River Gaywood – River Restoration and Maintenance Proposal

Prepared for King's Lynn Internal Drainage Board by Emily long, MSc, Norfolk Rivers Trust

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Glossary of Terms

Bank height – height of the river bank from mean water level

Bank width – width of the river at mean water level.

'Dig and dump' – A method of creating berms in the channel by excavating a pool and building the side of the channel up either side before it to create a pinch point.

Large Woody Debris/LWD – features of wood staked into the river, can either be created from smaller pieces tied together or whole branches/trees installed. These are usually installed with the root ball (if present) facing into the centre of the channel. These are staked in and tied using twine or wire to hold in place.

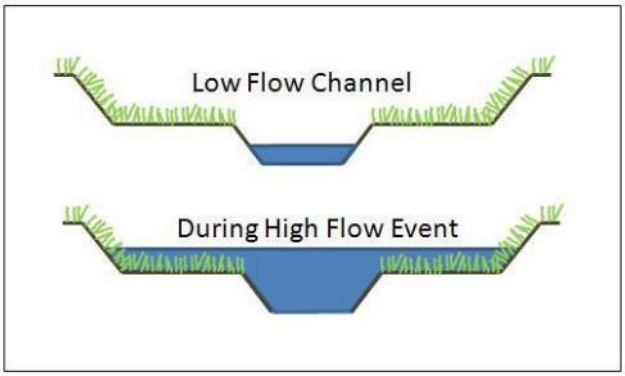
Riparian edge – the interface between the land and river/stream.

Sinuosity - is the ratio between distance covered by the meander and the straight line distance covered by the meander. It runs from 1.0 for a completely straight **river**, to 1.5 for a typical meandering **river**, up to 3.0+ for a twisting course

True left hand bank/Left hand bank - The left hand bank of the river when looking down stream

True right hand bank/Right hand bank – The right hand bank of the river when looking down stream

Two-staged channel – shape of channel allow a narrower low flow channel and wider high flow channel. See diagram below.



Woody faggots – bundles of branches tied together, usually made of hazel.

1. Introduction

1.1 Background

The Board manages the Gaywood catchment, running from the headwaters at Well Hall to the Millfleet structure at its confluence with the Great Ouse in King's Lynn. The river runs a total length of 13.2Km moving through a rural, agricultural landscape into an urban setting.

The river is a chalk stream being fed by springs rising at Well Hall and to the north-west of Pott Row. Chalk Streams are rare and important habitats characterised by their unique array of fauna and flora and are considered a priority habitat under the UK Biodiversity Action Plan.

The river and its associated drains run through three designated environmental areas; Derby, Sugar and Leziate Fens which are all Sites of Specific Scientific Interest (SSSI) noted for their fenland character, shown in Figure 1. These habitats are reliant on water level management to maintain their unique flora and fauna, therefore management of the watercourse through this section must be considerate of the designation. Roydon Common is also situated in the catchment, being designated as a SSSI, Special Area of Conservation (SAC) and RAMSAR site, as well as being a national nature reserve. Additionally, there is a high level of archaeological interest throughout the catchment, particularly to the east of the A149, Queen Elizabeth Way, and through The Walks in King's Lynn.

The river is an ordinary watercourse forming an important function for the surrounding land use and is an important feature through the urban centre of King's Lynn. Several projects have centred on the Gaywood, connecting people to the river, for example the Gaywood Valley Living Landscape project run by Norfolk Wildlife Trust.

1.2 Current Status

The Gaywood is deemed to be a natural watercourse, i.e. not heavily modified, under the Water Framework Directive (2000/60/EC) and currently receives an ecological status of **Good.** A breakdown of the current classification and expected classification in the second River Basin Management Plan is summarised in Table 1.

The status of the River Gaywood is currently monitored by the Environment Agency as part of their annual monitoring programme. It has a flow gauging station at Sugar Fen, which is also the site for water chemistry and invertebrate (biological) monitoring, and an additional invertebrate monitoring site within King's Lynn near Kettlewell Lane. In addition to this, there are two other water level gauges, one near Derby Fen and one near Church Farm. A River Guardian from Norfolk Rivers Trust collects water quality data from 4 sites (Church Farm, Sugar Fen, Leziate drain, Derby Fen) on a monthly basis. These locations are seen in Appendix 1.

Additional monitoring on the river is advised in association with the restoration measures proposed in this report. If run in conjunction with a restoration project, pre and post monitoring should be covered within the project budget to establish

success of the project objectives. Additionally, changes to maintenance regime may be monitored to assess positive/negative impact, which could be financed by board. It is also suggested that fish monitoring is established on the river, with anecdotal reports of declining populations which are currently not monitored. This could be initiated by Norfolk Rivers Trust within the current budget, but long term continuation would need further financing considerations.

Water Framework Directive Status	Current River Status (2009)	Predicted by 2015
Bad		
Poor		
Moderate		
Good	**Overall status,** Invertebrates Dissolved Oxygen	**Overall status** Invertebrates Dissolved Oxygen
High	Ammonia, PH Phosphate	Ammonia, PH Phosphate
	Hydrology supports good ecological status	

Table 1 The current Water Framework Directive status as published in the 2009 Anglian River Basin Management Plan, and the proposed status for the Second River Basin Management Plan to be published later in 2015.

1.3 Objectives

The objective of this report is to outline a plan of restoration and maintenance methods to increase the ecological diversity of the river, whilst ensuring appropriate drainage and flood risk management. This includes traditional mechanical maintenance activities and proposals to restore and increase the rivers natural processes to reduce the need for mechanical maintenance.

The Water Framework Directive holds a **No deterioration** clause, to prevent the degradation of waterbodies, with particular emphasis on those that have reached Good ecological status or potential. As the Gaywood is already set at Good, and is expected to hold the classification though the next round of planning a series of measures have been suggested by the Environment Agency to ensure that there is no deterioration. These are briefly outlined below in Table 2.

Measure	Description
Habitat management	Create wetland priority habitats for priority species e.g. otter and watervole
Improve floodplain connectivity	Maintain and create wetland priority habitats for priority species, e.g. otter and watervole
Bank rehabilitation/re-profiling.	Bank rehabilitation/re-profiling to improve hydrology

Table 2. Measures set out to achieve no deterioration from Good Ecological Status under the Water Framework Directive, measures expected to be published in the Second River Basin Management Plan later this year.

1.4 Considerations

Walkover surveys were carried out in December 2014 and January 2015 to inform this report. This time of year allows more of the channel morphology to be assessed as plant growth is at a minimum, however, this does not allow for a full consideration of macrophyte growth within the channel. Desk based surveys were undertaken, alongside consultation with landowners, the Environment Agency and other conservation bodies to gain information on macrophyte abundance and diversity. Therefore these recommendations take into account all available information but are subject to review throughout the growing season.

At present the Gaywood has an operating hydraulic model for the lower reaches, extending from the Millfleet structure to the A149. It is proposed that a full hydraulic model is carried out through the whole of the catchment to fully assess the proposed measure and ensure positive changes to flood risk are seen before works are undertaken.

It should also be noted that whilst some consultation has been undertaken with landowners with regards to these plans, no formal commitment has been given to allow restoration works to take place. Therefore these proposals highlight the best outcomes for the river, but do not necessarily reflect an agreed outcome.

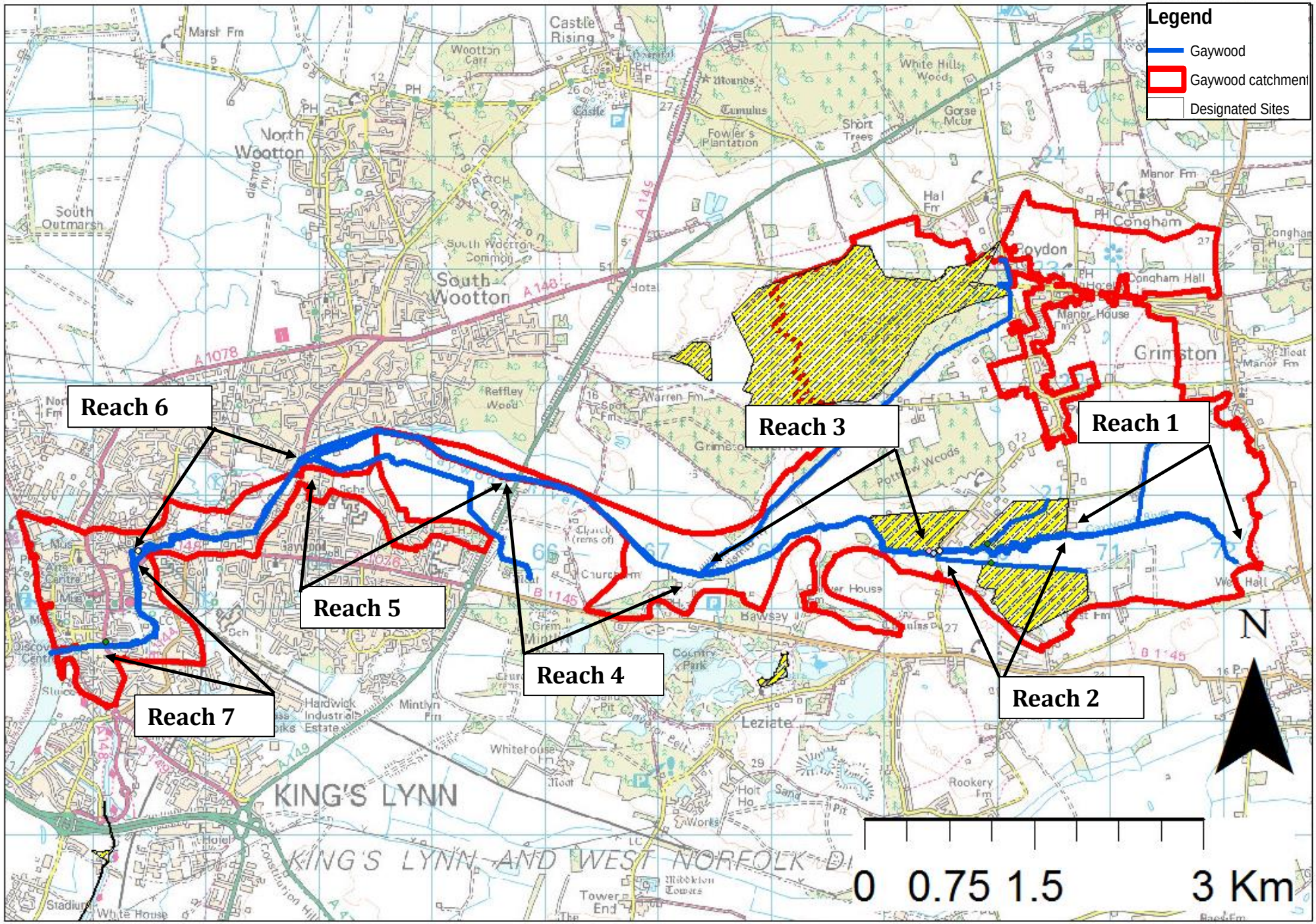


Figure 1 Map showing selected reaches of the Gaywood as outlined in this report.

2. River Plans

The river has been split into 7 reaches of similar character, shown in Figure 1. The current condition of the reach is described followed by proposed restoration and maintenance plans. These are summarised as maps at the end of each section, and linked to the text below by the corresponding text box numbers as stated. Bank heights are given as height from mean water level, and with is given as the distance between banks at mean water level

2.1 Reach 1 – Well Hall to Derby Fen

2.1.1 Current state

The upper reaches of the River Gaywood show its natural chalk stream character, despite being straightened. The upper sections, below the springs and ornamental lakes of Well Hall show a dynamic stream with gravel bed, photo 1. Bank widths vary dramatically from 2 to 5m wide with variable bank heights of 0.3 – 3m. The top section runs through woodland, before opening out onto arable land, although the river still has a high level of cover through this section. Grazing pastures are seen to the north, right hand bank, at the lower end of the reach. Water depths range from 20cm in the upper reaches to 40cm by Derby fen. Substrate moves from uncovered gravels to a sandier bed moving through the reach.

Photo 1. Upper reaches of the River Gaywood, showing gravel bed and woody debris. Located at the top of the catchment.

Although the bank heights are varied throughout the stretch there is little evidence of flood plain connection other than in the upper most stretches where a natural valley shape is seen. Therefore the river is taken as being disconnected from its natural flood plain.

This reach, although straightened, shows an abundance of natural process with most of the stretch being tree lined on the southern bank. The top sections have an abundance of woody debris in the channel which thins slightly as the river

progresses down-stream, however some debris dams and woody features are seen throughout.

Where the vegetation clears some evidence of aquatic vegetation is seen with patches of common reed, *Phragmites australis*, becoming dominant. The river is lined with scrub vegetation and brambles, making access to the river difficult. In the mid-section where cover is slightly reduce large beds of starwort *Callichitre agg.* which are acting to narrow the channel and introduce localised sinuosity, photo 2.

Photo 2 showing the lower section of the reach with Callichitre agg. Beds acting to narrow the channel.

No formal structures are seen through the reach, but several crossing points, by means of a wooden plank, are periodically present.

Several drains join the river through this stretch but no evidence of pollution of high sediment inputs was seen. The survey period was fairly dry.

2.1.2 Proposed restoration options

The naturalised state of this reach provides a diversity of habitats and varied flows, depths and bank heights. Although the river is largely disconnected from its floodplain there is limited opportunity to rectify this, and the variation within the channel makes some allowance for wetted vegetation berms, particularly though the mid-section.

No immediate restoration options are required throughout this section, but the habitat would benefit from some canopy thinning in the densest areas, Box 1.

2.1.3 Proposed maintenance regime

There is currently no maintenance on this section and it is proposed that this continues, Box 1. There is limited flood risk to agricultural land or properties and access is restricted.

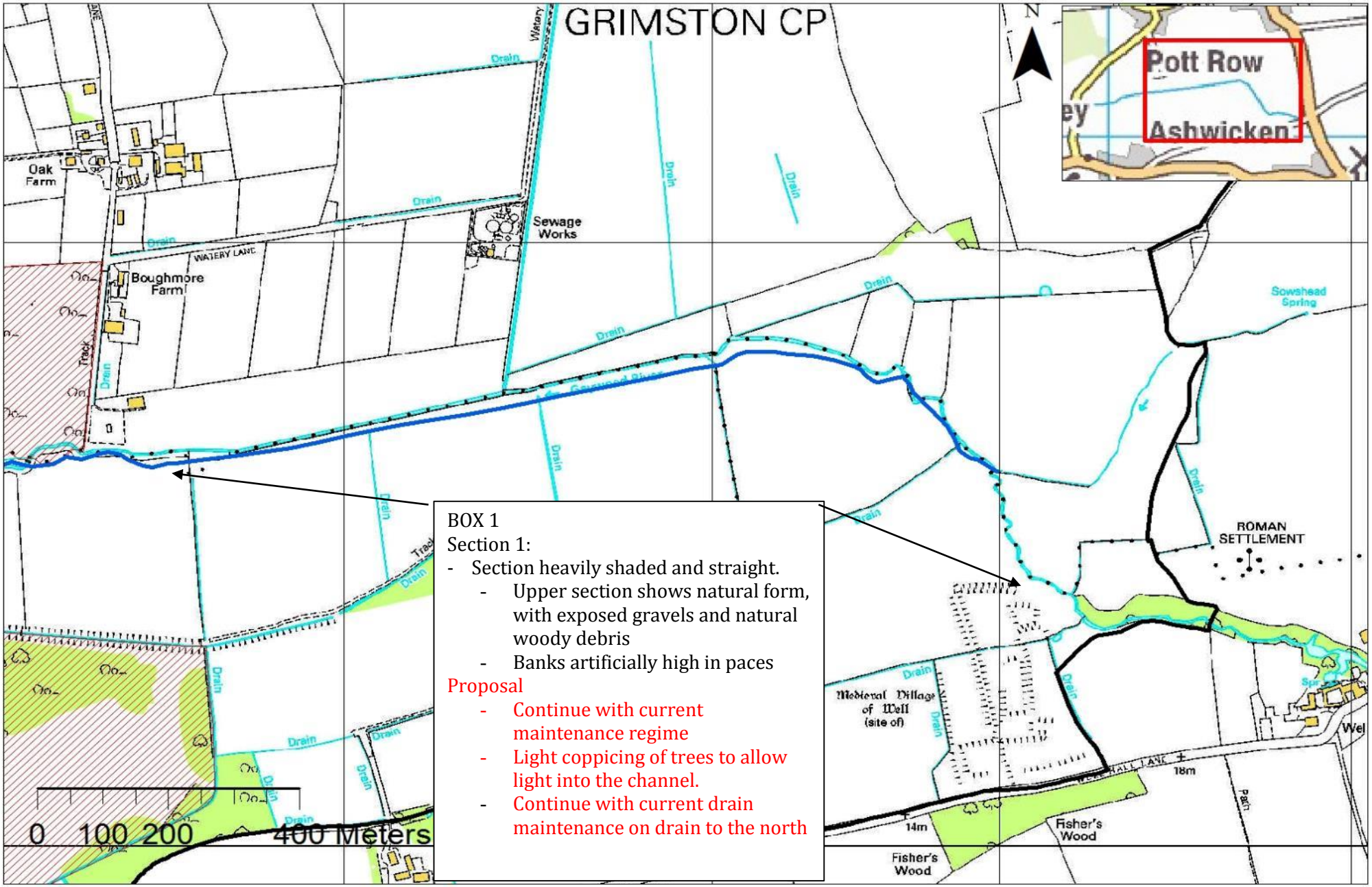


Figure 2 Proposed restoration measures for Reach 1. Black text indicates current features/state, red text indicates proposed measure.

2.2 Reach 2 – Derby Fen to Leziate Drove

2.2.1 Current State

The river has previously been re-meandered through this section creating a sinuous form. Despite this, the section appears to be overly wide with evidence of natural channel narrowing through sedimentation and emergent vegetation beds growing out into the channel. This creates some flow variation. The river is an average of 3.5m wide with banks varying between <0.5-2m. Two riffle sections are present through the section, these were installed as part of the restoration scheme and are still functioning. Between the riffle sections the bed is predominantly sandy but areas of higher flows expose the underlying gravels.

Derby Fen SSSI lines the majority of the northern bank, designated and managed as heathland fen. Private gardens end the reach on the northern bank below the fen. The southern bank is comprised of grazing pastures.

There is scattered cover present on the northern bank (right hand bank) through Derby Fen SSSI with a range of trees, brambles and scrub lining the banks. There is fencing along the length of the river bank on both sides with a wide buffer seen on the southern bank. The fencing on the southern bank was old and broken in places.

Evidence of heavy poaching is evident, notably on the outside of the meander bends to the south-side (left hand bank), Photo 3. This has resulted in collapsing, steep banks exposing the sandy sediments of the catchment and widening the channel.

Photo 3 erosion from poaching on outside of meander bend. Lower bend shown in photo. Picture taken from right hand bank.

Some evidence of aquatic vegetation was seen through the section, submerged beds of starwort, *Callichitre agg.* and water cress *Nasturtium officinale* are seen in the channel with the banks dominated by grasses and tussock sedges. These were not able to be identified as they were last year's growth. Stakeholder engagement

informs that this section can suffer from high macrophyte growth, largely from cress beds.

The third meander loop downstream shows very marshy habitats on both sides of the river with banks lower than average. The inside of the meander bend, seen on the northern side, is fenced in line with the river channel protecting the marshy habitat.

The lower end of the restored section is marked by a low level weir. This is causing a small impounding effect through the meanders, Photo 4. Below the weir the channel narrows and banks increase in height with the channel become straight and featureless.

Photo 4 showing impounded section above low level weir.

Other structures seen through the section include a gauging weir at the lower end of the meandered section and a foot bridge at the top end. A road bridge marks the end of this reach.

2.2.2 Proposed restoration measures

The previous restoration efforts through this section have acted to increase the diversity of the reach, but heavy poaching has been detrimental.

Fencing along the southern, left hand bank is currently being carried out by Norfolk Rivers Trust as part of the 9 Chalk Rivers Project, which will protect the reach from poaching and reduce the sediment input into the river, BOX 1.

Through the meandered section the river shows signs of natural recovery through channel narrowing. It is proposed to encourage this process through some formal narrowing, increasing flow diversity and allowing natural gravels to be exposed, BOX 2. This could be achieved by re-profiling the banks or adding woody faggots to create berms. This could be coupled with further flood-plain reconnection, allowing a better connection between the river and flood plain. This is particularly important through Derby Fen, where water level management is key to

maintaining the designated habitats, which are currently deemed in an 'unfavourable condition' (Natural England, 2013). This could be achieved through Environmental Payments and working closely with Natural England.

Bank repairs are also proposed to encourage stabilisation of the southern bank, BOX 3. This should be carried out after effective fencing is established. Repairs should be achieved using soft-engineering techniques such as coir rolls or matting. This is likely to require additional material which could be won by the construction of scrapes/ponds with landowner agreement.

The removal of the small weir is also proposed, releasing the impounded stretch and allowing natural processes to occur, BOX 4. If undertaken simultaneously with channel narrowing no detrimental impacts would be seen in the upstream section. These measures can be seen in Figure 2.

2.2.3 Proposed maintenance regime

Although there is some anecdotal evidence of high macrophyte growth through the section it is proposed that changes to channel morphology to increase flow variation is the preferred control method. At present maintenance operations are impeded by the heavily poached land and reduced access. As there are signs of natural recovery through the reach it is suggested that once repairs have been put into place and potential channel narrowing occurred, then the commencing of maintenance be reviewed.

Formal surveys of macrophyte abundance is proposed in the optimum survey window (May-August), with results used through various determination tools for channel management and conveyance. This will give further information to the requirements of regular weed maintenance.

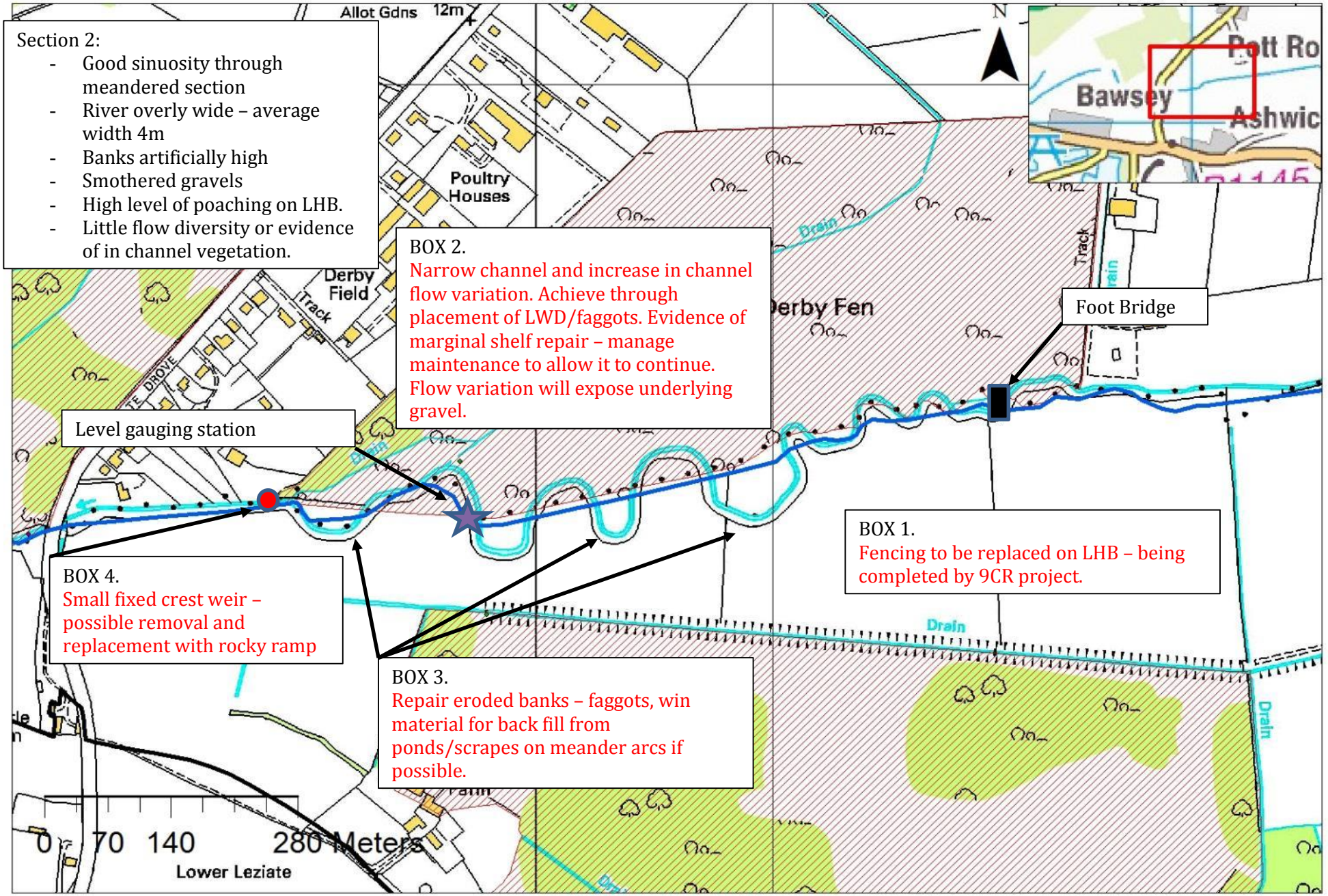


Figure 3 Proposed restoration options for Reach 2. Black text highlights current features. Red text indicates proposed measure.

2.3 Reach 3 – Leziate drove to Dismantled railway

2.3.1 Current state

The top of this section is marked by Sugar Fen SSSI on the right hand bank, which shows the most variation in channel, Photo 5, with the lower reaches being marked by straightened, uniform channels with little flow variation, Photo 6. The channel is 2.5-3m wide at the top of the reach with some sections narrowing to 1m wide downstream. The banks are generally high and steep ranging between 1-3m high undulating along the rivers course. Grazing pastures dominate the surrounding land use. The northern bank is well fenced along the reach with the southern edge periodically fenced. An access track is seen along the river's edge to the south.

Photo 5. Sugar fen, showing channel riffle and over-hanging cover.

Photo 6 the uniform sections of the lower reach, taken looking upstream from the right hand bank.

There are patches of over-hanging cover present throughout the stretch, Sugar Fen SSSI notes tree lined sections with some coarse woody debris in the channel, with additional trees seen on the true left hand bank to the bottom of the reach near the dismantled railway. The banks are lower on the true left hand bank through this section. Trees and scrub line much of the true left hand bank through the bottom of the reach with limited cover on the right hand bank.

Gravels are present throughout the reach in where flows are higher. Riffles are seen along the edge of Sugar Fen and lower through the narrower stretches. Where the channel widens and flows slacken the bed becomes dominant with sand and silt.

Some bank protection is seen through the lower section with wooden revetment lining the southern bank, Photo 7. Through the mid-section of the reach the southern bank shows a high embankment which slopes up gradually over 10-15m, with a fence running along the top. This is typical of the reach, with the southern back rising quicker up the valley sides than the northern, flatter floodplain.

Photo 7 Showing wooden revetment on left hand bank.

This reach is currently maintained by the King's Lynn Drainage board, accessed from the right hand bank for the lower section of the reach, switching to the left hand bank half way through. All in-channel vegetation is removed and one bank cut. No in-channel vegetation was seen through this survey. Longer grasses such as reed-sweetgrass, *Glyceria maxima* and creeping bent, *Agrostis stolonifera* are seen on the wild bank. Reports of water cress (or fools watercress, *Apium nodiflorum*) clogging the channel are noted.

A gauging station marks the top of the reach with a concrete flume, Photo 8. One access bridge is seen through the middle of this section providing vehicular access on a rough track. Field drains are evident draining the surrounding land use.

Photo 8 Environment Agency gauging station at Sugar Fen

2.3.2 Proposed restoration options

The channel is very uniform throughout this stretch, lacking in wetted margins and berms. Opportunities are presented throughout the reach to increase these habitats by re-profiling the banks, creating a two-stage channel, BOX 1 and BOX 2. Particular opportunities are seen on the northern edge through Sugar fen and through the middle section. The lower section is wooded, with already reduced bank heights creating wet woodland, therefore no opportunities are seen here.

Gravels are present where flows are faster, by increasing the flow diversity through the creation of wetted berms/marginal fringes additional natural gravels may be excavated. Restoration options are shown in Figure 4.

2.3.3 Proposed maintenance regime

This reach is currently cut on an annual basis, removing all in-stream vegetation and one bank. At the present morphology this programme will need to continue with reports of large beds of water cress choking the channel. With the creation of wetted berms and two staged channels the increased flow diversity should hopefully reduce the need for such a rigorous maintenance regime.

It is proposed that a full macrophyte survey is undertaken through the survey season (May-July) to record growth and determine full required extent of cutting requirements. This is proposed to be reviewed on a regular basis to ensure that un-necessary maintenance isn't carried out and natural processes allowed to develop around the proposed restoration when implemented. Consideration for field drainage will also be made throughout this process to ensure ample drainage.

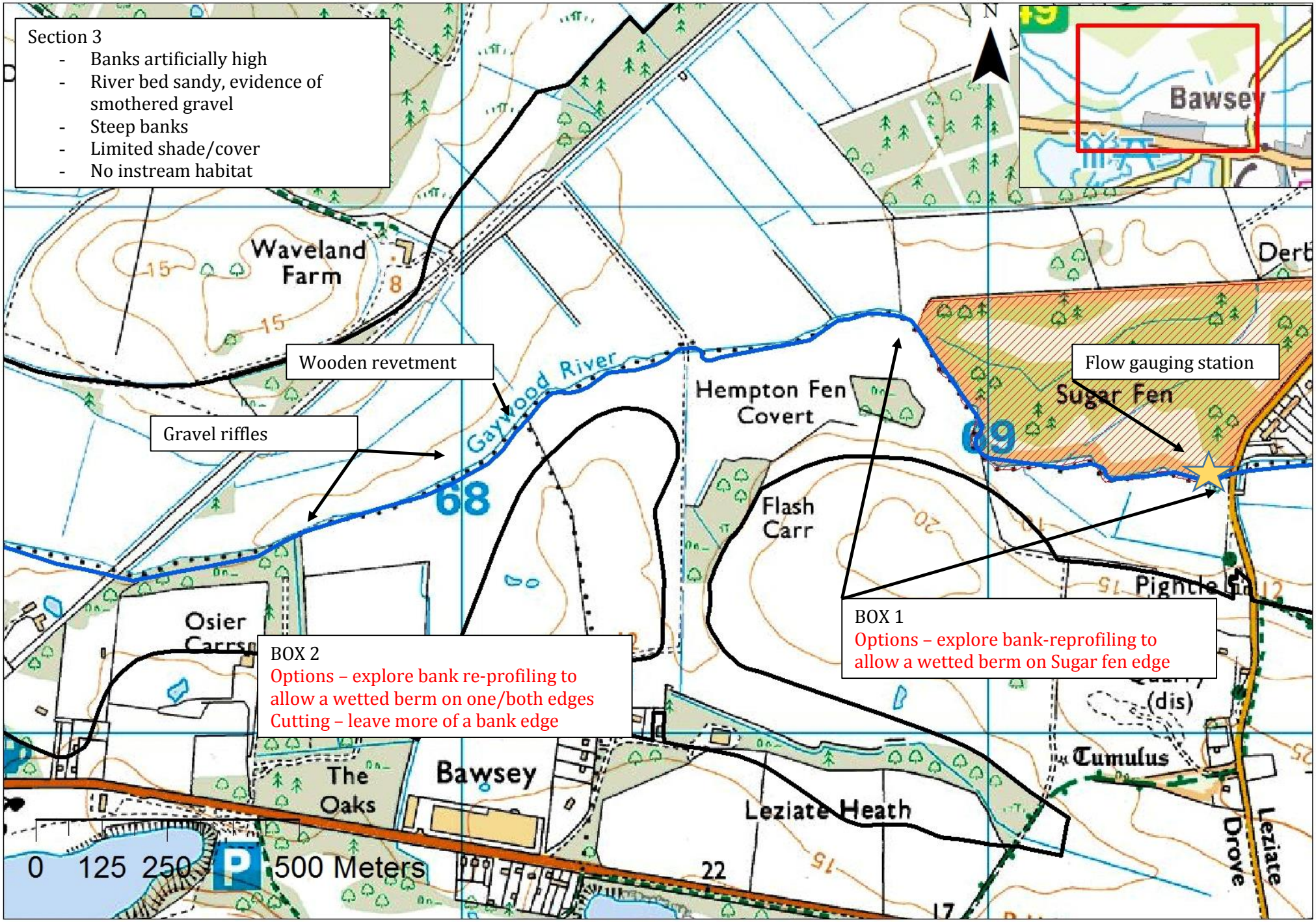


Figure 4 Proposed restoration and maintenance measures for Reach 3 and the top of Reach 4. Black text states current features/state, red text states proposed measure

2.4 Reach 4 – Dis-used railway to A149 Queen Elizabeth Way

2.4.1 Current state

Further down the catchment the river becomes more managed and modified, becoming straightened and uniform. Widths vary from 2-4m wide with steep (45°) banks ranging from 1.5-4m high. Both banks are fenced, with grazing pasture dominating the landscape.

The channel is featureless throughout this stretch with uniform flows and little channel variation, Photo 9. The reach is managed by the King's Lynn IDB cutting the in-channel vegetation and one bank. Bankside cuttings reveal reed sweetgrass, *Glyceria maxima,* common reed, *Phragmites australis* and creeping bent *Agrostis stolonifera*.

Photo 9 highlighting the uniform nature of the reach.

Limited cover is seen through this stretch. A few trees/scrub are seen, largely boarding drains entering the water course. Several drains enter the reach, those from the southern bank being dis-coloured with ochre and potentially pollution. Several historic pollution incidents are known through this stretch.

The southern, left hand bank, displays high level terracing to the eastern, upstream, end of the reach, with an upper terrace of a 4m high embankment, Photo 10. Fencing is present on the lower terrace 1-2m high, but is poorly maintained. Two vehicular bridges cross the reach, the lower housing telemetry on the downstream side.

Photo 10 showing the terracing on the left hand bank.

The fields to the north show some large scrapes set back from the river creating wetland habitat and a blocked drain, Photo 11.

Photo 11 Blocked drain and wet scrapes on field of right hand bank.

2.4.2 Proposed restoration measures

The channel is very uniform throughout this stretch, lacking in wetted margins and flow variation. Opportunities are presented throughout the reach to increase these habitats and flow diversity by re-profiling the banks, creating a two-stage channel, increasing capacity whilst narrowing the low-flow channel, BOX 1. It is proposed to carry out this measure through as much of the reach as landowner consultation will allow. This could possibly been done in combination with Environmental Payments.

Gravels are present where flows are faster, by increasing the flow diversity through the creation of wetted berms/marginal fringes the sandy bed may be scoured, exposing the underlying gravels. Restoration options are shown in Figure 5.

Norfolk Rivers Trust has previously explored a project through this reach to create a large scale wetland mosaic and improved river system. This was not progressed due to land owner concerns. Therefore restoration options have been kept fairly small throughout this reach, and little opportunities may be presented.

2.4.3 Proposed maintenance regime

This reach is currently cut on an annual basis, removing all in-stream vegetation and cutting one bank. At the present morphology this programme will need to continue with reports of large beds of water cress choking the channel. With the creation of wetted berms and two staged channels the increased flow diversity will negate the need for such a rigorous maintenance regime.

It is proposed that a full macrophyte survey is undertaken through the survey season (May-July) to record growth and determine full required extent of cutting

requirements. This is proposed to be reviewed on a regular basis to ensure that un-necessary maintenance isn't carried out and natural processes allowed to develop around the proposed restoration when implemented. Consideration for field drainage will also be made throughout this process to ensure ample drainage.

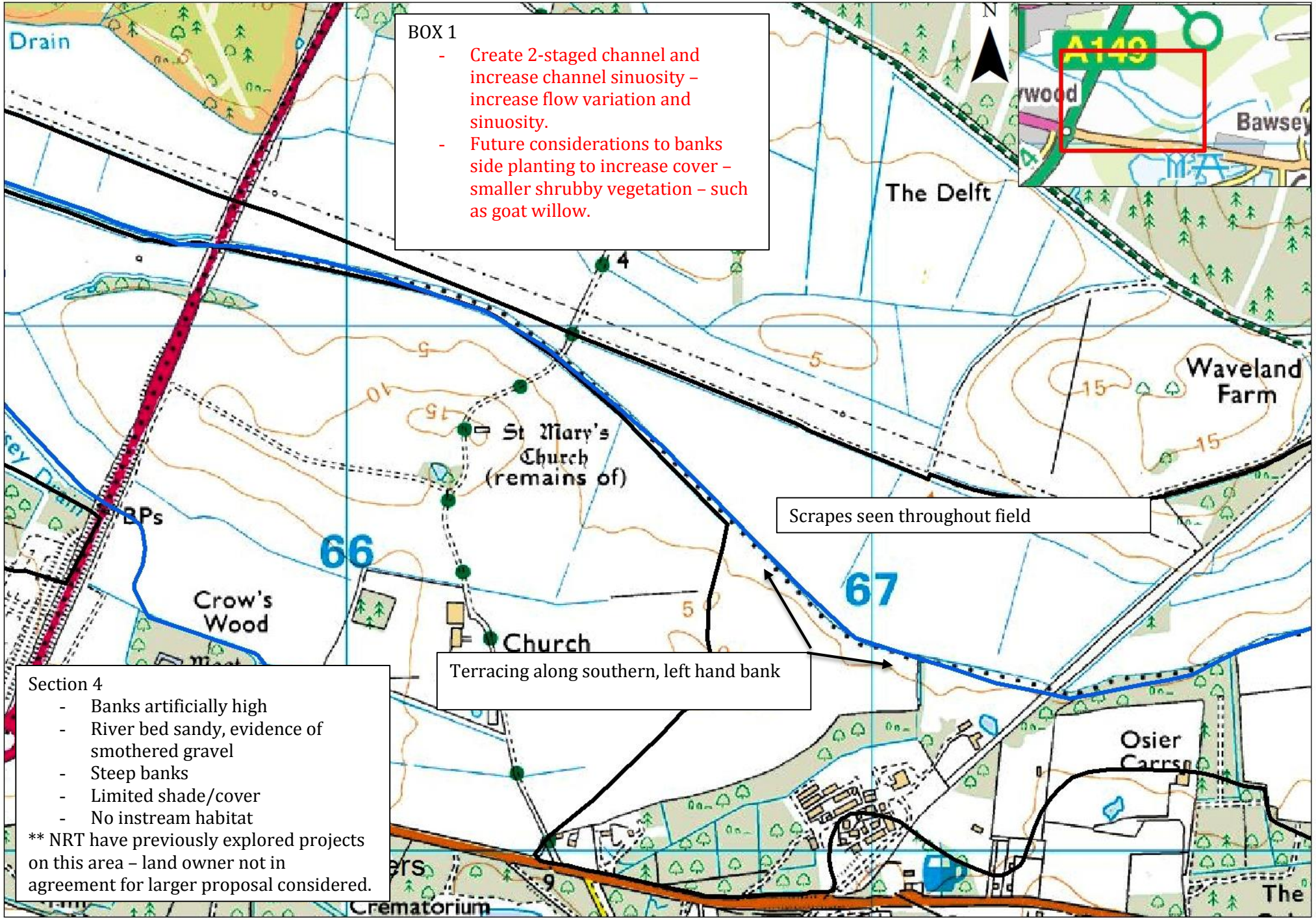


Figure 5. Proposed restoration and maintenance options for Reach 4. Black text outlines current features, red text indicates proposed actions.

2.5 Reach 5 –A149 Queen Elizabeth Way to A148

2.4.1 Current state

This Reach of the Gaywood marks the transition from the upper rural reaches to a more urbanised environment. The river is perched through the reach with the floodplain below the river level, being more pronounced at the eastern section and lessening as the river travels west. The river is 4m wide with banks 1m high.

The river is featureless with uniform flows and no bank features, Photo 12. The river is maintained by the King's Lynn IDB, cut from the southern, left hand bank removing all in channel vegetation and cutting the banks. No vegetation was seen throughout the survey, but previous visits to the site have shown evidence of fools watercress *Apium nodifflorum* and floating pondweed *Potamogeton natans* in the channel. These demonstrate the slow flowing, ponded nature of this stretch.

Photo 12 showing the limited in channel features of the reach.

Two drains enter the river through this section, the first via a pumping station which drains the land to the south of the river, discharging into the Gaywood about a third of the way down the reach. The second is to the middle of the reach, where a drain enters from the north via a gravity outfall. This drain is often discoloured, with a floating scum on the surface, Photo 13. At the eastern end the Gaywood enters the urban fringes, with a footbridge crossing the river and a marked increase in litter in the river.

The undeveloped area to the south of the river is owned and managed by the King's Lynn Board. This was bought as a flood storage area to improve drainage of the upper catchment without compromising flood risk through the lower reaches where the river becomes tide-locked. To date the storage area has not been formalised so would operate naturally with water levels overtopping the river in high flows.

Photo 13 Showing discoloured water and scum on the top of the drain to the north of the Gaywood.

2.4.2 Proposed restoration measures

The channel is very uniform throughout this stretch, lacking in wetted margins and flow variation. Few opportunities are presented throughout the reach to increase these habitats and flow diversity by re-profiling the banks under the current site configuration. One opportunity to create a two-stage channel is seen at the western extent. This would allow a narrower low flow channel to be created with a wetted berm. This area is located between the footbridge and A148, as shown in Figure 6, BOX 1.

Norfolk Rivers Trust are currently exploring restoration options for the area to the south of the river which is owned and managed by the King's Lynn Board. This proposal will be submitted separately.

2.4.3 Proposed maintenance regime

This reach is currently cut on an annual basis, removing all in-stream vegetation and one bank. At the present morphology this programme will need to continue with reports of large beds of water cress choking the channel. With the creation of wetted berms and two staged channels the increased flow diversity may allow for some reductions in weed cutting through this stretch. Due to the location of the reach on the edge ok King's Lynn this would need to be carefully modelled and considered.

It is proposed that a full macrophyte survey is undertaken through the survey season (May-July) to record growth and determine full required extent of cutting requirements. This is proposed to be reviewed on a regular basis to ensure that un-necessary maintenance isn't carried out and natural processes allowed to develop around the proposed restoration when implemented. Consideration for field drainage will also be made throughout this process to ensure ample drainage.

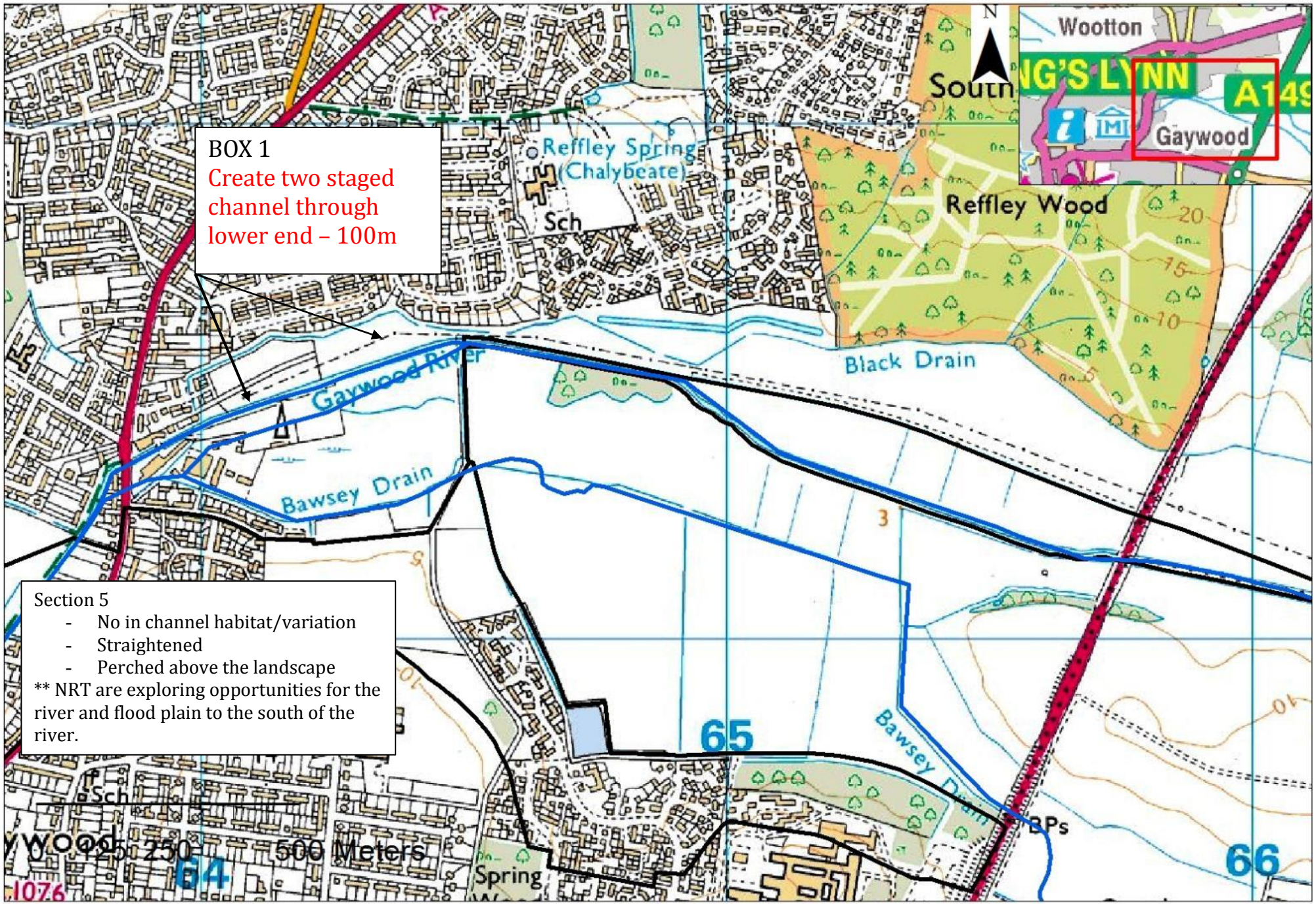


Figure 6 Proposed restoration and maintenance options for Reach 5. Black text outlines current features, red text indicates proposed actions.

2.6 Reach 6 – A148 to A148 through Lynn Sports Park

2.6.1 Current state

The Gaywood becomes urbanised through this section running between houses and a sports park, Lynn Sport. The river here is wide and shallow with high embankments. The river is hidden from view from the park, sunken in the landscape and borders private gardens from the eastern edge. The river is straightened and uniform with a mix of artificial bank protection through the east.

Towards the lower end of the reach the river runs through housing with wooden toe boarding and steep banks. The downstream extent of the reach runs past some allotments, with high steep banks with artificial revetments. The reach is remnant of an urban river with little in channel features and modification.

Little vegetation was seen in the channel through this reach, which is a true reflection of growth throughout the year. Therefore, no maintenance is currently required. Multiple road and pedestrian crossings are seen through this stretch, highlighting its urban environment.

Litter and scum was evident within the channel in multiple places.

Norfolk Rivers Trust have received some un-confirmed reports of signal crayfish *Pacificastacus leniusculus* through this section.

2.6.2 Proposed restoration measures

The channel through the Lyn Sport Park shows opportunities to improve the riparian edge of the river and increasing its sinuosity, BOX 1. By creating a terraced channel through this section the banks of private gardens could be better protected with increased flow variation introduced. This would be achieved by building a lower berm from woody faggots on the left hand bank, and backfilling with material. These berms could be introduced at interval down the reach to impose a sense of sinuosity. The right hand bank could potentially be moved and re-profiled to add to the diversity if space allowed. This would benefit the river channel and local community.

This proposal could be achieved through the current housing developments which are proposed in this area. Norfolk Rivers Trust have previously contacted Norfolk County Council with regards to this plan with interest in developing the project with a positive outcome. This has not since been progressed doe to time pressures on other projects, but is hoping to be picked up in the spring/summer.

An additional section through the allotments downstream of Lynn Sport also offer the opportunity for berm creation, BOX 2. Additionally here you could install floating islands, which are rafts of vegetation that are fixed to a wall, moving with river levels. These have proven successful at increasing habitat without impacting of channel capacity or conveyance.

A signal crayfish survey is proposed through the reach in the appropriate window to substantiate potential presence of signal crayfish.

2.6.3 Proposed channel maintenance

As little vegetation growth is seen through the reach, no maintenance is currently required. .

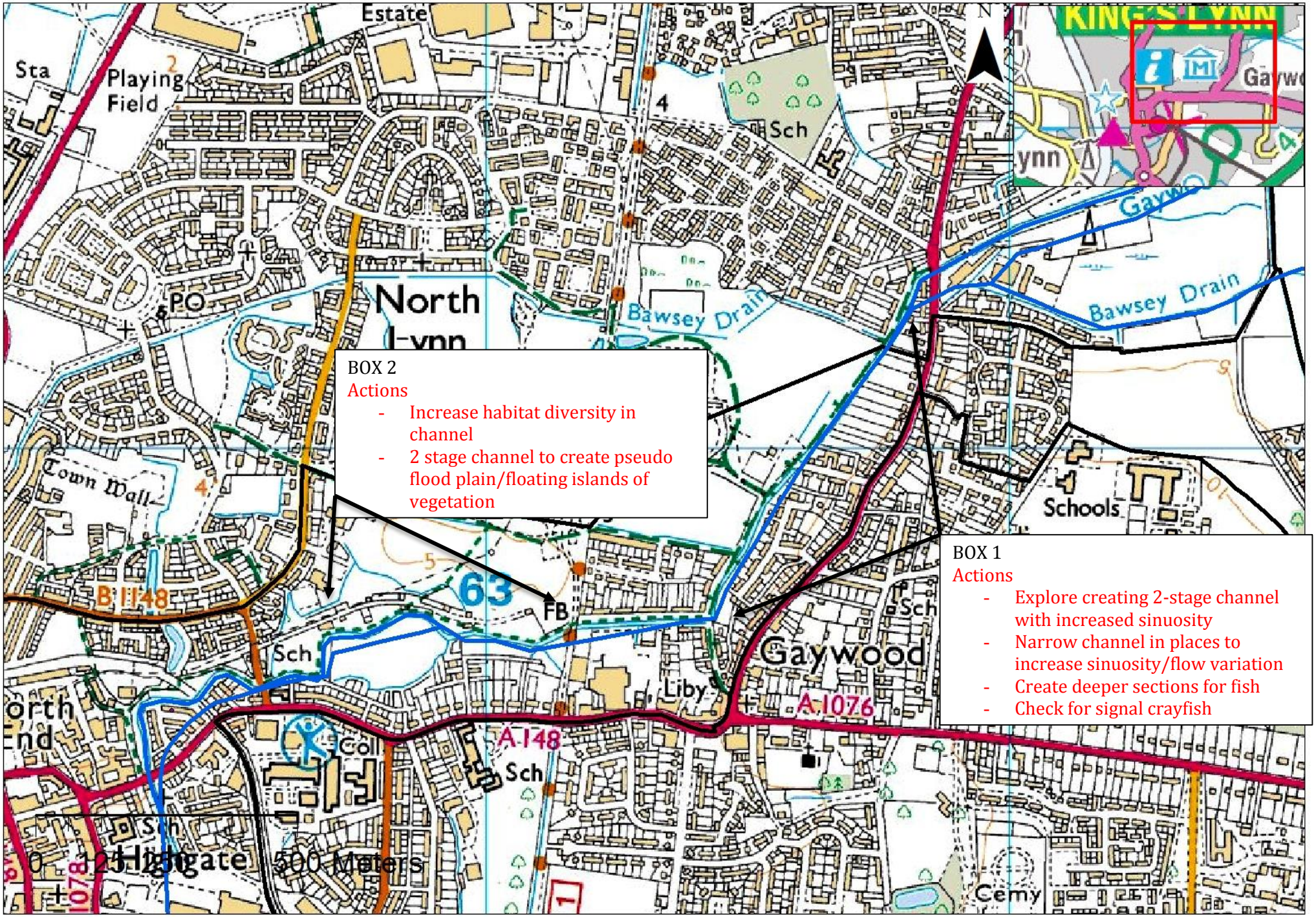


Figure 7Proposed restoration and maintenance options for Reach 6. Black text outlines current features, red text indicates proposed actions.

2.7 Reach 7 – A148 - Outfall

2.7.1 Current state

The Gaywood River runs through domestic housing areas and industrial sites at the top of this section before running through The Walks and finally to its outfall with the Great Ouse through the Millfleet structure which marks the end of the IDB's jurisdiction. The river runs throughout culverts for periods of this reach.

The top section of this site near Kettlewell Lane has had restoration efforts undertaken, improving the green space and the river. These measures have seen scrubby vegetation cleared, banks repaired and the channel modified slightly to increase flow variation, Photo 14.

Photo 14 The River Gaywood at Kettlewell Lane.

The Walks Park represents the most open stretch of river through a heavily manicured gardens. The river displays artificial wooden banks through the section and is wide and uniform. Banksides are vegetated with planted species for aesthetic purposes. Towards the lower end of the walks there are erosion problems that run past the school, causing sedimentation inputs and un-stable banks. High numbers of ducks are present through the stretch causing erosion of the banks and contributing to decreased water quality. The Walk's Rivulet is also seen within the park, originally constructed to take water to swimming baths, this runs parallel to the river with a similar characteristic.

2.7.2 Proposed restoration measures

Seven Sisters drain joins the channel at the lower end of the walks providing an informal overflow channel for the river whilst draining surrounding housing estates. This drain was enhanced in March 2015 to include a more sinuous channel, areas of open water and bankside planting. The structure at the southern end was uncovered, Photo 15.

Photo 15 Seven Sisters drain project, before planting, but after excavation of new channel.

Bank protection below The Walks is also proposed, using the most sustainable methods possible. It is likely that soft-engineering methods will be insufficient to support these banks, but a solution should include maximum environmental benefits.

2.7.3 Proposed maintenance regime

Due to the highly urban environment of this stretch and the implied flood risk, current maintenance plans should continue to ensure no increase to flood risk. The channel is highly modified through this reach with little opportunity for improvements.

Figure 8 Figure 7 Proposed restoration and maintenance options for Reach 7. Black text outlines current features, red text indicates proposed actions.

3. Summary and future considerations

3.1 Summary

The River Gaywood is a small chalk stream in north-west Norfolk that springs from the chalk aquifer to the east near Well Hall before running west eventually joining the Great Ouse in King's Lynn. The river migrates from a rural environment dominated by agriculture and pasture to a highly urbanised environment. The river can be broadly split into four sections:

1. Reach 1 - The top section showing more naturalised features and natural processes with typical chalk stream character. Flow is varied with an abundance of exposed gravel and large woody debris features. The river is heavily tree lined through this section preventing regular maintenance access.
2. Reaches 2 & 3 - The middle section marks the movements into a more managed modified channel. Reach 2 shows a previous re-meandering project which has been partially degraded through heavy poaching. These sections border two SSSI sites which improve the ecological diversity of the reach which is otherwise lacking in features. The channel is overly wide, with high banks and uniform flow. These areas present the largest opportunities for restoration options.
3. Reach 4 & 5 – These sections continue the progression into an urbanised channel with a uniform channel and unbroken flows. The banks are high to the east, reducing in height to the west where the river becomes perched above the floodplain. Restoration options here are centred on the creation of a two-stage channel increasing channel capacity whilst allowing a narrower low flow channel to improve flow variation and wetted marginal habitat.
4. Reach 6 & 7 highlight the urban reaches of the river with artificial banks and wide uniform channels. The river is featureless, with litter present within the channel. Opportunities for restoration in this area are centred on the urban parks where space is more abundant.

The measures proposed are designed to increase flow diversities with the aim to decrease the need for mechanical maintenance of the river system and to increase the ecological biodiversity. This in turn works to contribute to the Water Framework Directives Ecological status determination and prevent deterioration from current status. These are outlined in *Table 3*.

Restoration measure proposed	**Opportunity to implement measure (Km/Ha)**	**Reach opportunity is present within**
Channel narrowing/two-stage channel creation/wetland creation	6.5Km	2,3,4,5
Bank re-profiling and repair	0.8Km	1,2,3

Table 3 Summary of restoration measures and areas identified.

The measures proposed can be both undertaken as part of general maintenance where possible and run as part of a larger restoration scheme. Funding would need to be secured between the Board and Norfolk Rivers Trust to ensure to success and completion of this proposed plan.

3.2 Future considerations

3.2.1 Climate change

With expected rises in air temperatures through climate change it is expected that water temperatures in rivers will also rise. This poses a significant risk for the river life, most notably fish species such as trout whose egg survival rate is significantly impacted upon by small changes in temperature. Therefore, a future consideration to the river would be the need to add cover, allowing shade to help regulate temperatures. As well as being important for spawning fish, it will also ensure resilience of the whole ecosystem to climate change and help regulate plant growth and habitat connectivity. Long stretches of river with no cover can pose a significant barrier to migrating species.

Current concerns around bankside planting are centred on access requirements, potential threats to flood risk and ongoing maintenance issues. Planting has therefore not been suggested as part of this plan through the lower sections. It will however need to be considered further in the future, with aspirations to increase tree cover added to the mitigation measures for the second River Basin Management Plan.

3.2.2 Population growth

Population growth and the increased need for water, both for domestic and agricultural use is a growing concern for chalk streams. Being predominantly aquifer fed, an increase in abstraction from the aquifer and instream agricultural abstraction can act to drop water levels in the river impacting on flows and available habitat. The restoration proposals above aim to introduce channel narrowing, both in the form of berm creation and two-stage channel creation to help mitigate against reduced flows. This will aid the resilience of the system to climate change.

As the Gaywood runs through the centre of King's Lynn an increase in population growth will also place pressure on the river with increased development and drainage requirements. It is important to consider space for the river and any impacts on increased urban drainage on water quality.

4. References

Environment Agency, 2009. 'River Basin Management Plan – Anglian District - Anglian Water River Basin Management Plan

Natural England, 2013. 'Condition of SSSI Units for Site Leziate, Sugar and Derby Fens'. https://designatedsites.naturalengland.org.uk/ReportUnitCondition.aspx?SiteCode=S1002837&ReportTitle=LEZIATE,%20SUGAR%20AND%20DERBY%20FENS

5. Appendix 1 – Monitoring points on the Gaywood.