Slade Brook NFM

Appendix B - NFM walkover assessment.

Draft Technical Note

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Contents

List of Figures

List of Tables

1 Geomorphological and Ecological Introduction

Geomorphological and ecological walkovers were completed on 12/12/2023 and then again on 12/03/2024 after further opportunities had been identified.

On the 12/12/2023 walkover the following sites were assessed:

- Site 2 Violet Lane Upstream
- Site 3 Violet Lane Downstream
- Site 4 Prologis/Linear Park Walking Paths
- Site 5 Meadow Road Park
- Site 6 Kettering Town Cricket and Sports Club
- Site 7 Thorpe Reservoir
- Site 8 Cransley Reservoir
- Site 9 Coppicemoor Spinney

During the site visit the weather was cold with temperatures of 5 - 8 °C, the sky was grey with some drizzle and patches of rain. River levels were raised due to high rainfall and frequent storm events experienced throughout the autumn. The water level was falling but measured at 0.3mAOD at 10:15am which is within the normal range of 0.08 to 1.30mAOD for the River Ise level at Slade Brook (https://riverlevels.uk/ise-barton-seagrave-slade-brook).

On the 12/03/2023 walkover the following sites were assessed:

- Site 2 Violet Lane Upstream
- Site 3 Violet Lane Downstream
- Site 4 Prologis/Linear Park Walking Paths
- Site 9 Coppicemoor Spinney
- Coppicemoor Brook - Middle Ground
- Coppicemoor Brook - Underwood Hill Spinney

During the site visit the weather was cold with temperatures of 7 - 12 °C, in the morning there was heavy rain which slowly broke up through the day and was sunny in the late afternoon. River levels were high at 0.26mAOD which is within the normal range for the River Ise level at Slade Brook (https://riverlevels.uk/ise-barton-seagrave-slade-brook).

Geomorphology assessments are typically conducted from upstream to downstream in order to assess the processes as they occur in the channel. This report will make it clear which project area each survey site/photo location is within for clarity.

The site survey was conducted at opportunity sites as shown in Figure 1-1.

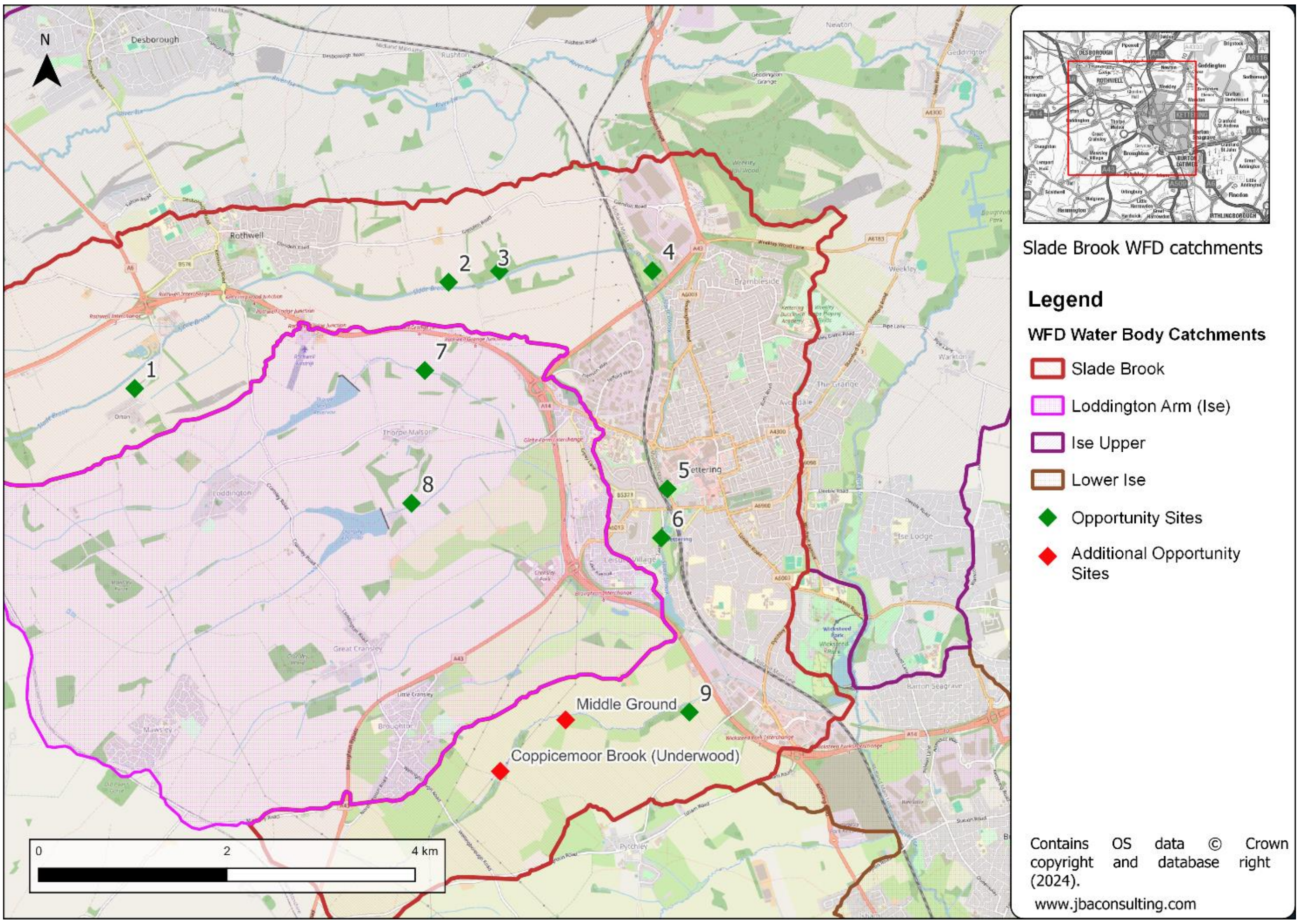

Figure 1-1 Opportunity site locations.

1.1 Site 2 Violet Lane Upstream

For both visits to site 2, the upstream side of Violet Lane (Figure 1-2), permission had not been granted to access the land. In this upper reach of the Slade Brook, the channel is tree lined whilst running through neutral grassland pasture (Figure 1-3 to Figure 1-4). From the road it appears that the channel is trapezoidal, disconnected from its floodplain and has minimal buffer zone along the right bank. The riparian zone consists of deciduous trees, dominated by Elm *Ulmus* and Willow *Salix* species which line the banks, the banks are short and steep. The fields look like they've been changed from arable to pasture.

The water was turbid and fast moving so the riverbed substrate was not visible during the site visit.

The valley appears to be very confined, short, and therefore limited for space for a floodplain. However, there could be scope to increase some space for water in the valley and lower the surrounding land in order to create a wet woodland.

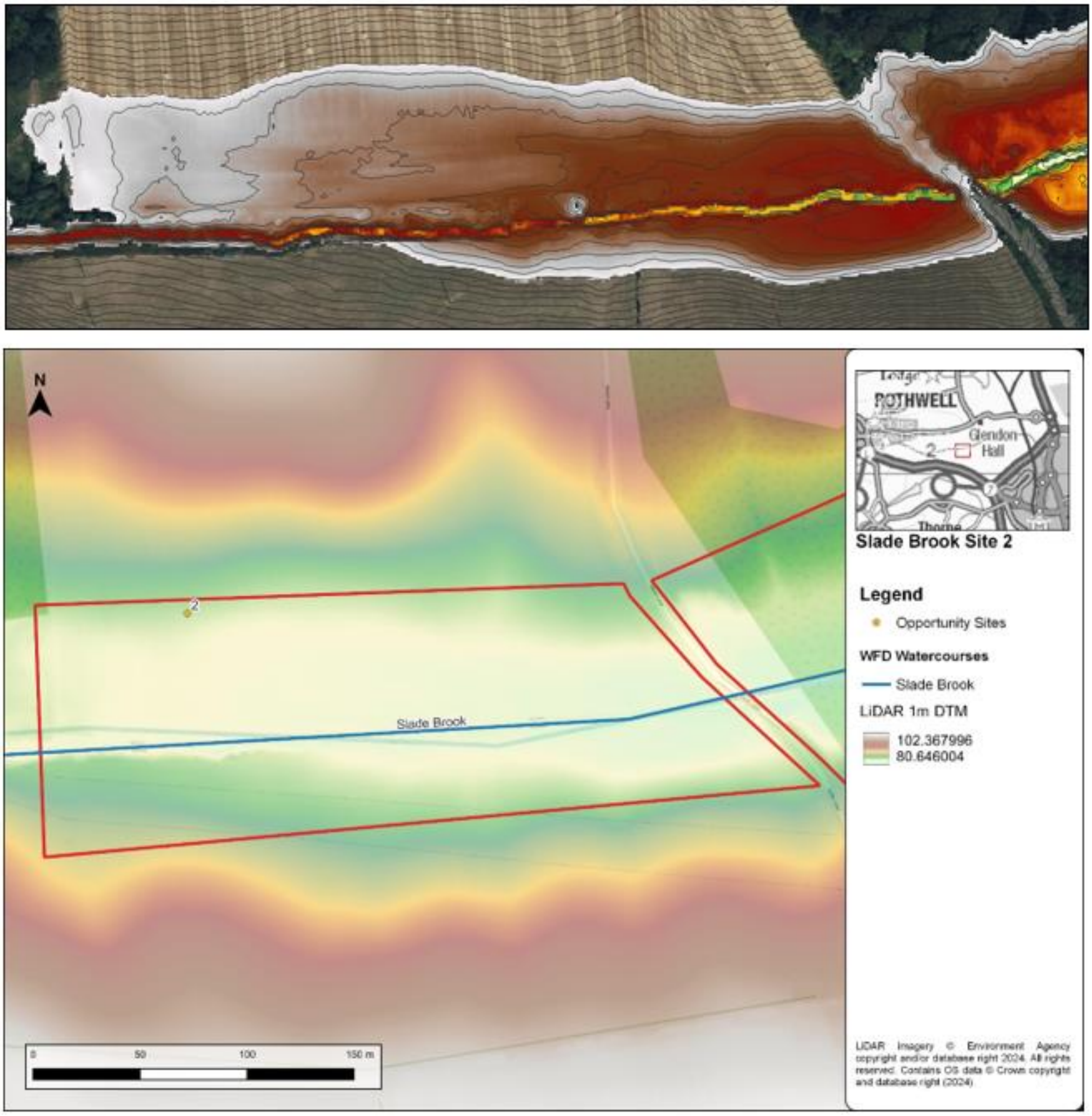

Figure 1-2 Location of Slade Brook in the vicinity of Violet Lane with LiDAR. Contour lines shown at 0.25m increments.

Figure 1-3 Standing downstream on Violet Lane looking at the left bank and floodplain of Slade Brook

Figure 1-4 Standing downstream on Violet Lane looking upstream at the right bank and floodplain of Slade Brook

Table 1-1 Opportunities for Site 2 Violet Lane Upstream

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement. Should be combined with other opportunities. Has potential to increase flood risk upstream, requires investigation. Potential impacts on road culvert would need consideration.
Increase the riparian zone	Set bank fencing on right bank and create buffer/riparian zone.	Requires landowner engagement.
Increase connectivity to the floodplain	Widen the channel corridor and lower the banks to allow connectivity of the channel with the floodplain on the fields.	Requires landowner engagement.
Create a wet woodland	Widen the channel corridor and lower the banks to allow connectivity of the channel with the floodplain into the woodlands and plant more trees in the fields.	Requires landowner engagement.

1.2 Site 3 Violet Lane Downstream (Glendon Wood)

Conditions at Site 3 were observed on both site visits (12/12/2023 and 12/03/2024) (Figure 1-5). During both site visits, conditions were similar and are compared in the photos below.

Overall, the site downstream of Violet Lane the Slade Brook runs through a deciduous woodland which mainly consists of Elm with Sycamore *Acer pseudoplatanus*, Oak *Quercus robur*, Hawthorn *Crataegus monogyna*, Elder *Sambucus nigra* and Ash *Fraxinus excelsior*. The ground flora included Lesser Celandine Ficaria verna, Dog's Mercury Mercurialis perennis, Garlic Mustard Alliaria petiolata, Lords and Ladies Arum maculatum, Common Nettle Urtica dioica, Current *Ribes* sp. Evidence of Badger (latrines and paths) were evident through the woodland.

Hard-core debris has been fly-tipped into the Slade Brook from Violet Lane which it located roughly 10 metres downstream of the Violet Lane culvert (Figure 1-6 to Figure 1-7). This material consists of coarse bits of concrete and builders' rubble which is causing erosion of the Violet Lane bank and culvert. It is recommended that this material is removed from the channel as it is not natural and is causing adverse impacts to the watercourse and stability of the Violet Lane banks.

The channel is slightly recovered from upstream but is still largely straight and trapezoidal. Woody debris has been allowed to fall and remain in the channel. The channel appears quite responsive to woody material and has begun to influence geomorphic processes by scouring the banks and creating pockets of erosion and deposition into the channel Figure 1-7 and Figure 1-9). The sinuosity is slowly recovering and allowing for diverse features to develop such as riffles, marginal bars and diverse flow biotopes.

Same as Site 2, Violet Lane Upstream, the valley is confined with limited space for floodplain reconnection however there is evidence in the LiDAR of interactions of the water to the wider valley and perhaps this can be encouraged to be reconnected.

The water is turbid and it is likely that much of the sediment in the channel is derived from channel banks as they appear highly erosive (Figure 1-10). However, the surface water flow is inputting high amounts of sediment into the channel as well.

Surface water channels were noted to be freely draining into the Slade Brook. In Figure 1-12 for example, the water is freely draining the floodplain and passes through a culvert before entering the Slade Brook. The water is highly turbid and inputting a significant amount of sediment into the channel. An opportunity exists here to partially block the channel with a leaky barrier/dam to slow the flow and store more water on the floodplain, creating a wet woodland (Photo location 6 - Figure 1-12).

Figure 1-5: Slade Brook - Site 3 photo locations.

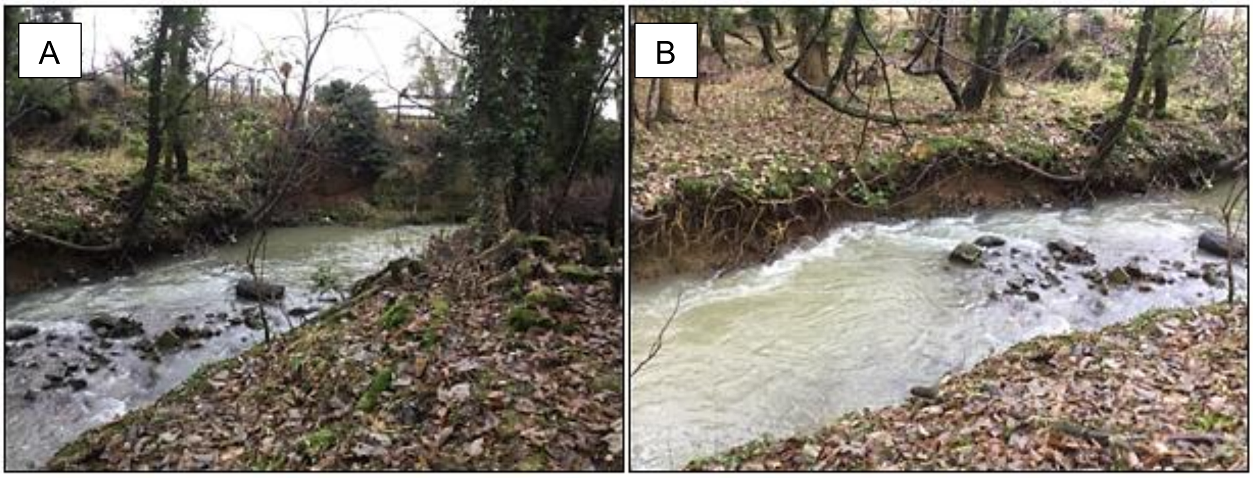

Figure 1-6 Photo location 1, standing on the left bank looking upstream at the Violet Lane culvert (12/12/2023).

Figure 1-7 Photo location 2, standing on the left bank looking downstream at some woody debris that has been deliberately added by the landowner into the channel (12/12/2023).

Figure 1-8 Photo location 1, standing on the left bank looking at the floodplain. The floodplain was holding water although it was not clear whether this was water from a recent flood being held back or the result of surface water draining into the floodplain (12/03/2024).

Figure 1-9 Photo location 3, standing on the left bank looking downstream the in channel conditions(12/03/2024). In photo A, the channel is straight but in B the channel appears quite responsive to woody material and a riffle that has developed. The dashed white line indicates the area that has been eroded, slowly increasing the sinuosity and diversity of the channel.

Figure 1-10 Photo location 4, standing on the left bank looking across at a surface water flow entering the Slade Brook (12/03/2024). The dashed white line emphasises the sediment plume being generated by the surface water flow.

Figure 1-11 Photo location 5, standing on the left bank looking across at a woody debris spanning the channel at multiple locations (12/03/2024)

Figure 1-12 Photo location 6, on the left bank looking at a surface water channel draining into the Slade Brook (12/03/2024)

Figure 1-13 Photo location 6, on the left bank looking at a surface water channel draining into the Slade Brook (12/03/2024). The dashed white line emphasises the sediment plume being generated by the surface water flow.

Figure 1-14 Photo location 7, on the left bank looking at the conditions of the floodplain and a natural woody debris dam that has formed in the channel (12/03/2024)

Figure 1-15 Photo location 8, on the left bank looking at a surface water channel draining into the Slade Brook (12/03/2024)

Figure 1-16 Photo location 9, standing on the left bank looking across at a woody debris spanning the channel at multiple locations (12/03/2024)

Figure 1-17 Photo location 10, on the left bank looking at a surface water channels draining into the Slade Brook (12/03/2024). Photos B and C show, B) downstream at the confluence with the Slade Brook and C) upstream where there is a blockage of natural debris in the drainage channel.

Table 1-2 Opportunities for Site 2 Violet Lane Upstream

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement.
Increase connectivity to the floodplain	The channel is incised so the bed would require raising to reconnect to the floodplain and lower the banks where possible.	Potential to cause flooding upstream. Would need landowner permission.
Create a wet woodland	If it is possible to raise the water table, this could increase the connectivity into the woodland to create a wet woodland. This could possibly be achieved using principles of stage zero.	Could cause flooding upstream. Would need landowner permission.
Remove fly-tipped rubble	This rubble is destabilising the bank beneath the road. The material is oversized and causing negative impacts in the channel.	Requires survey to determine if any damage has been caused to the highway. Requires landowner and highways engagement.
Culvert removal and increase connectivity with floodplain	Removal of culvert on tributary and encourage water to flow through the floodplain (Figure 1-12)	Would need landowner permission.
Block drainage channels	Many surface water channels were noted on site which freely drain into the Slade Brook and had high levels of turbidity, increasing the sediment inputs into the channel.	Investigation required to ensure blocking up the channels will only wet up the floodplain in the woodland and not negatively impact other areas. Would need landowner permission.
Leaky barrier locations	Leaky barrier locations have been located where woody material had naturally accumulated and will seek to enhance these features rather than potentially negatively impacting existing features by installing leaky barriers at other locations.	Consideration in the design required given the likely higher velocities in this location.

1.3 Site 4 Prologis/Linear Park Walking Paths

The Linear Park site (Figure 1-18) was assessed on the 12/12/2023 and 12/03/2024 (Figure 1-27). At this site the Slade Brook enters the site via a culvert under the Midland Main Line Railway. At this upstream point of the site (Figure 1-19) the watercourse is confined within a narrow (water width approximately 2m) trapezoidal and straightened channel that is disconnected from its floodplain.

The banks are lined with trees and scrub including Willows, Hawthorn, Blackthorn *Prunus spinosa*, Oak, Great Willowherb *Epilobium hirsutum* and Pendulous Sedge *Carex pendula*, which provide a mosaic of shade for the channel. The vegetation interacts with the surface water by trailing into the water and stirring up the surface flow. The flow was a free-flowing run with little flow diversity however the water levels did appear higher than normal and there could have been features under the water that were not visible that influence flow diversity in lower flow conditions. The bed substrate was not visible due to the turbidity of the water during the site visit.

Further downstream at Photo Locations 2, 6 and 8 (Figure 1-20, Figure 1-24 and Figure 1-26) there does appear to be a two stage channel with a berms or benching running throughout the reach. It's not clear whether this is natural or as a result of modification or maintenance. The banks and riparian habitats are suitable for supporting Water Vole.

The Linear Park is part of the Prologis Industrial Estate which has a balancing pond to attenuate surface water input from the industrial estate at Photo Locations 3 and 4 (Figure 1-21 and Figure 1-22). The balancing pond can overspill into the Slade Brook via the overflow spill way which passes over the footpath.

Evidence of standing water on the right bank visible during the site visit (Figure 1-23 and Figure 1-25) with the ground is saturated through heavy rainfall over many months and the adjacent land to the west rises steeply up to the railway line. The footpath on the right bank was wet and muddy, the water was quite deep in places. The habitat along the right bank are less intensively managed, with large areas of tall grassland and groups of trees with mown cut paths. The left bank is representative of a typical parkland with highly managed grassland and defined areas of trees and scrub (Dandelion *Taraxacum officinale*, Perennial Rye-grass *Lolium perenne*, Cow Parsley *Anthriscus sylvestris*, Common Nettle, Cleavers *Galium aparine*, Broad-leaved Dock *Rumex obtusifolius*, Creeping Buttercup *Ranunculus repens*, Blackthorn, Meadowsweet *Filipendula ulmaria*, Rosebay Willowherb *Chamaenerion angustifolium*, White Clover *Trifolium repens*, Daisy *Bellis perennis*).

Figure 1-18 Location of Slade Brook in Prologis/Linear Park with LiDAR. Contour lines shown at 0.25m increments.

Figure 1-19 Photo location 1, upstream at the outfall of the Slade Brook from the culvert under the Midland Main Line railway (12/12/2023). Standing on the left bank looking A) downstream and B) across. The water was too turbid to see the river bed substrate. The flow was raised due to recent high rainfall.

Figure 1-20 Photo location 2, standing on the left bank looking downstream at the condition of the floodplain and channel (12/12/2023)

Figure 1-21 Photo location 3, this photo was taken on the path of the left bank, the Slade Brook is in the tree line on the right of this photo (12/12/2023). An overspill from the Prologis Industrial Estate balancing pond is seen crossing this footpath.

Figure 1-22 Photo location 4, the balancing pond for Prologis Industrial Estate (12/12/2023)

Figure 1-23 Photo location 5, water logged conditions on the right bank of the Slade Brook (12/12/2023)

Figure 1-24 Photo location 6, photo was taken on the right bank looking slightly downstream and across to the left bank (12/12/2023)

Figure 1-25 Photo location 7, water logged conditions on the right bank of the Slade Brook (12/12/2023)

Figure 1-26 Photo location 8, on a bridge looking upstream at Slade Brook and the outfall on the left bank (right of photo). The conditions were waterlogged on the right bank and there is a tarmac footpath on the left bank (12/12/2023)

Figure 1-27 During the 12/03/2024 site survey at A) photo location 7, and B) photo location 8. There were no notable changes to the site between the two site visits.

Table 1-3 Opportunities for Site 4 Prologis/Linear Park Walking Paths

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Should be combined with other opportunities. Has potential to increase flood risk upstream, requires investigation. Public perceptions and amenity value of the brook within a public park.
Increase space for water laterally	The channel is confined in what looks like a two-stage channel and the banks limit the movement of the water laterally. However, land on the right bank is waterlogged and difficult to traverse. Consider lowering the right bank and connecting to floodplain and into the woodlands to encourage wetland habitats.	Could cut off the public from accessing picnic areas and other amenities.
Install a boardwalk	There is a preferential walking route on the right bank to picnic benches and bins. To keep these connected and to include the public in this intervention a boardwalk could be installed to allow access to remain and allow the public to view the wetland. Alternatively a new footpath could be installed higher up the bank to the west to maintain an open route during time when the area is in flood or too boggy to walk on.	Maintenance upkeep of the boardwalk would need to be agreed with landowner.
Wetland creation	Creation of wetland, reedbeds, ponds and/or back waters.	Public safety and disturbance to wetland habitats. Existing paths may need to be modified. Public perceptions and amenity value of the brook within a public park.
Meander channel	The channel is straight through this section, meandering the channel to provide sinuosity and ecological/ hydrological variation. The brook would be lengthened, increasing the capacity of the channel.	Existing paths may need to be modified.

1.4 Site 5 Meadow Road Park

At Meadow Road Park (Figure 1-28) the Slade Brook is deeply confined and incised within a concrete channel on the western boundary of Meadow Road Park (Figure 1-29). At this site there is very limited access to the Slade Brook with only 40m of open channel. Scattered vegetation has begun growing out of the concrete and brick wall banks. It was not possible to see the riverbed substrate due to the turbidity of the water during the site visit.

A third culvert or outfall runs from the brook to the east. The ground surrounding the brook is raised by 3m above the riverbed level (Figure 1-28). Further to the southeast the ground is lower and waterlogged (Figure 1-30). Opportunities here could be costly but could potentially include lowering the ground at the brook, making space for water and water features and raise waterlogged areas to improve recreational use.

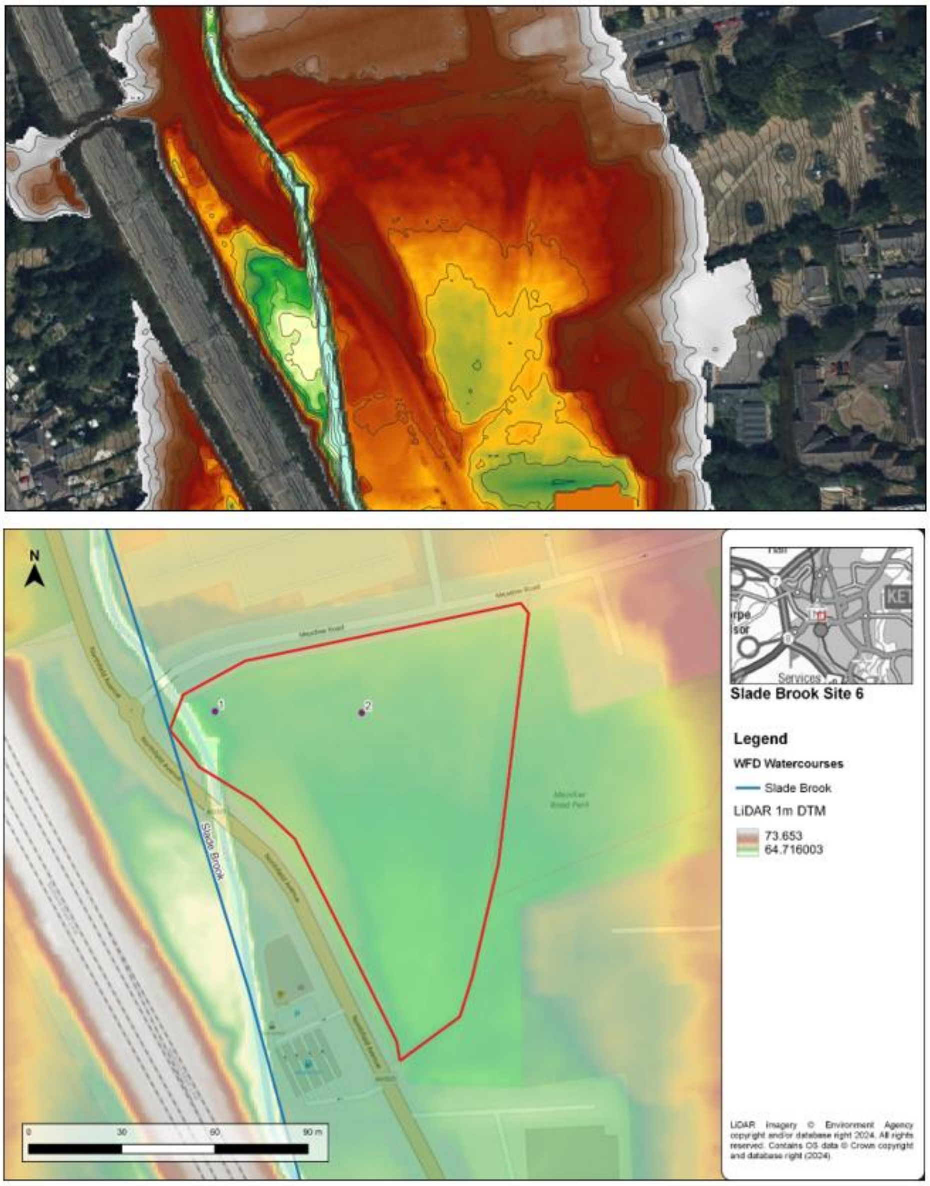

Figure 1-28 Location of the Slade Brook in Meadow Road Park with photo locations and LiDAR. Contours shown at 0.25m increments.

Figure 1-29 Slade Brook at Meadow Road Park A) standing downstream on the left bank and looking up to the Meadow Road culvert, B) standing upstream on the left bank looking downstream at the Northfield Avenue culvert. A third culvert or outfall enters the Slade Brook which is open up to the fence line in the park

Figure 1-30 Facing southeast of the field at the waterlogged conditions at Meadow Road A) Standing on the left bank of the Slade Brook at Meadow Road Park. B) The Slade Brook is to the right of the fence where a culvert or outfall is situated under the ground.

Table 1-4 Opportunities for Site 5 Meadow Road Park

Opportunity	Description	Constraints
Increase space for water laterally	The channel is confined in a concrete channel with limited space for natural processes. Potential to widen the space 10 - 20m and create a swale/sustainable urban drainage system (SUDs) feature. This opportunity could also help retain a small amount flood waters and help to slow the flow.	This opportunity requires identifying asset owner of the culvert/outfall. Would need to identify underground services.
Create a meander/pocket park	The channel is confined in a concrete channel with limited space for natural processes. However, land on the left bank is waterlogged and difficult to traverse, creating an unusable recreational space. Consider lowering the left bank and connecting to floodplain and create a pocket park where the public can connect with the watercourse https://news.leeds.gov.uk/news/first-look-at-plans-for-citys-new-waterside-pocket-park. This opportunity could also help retain a small amount flood waters and help to slow the flow if combined with other opportunities in the catchment.	Would require PSRA. This opportunity requires identifying asset owner of the culvert/outfall. Would require engagement with the council and community.
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Only if space is expanded, too short and difficult to enter and maintain. Should be combined with other opportunities. Has potential to increase flood risk upstream, requires investigation. Potential impacts to the culverts.

1.5 Site 6 Kettering Town Cricket and Sports Club

The Slade Brook is incised within a confined channel on the western boundary of Kettering Sports Club (Figure 1-31). The watercourse is confined within a narrow (water width less than 2m) trapezoidal and straightened channel that is disconnected from its floodplain (Figure 1-32 to Figure 1-33). The banks are lined with trees (mainly Willows and Ash) and scrub which interacts with the surface water by trailing into the water and stirring up the surface flow. The flow was a free-flowing run with little diversity. The bed substrate was not visible due to the turbidity of the water during the site visit.

A raised feature exists in the channel however its function is unknown. It may be a weir or it could be a utility pipe that is being protected. This is disconnecting the continuity of flow, preventing geomorphic processes, and potentially disconnecting aquatic organism populations.

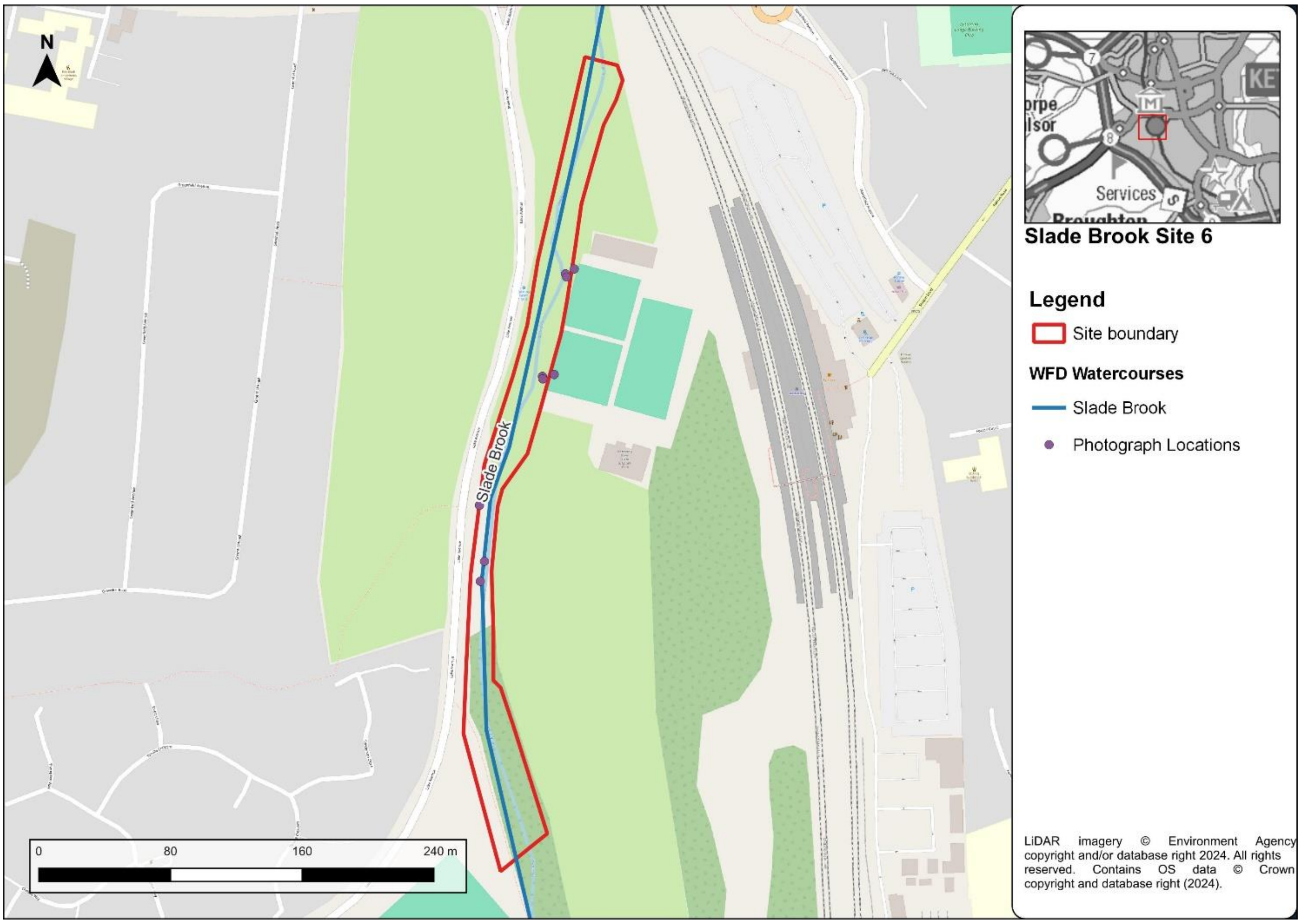

Figure 1-31 Location of Slade Brook on the boundary of Kettering Town Cricket and Sports Club

Figure 1-32 Looking downstream at Slade Brook (Left) looking upstream (right) at a raised feature (possibly weir) in the Slade Brook

Figure 1-33 On the right bank looking across to the cricket field at Kettering Sports Club

Table 1-5 Opportunities for Site 6 Kettering Town Cricket and Sports Club

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement. Has potential to increase flood risk upstream, requires investigation.
Increase space for water laterally	The channel is confined within a narrow trapezoidal and straightened channel with limited space for natural processes. Potential to widen the space 10m and create a swale/Sustainable Drainage System (SuDS) feature. This opportunity could also help retain a small amount flood waters and help to slow the flow. Marginal vegetation could be planted to improve ecological value.	This opportunity requires engagement with the landowner of the Cricket Club. Identification of asset owner of weir structure. Identification of underground services. Space needs consideration for maintenance or designing so that it requires minimal maintenance.
Create a pocket park	The channel is confined with limited space for natural processes. However marginal land on both banks could be lowered to create a pocket park where the public can connect with the watercourse https://news.leeds.gov.uk/news/first-look-at-plans-for-citys-new-waterside-pocket-park. This opportunity could also help retain a small amount flood waters and help to slow the flow if combined with other opportunities in the catchment.	Would require PSRA. This opportunity requires engagement with the landowner of the Cricket Club. Space is limited on the right bank between the brook and Lake Avenue.
Remove raised feature/weir	A raised feature is acting as a weir in the Slade Brook and disconnecting the continuity of the watercourse. An opportunity exists to remove this obstacle and improve in channel processes.	Feature requires investigation to understand its function and whether it can be removed.

1.6 Site 7 Thorpe Reservoir

The unnamed watercourse downstream of the Thorpe Reservoir is a tributary of the Loddington Arm (Ise). This watercourse is confined within a steep valley surrounded by Inferior Oolite group, a Jurassic sedimentary rock consisting of limestone, sandstone, siltstone and mudstone (Figure 1-34). The riverbed was mostly visible during the site visit and sediment in the channel consists of sandy patches overlain coarse gravels (Figure 1-36).
The channel here is straight, which is consistent along the whole brook. The banks are shallow with little buffer between the brook and the arable land. The brook is lined with trees and scrub, mainly Ash, Hawthorn, Willows, Blackthorn *Prunus spinosa*, Crab Apple *Malus sylvestris*, brambles *Rubus fruticosus* agg. and nettle *Urtica dioica*. A line of Willow trees have been planted along the field boundary on the left bank.

The conditions within the valley floor were wet, with waterlogged locations on the farm track (Figure 1-37 to Figure 1-38) which was likely increased due the presence of a spring. Springs are typical in this Northamptonshire landscape (Northampton Sand Formation) due to the Jurassic Oolite bedrock groups and where the aquifer intersects ground surface. This spring being ploughed and part of the arable field was likely increasing sediment connectivity to the watercourse as sediment movement (erosion and deposition) was visible within the wetted area.

Due to the Thorpe Reservoir upstream, the watercourse only receives a regulated flow which prevents flow diversity downstream. However, due to the landscape, the channel is within a steep valley with little surface roughness due to the ploughed arable fields and not much permanent vegetation or woodland to intercept rainfall and surface water flows. It is possible for flashy floods to occur even with the regulated flow from the Thorpe Reservoir due to the steep and smooth landscape characteristics. It did appear on site that the downstream extent of this watercourse that the discharge was higher than upstream (Figure 1-39), which could be due to the spring (Figure 1-37) and field drainage of the steep valley sides (Figure 1-35).

Another risk of this landscape is the potential to generate excessive sediment into the channel due to fresh ploughing and low vegetation cover of these fields in wet autumn and winter conditions. In this location, the Loddington Arm (Ise) Water Body is currently at 'Moderate ecological status' for Phosphates which has been identified in the RNAGs as diffuse source from agriculture, transport drainage and sewage discharge. Therefore, in this location phosphate inputs are likely generated on these slopes.

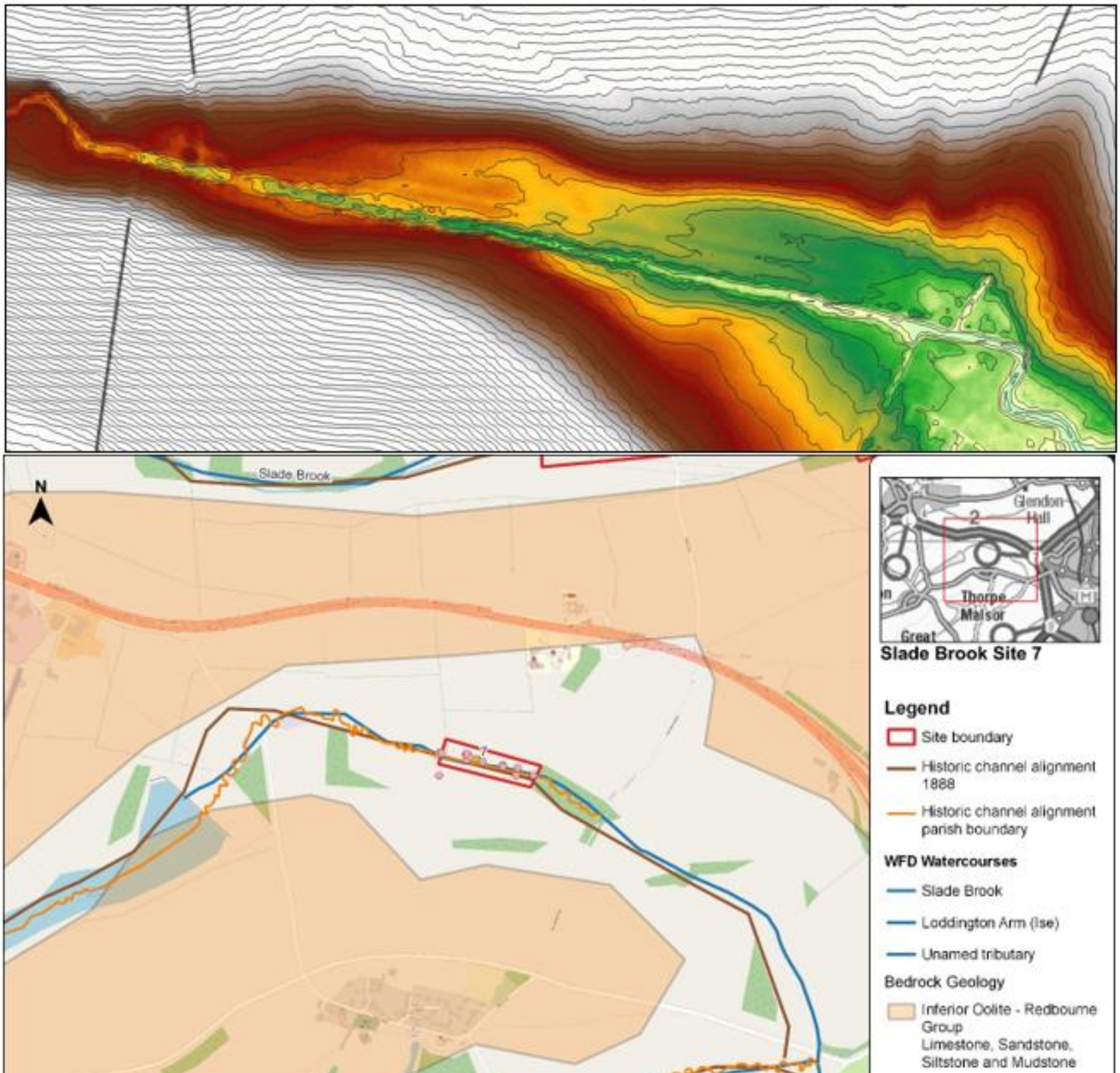

Figure 1-34 Location of the unnamed tributary of the Loddington Arm (Ise), downstream of Thorpe Reservoir with geology and historical channel locations. Contours shown at site 7 - 0.25m increments.

Figure 1-35 Standing on the right bank on the top of a steep valley looking at the surrounding landscape for the unnamed tributary of the Loddington Arm (Ise)

Figure 1-36 Taken on the left bank looking downstream. The unnamed watercourse is lined by a hedgerow with mature trees mixed in on the right bank, which provides shade to the brook. The channel is a straightened channel with a farm track and rough grassland running along the left bank. The sediments in the channel consist of patches of sand and coarse gravels.

Figure 1-37 The track on the left bank was waterlogged during the site visit with surface water present (potentially from a spring). The hedgerow overhangs the watercourse, potentially overshading the channel.

Figure 1-38 Extent of the wet conditions caused by the spring on the left bank.

Figure 1-39 Flow conditions at the downstream extent of the proposed restoration site. The flow appears faster with heavier discharge which could be the result of the drainage from the adjacent fields.

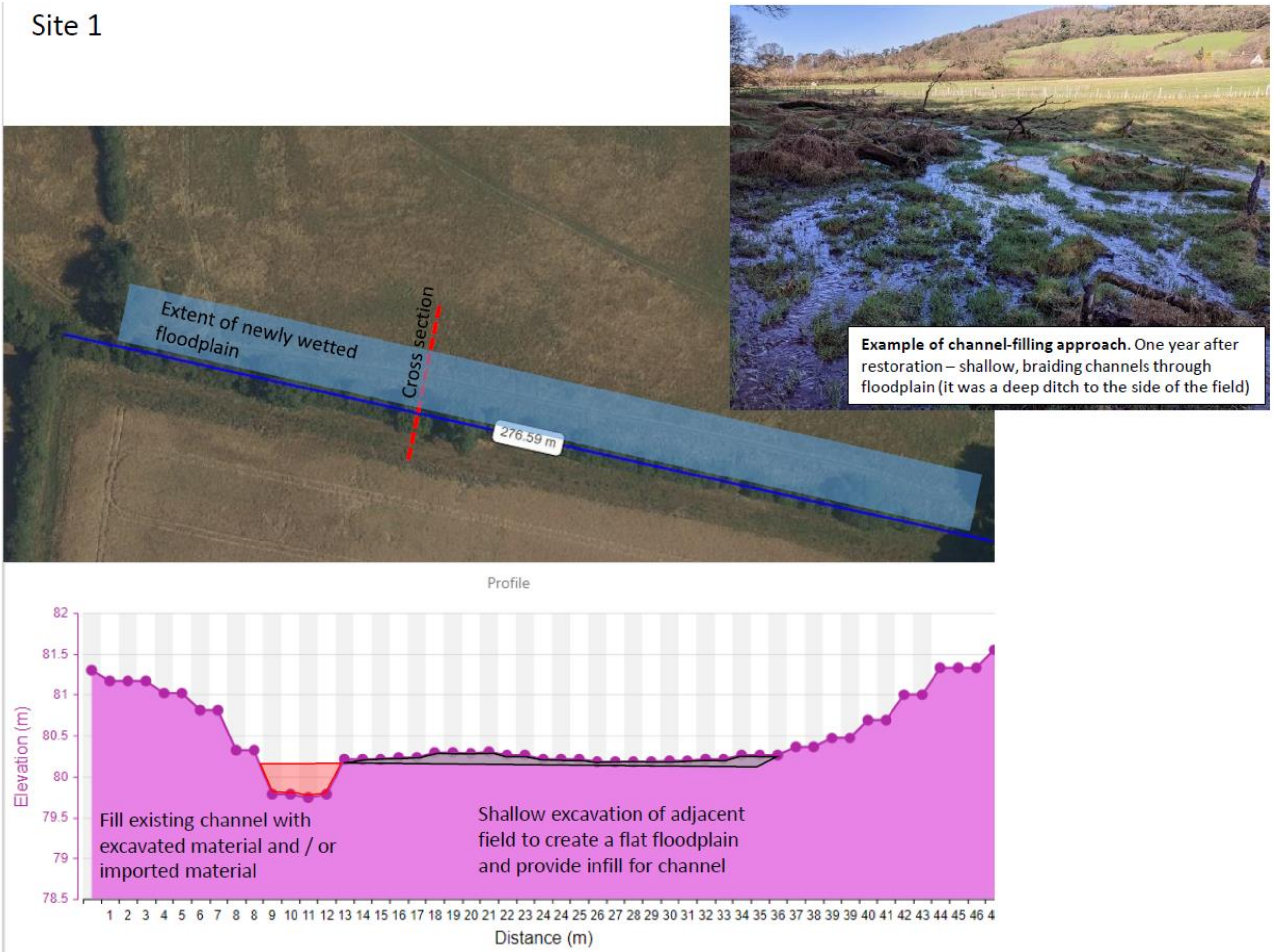

Figure 1-40 Opportunities identified by the client on site for the site downstream of Thorpe Reservoir

Table 1-6 Opportunities for Site 7 Thorpe Reservoir

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement.
Increase space for water laterally	The channel is confined within a narrow trapezoidal and straightened channel with limited space for natural processes. Potential to widen the space 20 - 30m and create a wetland feature with increased riparian zone. This opportunity could also help retain a small amount flood waters and help to slow the flow. The benefit for flood reduction will limited here due to the regulated flow so the benefit here would be for biodiversity and habitat creation.	This opportunity requires engagement with the landowner. This opportunity looks to replicate a stage-zero approach however with the regulated flow, a stage-zero may not be possible but a similar opportunity for a wetland and wider riparian zone would be possible.
Raising the bed level	In order to connect the channel to the floodplain (or wider valley bottom, as the channel cannot flood due to regulated flow) the bed level may need to be raised and/or the banks lowered.	Could potentially raise the water table upstream. Requires investigation.
Increase the riparian zone	Create a buffer/riparian zone along the right bank. This would help intercept surface water and arable run-off.	Requires landowner engagement.

1.7 Site 8 Cransley Reservoir

The Loddington Arm (Ise) downstream of Cransley Reservoir, similar to Site 7 (Section 1.6) only receives a regulated flow from the upstream reservoir. The paleochannels on the floodplain match up with the parish line boundaries showing the previous course of the Loddington Arm watercourse (Figure 1-41). These paleochannels are still hydrologically connected to the water table and connected to the wider floodplain Figure 1-44 and Figure 1-45. The current planform is highly modified with the channel straightened, likely to create more space for grazing.

The watercourse is located within the wooded corridor of mature trees and scrub (Willows, Hawthorn, Crab Apple, Hawthorn, Ash, brambles) however this is likely to be overshaded and watercourses benefit from a mosaic of light and shade for the macrophyte communities.

The channel was largely inaccessible due to the stockproof fencing right up to the banks and scrub however the channel, although straightened, had shallow banks and woody material had been allowed to accumulate in the channel which provides in-channel habitats and flow diversity (Figure 1-43). The water level of the channel seemed to match the water levels in the paleochannels, showing that the water table of the site had not been lowered and that the channel is not incised. It would be possible to reconnect this watercourse to the floodplain.

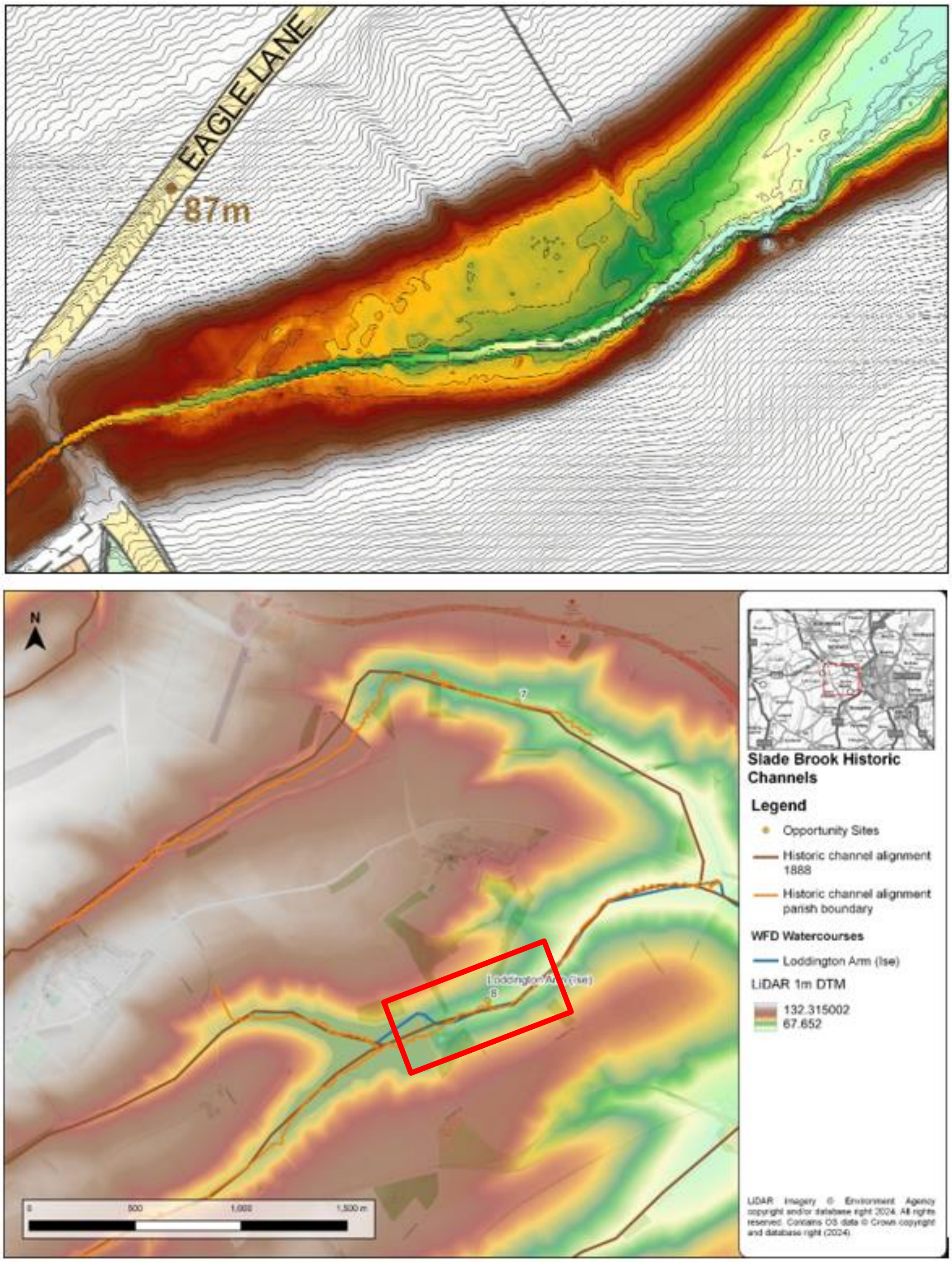

Figure 1-41 LiDAR showing the paleochannel on site and the photograph locations. Contours shown at site 8 - 0.25m increments.

Figure 1-42 Taken on the left bank looking downstream at the floodplain for Loddington Arm (Ise) watercourse. The floodplain is a permanent grassland that is currently grazed by sheep

Figure 1-43 On the left bank looking at the watercourse which is within a wooded corridor. The watercourse is lined with both mature trees and scrub but is potentially overshaded. A) Woody material was allowed to accumulate within the channel, B) the channel is straightened and the water appears turbid, the riverbed was not visible

Figure 1-44 There are paleochannels visible on the floodplain on the left bank. These paleochannels are already holding surface water and showing the waterlogged conditions of this field

Figure 1-45 A paleochannel channel on the left bank.

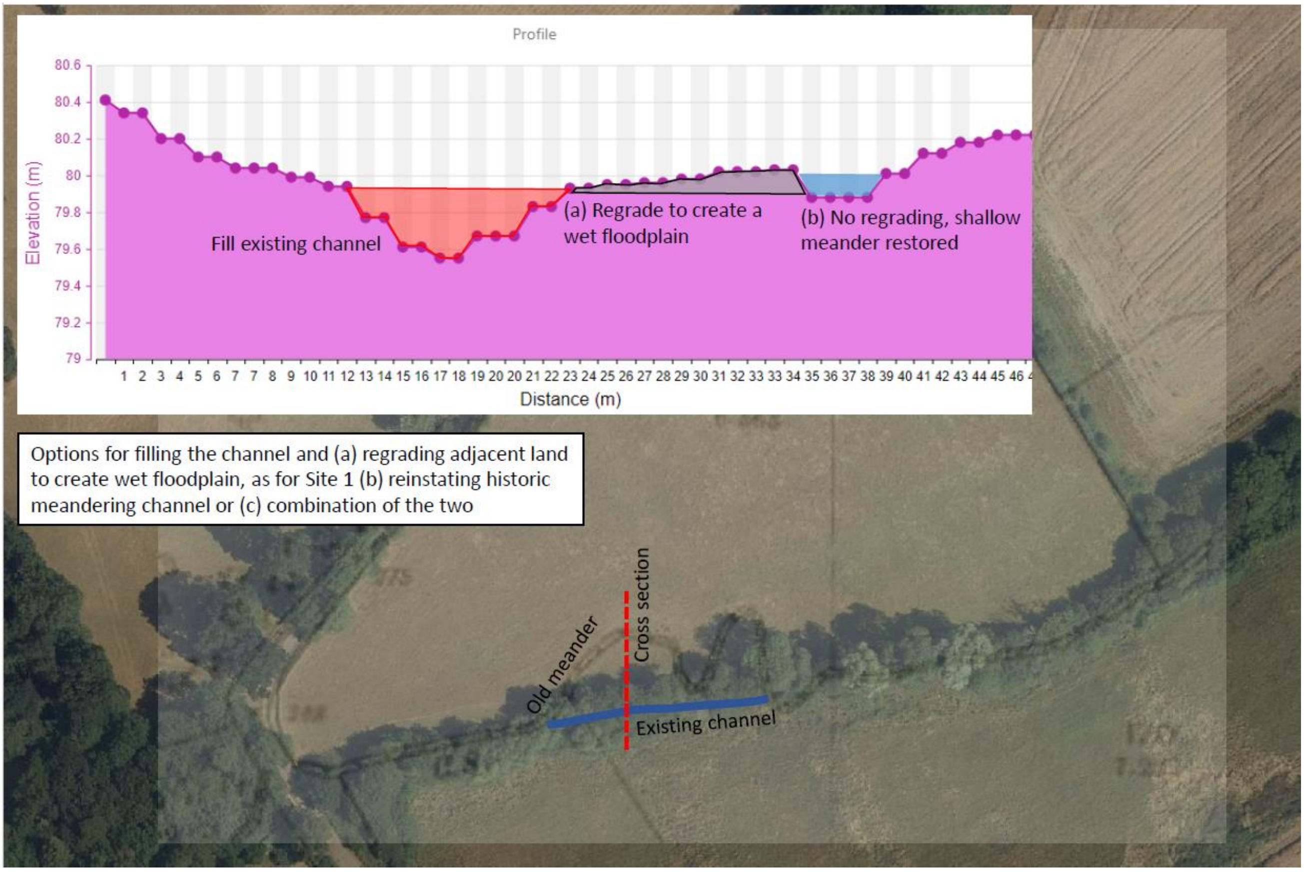

Figure 1-46 Opportunities identified by the client on site for the site downstream of Cransley Reservoir.

Table 1-7 Opportunities for Site 8 Cransley Reservoir.

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement.
Reconnect the watercourse to the paleo-channel	Infill the current channel and regrade the site to allow the watercourse to resume its flow in the paleochannel. This will help to create: • More space for water, • Increase space for morphological processes, • Improve the sediment regime, • Improve water quality, • Increase the riparian zone, • Increase habitat.	Requires landowner engagement. May increase flood risk upstream, requires investigation.

Opportunity	Description	Constraints
Wetland creation	Introduction of woody debris to connect the watercourse to with the floodplain, encouraging wet woodland habitat. Re-meander the channel upstream and create wet grassland habitat.	Requires landowner engagement.

1.8 Site 9 Coppicemoor Spinney

Site 9, Coppicemoor Spinney was assessed on the 12/12/2023 and 12/03/2024.The Coppicemoor Brook runs through a wooded corridor which is surrounded by arable fields on each bank (Figure 1-48 and Figure 1-51). Running along the hillslope is a farm track which was used to access the watercourse (Figure 1-52). Despite the steepness of the watercourse the ground was saturated and retaining significant amounts of water (Figure 1-53 and Figure 1-54). The ground over was quite thin with winter crops sprouting through the stubble of the previous crop.

The water in the channel was turbid during both site visits and it was not possible to see the riverbed (Figure 1-48 and Figure 1-56 to Figure 1-55). Upstream the channel had some slight sinuosity to it however it was trapezoidal and disconnected from its floodplain. Downstream the flow was rapid and flumed through a straightened and trapezoidal channel. The channel was lined with Hawthorn, Willows, Oak, Sycamore, Elder and Ash trees, with Rosebay Willowherb *Chamaenerion angustifolium* forming marginal vegetation. Vegetation was able to interact with the channel and the current cover upstream likely creates a mosaic of light and shade of the channel however it is possible that the channel becomes choked with vegetation in the summer.

Downstream the tree cover increases and a wider buffer from the arable field is seen on the left bank (Figure 1-55). Woody material has entered the watercourse and some appears to have been left for long enough to begin improving the morphology of the channel by increasing erosion of the banks, which will create sinuosity of the channel.

There does appear to be a sediment pathway that likely increases sediment and agricultural pollutants into the channel at the bridge (Figure 1-58). As the watercourse is at the natural low point of the farm track on both banks, overland surface flow are able to converge at this location and discharge into the channel. The Brook flows through a culert under the A14 before joining the Slade Brook within the Urban area.

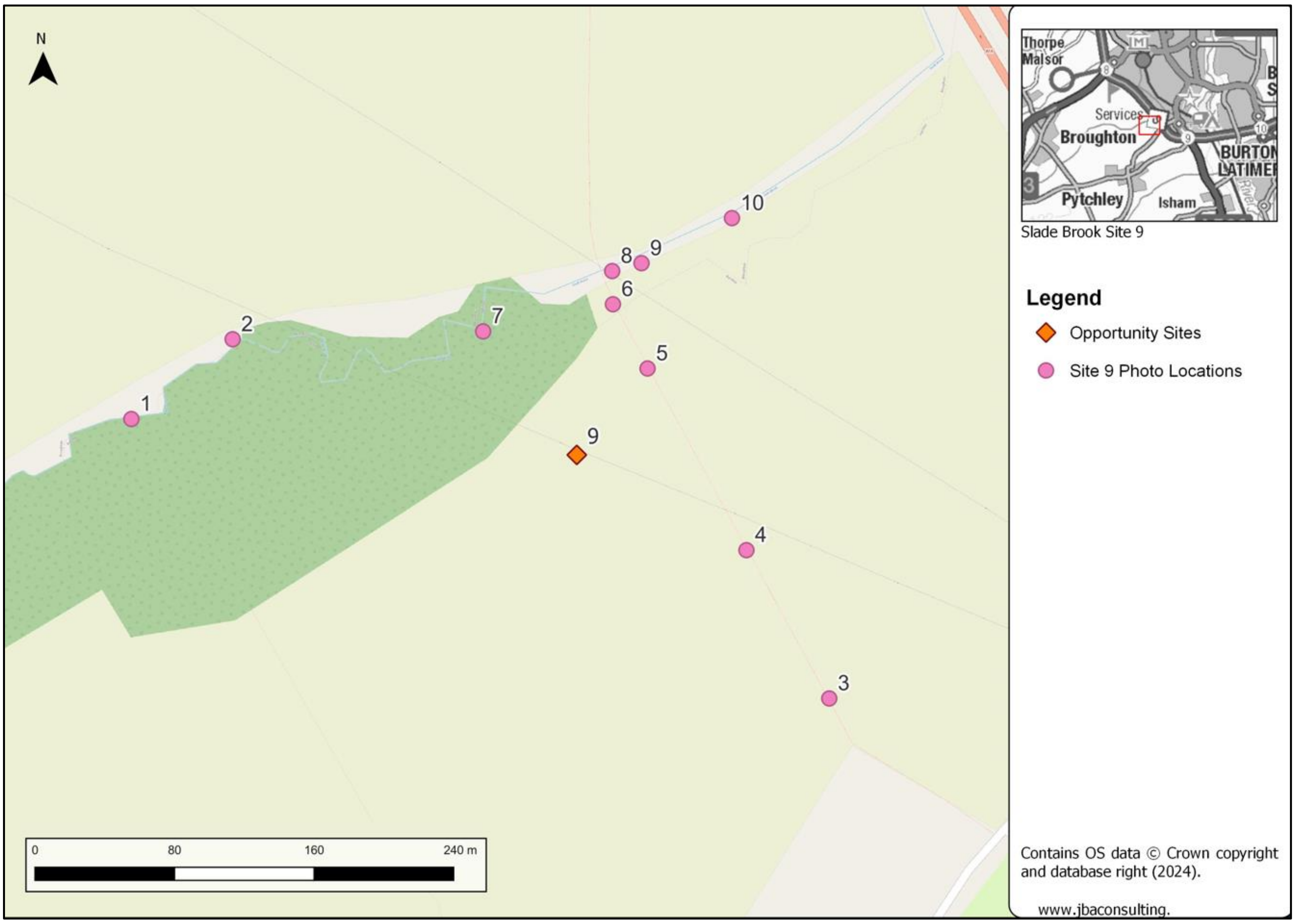

Figure 1-47 Coppicemoor Brook - Site 9 photo locations.

Figure 1-48 Standing upstream on the left bank A) looking upstream, B) looking downstream and C) at the land on the left bank (12/03/2024). The Coppicemoor Brook at this location is heavily turbid with significant amount of sediment suspended in the water.

Figure 1-49 Standing upstream on the left bank A) looking upstream and B) looking downstream (12/03/2024).

Figure 1-50 Standing upstream on the right bank at surface water draining from the arable field, through the woodland and into the Slade Brook (12/03/2024)

Figure 1-51 Taken on a farm track on a hillslope on the right bank looking towards the downstream extent of the Coppicemoor Brook as it exits the site through a culvert under the A14 (12/12/2023). The Coppicemoor Brook runs through the treeline/hedgerow in the distance.

Figure 1-52 Standing on the hillslope on the right bank A) looking up the slope, B) looking down the slope towards the Coppicemoor Brook in the treeline (12/12/2023)

Figure 1-53 Despite the steepness of the hillslope, the hill is retaining water in lower reliefs, B) also shows mounds of soil and a potential mitigation field buffer close to the brook (12/12/2023)

Figure 1-54 Waterlogged conditions on the site on the right bank of the brook (12/12/2023)

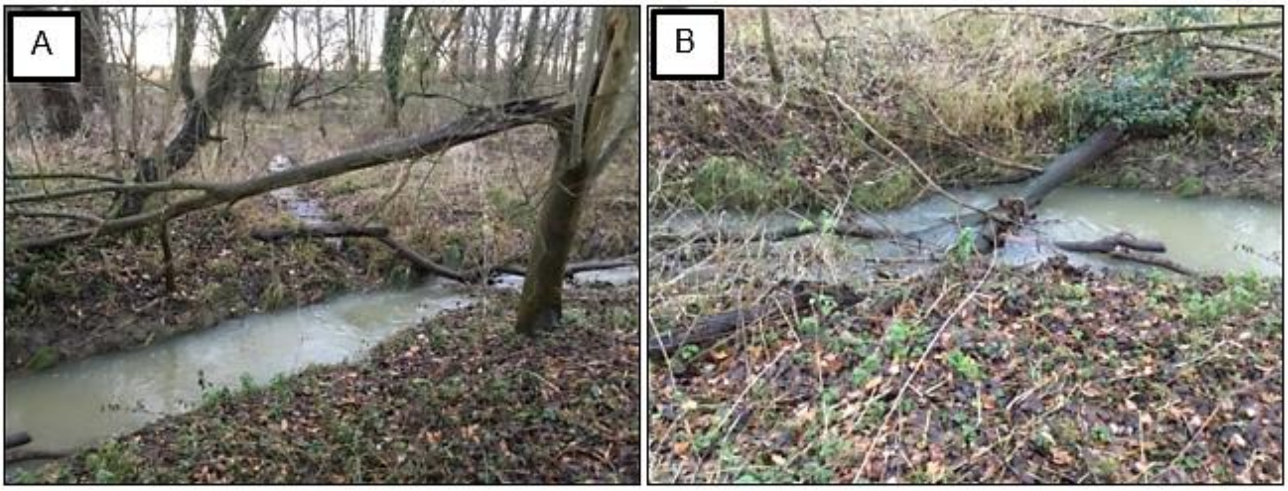

Figure 1-55 Standing on the left bank looking across A) to a tributary on the right bank and B) at fallen woody debris in the channel which is causing localised erosion and morphological improvements to the channel (12/12/2023)

Figure 1-56 Standing on the farm track bridge looking A) downstream and B) upstream (12/12/2023)

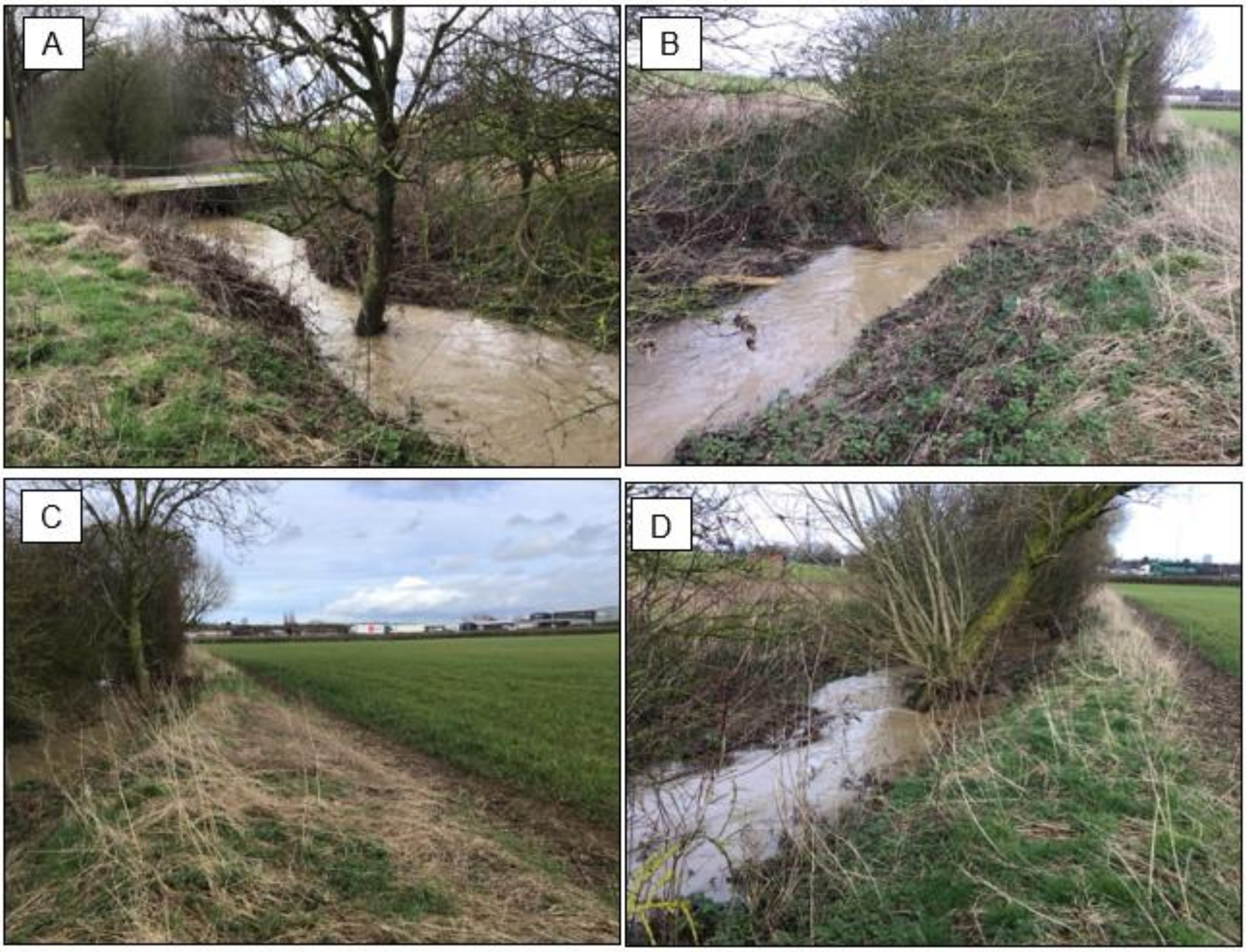

Figure 1-57 Standing downstream on the right bank looking A) upstream, B) downstream, C) at the land on the right bank and D) standing further downstream looking at where the channel has out-flanked the left bank and created a mid-channel island (12/03/2024).

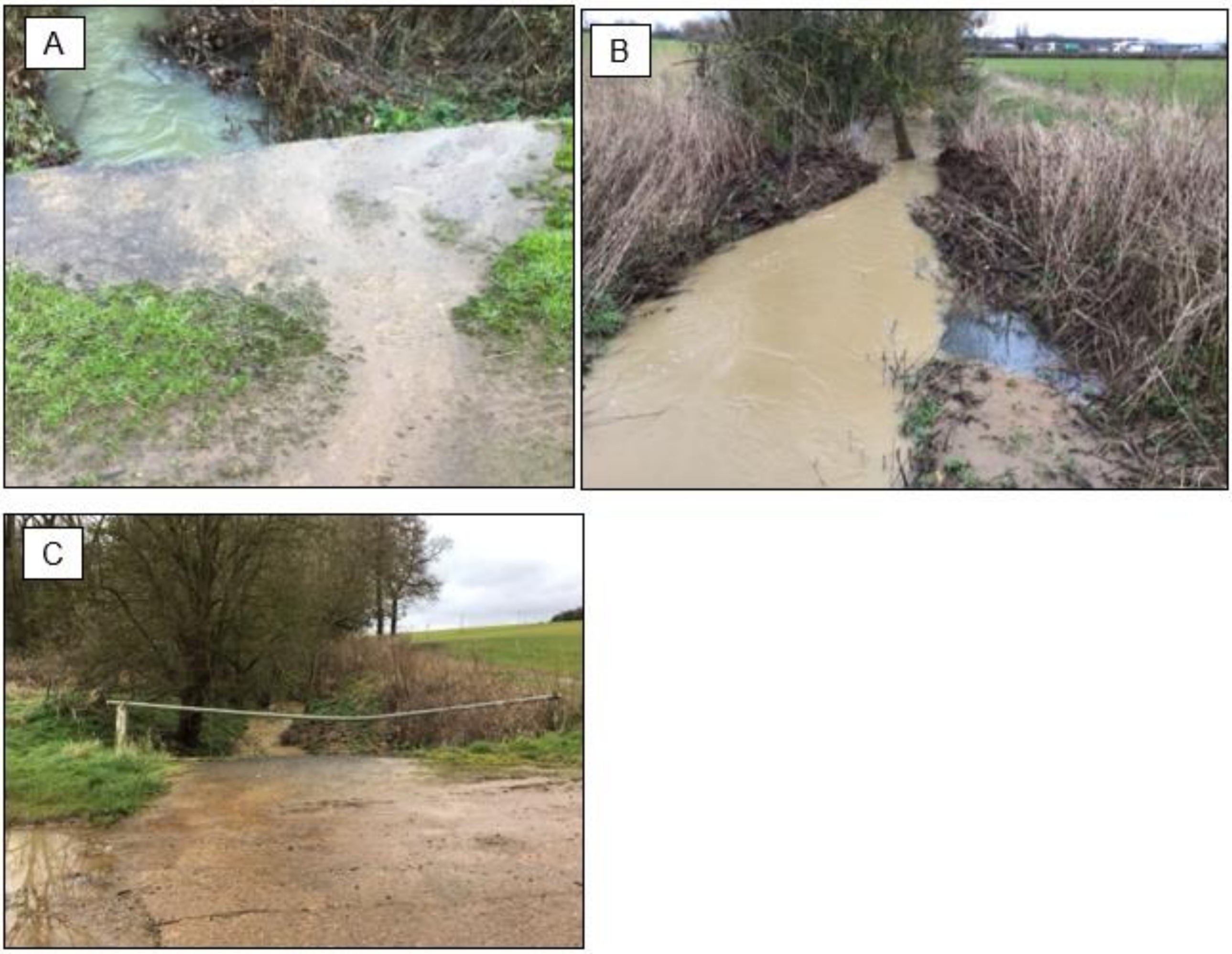

Figure 1-58 Standing on the bridge looking A) downstream (12/12/2023), B) downstream (12/03/2024) and C) upstream with a wider view of the bridge/culvert (12/03/2024). A sediment pathway connects the farm track to the Coppicemoor Brook which likely introduces excess sediment into the channel.

Table 1-8 Opportunities for Site 9 Coppicemoor Spinney

Opportunity	Description	Constraints
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement. Has potential to increase flood risk upstream, requires investigation.

Opportunity	Description	Constraints
Increase space for water laterally	The channel is confined within a narrow trapezoidal and straightened channel with limited space for natural processes. Potential to widen the space 40 - 60m into the adjacent arable field and create several swale/wetland features. This opportunity could also help retain a small amount flood waters and help to slow the flow.	Requires landowner engagement. Existing Arable Field.
Wet woodland creation	Allow connectivity of the channel with the floodplain into the woodlands to create wet woodland habitat. This is likely to be undertaken through the addition of Leaky Barriers.	Requires landowner engagement.

1.9 Middle Ground - Coppicemoor Brook

On the 12/03/2024, upstream of Coppicemoor Spinney a un named field drain a tributary of the Coppicemoor Brook were assessed for further opportunities. The un named field drain runs at the margin of arable fields. The arable fields are on a steep slope that the brook flows down. There is a thin buffer, and the brook is tree lined, shading the watercourse. The brook appears heavily managed, straight and trapezoidal. There were also many badger burrows and evidence of their activity along the banks.

In Figure 1-60 a field access culvert is potentially blocked up and constricting the flow of the brook. The reach is impounded for approximately 100m upstream and at the culvert the impounded flow overtops the structure. Some flow is able to pass through the culvert, but a significant proportion enters the field on the right bank. This flows along the right bank until it enters a field shown in Figure 1-61. The flow is a sluggish glide along the whole length of the brook.

There is another field access culvert at Figure 1-61 which flows freely until it enters the Coppicemoor Brook. Due to the vegetation and the tributary being obscured by the field access culvert at Figure 1-62, it was difficult to see the confluence. The flow of the Coppicemoor Brook was significantly faster than un named field drain with broken and unbroken standing waves. There is a wider buffer strip for the Coppicemoor Brook (Figure 1-63) however unlike the un named field drain, the Coppicemoor Brook is at the valley floor and drained into by steeply sloped, undulating arable fields.

Like the un named field drain, the Coppicemoor Brook at this location appears to be heavily managed, incised and trapezoidal and the flow is flumed through the reach. Looking at the maps, this is the straightest reach of the Coppicemoor Brook within the Coppicemoor Spinney area and conditions up and downstream may differ to this particular location.

Therefore, opportunities exist to increase the sinuosity of the Slade Brook for river corridor continuity.

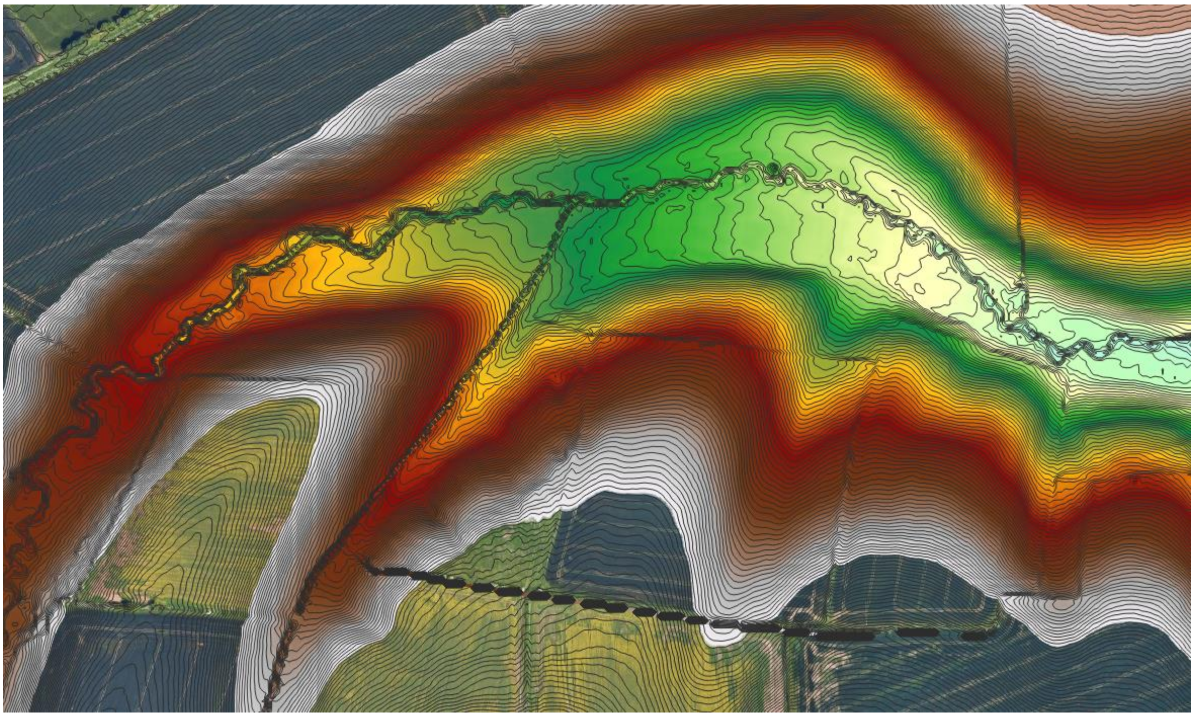

Figure 1-59: Coppicemoor Brook - Middle Ground photo locations, with LiDAR. Contours shown at site 8 - 0.25m increments.

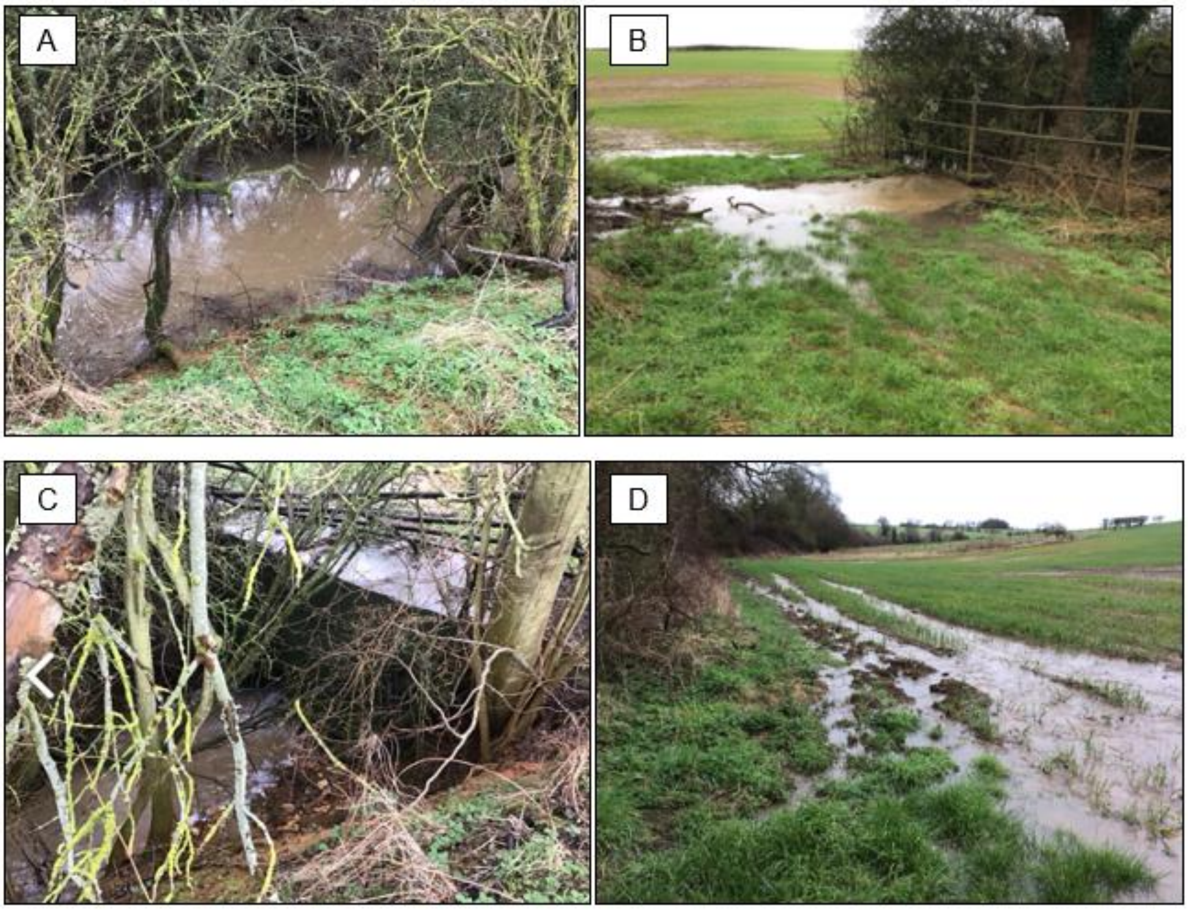

Figure 1-60 On the left bank of a field drain looking at A) the impounded flow of the channel, B) the field access culvert which is being overtopped by the impounded flow, C) the culvert outfall where the flow is significantly constricted but some flow is coming through and D) the flow path of the water that has overtopped the structure and flowing down the valley.

Figure 1-61 On the left bank of a field drain looking at A) the outfall for the field access culvert, B) the entire structure of the field access culvert. In B the field beyond the fence is full of rushes and a potential paleochannel or low relief that is holding water from the flow path seen in Figure 1-61 D

Figure 1-62 A) On the right bank of the Coppicemoor Brook looking at the inlet for the field access culvert/bridge, B) on the left bank looking at the outfall of the field access culvert/bridge.

Figure 1-63 on the left bank of the Coppicemoor Brook looking at the buffer margin and conditions of the arable field. In photo A) areas of water retention can be seen in the undulating valley reliefs (white dotted line), and B) the width of the buffer strip can be seen which covers approximately 15 - 20m from the field edge to the brook.

Figure 1-64 on the left bank of the Coppicemoor Brook looking upstream at the brook.

Table 1-9 Opportunities for Coppicemoor Brook Middle Ground

Opportunity	Description	Constraints
Widen the buffer strips	There is not much space between the arable fields and the brook. It is recommended to create more space and allow for natural processes and NFM interventions to be installed in the brook. Could generate BNG and ELMs benefits.	Requires landowner engagement.
In-channel improvements	Install in-channel improvements: • Pool riffle sequence, • Woody debris, • Berm features.	Requires landowner engagement.
Increase space for water laterally	The channel is confined within a narrow trapezoidal and straightened channel with limited space for natural processes. Potential to widen the space 10 - 20m. This opportunity could also help retain a small amount flood waters and help to slow the flow.	Requires landowner engagement.
Wetland creation	Due to the blocked culvert, the brook is already connected to the floodplain. This should be further encouraged and to maximise the benefits and ecological potential of the wetland. Could generate BNG and ELMs benefits.	Requires landowner engagement.
Swale creation	In Figure 1-63 a concave undulation in the slope gives relief to hold water. This could be improved to hold more water by installing a swale feature to slow the drainage and create an ecological feature. This will also seek to reduce sediment and erosion into the Slade Brook. Could generate BNG and ELMs benefits.	Requires landowner engagement.

1.10 Coppicemoor Brook Underwood's Hill Spinney

On the 12/03/2024 the Coppicemoor Brook was assessed for further opportunities at Underwood’s Hill Spinney. At this location, the opportunity identified is to slow a surface water flow from the right bank into the Coppicemoor Brook.

The Coppicemoor Brook runs through a wooded corridor which is surrounded by arable fields on each bank. The channel is confined by the steep valley sides and is sinuous however due to the high water levels and turbidity it was not possible to view in-channel features Figure 1-66. However, it was possible to see woody material and vegetation interacting with the watercourse.

Some natural bank protection may need consideration by the footbridge to prevent further erosion that is currently being caused by the volume and flow of water moving through this section of the brook (Figure 1-66). To allow the riparian zone to develop, crown thinning is suggested in this area that will reinforce the stability of the bank and reduce erosion. Willow spiling could also be utilised to support the bank and protect from erosion. Additionally, the vegetation by the brook is mostly comprised of horsetails and nettles, and would have no particular maintenance requirements, however some yearly monitoring may be suitable.

On the right bank, a surface water flow originates in an arable field (Figure 1-67, A) in a low relief in the middle of the slope. After approximately 60m this surface water flow exits the arable field (Figure 1-67, C and D) and enters a scrubby concave relief on the valley side (Figure 1-67, E) before entering the Coppicemoor Brook (Figure 1-67, F). During this process, the flow is able to entrain a significant amount of sediment and is evidenced in Figure 1-67, F.

Running down the hillslope is a bridleway which was used to access the watercourse. The bridleway is heavily poached and likely also inputting sediment into the Coppicemoor Brook (Figure 1-67). A drain runs along the bridleway; the drain doesn't connect directly to the bridleway but there is a risk that, in heavy rain, the bridleway could input significant amounts of sediment into the brook.

There is potential for bunds in the depression in the land to further aid filtering of the water before it enters the watercourse. The 'slowing the flow' process would cause sediment and pollutants and contaminants to be taken out of the surface water flow. Landmarks such as electricity pylons, mature trees and frequently used footpaths need to be surveyed to ensure works could be carried out safely (Figure 1-70).

Figure 1-65: Coppicemoor Brook Underwood's Hill Spinney Photo locations.

Figure 1-66 Standing on the bridleway footbridge looking at the Coppicemoor Brook A) upstream and B) downstream.

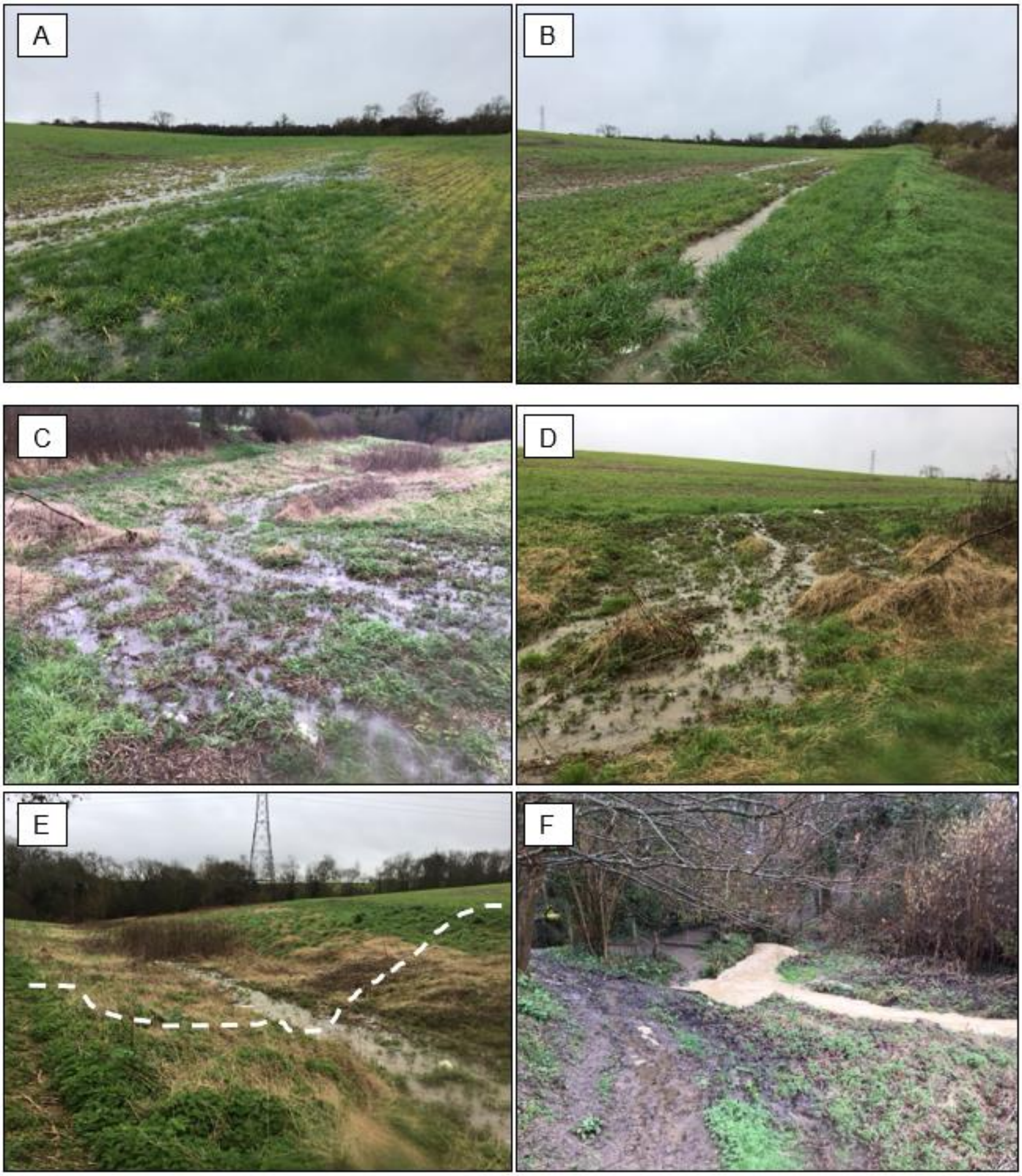

Figure 1-67 A) Photo location 2, A surface water flow originates in this arable field, B) the flow runs along the edge of the arable field, C, D) the flow becomes braided and exits the arable field, E) the flow enters a concave relief in the valley slope (white dotted line to show the concave relief channel) and F) the flow enters the Coppicemoor Brook.

Figure 1-68 Photo location 3, a bridleway crosses the Coppicemoor Brook A) on the right bank where a drain flows alongside the bridleway, B) the poached and ponded conditions of the bridleway and C) the drain entering the Coppicemoor Brook (white dotted line to show the drainage).

1.10.1 NFM opportunities at Coppicemoor Brook - Underwood's Hill Spinney

From the outskirts of Broughton to the watercourse the gradient slopes moderately downwards. The land use across this location is improved, most likely grazed, grassland in the uppermost reaches. The improved grassland fields in this location have ridge and furrow features, likely due to historical farming, although in present day, this is directing water downslope towards the Coppicemoor Brook watercourse (Figure 1-69). It is highly likely that the livestock grazing in this location will have compacted the surface soils and potentially damaged the ridge and furrows. These compacted soils are likely to encourage surface runoff and further erosion of the heritage features.

Between fields are established hedgerows which are causing water to pool and move north easterly towards the end of the hedgerows before continuing downslope across the agricultural field towards the watercourse (Figure 1-67). There is some damage to the hedgerows from livestock, fencing them off to prevent grazing should be considered as these are currently slowing the flow and encouraging some infiltration. Badgers are active in this area (numerous setts, latrines and paths), particularly along the southern channel flowing into Slade Brook. There are clear signs of soil erosion in this location from fine sediment in the pooled water upslope of the hedgerows. Looking more widely across the catchment it is highly likely that soil management/improvement measures would be highly effective at reducing soil erosion and surface water runoff.

Figure 1-69 Improved grassland field with ridge and furrow features (left) causing water to pool in front of hedgerow (right)

Between the grassland and the watercourse is an arable field recently cropped. Surface water was visibly running off the land in this location towards the watercourse. It is highly likely this runoff is due to compacted soils and low surface roughness therefore producing surface runoff rather than infiltration (Figure 1-67). The agricultural field was in use, so surface roughness will change dependent on seasonality and crop planting, but the topography will still direct water downslope towards Coppicemoor Brook.

Figure 1-70 Electricity pylons and mature trees to be considered before works are carried out.

Table 1-10 Opportunities for Coppicemoor Brook - Underwood Hill's Spinney

Opportunity	Description	Constraints
Expand and improve the swale	In Figure 1-67 a surface water flow originates in an arable field. It is currently unregulated and generates fast flows and sediment into the Slade Brook. To reduce negative impacts and improve the flow for NFM, it is recommended that the area where this flow exists is converted into rough grassland for a swale. Within this swale there should be added roughness and woody material installed to slow the flow and provide areas for sediment deposition. Could generate BNG and ELMs benefits.	Requires landowner engagement.
Bridleway improvements	In Figure 1-68 a bridleway has become significantly poached and is generating a lot of sediment which can easily be washed into the Slade Brook. It also provides poor access for the path users. It is recommended that improvements are sought to reduce the poaching of the path. This could be the instalment of a sturdy pathway material that is suitable for a bridleway.	Requires landowner engagement.

1.11 Geomorphological and Ecological Summary

This project was commissioned to assess and develop potential river restoration opportunities for the Slade Brook and Loddington Arm (Ise), Kettering. Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and NFM. This report focuses on the opportunities for Ecology and Geomorphology for sites 2 to 9 and additional sites at Coppicemoor Spinney and Underwood’s Hill Spinney.

These opportunities are underpinned with baselines that were developed from both site walkovers and desk-top studies. The baselines in this report cover geomorphology and ecology. Constraints were also identified through assessments of land use and geological / ecological constraints.

From the pressures described above the criteria for opportunities this project focused on were:

- Improving public access and reducing pressures on the banks,
- Increasing connectivity to floodplains,

- Improving or creating wet woodlands,
- Increasing water retention in the upper catchment,
- Increasing resilience to prolonged dry weather,
- Improving in-channel flow diversity,
- Improving in-channel habitat,
- Improving riverbed conditions.
- Reducing agricultural input and pollutants.

Hydraulic modelling was used for a high-level feasibility assessment of the opportunities presented in this report for Natural Flood Management (NFM). This report concludes with findings from this study and the NFM modelling. From these conclusions, recommendations are made for next steps further investigations and projects.

2 Natural Flood Management Introduction (upper catchment)

This project was commissioned to assess and develop potential river restoration opportunities for the Slade Brook and Loddington Arm (Ise), Kettering. Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and NFM. This section focuses on the opportunities for NFM in the upper catchment.

2.1 Upstream Cransley Brook

Cransley Brook is to the north of the town of Broughton. Figure 2-1 shows that there is a minimal buffer at either side of the watercourse. The perimeter of an agricultural field is less than a metre away from the bank top along some northern sections of the watercourse. Ploughing, irrigation and pesticide procedures all undertaken on agricultural land can affect the volume and quality of water entering watercourses. At Cransley Brook, the proximity of the field to the watercourse means there is limited possibility for water to filtered before entering the watercourse. The topography also suggests that the speed in which the water will move in the watercourse could cause backing up and overtopping if the brook cannot cope with flashy events. Tramlines upslope indicate that water and associated sediment and pesticides are likely being funnelled into this watercourse during high rainfall events; should the field be ploughed east to west the flow of water into the water course would be slowed. Soil management and improvement techniques along side improvement to the riparian zone is recommended in this location and is likely to produce significant water quality improvement. Similar signs of sediment/surface water runoff was evident in this location as per Coppicemoor Brook.

Figure 2-1 Cransley Brook

Figure 2-2 Southern bank of Cransley Brook, potential for additional floodplain woodland establishment.

Whilst the southern bank of the watercourse is planted with trees, additional floodplain woodland establishment would be beneficial (Figure 2-2).

2.2 Land upslope of Great Cransley Reservoir.

Great Cransley is to the north of Broughton and the west of Loddington Road. Figure 2-3 shows two different improved grassland areas where the soil has been compacted by the horses kept in the fields. The topography of the land could be used to establish wetland vegetation and create ponds to store water in high rainfall events. Fencing areas off to promote vegetation growth at the lowest points could slow the flow of water (Figure 2-3). Soil improvements will increase infiltration capability of the soil and footpath improvements would reduce poaching along the currently suggested public footpath and would encourage users to stick to a more direct route across the field. These conditions were evident across the majority of the upper catchment areas visited by the survey team.

Figure 2-3 Two fields showing the effects of horses compacting and trampling the soil.

Cransley Reservoir is to the south east of Loddington. Figure 2-4 shows the three sites surveyed in the area. The watercourse at Site 1 is relatively fast flowing, approximately 1.5 metres wide and 1 metre deep. The meandering channel presents opportunities for leaky barriers using local materials from surrounding woodland (Figure 2-5). There is a small floodplain available on the left bank. As a minimum it is recommended to increase the riparian buffer in this location. Alternatively, river restoration or wetland creation could have significant environmental enhancements. The left bank floodplain is currently improved grassland likely used for pasture. There is limited NFM benefit in this location given the proximity of the reservoir downstream.

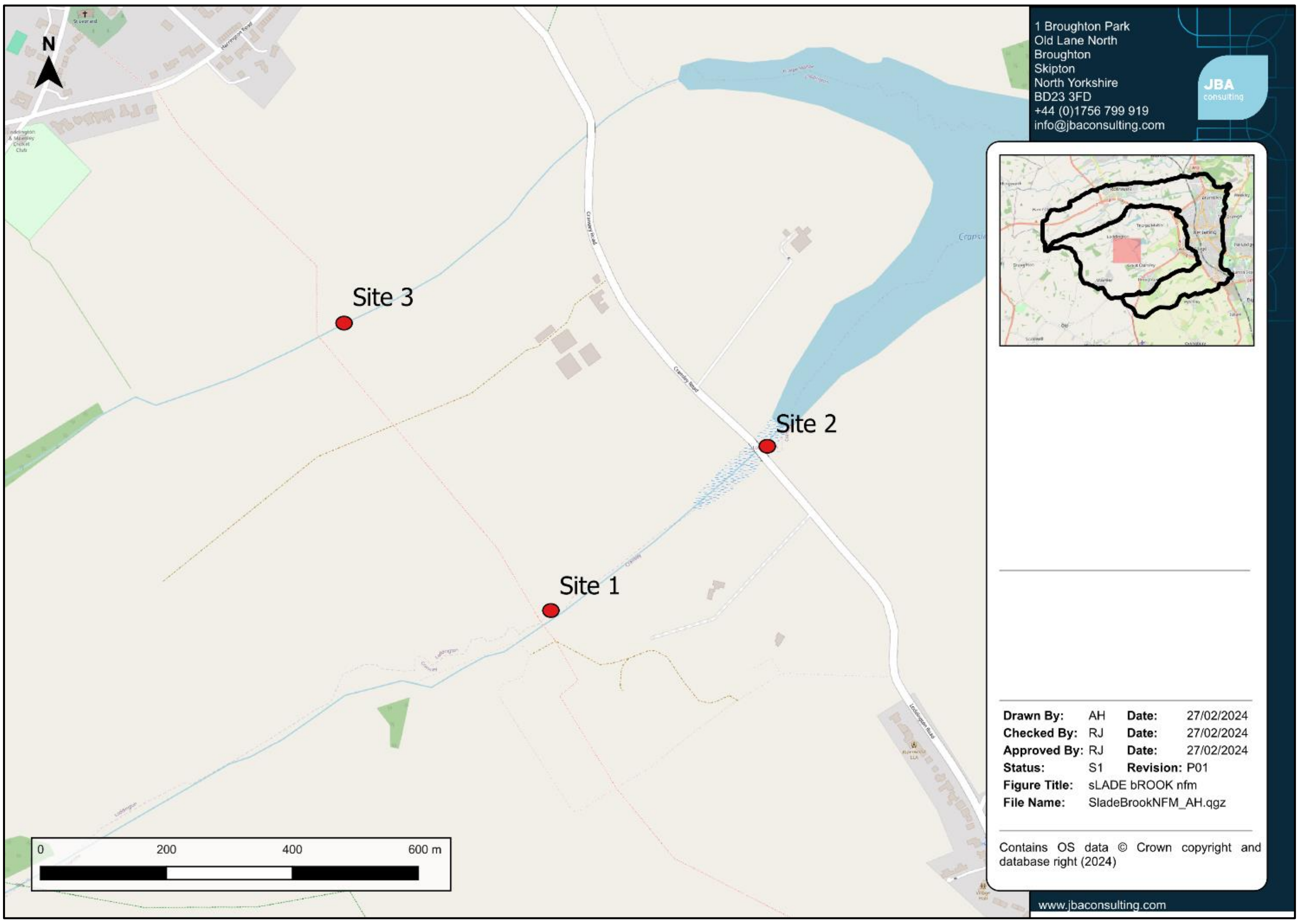

Figure 2-4 Cransley Reservoir sites.

Figure 2-5 Site 1 watercourse, potential for leaky barriers and wetland/floodplain reconnection.

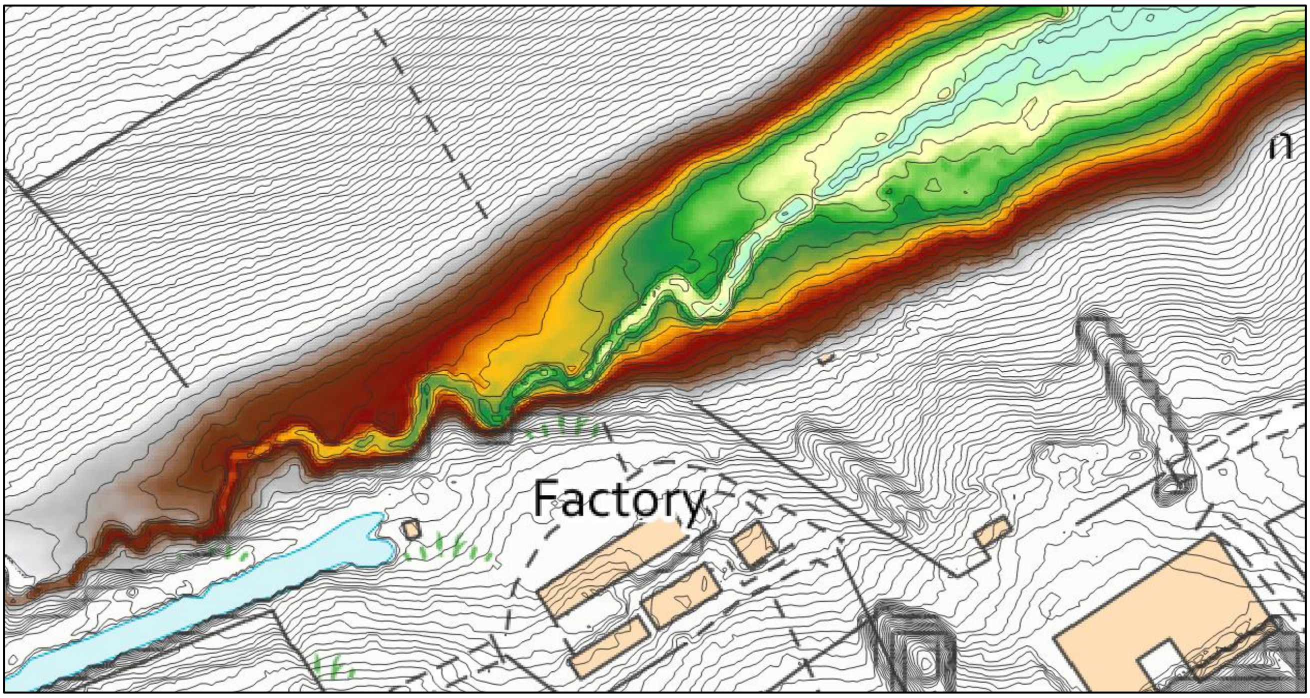

Figure 2-6 LiDAR analysis of Site 1, (Upstream Cransley Reservoir, Southern stream). The floodplain is constrained to 40m. Contours shown at 0.25m increments.

Site 2 is adjacent to Cransley Reservoir, NFM potential at this site would be woodland planting on the floodplain. This location is probably already done a decent role in environmental enhancement through rough vegetation and floodplain connection. Further enhancement of this area could have significant habitat improvements (Figure 2-7).

Figure 2-7 Potential for woodland planting (left) to slow flow into watercourse (right)

Site 3 is a part of the watercourse stemming from the Northern stream of Cransley Reservoir. Similar conditions were observed at this site to upstream site 1, (Upstream Cransley Reservoir). Although the watercourse is much steeper and floodplain further constrained (20m). There is more potential slightly downstream where the floodplain width increases to 40m. The footpath has been raised and culverted, likely as a result of historic flooding (Figure 2-8). This area could be fenced off to livestock to allow vegetation to establish, alongside some additional planting of tree and other native species. Wetlands could also be created along further reaches of the channel, as well as berms and leaky barriers to encourage further floodplain reconnection similar to site 1, (Upstream Cransley Reservoir).

Figure 2-8 Raised and culverted footpath

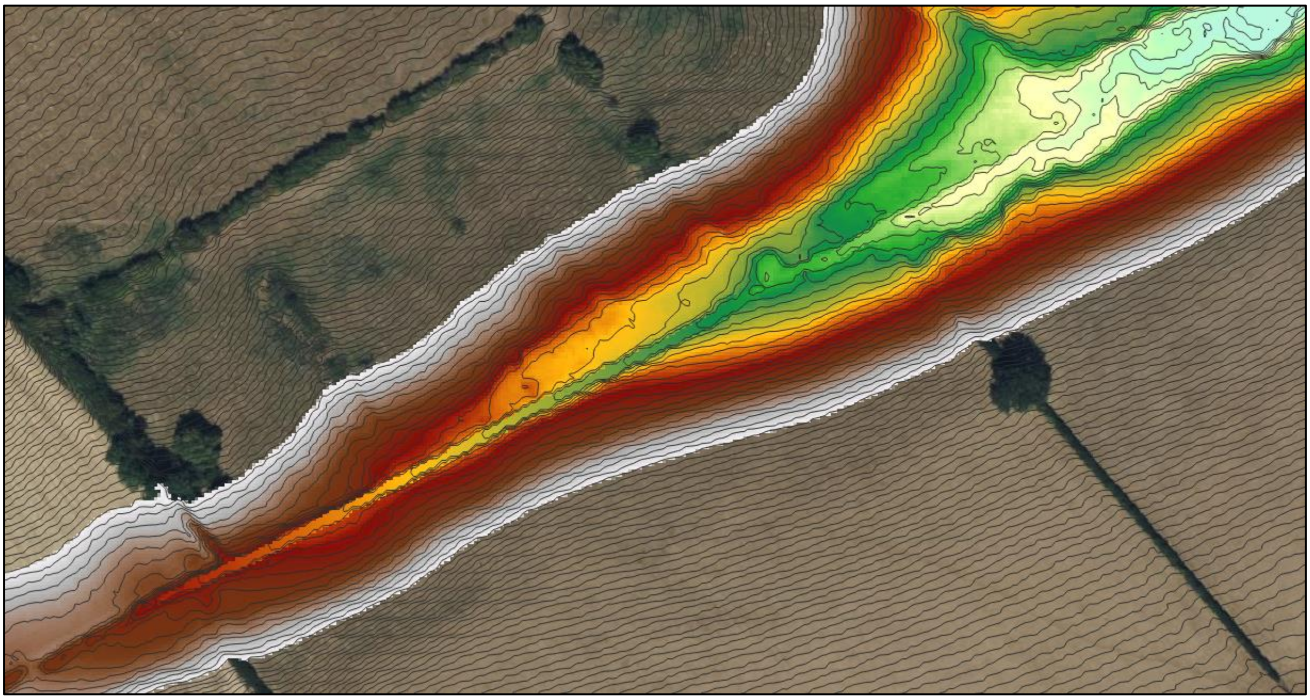

Figure 2-9 LiDAR analysis of Site 3, (Upstream Cransley Reservoir). The floodplain is constrained to 20m. Contours shown at 0.25m increments.

2.3 Loddington Wetland (SP 81304 78537)

Loddington Wetland is at the north of Loddington and is a part of the watercourse tributary to Thorpe Malsor Reservoir. Figure 2-10 shows a large storage area and bund, which makes up the wetland feature (offline from the watercourse). A footpath runs across the downslope of the wetland and around the right bank. There are several community engagement signs in this location around bird watching.

The bund itself is holding back a substantial amount of water in this location and the exact connection to the watercourse is unknown. There maybe further opportunity to add leaky barriers into the parallel watercourse and encourage additional flows into this feature in times of flood.

However, the JBA surveyors have raised considerable concerns over the structural foundation of the bund. No clear overflow or outflow from the feature was identified on site. There were clearly signs of slumping/erosion of the bund. It is likely that the feature is of high risk of failure and therefore not recommended for further NFM enhancement. Structural surveys are recommended given the risk to the public in this location.

Figure 2-10 Large storage area with bund, further investigation required.

In the watercourse is an informal barrier, likely to feed into a pond in the rear garden, contact with the landowner needed to confirm (Figure 2-11). The watercourse at this site is fast flowing, approximately 1 metre wide, 1.5/2 metres deep and has a heavy sediment load. It is likely that this will cause the informal barrier to fail, but following discussion with the landowner, an alternative option may be suitable.

Figure 2-11 Informal barrier in watercourse, further investigation required

2.4 Rothwell

The Rothwell site is to the east of the Slade Brook watercourse (SP 81724 80147), the site is currently improved grassland with some established vegetation. NFM suggestions for this site would be to create some additional riparian floodplain via woodland and wetland planting to slow the flow of water downslope into the watercourse (Figure 2-12).

Figure 2-12 Rothwell site, potential for additional riparian floodplain and woodland and wetland planting.

2.5 Upper Catchment Natural Flood Management Summary

Opportunities were pursued that would provide improvements for water quality, in-channel conditions, riparian habitat, floodplain reconnection and NFM. This section focuses on the opportunities for Natural Flood Management within the upper catchment.

These opportunities are underpinned with baselines that were developed from both site walkovers and desk-top studies. The baselines in this report cover natural flood management. Constraints were also identified through assessments of land use and geological / ecological constraints.

From the walkover the opportunities for this project were:

- 66,608m² area with potential for leaky barriers
- 6,264m² of runoff attenuation features
- 330m of raised track
- 1,738m² of ridge and furrow bunds
- 34,667m² of riparian buffers
- 207,560m² of soil improvement
- 28,059m² of wetland creation
- 18,558m² of woodland planting

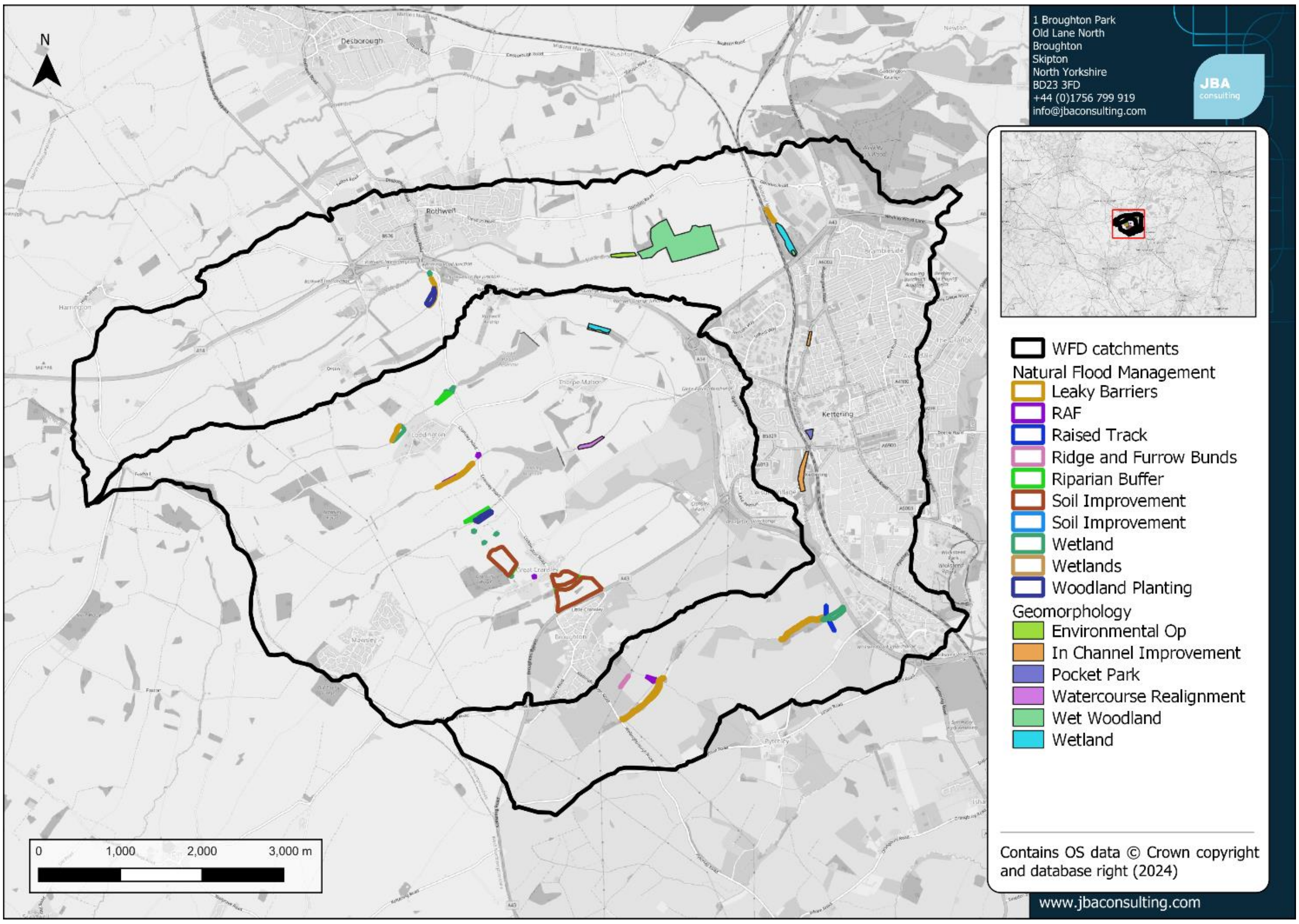

Figure 2-13 Potential Geomorphology and NFM options following site walkover.

Table 2-1 Key NFM Interventions Summary

Opportunity	Geomorphology	Ecology/Fisheries	Engineering & NFM
Leaky Barriers	At high flow events leaky barriers aim to slow the flow downstream, to aid the water to build-up and to spill out onto the floodplain. During this high flow events an area of impoundment will develop, however this will be temporary as it will only occur at rare high flood events. Localised scour can occur downstream of the barrier and deposition is likely to occur upstream of the barrier. This will aid bed recovery from past modifications and aid the development of improved in channel features such as the development of pool, riffle and bar formation, therefore increasing the channel morphology diversity.	They can develop areas of pool, riffle and bar features creating new habitat features within the channel. This development of new habitat will improve the channel morphological diversity. The new habitat features can provide suitable habitats for supporting populations of invertebrates, fish, reptiles, amphibians, therefore increasing the biodiversity of the river. Can have the potential to restrict fish passage should the leaky barriers become blocked and are not well maintained. Leaky barriers can provide fish shelter from faster flow velocities, provide shade therefore cooler water temperatures and shelter from predators and potential feeding opportunities.	Requires acquisition of significant timber (e.g. tree trunks and large branches) Large woody dams are created by laying two large stacks of tree trunks in a cross formation across the channel. and wherever possible, every single tree trunk/branch used to create a leaky barrier should be long enough to fully span the whole channel width, plus extend a further 1-2m (into the bank) and securely anchored in position, (e.g. using vertical stakes and pins or lashing fixing them to other trees). Smaller timbers can be placed in-between larger ones. Horizontal logs are normally secured together to avoid the top logs floating off during flood events The method of anchoring is very site specific (bed and bank characteristics). If site conditions allow, then two trees either side of the channel can allow provide additional anchor points. All other vertical anchors (not supported by bankside rooted trees) should be driven into the banks and not into the stream bed (where they will be more susceptible to scouring action). Bank conditions should be frequently monitored as disturbing the bank during installation can causes accelerated future erosion. Design life of the structure would be unknown as subject to accelerated deterioration.

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			Typically, the top of opening underneath barrier is set at 30cm above normal baseflow level, though local site characteristics may influence this setting. At higher flows barrier will partially block flow (until overtopped) and force excess floodwater out on local floodplain where further attenuation and temporary storage can take place.
River and Floodplain Restoration.	Naturally functioning rivers will create features such as bars, riffles and pools which can help slow the flow. Allowing more natural lower energy flooding reduces risk of bank erosion and embankment failure. Removes need for maintenance of artificial engineering works Provides rich wildlife habitat and better fisheries.	River and floodplain restoration can also create habitats such as wetlands and wet woodlands which benefit a wide range of species including breeding and wintering wading birds.	Storage of potentially large amounts of floodwater on the floodplain, with a controlled discharge back to the river once the flood event has passed. Re-creating meanders will increase the time taken for the floodwater to flow downstream by making it take a longer route. The greater length of a meandered river allows it to carry a greater volume of water before it spills out of its channel. Dimensions are entirely site dependent and will need detailed specialist advice. Pre-work assessments and surveys will be required to ensure that works do not increase flood risk (for example, an embankment may be holding water back during a flood event and removal could increase flood risk). Previous meanders and curves in the water course can be identified by historic aerial photographs and maps.

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Floodplain excavation for wetland habitat	Proposed floodplain excavation of 0.5m to increase wetland storage area. Floodplain connectivity will be improved through thereby increasing the morphological diversity.	The size of the wetland habitat will increase developing an area suitable for numerous of species, through creating a wetland area, marginal and dry habitat. The wetland area in high flood events may trap fish, with the slower velocities in the wetland develop an area of shelter. A potential risk is fish stranding's which can be avoided should a suitable outlet is designed. Any outlet design will need to take into consideration of allowing fish back into the watercourse, with the location of the outfall should not be positioned directly onto grassland.	Broad and shallow ground excavation in suitable wetland configuration – bare soil revegetated. If constructed with an additional earth bund at ground level - able to temporarily store floodwater which then drains out after the main flood peak in the watercourse has passed. Design and dimensions are entirely site dependent and will need detailed specialist advice. Wetlands should be designed with a significant storage capacity.
Riparian Buffer Strip	Riparian woodlands are usually planted as buffer zones, in between the watercourse and adjacent land, which allows the maximum amount of contact between the trees and water.	Riparian buffer strips help create wildlife corridors and sites for ground nesting birds, small mammals and beneficial insects. Buffer strips can also provide support more foraging pollinators. Low levels of vegetation	Riparian buffer strips should be 5-10m wide and may require fencing to exclude livestock from the riverbanks. These planted areas can be enhanced into hedgerows which are natural weather barriers, protecting crops, soils and livestock, provide ideal habitat for farmland birds and wildlife species, but also perform a natural

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	They can provide a physical barrier that helps restrict the flow of storm water, carrying sediment and nutrients, and prevents them from being washed from the field into the watercourse. They can be used in both arable and grass fields and give the same result. They typically offer the benefits of encouraging soil infiltration, increasing hydraulic roughness, enhancing evapotranspiration and also the potential for retaining woody material. They additionally improve bank stability through an increased root network within the soil substrate. This vegetation can range from rough grasses/semi-natural vegetation to woodland.	maintenance might be required to control the vegetated area specially to control any invasive species. Additionally, they provide an area that is shaded with a moderate temperature providing an area of refuge, for both terrestrial and aquatic life. By building a small mound down the in-field buffer strip, a beetle bank can be created, further benefiting the wildlife and encouraging natural predators of crop-eating insects.	flood management function by trapping and slowing water flow. Consideration should be given for access to the vegetated buffer strip for maintenance of the vegetation and any in stream features. There could be a designated narrow access route from one side of the stream only where larger woody material (e.g. trees/shrubs) is excluded. Therefore, access is available for powered machinery and/or delivery of trees trunks/branches for restoration/recreation of leaky barriers.

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Soil and Land Management	There may be opportunities to create wetlands. Flood storage areas can also be constructed using appropriate design and consent standards. Species-rich grasslands can be restored supporting rare wildlife. Measures designed to limit surface runoff from arable fields into watercourses and reduce quantity of fine sediment as well as the associated high phosphate/nitrate loads into the watercourse.		Wherever possible, fields or parts of fields from which there is a high risk of enhanced runoff flooding property and roads, and causing sediment pollution of watercourses, should not be used for growing vegetables. Land should be roughly cultivated immediately after harvest to remove wheel ruts. Temporary ditches and single plough furrows can be created to divert runoff from headlands to soakaway areas. High risk gateways should be blocked where these are at the bottom of slopes and new field gates opened in less risky sites. More permanent hedge banks and silt traps can be constructed to attenuate runoff. Land should be subsoiled where deeply compacted by wheelings whenever the soil becomes suitably dry in summer. Grassed strips and woodland can be planted in valley bottoms, but soil structural damage should be removed first and these areas should not be used as access routes across the farm. Slurry spreading should be carried out when the soil is dry.

2.6 Next steps

In order to pursue these opportunities into future projects, high-level next steps have been identified for each opportunity. These next steps include further investigations, assessments, surveys and modelling. Next steps were also identified following the hydraulic modelling. Below in Table 2-2 is a comprehensive list drawn together to combine both the next steps.

- Undertake landowner, stakeholder and community engagement to gain a wider understanding as to the likelihood of implementation of the features.
- Review the features to be implemented and agree outline designs (and subsequently detailed designs where necessary) with appropriate levels of modelling.
- Understand and assign maintenance requirements and responsibility of assets to an appropriate authority.
- Apply for necessary planning and consenting permissions, with a suitable level of consideration for wider environmental issues such as ecology, carbon, water quality, landscape and heritage.

Table 2-2 List of next steps for each opportunity identified in this project.

Opportunity	Next steps
Leaky Barrier and Wet Woodland at Site 3 - Glendon Wood	Overall, the site downstream of Violet Lane the Slade Brook runs through a deciduous woodland which mainly consists of Elm with Sycamore Acer pseudoplatanus, Oak Quercus robur, Hawthorn Crataegus monogyna, Elder Sambucus nigra and Ash Fraxinus excelsior. The ground flora included Lesser Celandine Ficaria verna, Dog's Mercury Mercurialis perennis, Garlic Mustard Alliaria petiolata, Lords and Ladies Arum maculatum, Common Nettle Urtica dioica, Current Ribes sp. **Evidence of Badger (latrines and paths) were evident through the woodland**. Hard-core debris has been fly-tipped into the Slade Brook from Violet Lane which it located roughly 10 metres downstream of the Violet Lane culvert. It is recommended that this material is removed from the channel as it is not natural and is causing adverse impacts to the watercourse and stability of the Violet Lane banks. Surface water channels were noted to be freely draining into the Slade Brook. The water is highly turbid and inputting a significant amount of sediment into the channel. An opportunity exists here to partially block the channel with a leaky barrier/dam to slow the flow and store more water on the floodplain, creating a wet woodland. For the leaky barrier in the Slade Brook channel reach it is recommended to undertake the following steps.

Opportunity	Next steps
	• Landowner and stakeholder engagement. • Depending on scale of opportunities, may require either detailed or geomorphological design. • Flood risk activity Environmental permit. • INNS survey and the production of an invasive species management plan if required. Including for Badgers.
River restoration at Site 4 Prologis/Linear Park Walking Paths	The banks are lined with trees and scrub including Willows, Hawthorn, Blackthorn Prunus spinosa, Oak, Great Willowherb Epilobium hirsutum and Pendulous Sedge Carex pendula, which provide a mosaic of shade for the channel. The vegetation interacts with the surface water by trailing into the water and stirring up the surface flow. Further downstream there does appear to be a two stage channel with a berms or benching running throughout the reach. It's not clear whether this is natural or as a result of modification or maintenance. The banks and riparian habitats are suitable for supporting Water Vole. For the channel restoration in this location it is recommended to undertake the following steps. • Landowner and stakeholder engagement. Including public interaction. • Topographical surveys. • Depending on scale of opportunities, may require either detailed or geomorphological design. • Flood risk activity Environmental permit. • Installation of Boardwalks and management plan for existing footpaths. • Possible planning permission needed. If needed, then EIA may also be needed.
Coppicemoor Brook at site 9 and upstream - wetland and leaky barriers.	Downstream the flow was rapid and flumed through a straightened and trapezoidal channel. The channel was lined with Hawthorn, Willows, Oak, Sycamore, Elder and Ash trees, with Rosebay Willowherb Chamaenerion angustifolium forming marginal vegetation. Vegetation was able to interact with the channel and the current cover upstream likely creates a mosaic of light and shade of the channel however it is possible that the channel become§s choked with vegetation in the summer. **There were also many badger burrows and evidence of their activity along the banks.** For the leaky barrier in the Coppicemoor Brook channel reach it is recommended to undertake the following steps. • Landowner and stakeholder engagement.

Opportunity	Next steps
	• Depending on scale of opportunities, may require either detailed or geomorphological design. • Flood risk activity Environmental permit / Ordinary Watercourse Application • INNS survey and the production of an invasive species management plan if required. Including for Badgers.

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