designated as a County Wildlife Site. This area of confluence, which includes the Southgate Spring, may be considered as the permanent source of the river.

Seasonal winterbourne flow in the headwaters near Swimmer Barn, Southgate. February 2014.

South Creake and North Creake

The Burn has a regular presence through South and North Creake. It has a shallow channel which has been conspicuously straightened and canalised for flood management purposes; in some stretches it is embanked above the level of the valley floor. It flows over superficial layers of slope-derived deposits and alluvium resting on chalk bedrock. Because of the proximity of the aquifer it maintains a constant flow, although water levels may seasonally vary, sometimes falling to as low as 15 cm (6 inches) in dry summers but also occasionally filling the channel to the top of the banks. It is augmented by springs along its route, as in the woodland near Manor House. Silt is washed into the river from farmland in a few places, most notably at Holgate Lane where it crosses a ford. The valley opens out significantly beyond North Creake. Water is said sometimes to erupt from the ground under artesian pressure in the meadows between Norman Lane and Creake Abbey. In past centuries this abundant flow gave rise to areas of fenland, indicated today by shallow tracts of wasting peat on the valley floor north and south of the Abbey. The river was artificially straightened in the early 19th century, probably as part of a drainage project, and now runs down the centre of the valley.

The Burn is confined by embanked dredging spoil at Abbey Farm meadows. It is prone to disappear in this stretch, due to seasonally intermittent flow.

From Burnham Thorpe to Norton Sluice

North of the Abbey, the Burn continues its canalised course between banks of dredging spoil which separate it from its floodplain. It passes through an area of banks and drainage ditches at Open Meadow which may represent the remnants of a floated water meadow complex. The river is reported to run dry periodically between the Abbey and Thorpe Common some 2.5 km (1½ miles) away down river; the floodplain in this stretch of the valley is underlain by permeable slope-derived deposits overlying chalk bedrock. Its re-emergence at Burnham Thorpe Common coincides with the transition of its geological substrate from sandy deposits back to peat. This tract of valley peat extends downstream as far as the tidal sluice at Burnham Overy. It indicates that brackish water conditions and coastal reed marshes extended upriver in past centuries as far as Thorpe Common. Traces of former saltmarsh creeks are present on the floodplain. The river is joined by its only significant tributary, the Goose Beck, at Burnham Market; this is fed by permanent springs at Westgate, and is headed by a long, dry valley developed on chalk bedrock containing a winterbourne. Chalk is also exposed more widely along the lower reaches of the Burn valley, and Marly Drift mantles the higher ground; both give a calcareous character to the groundwater welling up in the valley floor. There is discharge from a sewage works at Burnham Market, but this does not make a significant contribution to river flows. The river's course is interrupted by two mill dams in Burnham Overy: the pool of the upper mill backs up into an extensive area of carr (wet) woodland; the pool of the lower mill is substantially embanked above the surrounding floodplain meadows. The river and groundwater feed water-dependent habitats in the grazing marshes and inter-tidal saltmarshes. The river discharges into Overy Marsh at Norton Sluice.

Ponded section of River Burn above National Trust Mill.

Tim Holt-Wilson
Norfolk Geodiversity Partnership

HISTORY OF THE RIVER BURN (NELSON'S COUNTRY)

Ancient history

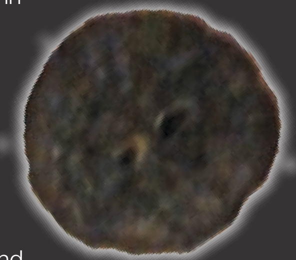
20,000 years ago, The Burn was a wide meandering river fed by glacial waters. Norfolk and most of East Anglia was covered by ice sheets. Norfolk was probably inhabited from around this time, although it might have been earlier.

Tools from this period have been found in gravel pits and rivers, brought up by fishermen in their nets. In addition to these tools, animal bones and plant remains have been found in sand and mud deposits. These deposits were first recognised at Cromer in the middle of the last century and are called the Cromer forest bed series because of the fossilised wood it contains. Many of the plants have been identified from pollen, such as Oak, Ash, Hazel, Lime and Hornbeam. Fir and Spruce have also been found but they are no longer native to Britain. Animals which would appear exotic to us now roamed the area. These included an early species of large elephant, a smaller species of rhinoceros, which is related to the present day Sumatran rhinoceros, and three or four species of giant deer, the males of which had very large antlers, measuring over three metres across. Within the woodland of the Cromerian inter-glacial were lakes and slow flowing rivers.

Man was certainly present in East Anglia during the period which we know as Hoxian Interglacial. This began about 400,000 years ago. These Palaeolithic (old Stone Age) people used large flint flakes and later hand axes as tool. These people hunted horse, deer, oxen, elephant and rhinoceros; they also went wildfowling and fishing.

The Mesolithic (middle Stone Age) period is defined in Britain as the time between the final retreat of the glacial ice to about 8,300 BC. Norfolk like most of Britain was occupied by small groups of hunter-gathers. Their distinctive flint work including long blades and macrolides, which were probably hafted in wood, creating saw like cutting edges and arrowheads, were used for hunting small animals. Flint axes were also used for felling trees.

In the Neolithic (New Stone Age, 4,500 BC) settled communities gradually arose in Britain, partly or fully dependent on arable farming or stock raising. This would have resulted in a change in the landscape of the Burn Catchment. The range of crops that were grown included Rye on poor ground, Barley on good (mainly used for beer making) with other crops including peas, beans and grasses.



During the Copper and Bonze Age (c. 2,500BC) environmental evidence indicates that humans felled considerable areas of ancient wildwoods. Thus the process commenced by Neolithic arable farming and pasture was extended to allow production of food for an expanding population.

Bronze Age tools including a well preserved axe head.

History of the Burn from Mouth to Headwaters

Norfolk was not always a backwater. At the time of the Domesday Book, Norwich was the second largest city in England. This did not change until well into the eighteenth century. Agriculture was a vital part of this success. One agricultural practice starting in the Middle Ages and continuing until the 18th century, was the use of oak woodlands in Common Land as foraging areas for grazing pigs which fed on acorns. In the medieval period, the county was the most prosperous in England, and this goes some way to explaining one of the most striking features of the Norfolk landscape – the very high density of Parish Churches.

The Estuary of the Burn in medieval times was a harbour known as Skottermouth, probably from the Norse and Skutic, meaning "projective ridge," due to the shelter offered from northerly gales by a stretch of dunes called Burnham Meals. Documents from 1565 refer to two navigable creeks as Burnham Rodested and it was recorded that between them Norton, Overy and Deepdale had seven mariners. The estuary was clearly an important hub for waterborne trade, with the banks of the river between Overy town and Burnham Norton hosting a boat market. Records from Creake Abbey show that the Canons brought such things as salt and fish from Cromer and hay from Setchey, which might have come via Burnham Rodested.

Many people know of the Burnhams because of Admiral Nelson but there is another famous Sea Captain, Richard Woodget, the Master and Captain of the record-breaking Clipper "The Cutty Sark". He was born in Norton Cottage in 1846 and was known for his hobbies on board "The Cutty Sark", such as learning to ride a bike and to roller skate on the tween decks when the ship was in ballast (empty to us land lubbers!)

Continuing further from Overy we come to Burnham Thorpe, the birthplace of the famous Admiral Nelson. Because his father's parsonage was being repaired and redecorated at the time of his birth, Nelson was actually born at the shooting box where his family were staying with friends. Born seven weeks premature on 29th September 1758, he was baptised within a few hours as it was thought unlikely that he would survive. It is said that during his childhood he would play with toy boats in the Burn which ran past his house. The lectern in Burnham Thorpe church is constructed with timbers that came from Nelson's flagship, HMS Victory, given to the church by the Board of The Admiralty.

If you follow the Burn towards North Creake, you will come to the ruins of North Creake Abbey. Starting life in 1206 as a small chapel, in 1226-7 the chapel received Royal Favour and it passed to the Black Canons, a name derived from the colour of their habits. In 1483 there was a disastrous fire and much of the abbey was destroyed. In the sixteenth century Plague ravaged the Abbey sparing only the Abbot himself, Giles Sherygnton, who died alone on 12th December 1506.

Further up the River Burn is South Creake where, a short walk from the centre of the village, you will find Bloodgate Hill. Here there was an Iron age encampment. Behind a ring of earthworks the Saxons of East Anglia gathered to watch the Danes marching up from the sea. The invaders did not pass the fort without a fight. Legend has it that the bodies of the slain were piled up to the height of the defences and the blood flowed like a river down the hill, hence its name Bloodgate Hill. Not much is visible, but it is still worth a visit for the view of the surrounding countryside. This was the beginning of the Viking invasion that defeated King Edmund The Martyr and turned East Anglia into a Viking settlement.

Jumping forward in history about 1100 years, at the bottom of Bloodgate Hill is a place that was the birthplace of modern mechanised agriculture. Bluestone Farm was the first fully mechanised farm in England. The Alley brothers rented the 113 acre farm from Lord Townshend Bircham's Estate in 1930. They also introduced caterpillar tractors and were the first to plough to the unheard of depth of nine inches. Such innovations enabled man to further modify the landscape in the catchment of the Burn.

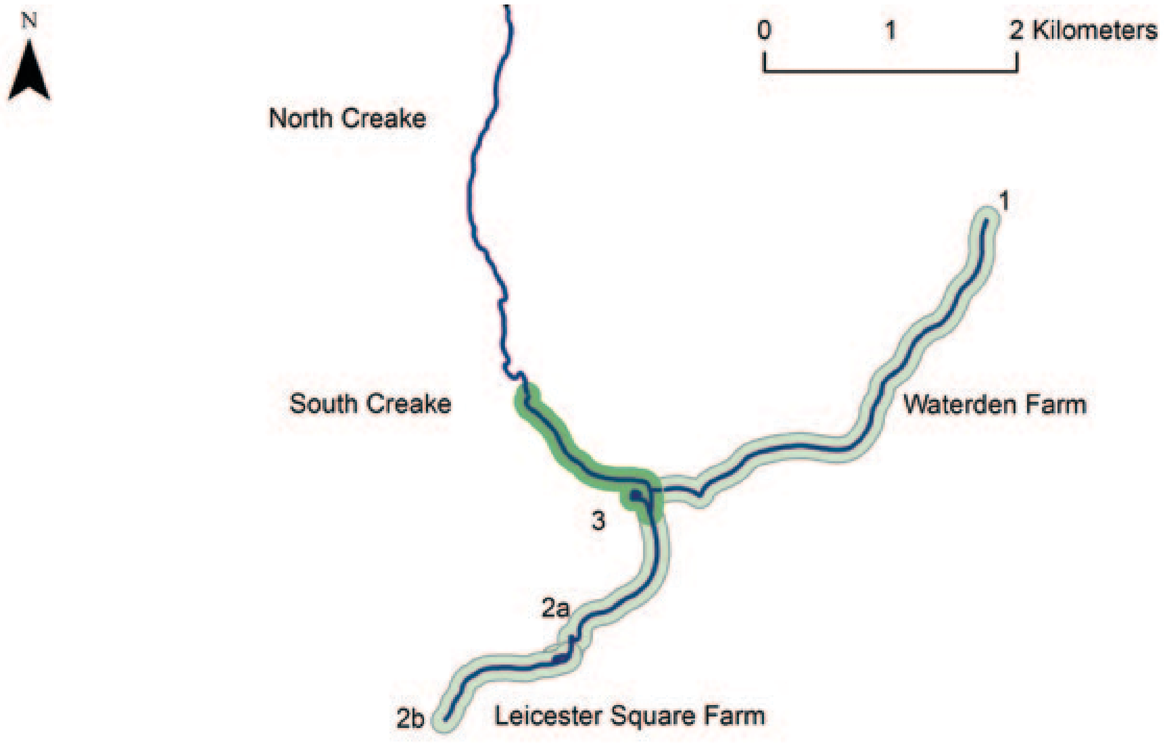
John Lorimer

THE BURN FROM SOURCE TO MOUTH

Section 1 – Sources to South Creake

This section of the stream is very much a winterbourne section, with the very highest reaches rarely running. It is not a useful concept to think of the Burn as having one particular source all the time. Rather, as one reaches the uppermost sections of the river, the point of first flows moves up the course with increasing groundwater levels.

In its highest reaches, the stream course originates from several areas (Map 3). As the stream proceeds downstream towards South Creake flows become more constant and it runs over clean gravels. It is completely straightened to run parallel to the road. It forms an attractive feature running through the front gardens of the houses at the beginning of the village. In South Creake village centre itself the stream changes character to a rectangular channel and is crossed by 2 fords. The slowed flow velocities here, and an abundance of ducks contribute to a silty channel with an absence of water plants. The fords and lack of varied water velocities due to the uniform river channel result in steadily increasing siltation in the stream below this point.



Map 3. Main sources - South Creake: light green shows the ephemeral sections of the stream and green represents the area of more constant flow. Locations of major sources: 1. Waterden to the East 2a. Leicester Meadows 2b. Source close to White Hall Farm 3. Meadow at Southgate is the main spring.

Photo 4. Clear gravels in section of River Burn above South Creake.

Photo 2. Water plants (macrophytes) including fool's watercress (Apium Nodiflorum) create some sinuosity and habitat variation within the straightened channel.

Photo 3.

Photo 4.

Photo 5. Ford over the Burn in South Creake.

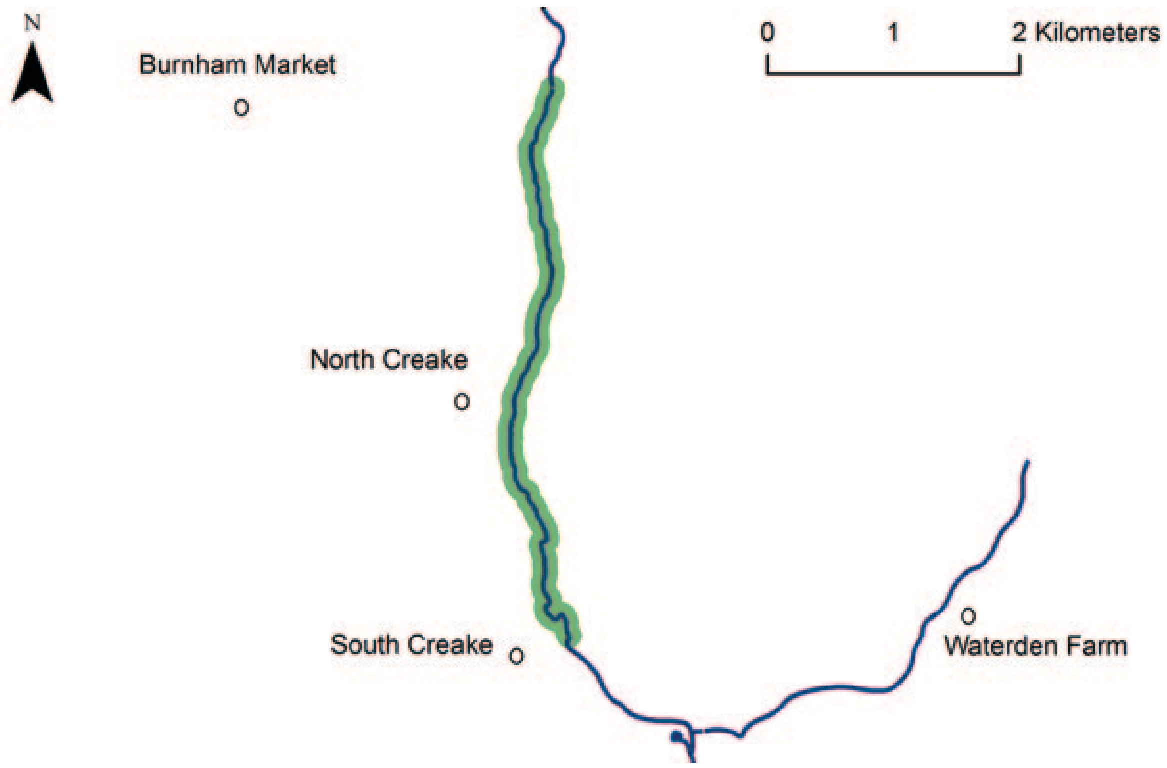
Photo 6. The stream becomes increasingly silted due to lack of natural stream morphology and sediment inputs.

Section 2 – Below South Creake to Burnham Thorpe

Between South and North Creake the stream runs in a straightened channel, a typical example shown in Photo 7. A 1996 Environment Agency report draws on evidence from hydrological model runs and an MSc thesis to demonstrate that the bed of the channel between North and South Creake is above the groundwater height, so would lose stream water to the ground in this section. This partially explains the notable vulnerability of this section to drying. However, model runs also showed that abstraction had probably led to a 13% increase in the number of days for which the stream was dry. The current situation in the context of this finding should be further investigated.

In North Creake, the stream again forms an attractive feature in many back gardens, and runs through an open space in the village. Some gardens gradually grade down to the river with native vegetation, making particularly good quality areas for wildlife such as damsel flies and water voles. Norfolk Rivers Trust are happy to advise on how to ensure that gardens are beneficial for wildlife. This section still dries out relatively frequently, with several dry periods in the early 1990s and a dry year in 2011 according to records kept by the residents.

Between North Creake and Burnam Thorpe the Burn flows in straightened sections through rough pasture. In some places, these areas are grazed to an extent which reduces riparian vegetation and causes banks to be over-widened as shown in Photo 8. Excessive livestock trampling in some places also causes sediment from collapsed banks to enter the river. The reduced marginal vegetation greatly decreases the value of the river for wildlife such as trout and morhens which shelter in marginal plants.



Map 4. River Burn between South Creake and Burnham Thorpe.

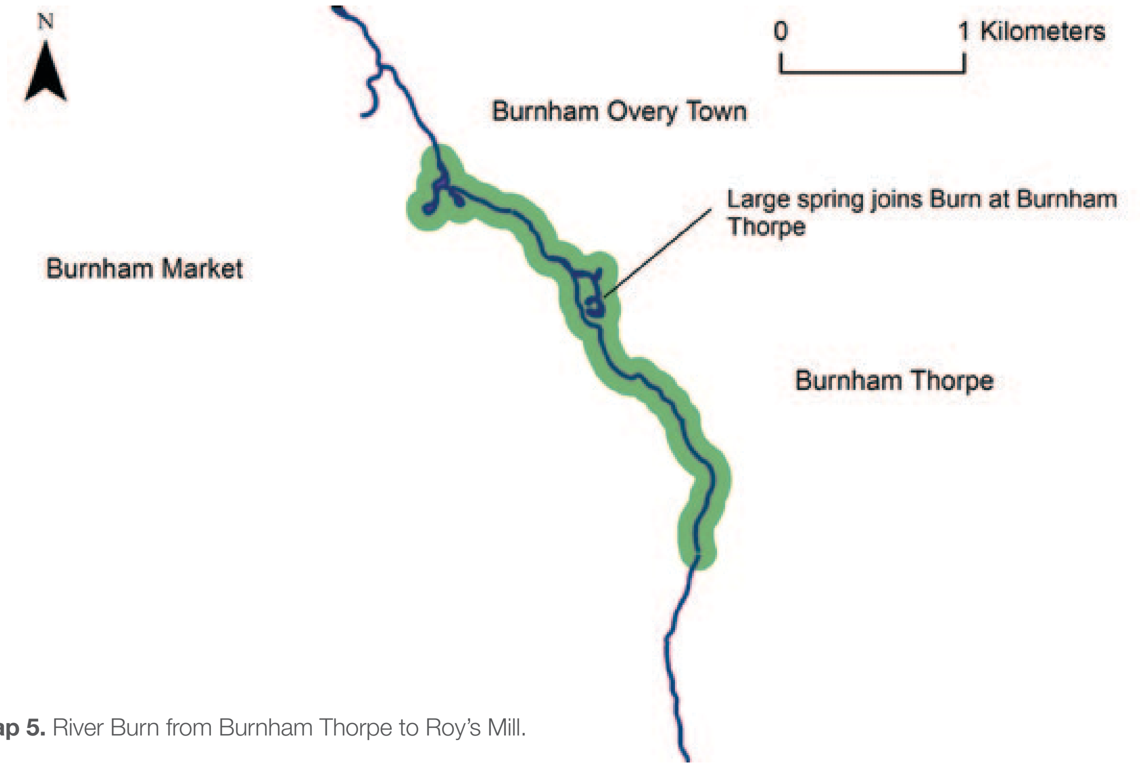
Photo 7. A representative section of the Burn between the Creakes

Photo 8. Representative section of grazed and straightened river channel. The channel banks are over-widened due to poaching and a lack of vegetation development. This results in siltation because the channel to too wide for the volume of flow, so gravels are covered in mud. In turn, this damages habitat, for instance preventing some species of fish from spawning.

Section 3 – Burnham Thorpe to Roy's Mill

Through Burnham Thorpe the river is again straightened to follow the course of the road. On the northern side of the village the stream is joined by a significant flow of water from clear springs which contribute greatly to flow and can dilute the considerable sediment load carried by the stream during rainy periods as shown in Photo 9. This input of flow gives this section of the river potential to have a thriving brown trout population, but density of trout is very low for reasons discussed later.

Below the springs, the river continues to flow through meadows, but has been deepened by dredging. The excess capacity of the channel contributes to sedimentation of this part of the channel and incursion of emergent water plants across the channel. The stream then enters wet woodland and heads towards Roy's Mill. The stream is joined by the effluent from Burnham Market Sewage treatment works at this point, which contributes to levels of phosphate which exceed Water Framework Directive targets. Below this point the Burn flows through and around Roy's Mill, which a Wild Trout Trust report suggests is an impediment to fish passage.



Map 5. River Burn from Burnham Thorpe to Roy's Mill.

Photo 9. Spring water joining flow at Burnham Thorpe (joining from left). This adds flow and dilutes sediment load from upper Burn (right fork).

Photo 10. Springs to North of Burnham Thorpe.

Photo 11. River Burn at Thorpe Common.

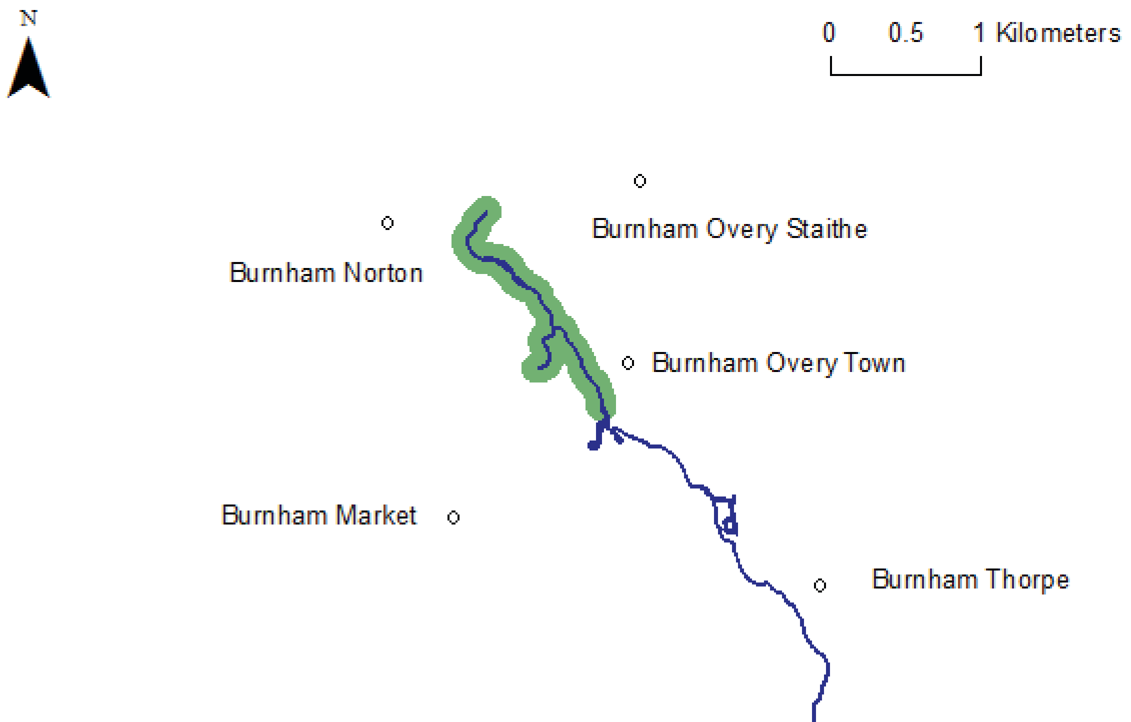
Photo 12. Burnham Thorpe Sewage Treatment Works outlet.

Photo 13. Outflow of channel which bypasses Roy's Mill.

Section 4 – Roy's Mill to tidal sluice outfall

Immediately below the mill the river flows under Mill Road and through an Environment Agency gauging weir. This represents a barrier to fish passage. Then the stream passes a section of wet woodland and the main river enters a long mill pond upstream of the National Trust Mill. This mill pond is clay-lined to ensure a waterproof seal. This work was apparently completed by Italian prisoners of war during the Second World War. The historic flow of the river is via a stream which is now a low-level drain which crosses the A149 about 100m to the West of the mill. Locals have seen large trout in this spring-fed channel below the road. The mill pond itself is clay lined and has silty substrate due to the slow flow velocity in this section. The mill is a barrier to fish passage.

Below the mill, the river moves through a deep channel towards the sea defences where a one-way tidal sluice prevents sea water from penetrating up the stream (Photo 15). According to the Wild Trout Trust report, this structure may discourage fish migration because they will be closed on an incoming tide, but is certainly not a total barrier.



Map 6. Lowest section of River Burn finishing at tidal sluice.

Photo 14. Burn upstream of tidal sluice.

Photo 15. Tidal sluice gates.

SECTION 2 THE PROBLEMS AND SOLUTIONS

The River Burn has been artificially straightened and deepened from source to mouth, with very few natural sections remaining. Impoundments along the river also prevent passage of migratory fish such as lampreys, eels and trout. Water quality in the lowest section of the river below the Burnham Sewage Treatment works is also poor due to nutrient enrichment.

RIVER STRUCTURE

The straightening of the Burn has three profound implications for the Burn's ecosystem. Firstly, the river is very much shorter than it would naturally be, and consequently represents a reduced habitat. Secondly, natural flow dynamics, which result from a meandering river, are not present, and this means that natural processes such as differential storage and removal of sediment by scour are impaired. Finally, it results in a lack of variety of habitat for aquatic organisms, and this leads to a lack of biological diversity.

Adding meanders to the entire course of the river will not be possible, but opportunities to do this in places would be very valuable. In cases where this is not possible, pool-riffle sequences could be restored by the "dig and dump" method. A natural river would also have backwater pools, and these features should also be reinstated. Moreover, any opportunities to add natural features such as woody debris, and to protect bank-side vegetation from over-grazing would be valuable.

FLOODPLAIN CONNECTIVITY

In a natural, highly productive stream, there is seasonal connectivity between the river and its floodplain and unimpaired movement of fish species along the river. The Burn's artificial river channel is designed in a way that rarely if ever allows over-bank flow in most sections. This greatly reduces the river's marginal habitat, and prevents the rich ecological interchange between the stream and its river corridor which would occur during seasonal inundation. Moreover, the inevitable response of a stream to over-capacity is to increase sediment deposition within the stream because the water will move slowly through the river channel. This causes siltation.


Photograph: © Jack Perks

FISH PASSAGE

Ecological restoration of the Burn would need to involve facilitation of fish passage past major barriers identified by a Wild Trout Trust report, in particular the National Trust Mill and the Burnam Thorpe Environment Agency gauging station. The tidal sluice, Roy's mill, a private weir upstream of Burnham Thorpe, and the tidal sluice weir also represent some impediment to fish passage.

WATER QUALITY AND SEDIMENT POLLUTION

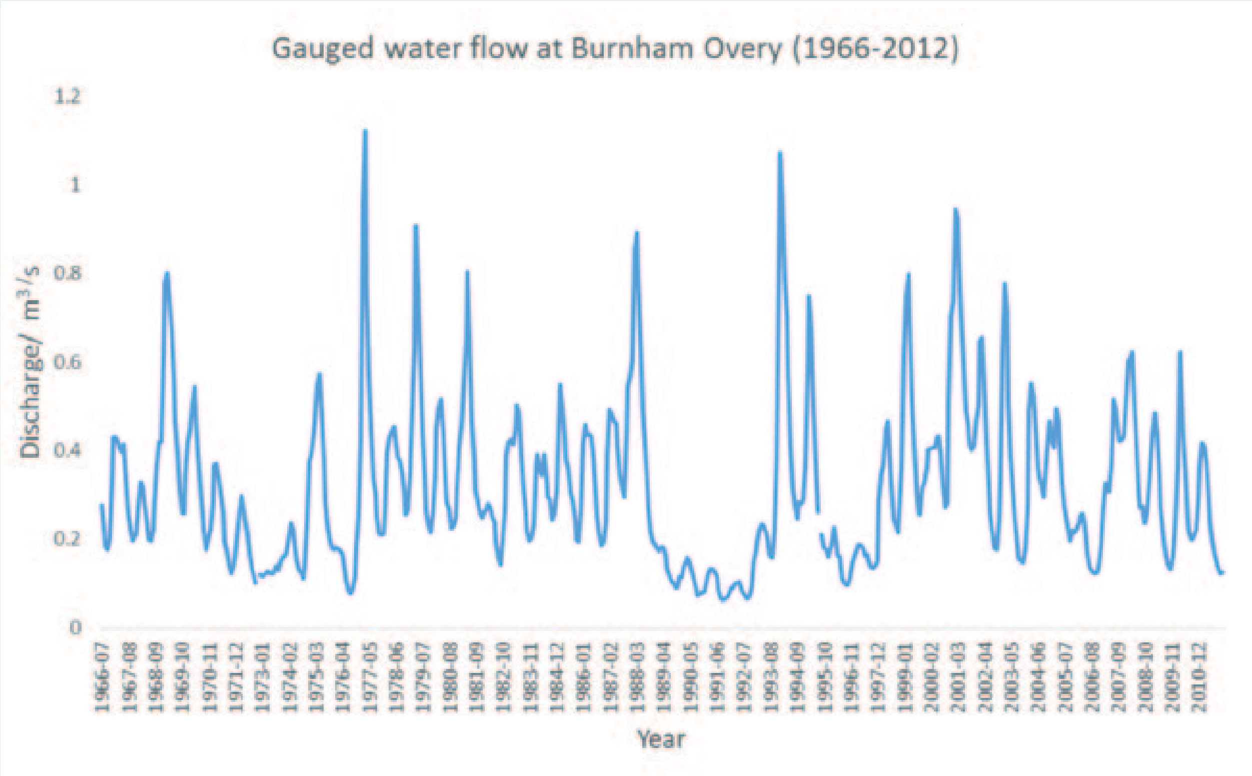
The elevated phosphate in the lower Burn, has probably contributed to very high water plant densities and algal growth below this point. In turn it is likely that this has lead to a seasonal supersaturation in dissolved oxygen, which is also of concern. A reduction in nutrients is therefore desirable, and a cost effective solution must be sought.

Moreover, sediment is washed into the Burn in several places due to livestock grazing, field erosion and damage to road verges. This sediment settles in the channel causing siltation. A catchment strategy to reduce siltation in the Burn is needed with targeted buffer strips, livestock management, and modifications to drains from the road network to reduce sediment inputs.

ENVIRONMENTAL FLOWS

Locally, there is concern about the lack of water in the upper part of the River Burn. The issue is complex due the natural state of the river as a winterbourne, and the aforementioned perched channel below South Creake. A simple examination of average gauged river flows at Burnham Overy over the last 48 years shows no appreciable change (it actually shows a tiny increase in flows but this would not be statistically significant).

Nevertheless, a more subtle analysis was reported in a 1996 Environment Agency report, which showed that abstraction caused a 13% increase in no-flow periods between 1972-1992, and this represents some cause for concern. The relative value of water for domestic use and for watering the crops, which we all consume, set against the importance of environmental flows is an important debate which will become increasingly acute in water-starved East Anglia. Further examination of the no-flow issue using available information and modelling exercises could allow decisions to be reached which allow natural levels of environmental flow, whilst allowing abstractions to continue.



INVASIVE SPECIES

Invasive species can outcompete British wildlife, and can cause specific problems such as river bank collapse and damage to property. Because they have evolved under different conditions, natural checks and balances such as predation often do not control them effectively.

There are some reports of Himalayan Balsam in the catchment. This has apparently been removed, but Norfolk Rivers Trust are keen to work with landowners and volunteer groups to help tackle invasive species as they arise. Moreover, invasive crayfish are reported in ponds in the upper catchment, however locations remain unsure. Norfolk Rivers Trust is keen to work with landowners to determine if crayfish are present. This is particularly important because the Burn could be a candidate for introduction of the imperilled native white clawed crayfish in the future. The lack of information about the exact location of invasive crayfish in the catchment could prevent this potential project.

Norfolk Rivers Trust always appreciate it when people report the presence of invasive species, and can often mobilise volunteer groups or relevant authorities to deal with the problem. Moreover, the link below can be used to report invasive species from your smart phone and trigger the local authority into action:
http://www.rinse-europe.eu/smartphone-apps


Photograph: © Mike Sutton-Croft

Himalayan Balsam (Impatiens glandulifera).

Giant hogweed


Photograph: © Olaf Booy

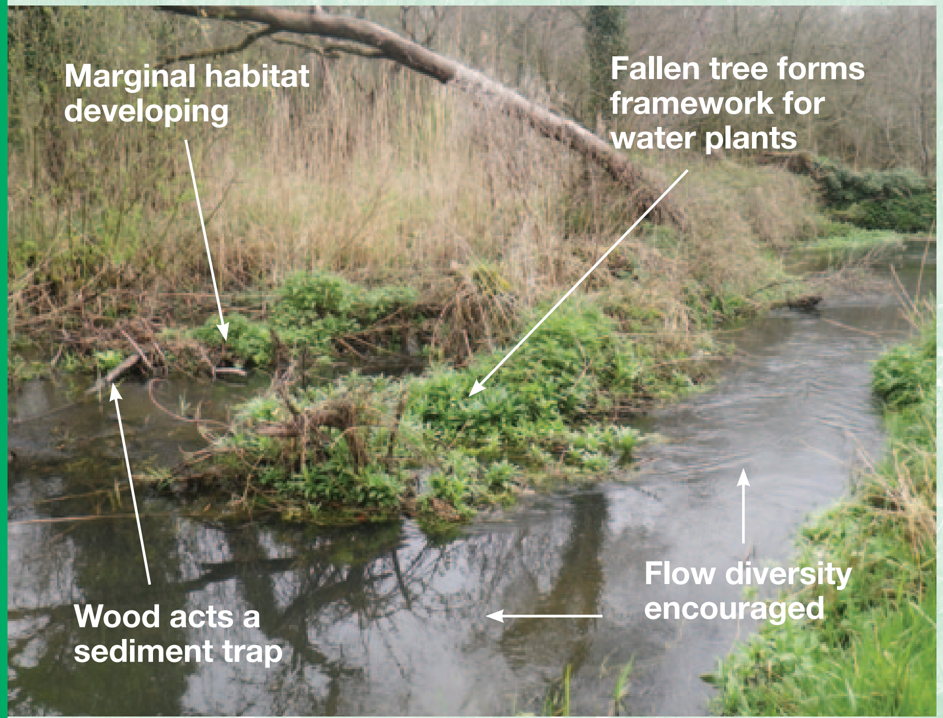
TREES AND WOODY HABITAT

Over the past two decades the importance of trees bordering rivers has become increasingly apparent.

Recent research has highlighted the threat that climate change poses to aquatic ecosystems through changing water temperatures. As water warms, oxygen levels decrease in water and this can cause death of aquatic organisms. Small streams such as the Burn are especially vulnerable. The recent Environment Agency project "Keeping Rivers Cool" highlights the importance preventing dangerous temperature increases in the water by shading. Trees also intercept and modulate agricultural nutrients and sediment. They can increase infiltration, thus reducing flooding.

Trees are also vital as "architects" of river structure. Live trees act as hard points, stabilizing banks and helping meanders to develop. Tree roots in banks provide vital habitats for a multitude of species, notably native crayfish, otters and eels. Dead trees in the river are equally important. They are a key habitat. Moreover, large dead wood (especially entire trees) initiate the natural recovery of rivers from straightening and cause flow diversity. In fact, tree planting and addition of large woody material are the most cost effective and among the most beneficial measures which Norfolk Rivers Trust undertake.

The Burn has tree cover through much of its length. However, there are still some sections which lack the desirable mixture of tree cover and shade which would keep the water cool and provide shelter for a variety of wildlife.



Natural tree fall has several benefits for habitat creation, channel structure and sediment modulation.

Growing trees have changed this former straightened drainage channel into a river with a more natural structure and in-stream islands (*anastonising* channel).

Tree acts as a hard point and has caused a meander to develop.

Tree acts as a hard point and has caused the development of a pool. Submerged tree roots are also excellent habitat for brown trout.

Natural tree fall has caused a great range of microhabitats and greatly increased in-stream surface area for a diversity of river invertebrates.

SECTION 3 AN ACTION PLAN

Despite its many problems the River Burn is a pretty little river which brings happiness to many gardeners and walkers. However, it could be a meandering stream, covered by dappled shade from native trees with a variety of habitat supporting a greater abundance of wildlife, in particular a healthy sea trout population and perhaps even native white clawed crayfish.

From a Water Framework Directive perspective, phosphate pollution, a poor fish community and seasonal oxygen supersaturation are of particular concern. Improving the fish community will involve tackling several issues: 1. Poor fish habitat, 2. Poor fish passage, 3. Nutrient enrichment, 4. Determining whether dry periods in the river are unnaturally long. Fish passage would increase the ability of fish to avoid pollution, drying, and exploit the best habits which the river has to offer. Also restoration of deep water habitat including pools and backwaters in the upper river would greatly increase the resilience of the fish community. However, all pressures need to be tackled together to solve the ecological problems of the Burn.

SECTION 1 – SOURCES TO SOUTH CREAKE

This section of the Burn needs to be treated as a river channel the whole way to the ephemeral sources even when the course is dry. Agricultural pollution and road run off should be avoided. Gardeners in South Creake have an opportunity to manage the river in sympathy with nature by keeping weed cutting to a minimum and using sinuous cuts where vegetation management is strictly necessary.

SECTION 2 – BELOW SOUTH CREAKE TO BURNHAM THORPE

The combination of a lack of natural structure (few pools or backwaters) and ephamoral flows mean that this section of river has few refuges during low flow periods. Therefore work on channel structure would be especially important here. Re-naturalisation in this section would also be important, and measures such as tree planting, addition of large woody habitat, and reducing grazing pressure on the stream margins could be very beneficial. Sensitive gardening could also greatly promote stream functioning in sections of rivers. Natural vegetation growth can restore river processes such as a sinuous pattern, scouring of gravels, and can represent important habitats in themselves. Marginal vegetation is also vital as cover for aquatic species such as trout.

Where the river is grazed vegetation is reduced and the stream becomes overwidened. Where it is ungrazed river channel is narrowed, and this differentially scours the central channel and traps sediment at the fringes. The ungrazed area also provides excellent cover for species such as brown trout and families of morehens.

SECTION 3 – BURNHAM THORPE TO ROY'S MILL

This section of river, which has assured flows, could benefit from channel morphology improvements to return the river to a natural form where possible. An increase of sinuosity and restoration of pool-riffle sequences would be beneficial. Improvements to fish passage at the mill would be a step towards rehabilitating the fish population.

Finally, damagingly high concentrations of phosphate from the Burnham Market Sewage Treatment works should be reduced. Phosphate is a nutrient which results from the breakdown of sewage once it has been treated, and is also present in cleaning products such as dish washer tablets. We all contribute to this problem. Phosphate stripping (chemical removal of phosphate) is the conventional method of removing phosphate, but is likely to be considered prohibitively expensive by Anglian Water. Therefore, creative solutions may need to be considered. An option that has been suggested by stakeholders is to increase the size of existing wetland treatment areas. Norfolk Rivers Trust are currently undertaking a pilot project to construct a similar wetland on the river Mun, and the monitoring results could help to inform future plans. Piping of treated effluent to the sea (1.7 km) might be another option. Phosphate is not a problem when sufficiently dilute, and the flushing by coastal waters could provide this dilution. These solutions would avoid the problems associated with eutrophication such as filamentous algal build ups reported in the National Trust Mill pond.

SECTION 4 – ROY'S MILL TO TIDAL SLUICE OUTFALL

Aforementioned improvements to water quality would benefit this stretch.

Options to improve channel structure could include increases in sinuosity around the existing channel's constraints, use of paleochannels (historic channels), or using "dig and dump" methods to instate pool-riffle sequences within the existing channel. Whichever method is chosen, the bank-full capacity and floodplain capacity of the river will need to be carefully considered. The current channel is acting as a sediment trap because it has a greater conveyance capacity than is required for the volume of water, and because of upstream sediment inputs. If the excess capacity is not altered then any channel morphology work will rapidly silt up. A two-stage channel with appropriate bank full capacity and a "floodplain" overspill is therefore probably the best solution as shown in Figure 1. This would have the benefits of: being ecologically beneficial, sustainable in the sense that silt management would not be required (or very little) and increasing flood storage capacity.

Additionally, rehabilitation of fish populations will only be accomplished if it is possible for them to bypass structures which currently prevent their movement and migration.

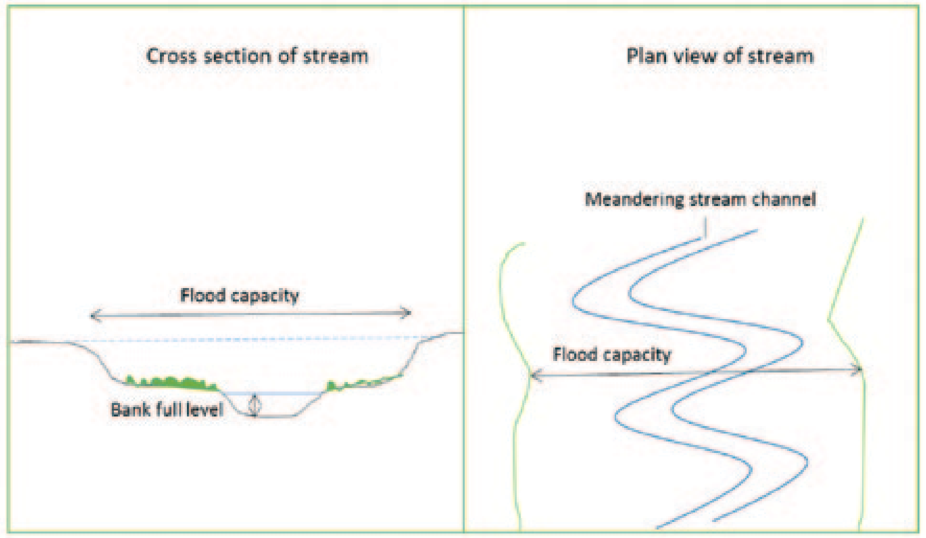
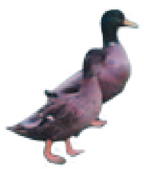


Figure 1. Structural modifications to streams should be based on bank full capacity (the height of common high flows) and should have sufficient flood capacity (maximal levels). If bank full capacity and sinuosity are properly incorporated, then sediment regime will also be modulated by alternate sediment storage in slow moving water and scour in faster water. This will reduce/negate need for sediment clearance.



COSTS AND TIMELINE

The Water Framework Directive objective for the Burn catchment is to reach Good Ecological Potential by 2027, and each of the actions set out in this report will assist in achieving that goal.

The river is approximately 12 km long and, due to centuries of modification, many sections of the river could benefit from ecological restoration to return it to a productive and natural state.

Overall, the order of priorities for the river are as follows:

1. Improve in-stream and riparian habitat. This would include targeted tree planting, addition of woody habitat, work on channel structure and reducing the diffuse sediment inputs from roads, livestock trampling and arable.
2. Ensure fish passage is possible past barriers, with an initial focus on the 2 impoundments identified as a particular priority.
3. Improve water quality in lowest section of the river.
4. Definitively investigate the alleged unnaturally frequent low flows in the top of the catchment.

Measures to improve in-stream habitat through tree planting, livestock fencing and placement of large woody debris where appropriate can start immediately. Volunteer groups could have an important role in making such work possible in the near future. Channel morphology work will need careful planning both in terms of technical aspects and in terms of gauging community opinion. This aspect of the work is therefore a longer term aspiration.

Success in attaining fish passage past priority structures is contingent on finding solutions that will be acceptable to owners of structures which cause the barriers. We are hopeful that Norfolk Rivers Trust's inclusive approach will help to achieve this. Similarly, improvements of the poor water quality in the lowest section of the Burn relies on investment in the Burnham Market Sewage Treatment Works. Creative solutions and a partnership approach might help to make the cost of such work financially viable. Finally, information about the low flows in the upper Burn should be collated with results reported to the community. If necessary, a high quality hydrological modelling exercise could be undertaken to inform wise use of water on the Burn.

Action	Number of kilometres / sites	Predicted cost	Achievable timeline	Responsibility / capability
Livestock Fencing and off stream drinking for cattle. Several fields up-stream of Burnam Thorpe.	1.5 km	£30,427	2021	Norfolk Rivers Trust (NRT)/ Natural England/ landowners
Channel structure (1): Roy's Mill to National Trust mill	0.8 km	£30,800	2021	Volunteers /NRT/ EA
River Structure (2): Immediately downstream of Burnam Thorpe Cricket pitch and including Thrope Common	1 km	£38,500	2021	Volunteers /NRT/ EA
Addition of woody habitat (2): Im-mediately downstream of Burnam Thorpe Cricket pitch and including Thrope Common	1 km	£13,112	2021	Volunteers /NRT/ EA
River structure (3) (Option 1 for this stretch): (priority for channel structure work on the Burn) between Creake Abbey and Burnham Thorpe	1.6 km	£61,600	2021	Volunteers /NRT/ EA
Addition of woody habitat (Option 2 for this stretch): (priority) between Creake Abbey and Burnham Thorpe using woody material	1.6 km	£20,926,40	2021	Volunteers /NRT/ EA
Wetland mosaic where opportunities arise in Burn above Burnham Thorpe and into headwaters. Including back-waters and ponds. This will increase low-flow resilience.	11 km	£26,501	2021	Volunteers /NRT/ EA
Tree planting	1.6 km	£331	2015-21	Volunteers /NRT
Prevention of silt from road runoff and fords	3 main fords Multiple inputs from road	Fords (3x £50,000) £153,000 Diffuse pollution: 10 person days per year for community engagement+ £1,500	2021	NRT/ Highways/ Landowner cooperation
Fish passage 1: past 2 priority structures	2: National Trust Mill, EA gauging weir	£100, 000	2021	NRT/EA
Fish passage past remaining 3 structures	3: Roy's Mill, Tidal sluice, Private weir upstream of Burnham Thorpe	£60, 000	2027	NRT/EA
Reduction in phosphate in lower river by phosphate stripping	1	£100,000 Thereafter: £500,000 pa	2021	Anglian Water
Reduction in phosphate in lower river by increase in wetland size	1	£50,000	2021	Anglian Water with advice from NRT
Reduction in phosphate by piping to tidal section of river	1	Pending answer from Anglian Water	2021	Anglian Water
Hydrological modelling exercise to determine the extent to which abstraction is impacting steam flows	1	£ 10, 000	2021	NRT/EA

*Note: costs include another 10% for monitoring where appropriate and always include VAT.

FURTHER INFORMATION

Environment Agency - Keeping Rivers Cool report
Rivers by Design - rethinking development and river restoration
World Wildlife Fund - Why are chalk streams special?
River Restoration Centre manual of river restoration techniques
Norfolk Wildlife Trust
River Rehabilitation for Eastern England Rivers
Environment Agency homepage
Introduction to the Water Framework Directive

Damselle.

THE RIVER BURN A WATER FRAMEWORK DIRECTIVE LOCAL CATCHMENT PLAN

THE NORFOLK RIVERS TRUST

RESTORING NORFOLK'S RIVERS

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