River Cole Feasibility and Design

Final Report

Warwickshire Wildlife Trust

C EC eco-engineering UK Ltd

December 2024

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EXECUTIVE SUMMARY

1. Historically, the River Cole has been subject to channel deepening, straightening and widening with the disconnection of the channel from its floodplain. This historical channel engineering is considered to have had a detrimental impact on river habitat, including the destruction of the natural pool-riffle habitat. WFD assessments indicate that the River Cole is rated poor for macrophytes and invertebrates.
2. CBEC was commissioned by WWT to identify key opportunities for future river and floodplain restoration along the River Cole through Coleshill, upstream of the confluence with the River Blythe.
3. The project was undertaken in two parts: (1) an options appraisal for ~12 km of the River Cole, and (2) the development of detailed designs following WWT and EA feedback. Four reaches were identified during the Options Appraisal. Reach 2, currently under HS2 construction, including a realignment of the Cole, was excluded from the detailed design phase due to lack of access and information.
4. A desk-based assessment was undertaken to review existing data on the River Cole. Data sources included archaeological / heritage information, historical maps, aerial imagery, flood risk maps, land use, soil, geology and ecological records. These data were used to provide the context and identify constraints for potential restoration options.
5. A Preliminary Ecological Appraisal indicated that there is a lack of backwater habitat, which forms crucial habitat for fish at various stages within their lifecycle. It was also highlighted that lakes, ponds, marsh and wet woodland should be protected and enhanced where present, and ideally created in areas where they are absent. Invasive Non Native Species (INNS) are present with Himalayan Balsam being extensive throughout the site while Japanese Knotweed is present within Reach 3.
6. A field-based survey of the physical condition of ~8 km of the River Cole ('fluvial audit') was undertaken to assess the distribution of morphological, sedimentary and ecological factors in combination with human impacts along the length of the restoration section. Detailed descriptions were provided for each reach (Reaches 1, 3 and 4) to illustrate the engineering pressures, morphological units and sediment dynamics observed. A fact sheet has been produced for each reach to document the dominant features in that reach.
7. A topographic survey was completed along the restoration sections to generate the data required to undertake hydraulic modelling and produce detailed design drawings.
8. An options appraisal was undertaken based on the assessment of physical form and process described above. The report describes each option in turn, briefly summarising each, including associated benefits, disadvantages and potential risks and mitigation measures, alongside a consideration of any further assessments required to progress the option to design/construction. An options matrix was produced for each reach to allow a visual comparison of the relative merits and constraints for each option. For each reach the different scales of intervention are presented and, in each case full scale intervention is recommended, in keeping with the aspirational nature if the project.
9. The survey data and options appraisal exercise were presented to WWT in the form a feasibility study (Sections 1-4 included of this report)
10. Following submission of the feasibility study, CBEC developed detailed designs for Reaches 1, 3 and 4. CBEC has, in agreement with WWT, adopted a highly aspirational approach to developing the detailed designs, with interventions designed to maximise morphological benefits and habitat creation. The proposed restoration measures include

a. Increasing in-channel complexity by placing lateral bar-apex large wood structures (LWS);
b. Increasing in-channel complexity by placing lateral bar-apex large wood structures (LWS);
c. Increasing the river-floodplain connectivity by excavating floodplain distributary channels;
d. Enhancing longitudinal connectivity over the gauging weir by means of a rock ramp fish pass;
e. Increasing channel width to depth ratio by reprofiling banks where feasible;
f. Remeandering sections of the main channel in Reaches 3 and 4;
g. Constructing floodplain mounds in Reach 4; and
h. Removal of INNS, revegetation of disturbed areas, and planting of riparian trees.

11. Design schematics and detailed design drawings are presented as part of this report. These are to convey the proposed designs and are not suitable to guide construction at this stage.
12. Hydraulic modelling was undertaken to assess design function and flood risk impact. The design includes braided channels, connecting the main channel to the floodplain in two areas. These are shown to be effective in the low flows, as well as the flood events. There is also a reduction in flooding in various areas, including the industrial development along Station Road, for up to the 1 in 30 years event. The effect is diminished for the higher return period events modelled (1 in 100, 100 cc and 1,000 years), as the floodplain becomes more extensively inundated
13. As agreed with WWT, the hydraulic modelling at this stage was develop to support the design feasibility assessment for the River Cole. For FRAP purposes, a more detailed hydrological assessment may be required, in liaison with the EA. It may be beneficial to carry out a more detailed assessment of the EA flood model and how it compares to the HEC-RAS model.
14. Construction estimates have been provided by a contractor, based on the Bil of Quantities provided by CBEC. As these designs represent a highly aspirational restoration approach, the costs of implementing full scale intervention reflect the scale of the designs. Designs can be revised to accommodate budget ceilings.

1. INTRODUCTION

CBEC was contracted by Warwickshire Wildlife Trust (WWT), who wish to consider the potential for restoring the River Cole along the final 12 km stretch which flows through Coleshill before the confluence with the River Blythe. The specific objective of the restoration project(s) is potentially reconnecting the Cole to its floodplain, restoring some natural process. The River Cole is 34km in length, rising from the slopes between Forhill and Wythall, approximately 9 km south-west of Solihull. The river initially flows south before heading north-west through Birmingham, eventually joining the River Blythe at Blythe's End, see Figure 2-1.

Warwickshire Wildlife Trust have identified a project area for which they wish to explore restoration options. This 12 km stretch of the River Cole comprises of the WFD waterbodies Cole from Springfield to Hatchford-Kingshurst Brook and Cole from Hatchford-Kingshurst Brook to River Blythe, with the latter forming the vast majority of the project area. The Coleshill and Bannerly Pools SSSI, situated predominantly on a parcel of land between the M42 and A446, is also included within the project area, although the main focus of this document is centered on the River Cole.

The River Cole above Kingshurst is considered to be ecologically important and supports several important species including otter (*Lutra lutra*) and Brown Trout (*Salmo trutta*). Historically, the River Cole has been subject to channel deepening, straightening and widening and disconnection of the channel from its floodplain. This historical channel engineering is considered to have had a detrimental impact on river habitat, including the destruction of the natural pool-riffle habitat. The River Cole in this section also has naturally low energy and a limited supply of coarse sediment, which means that the recovery of natural characteristics within the river will be slow.

At present, this section of the River Cole is under strain owing to the effects of pollution incidents and generally poor habitat exacerbated by limited longitudinal and lateral connectivity resulting from a gauging weir and steep embankments. In particular, 2022 Water Framework Directive (WFD) data indicate that the River Cole (From Hatchford-Kingshurst Brook to River Blythe) is rated poor for macrophytes, while the reach from Springfield to Hatchford-Kingshurst Brook is rated poor for invertebrates. A number of in-channel habitat improvement projects have been undertaken in the River Cole in recent years, with some projects attempting to address the modifications made to the watercourse historically, although these modifications remain a key issue for much of the watercourse.

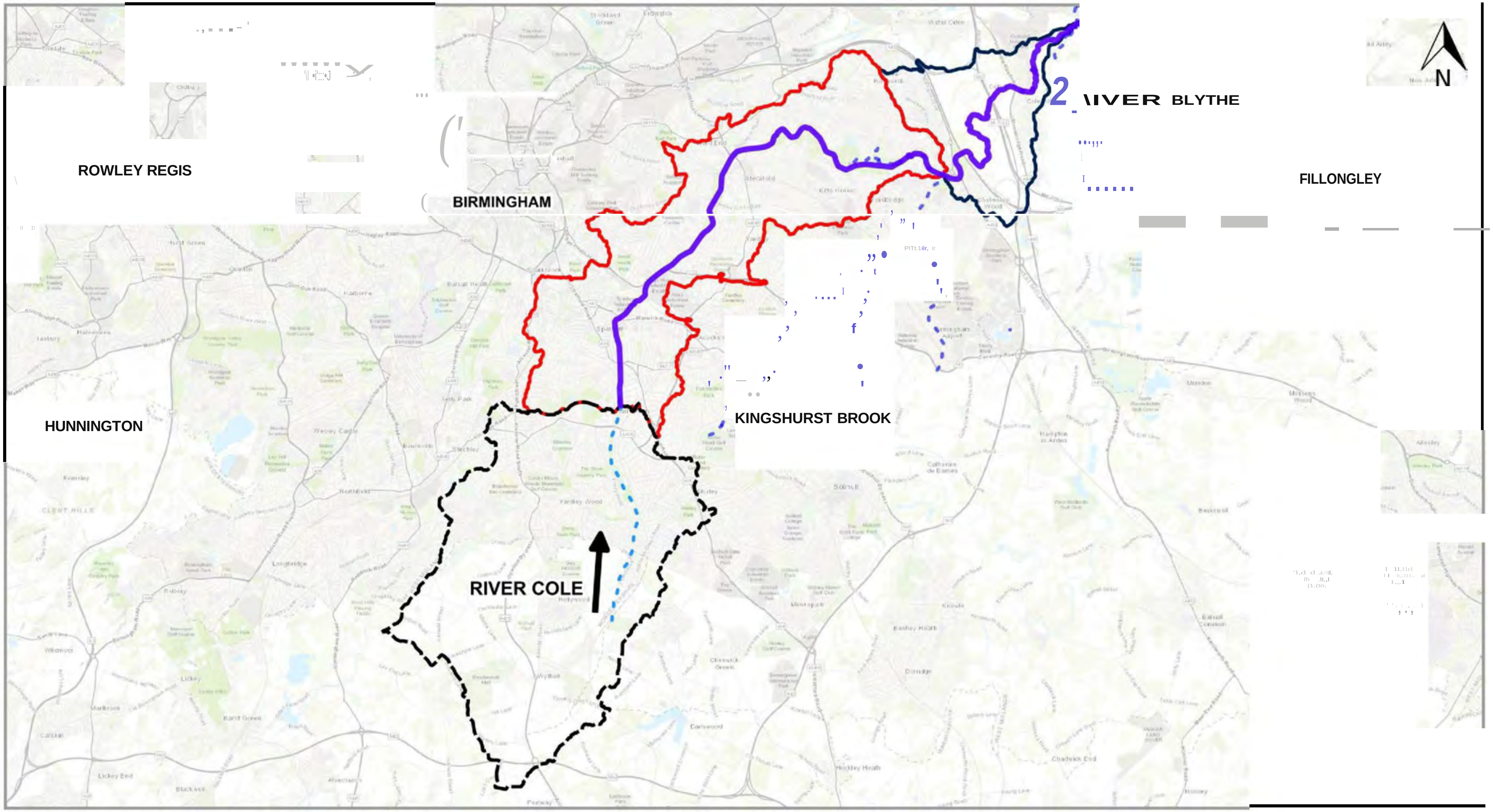
For this project, CBEC has been commissioned to identify key opportunities for future restoration projects in relation to several key themes: working with natural processes; restoration of floodplain connectivity; and function and restoration of natural river habitat. To achieve sustainable, long-term solutions for the River Cole, this project adopts a 'process-based' approach, allowing the restoration options to be developed within the context of the physical process regime of the River Cole and its wider catchment. The project is to be undertaken in two parts: (1) an options appraisal for ~12 km of the River Cole, followed by the development of detailed designs following stakeholder agreement on what is best for the catchment. This report details the options appraisal process for the River Cole, including a desk-based data review, a summary of CBEC's assessment of physical form and process in the watercourse and details of the proposed restoration options.

2. DESK-BASED DATA REVIEW

Catchment characteristics at the reach scale are influenced by both catchment-scale and reach-scale processes. Accordingly, it is important that any local restoration decisions are made with a full understanding of the wider catchment, including constraints to potential restoration options. This desk-based assessment includes consideration of a number of factors that will both inform the fluvial audit and underpin the development of appropriate restoration options.

A desk-based assessment was undertaken to review existing data on the River Cole. Data sources included historic maps, aerial imagery and previous reports and project outcomes. The total length of river under assessment extends approximately 12 km, beginning at Cooks Lane, Solihull, Ordnance Survey (OS) National Grid Reference (NGR) SP 17455 87876 to the confluence with the River Blythe (OS NGR: SP 21218 91168). A subsequent geomorphic walkover survey (fluvial audit) of the river was undertaken on 13th September 2023 by an experienced geomorphologist. Field data collected during the fluvial audit has been used to build upon the data compiled during the desk-based study and inform a greater understanding of the current processes affecting the River Cole. This provides a baseline for interpreting the current geomorphic condition of the Cole through the study area, and how the watercourse could be impacted by future proposals for restoration. Any existing data available relevant to the restoration reach and the wider catchment were considered as part of the desk-based data review and are discussed in turn below.

RIVER COLE - CATCHMENT OVERVIEW



River Cole
Upper River Cole
Tributaries and Other Waterbodies

Catchment Boundaries

Cole from Source to Springfield
Cole from Springfield to Hatchford-Kingshurst Brook
Cole from Hatchford-Kingshurst Brook to R Blythe

WEST MIDLANDS

CLIENT	WARWICKSHIRE WILDLIFE TRUST
PROJECT	RIVER COLE FEASIBILITY AND DESIGN

0 2.5 5km

Project no.	2150510
Date	22 NOV 2023
Drawn	RS
Surveyed	RS
Reviewed	SM

Scale @A4 1:130,000
British National Grid
GCS OSGB 1936

Figure 2-1: Overview of the River Cole and its WFD catchments.

2.1 ARCHAEOLOGY, HERITAGE AND DESIGNATIONS

A desk-based search of Historic England's online portal was undertaken to identify cultural heritage sites and buildings of historical interest (listed buildings) within the study site (Historic England, 2024) The Cole catchment encompasses a handful of archaeological and heritage designations. The majority of these are situated within the town of Coleshill. There are no heritage designations within 500m of the Coleshill and Bannerly Pools SSSI. A detailed list of all heritage designated areas and structures within a 150 m radius of the river channel is presented in Table 2-1. The majority of these are deemed to have little to no influence on the development of potential restoration options.

A Grade II* listed designation has also been identified as the Cole Bridge (1034701), spanning the river at Coleshill. This has the potential to restrict restoration operation development due to the specific requirements for careful planning and special permissions, which can often be difficult to obtain. The constraints imposed by these areas should therefore be considered as part of the options development and any subsequent design development and construction phase of works.

As the options outlined within this report are further developed, it will be important for the spatial planning team at Coleshill Town Council (the local planning authority for this area and historic asset) to be involved in discussions to highlight what planning permissions are required to implement the works.

Table 2-1: Archaeological and Heritage Designations within 100m of the study area, as described by Historic England (listed by Distance).

Name	Listing	List Entry ID	Distance from Channe	Location (Easting, Northing)
Bacons End Bridge	Grade: II	1076760	~om	SP 18305 87384
Cole Bridge	Grade: II*	1034701	~om	SP 19925 89513
Blyth Hall packhorse bridge over river Blyth	Grade: II	1226397	~71m	SP 21104 91007
1, High Street	Grade: II	1299644	~78m	SP1992289424
Coleshill Hall Farmhouse	Grade: II	1034691	~84m	SP 1908188250

Listing Meaning:

Grade I - A category for a building or site which is of exceptional national, architectural or historical importance.

Grade II - A category for buildings of special interest.

Conservation Areas -Areas earmarked as important for conservation

2.2 ECOLOGICAL RECORDS

Complimentary to the aims of river restoration, a large portion of the River Cole within the project area is designated as a Local Nature Reserve (LNR), see Figure 2-2. The Cole Bank LNR encompasses an area of 13.26 ha, spanning from Cooks Lane to the M6 motorway. It was designated in 2007 for its ecologically important mosaic of grassland scrub and wetland (Solihull.gov.uk, 2023). A small section of the River Coles southern bank at Coleshill (between Stonebridge Road and Lichfield Road) is designated as the Cole End LNR, comprised of a mixture of plantation and wet woodland. Warwickshire Wildlife Trust has identified Himalayan Balsam to be prevalent throughout the Cole End LNR, therefore any works undertaken by CBEC in this area are co to be conducted in a way that will minimise any further spread of this invasive non-native species.

Coleshill and Bannerly Pools SSSI is comprised of nationally significant and important habitats. The SSSI contains three distinct areas: Coleshill and Bannerly pools, and The Bogs. Together these areas form a valley mire ecosystem, the only one of which is found within Warwickshire. The system is characterized by deep peat deposits and rare assemblages of nationally restricted woodland, including acid valley alder wood and sump alderwood (Highways England, 2019).

Coleshill and Bannerly Pools SSSI was last assessed by Natural England as Unfavourable – Recovering in 2013. This was due to pressures from non-native invasive species, particularly Himalayan balsam and rhododendron. It was also noted that birch scrub was beginning to take over areas of fen, and was needing removal. A preliminary ecological appraisal of 2km of land surrounding Packington Landfill was conducted by Patrick Parsons in 2019. This included a survey of the full extent of the Coleshill and Bannerly Pools SSSI, and the presence of non-native invasive species was also identified during this survey. This appraisal also noted the presence of notable higher and lower plants throughout the SSSI, and the presence of notable bird species in the area surrounding Coleshill Pool. Due to the unspoilt nature of the Coleshill and Bannerly Pools SSSI, the presence of species protected under UK and European legislation cannot be ruled out. In 2011, Argus Ecology Ltd recorded the presence of great crested newts on a patch of terrestrial land lining Bannerly pool. It could therefore be assumed that Bannerly Pool supports a population of great crested newts (Patrick Parsons, 2019), and any future works undertaken by CBEC would have to proceed with care so as not to disturb this rare and protected species.

In addition to the Coleshill and Bannerly Pools SSSI (which is located to the south of Coleshill at the junction of the M6 and M42), the entire length of the River Blythe's channel is designated as a SSSI. The River Cole's confluence with the River Blythe is situated at the downstream extent of the project area, although the radial impact risk zones associated with the SSSI in this area could limit potential river restoration options and must be taken into account when considering option development.

RIVER COLE - ENVIRONMENTAL DESIGNATIONS

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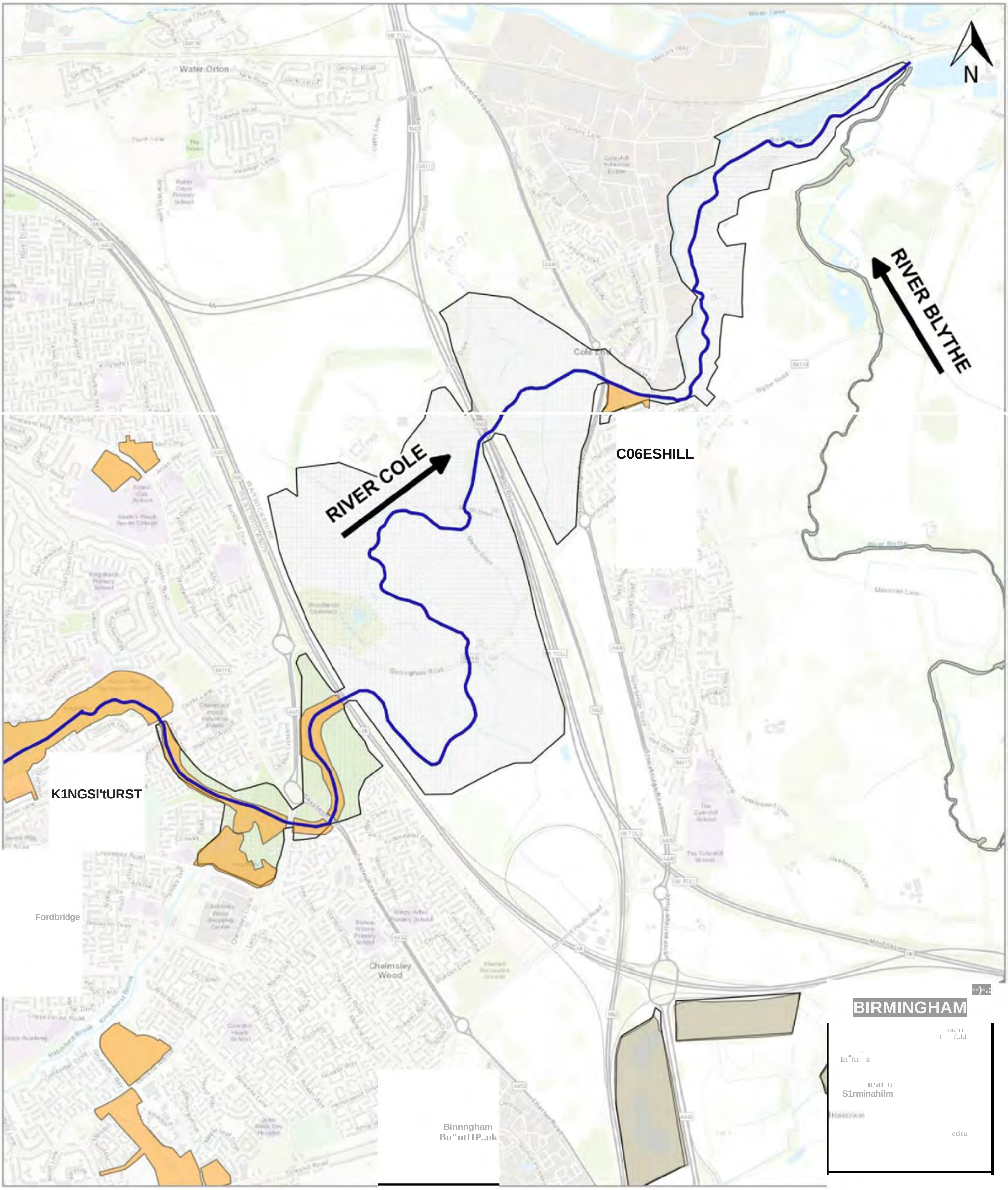

- River Cole
D Local Nature Reserves
D Project Area
D Sites of Special Scientific Interest

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no	2150510
PROJECT	RIVER COLE- FEASIBILITY AND DESIGN	Date	22AUG 2023
		Drawn	RS
		DesiQned	
		Reviewed	SM

0 250 500 750 1,000 m

Scale @ A4 - 1:25,000
British National Grid
GCS OSGB 1936

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Figure 2-2: Environmental designations within the project area.

2.2.1. Preliminary Ecological Appraisal

A Preliminary Ecological Appraisal (PEA) comprised of an aquatic habitat walkover, and a riparian habitat walkover was conducted by RSK Biocensus on the 9th-10th January 2024 and 13th-14th November 2023 respectively.

Key findings from the PEA indicate that there is a lack of backwater habitat, which forms crucial habitat for fish at various stages within their lifecycle. It was also highlighted that the Warwickshire biodiversity action plan indicated that lakes, ponds, marsh and wet woodland are listed as local target habitat types. Therefore, all of the above habitat types should be protected and enhanced where present, and ideally created in areas where they are absent.

The PEA also indicated that Invasive Non Native Species (INNS) are present throughout the project area in varying densities, with Himalayan Balsam being relatively extensive throughout the site. As was also identified within the fluvial audit (see Section 3), Japanese Knotweed is present within Reach 3 (see Figure 3-1), in two localised stands. Whilst it would be very costly to eradicate Himalayan Balsam from the River Cole due to its density, removal of the two individual stands of Japanese Knotweed could present an easy win.

Removal of the weir situated within Reach 1 (OS NGR: SP 18180 87360) was also suggested within the PEA, as it prevents a large barrier to the migration of fish. In support of the removal of the weir, it is suggested that further surveys be undertaken, including fish passage appraisal options and a subsequent feasibility study to determine if removal is technically feasible.

Implementation of flow deflectors, in the form of Large Woody Material (LWM), present a relatively easy and cost-effective option for increasing flow diversity, scour pools and clean gravels, all of which are essential habitat for juvenile fish. Within the PEA, it is suggested that Reach 1 would benefit the most from the introduction of LWM.

2.3 THE WATER FRAMEWORK DIRECTIVE

The River Cole lies within the Tame Anker and Meese management catchment and within the project area it is split into two WFD surface waterbodies, Cole from Springfield to Hatchford-Kingshurst Brook (Water body ID: GB104028042502) and Cole from Hatchford-Kingshurst Brook to River Blythe (Water body ID: GB104028042420). Whilst the River Cole has the potential to support a wide range of flora and fauna, long standing and widespread anthropogenic pressures have had a profound impact on the ecological, biological and chemical status of this watercourse. As shown in Table 2-2, the Cole from Hatchford-Kingshurst Brook to River Blythe (which the project area falls predominantly within) is designated as heavily modified, although it is classed a 'Moderate' under its ecological status, whilst the Cole from Springfield to Hatchford-Kingshurst Brook is not designated as artificial or heavily modified, but does have Poor ecological status, (Data.gov.uk, 2024). The land use around the Cole from Springfield to Hatchford-Kingshurst Brook is urbanised, and as such the EA has identified that diffuse urban run-off is a key issue, negatively impacting fish and invertebrates, as well as levels of phosphate and ammonia. The Cole from Hatchford-Kingshurst Brook to River Blythe is surrounded by more arable land, and run-off arising from poor livestock management, as well as intermittent sewage discharges, have been determined to be the reason that this waterbody has not achieved 'Good' status on several of its indicators.

Table 2-2 2019 WFD classification of Cole from Hatchford-Kingshurst Brook to R Blythe.

Element	2019 Status	Predicted Status by 2027	Reason for Failure
Biological Quality Elements (Moderate)			
Invertebrates	Moderate	Moderate	Disproportionately expensive: Unfavourable balance of costs and benefits
Macrophytes and Phytobenthos Combined	Moderate	Moderate	Disproportionately expensive: Unfavourable balance of costs and benefits
Macrophytes Sub Element	Poor	Poor	N/A
Phytobenthos Sub Element	Moderate	Moderate	N/A
Hydromorphological Supporting Elements (Supports Good)			
Hydrological Regime	Supports Good	Supports Good	Achieved in 201S
Supporting Elements (Surface Water)	Moderate	Moderate	Disproportionately expensive: Unfavourable balance of costs and benefits
Mitigation Measures Assessment	Moderate or Less	Moderate or Less	Disproportionately expensive: Unfavourable balance of costs and benefits
Physico-Chemical Quality Elements (Moderate)			
Ammonia	High	Good	Achieved in 201S
Dissolved oxygen	Good	Good	Achieved in 2015
Phosphate	Moderate	Moderate	Disproportionately expensive: Unfavourable balance of costs and benefits

Temperature	High	Good	Achieved in 2015
pH	High	Good	Achieved in 2015
Chemical (Priority Hazardous Substances) (Fail)			
Benzo(a)pyrene	Good	Good	Achieved in 2015
Dioxins and dioxin-like compounds	Good	Good	Achieved in 2015
Heptachlor and cis-Heptachlor epoxide	Good	Good	Achieved in 2015
Hexabromocyclododecane (HBCDD)	Good	Good	Achieved in 2015
Hexachlorobenzene	Good	Good	Achieved in 2015
Hexachlorobutadiene	Good	Good	Achieved in 2015
Mercury and Its Compounds	Fail	Good - 2040	Natural conditions: Chemical status recovery time
Perfluorooctane sulphonate (PFO5)	Fail	Good - 2039	Technically infeasible: No known technical solution is available
Polybrominated diphenyl ethers (PBDE)	Fail	Good - 2063	Natural conditions: Chemical status recovery time
Priority Substances (Good)			
Fluoranthene	Good	Good	Achieved in 2015
Cypermethrin (Priority)	Good	Good	Achieved in 2015

Table 2-3: 2019 WFD classification of Cole from Springfield to Hatchford-Kingshurst Brook

Element	2019 Status	Predicted Status by 2027	Reason for Failure
Biological Quality Elements (Moderate)			
Invertebrates	Poor	Moderate	Disproportionately expensive: Unfavourable balance of costs and benefits
Macrophytes and Phytobenthos Combined	N/A	N/A	Not Recorded
Macrophytes Sub Element	N/A	N/A	Not Recorded
Phytobenthos Sub Element	N/A	N/A	Not Recorded
Hydromorphological Supporting Elements (Supports Good)			
Hydrological Regime	Supports Good	Supports Good	Achieved in 2015
Supporting Elements (Surface Water)	Supports Good	Supports Good	Achieved in 2015
Mitigation Measures Assessment	N/A	N/A	Not Recorded
Physico-Chemical Quality Elements (Moderate)			
Ammonia	Good	Good	Achieved in 2021
Dissolved oxygen	Good	Good	Achieved in 2021

Phosphate	Moderate	Moderate	Disproportionately expensive: Unfavourable balance of costs and benefits
Temperature	High	Good	Achieved in 2015
pH	High	Good	Achieved in 2015
Chemical (Priority Hazardous Substances) (Fail)			
Benzo(a)pyrene	Good	Good	Achieved in 2015
Dioxins and dioxin-like compounds	Good	Good	Achieved in 2015
Heptachlor and cis-Heptachlor epoxide	Good	Good	Achieved in 2015
Hexabromocyclododecane (HBCDD)	Good	Good	Achieved in 2015
Hexachlorobenzene	Good	Good	Achieved in 2015
Hexachlorobutadiene	Good	Good	Achieved in 2015
Mercury and Its Compounds	Fail	Good - 2040	Natural conditions: Chemical status recovery time
Perfluorooctane sulphonate (PFOS)	Fail	Good - 2039	Technically infeasible: No known technical solution is available
Polybrominated diphenyl ethers (PBDE)	Fail	Good - 2063	Natural conditions: Chemical status recovery time
Priority Substances (Good)			
Fluoranthene	Good	Good	Achieved in 2015
Cypermethrin (Priority)	Good	Good	Achieved in 2015
Lead and Its Compounds	Good	Good	Achieved in 2015
Nickel and Its Compounds	Good	Good	Achieved in 2015

2.4 HISTORICAL MAPS AND AERIAL IMAGERY

Analysis of historical datasets (including historical maps, aerial imagery and photography) adds valuable temporal context to the data collected during field surveys. Such analysis facilitates, for example, the assessment of (a) the degree of dynamic behaviour resulting from natural fluvial processes, as opposed to human activity, and (b) the 'reference state' of the river system.

The earliest available Ordnance Survey maps of the study area, OS 6-inch (1886) (National Library of Scotland, 2023) depicts the River Cole as a fairly sinuous channel in a rural setting with evidence of natural features such as mid-channel islands and ponds in the floodplain. However, there is still some evidence of channel modification during this period, with some of the rivers flow being directed into drainage channels, most likely for drainage of arable land or powering of mills.

Comparison of the historic channel alignment with modern aerial imagery (Google Satellite, 2023) (Figure 2-3) shows that the main stem of the channel has been straightened and redirected as it passes the urban areas of Kingshurst and Coleshill. The channels islands were also lost prior to the 1950's. At some point after the 1950's, the River Coles flow was split between the original channel and a drainage ditch as it moves past Coleshill. The Coles confluence with the River Blythe has also been modified, having been moved further downstream towards the Whiteacre Waterworks pumping station. Although not delineated on either modern or historic maps, the dense network of smaller drains visible in aerial imagery are assumed to be recent additions associated with agricultural land use.

Historic mapping shows that the Coleshill and Bannerly Pool SSSI was originally situated within a larger connected area of woodland, marsh and bog. The south-western section outside of the A452 motorway was de-forested in 2022 as part of infrastructure works (Figure 2-4).

RIVER COLE - HISTORIC CHANNEL ALIGNMENT

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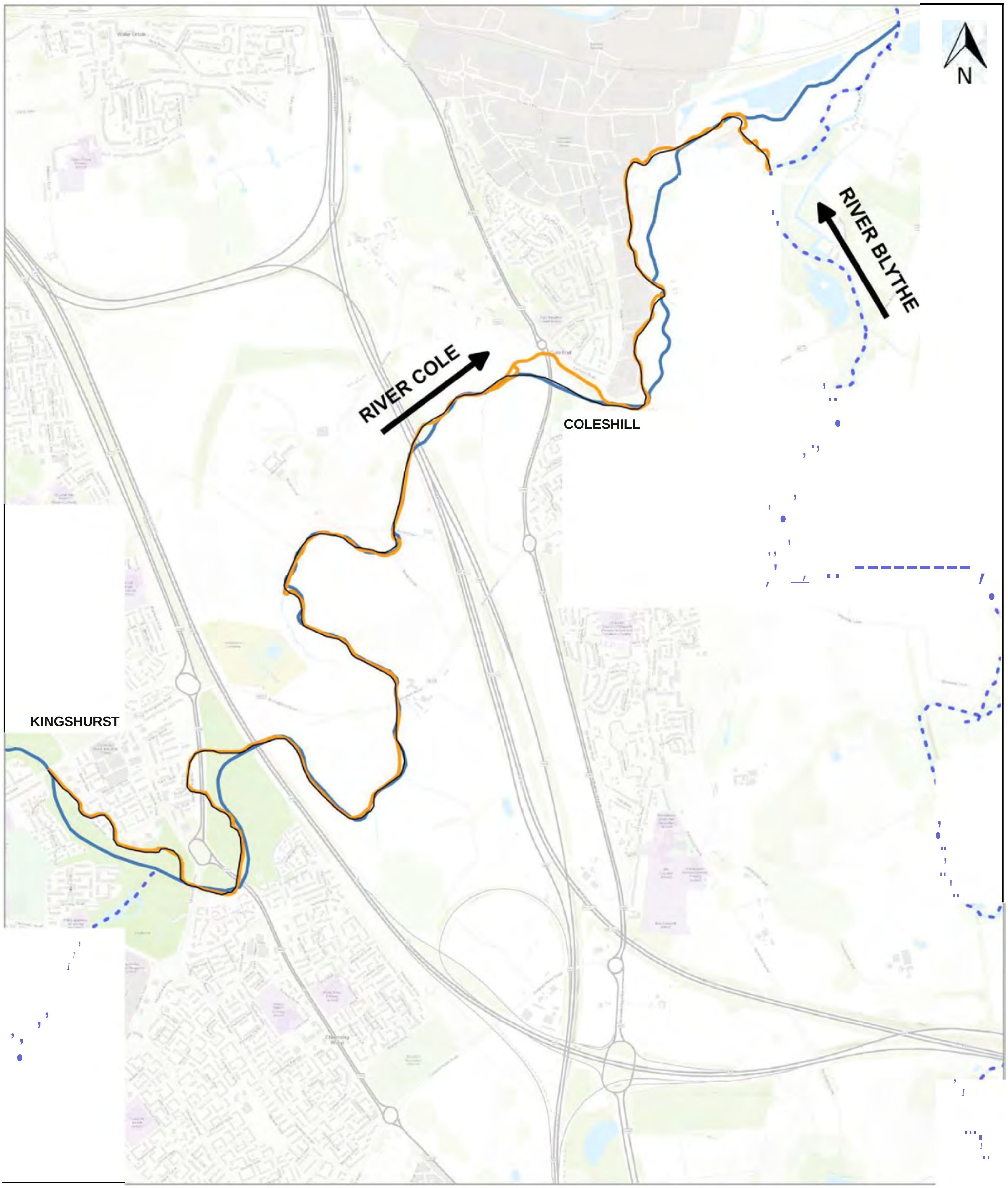


River Cole Channel Alignment

Present Day

1950 - 1959 [1]

1886 [1]

Tributaries and Other Waterbodies

[1] Data digitised from historic maps provided by National Library of Scotland, 2023

BIRMINGHAM

CLIENT: WARWICKSHIRE WILDLIFE TRUST

PROJECT: RIVER COLE- FEASIBILITY AND DESIGN

0 0.25 0.5 0.75 km

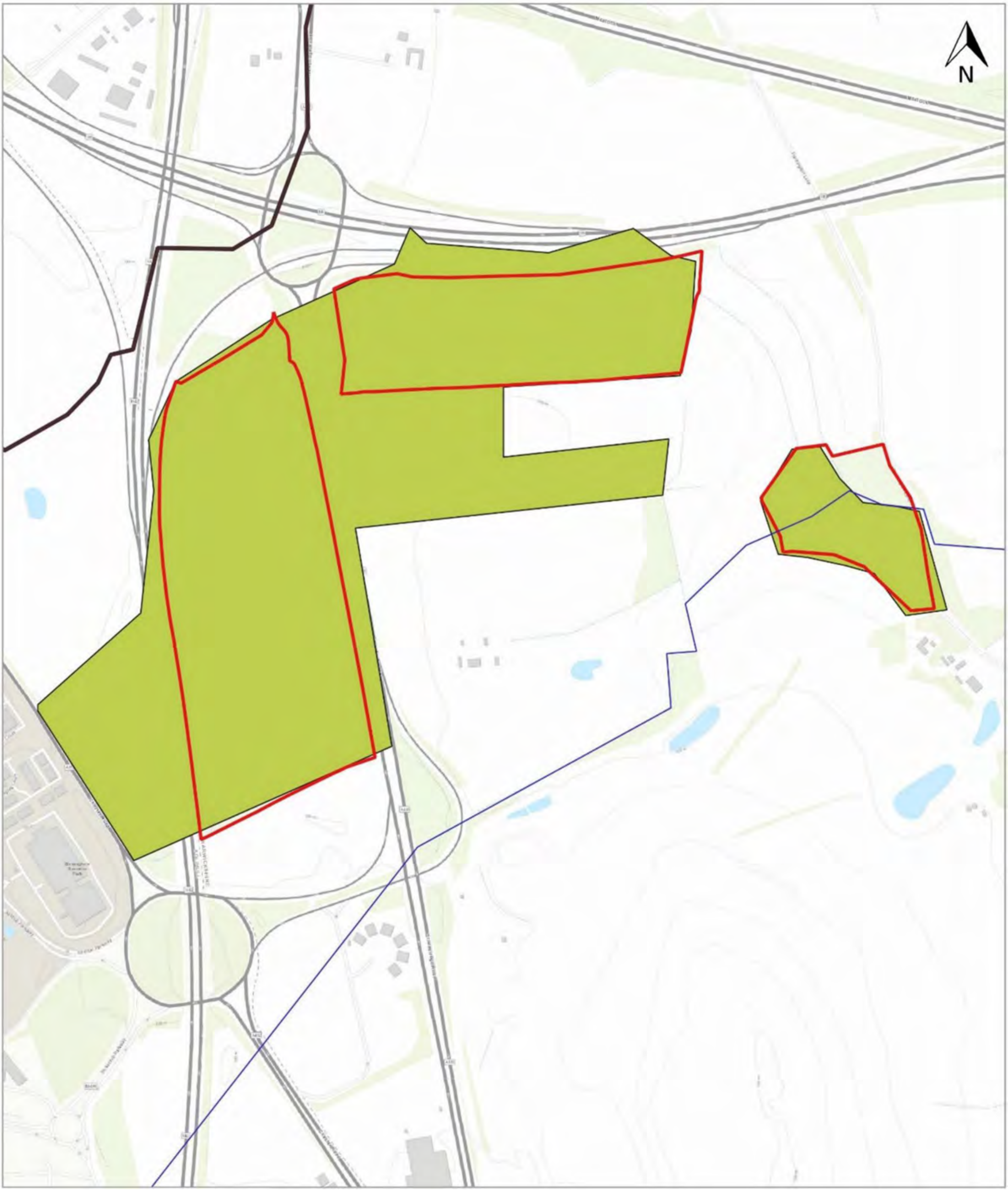
Project no.	2150510
Date	23 MAY 2024
Drawn	RS
Designed	
Reviewed	SM

Scale @A4- 1:22,000
British National Grid
GCS OSGB 1936

Figure 2-3: Historic channel alignment to the River Cole within the project area.

COLESHILLAND BANNERLY POOLS SSSI - LOCATION MAP

cbec



- Tributaries and Other Waterbodies
- Present Day Extent
- Historical Extent (1886)

BIRMINGHAM

CLIENT	WARWICKSHIRE WILDLIFE TRUST
PROJECT	RIVER COLE - FEASIBILITY AND DESIGN
Project no	2150510
Date	22AUG 2023
Drawn Designed	RS
Reviewed	SM

0 100 200m

Scale @ A4 - 1:8,500
British National Grid
GCS OSGB 1936

Figure 2-4: Historic extents of the Coleshill & Bannerly Pools SSSI.

2.5 HYDROLOGY AND FLOOD RISK

Assessment of the EA flood risk inundation map reveals that the River Cole is likely to flood along the majority of its length, particularly around its confluence with the River Blythe. There is also an area of elevated flood risk adjacent to the M42 motorway, just upstream of the historic site of the medieval Coleshill Manor, see Figure 2-5.

Given the probability of flooding in the study area, the creation of re-meandered sections of channel and wetland scrapes would potentially allow for increased flood water storage capacity. The slow release of both flood and surface water from wetlands would act as a natural buffer, whilst trapping potentially nutrient loaded sediments entering the river from arable land. Re-meandered sections of channel would also slow the conveyance of flood pulses downstream. This could have the potential to decrease the likelihood of flooding in the town of Coleshill, which last issued a flood warning in June, 2023 (FloodAssist.co.uk, 2023). In addition to Natural Flood Management (NFM), restoring the River Cole in this way could also provide additional benefits including improvement of local aesthetics, and providing recreation and amenity value to local residents.

Undertaking a higher resolution flood risk model would be the most appropriate methodology to establish if these findings are valid for the site conditions and for the validation of any channel modification or wetland design.
The Coleshill and Bannerly Pools SSSI is entirely within Flood Zone 1, and not at any significant risk of flooding, see Figure 2-6.

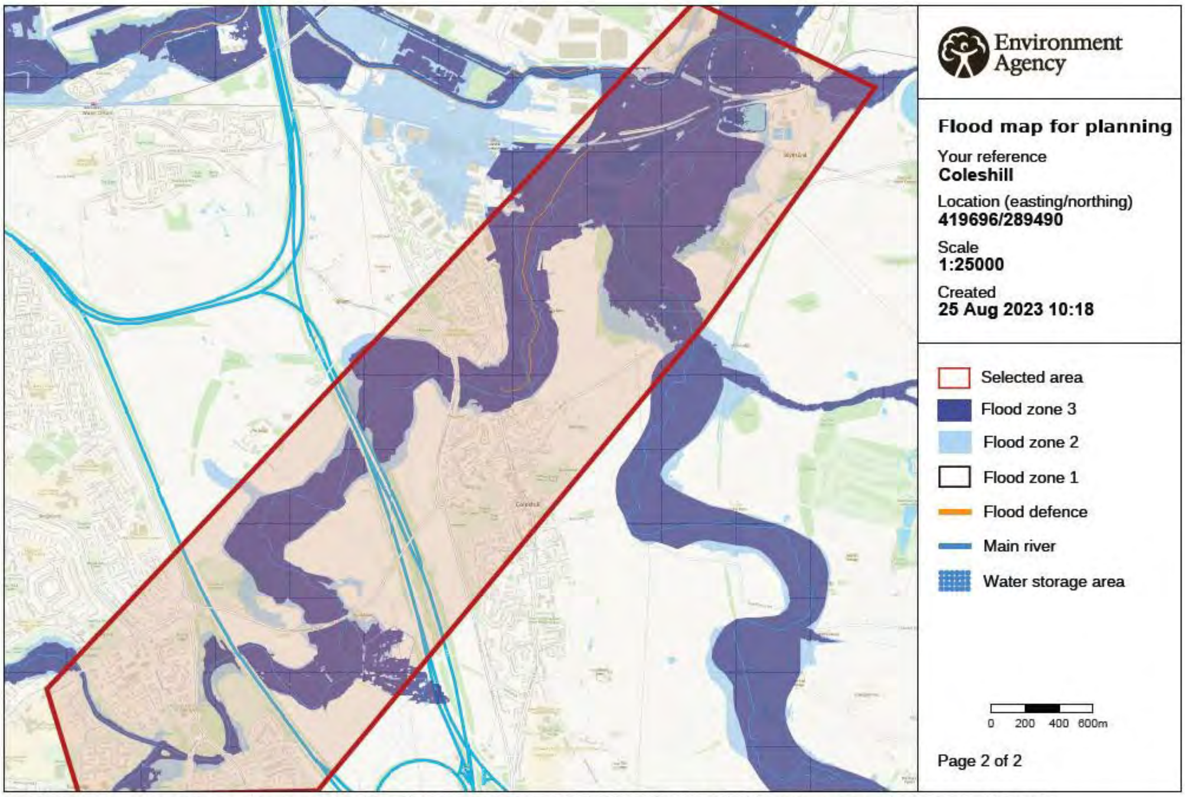


Figure 2-5: Flood risk within the project area. Source: Environment Agency.

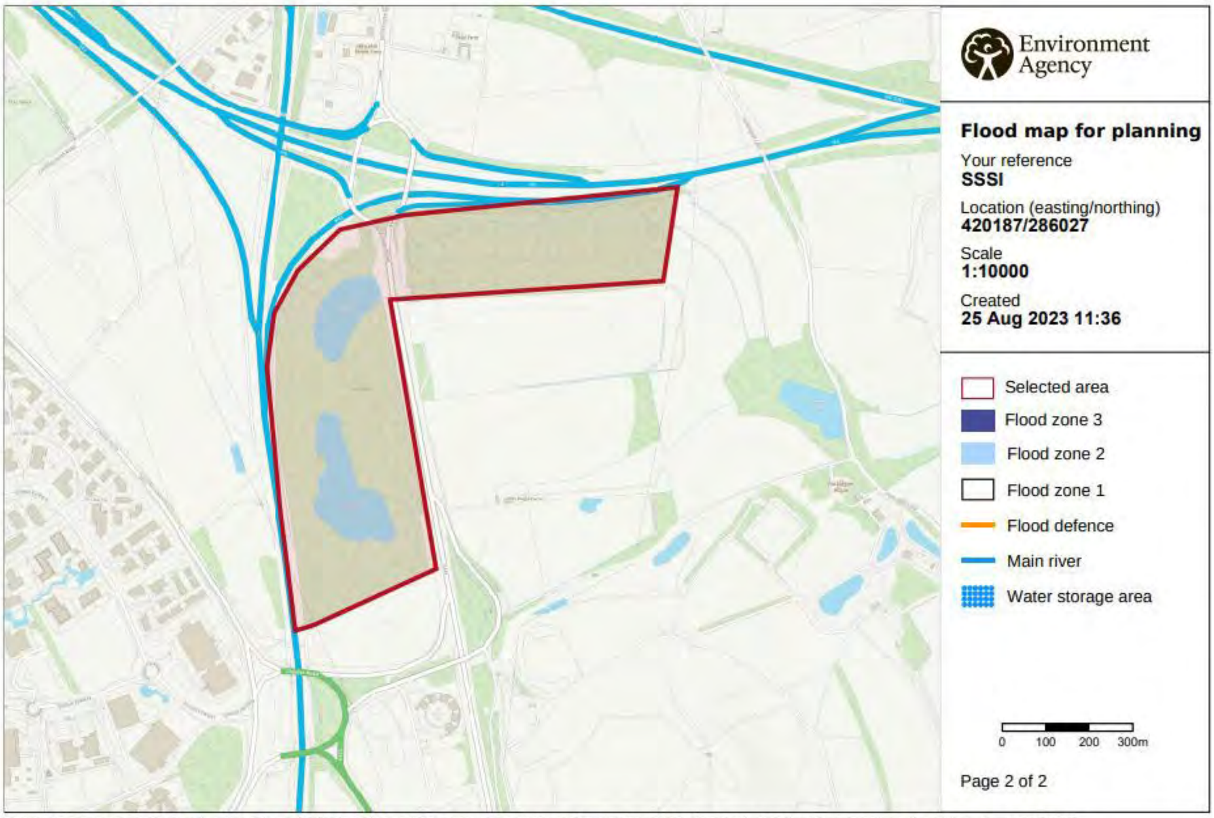


Figure 2-6: Flood risk within the Coleshill & Bannerly Pools SSSI. Source: Environment Agency.

A flood alleviation scheme has been constructed by the Environment Agency for the section of the River Cole directly downstream of Coleshill. Immediately downstream of Chestnut Grove, Coleshill, the River Coles main channel is split in two, see Figure 2-7, with the left flood alleviation channel (which follows the course of the original River Cole channel, being controlled by a series of sluice gates. No information was found as to which flood events the channel comes online for, although the sluice gates and associated structures are being inspected on a yearly basis and are in generally fair condition (EA Asset Management, 2024). The right channel, which carries the main river and was constructed around 2012, is embanked by high ground on either side for the purpose of flood management. The two channels are separated by the Coleshill flood bank (a 2.3 km earth embankment running through the agricultural land in between the channels on the left floodplain) was constructed in 2003.

Within the PEA conducted by RSK Biocensus, see Section 2.2.1, it was suggested that the periodic opening of the sluice gates could help turn the flood alleviation channel into a backwater, providing an essential habitat. However, during the topographic survey it was determined that this channel is extremely silted, as well as visibly polluted with Petro-chemicals (likely arising from runoff from the adjacent industrial estate. This could present a barrier to the formation of ecologically significant backwater habitat, as well as result in polluted water and sediment entering the River Cole should it be reconnected. Extensive remediation of the flood alleviation channel would therefore be required should any regular re-connection with the River Cole take place.

2.7 GEOLOGY & SOILS

Bedrock, superficial geology and soil cover are important considerations in the development of restoration options because these factors (together with topography and land use) exercise fundamental controls on sediment availability and the response of the fluvial system to rainfall. The bedrock geology of the River Cole catchment is characterised entirely by the Sidmouth and Branscombe Mudstone Formations, which are made up of sedimentary geologies with low permeability (BGS, 2022), see Figure 2-10.

Superficial deposits within the channel margins are dominated by quaternary alluvium, composed of clay, silt, sand and gravel; such deposits are characteristic of fluvial environments and range from coarse to fine-grain sediment sizes, see Figure 2-11. In addition to the presence of alluvium, the catchment is also overlain with glaciofluvial deposits (meltwater deposited sediments that are predominantly coarse sand and gravel with some finer silts). The Coleshill and Bannerly Pools SSSI is overlain predominantly by glaciofluvial deposits, with alluvium being present within the pool areas. Throughout the catchment, there are also isolated pockets of river terrace deposits (sand and gravels), and till, an unsorted, heterogenous mix of clay, sand gravel and lag boulders deposited by glacial activity.

The dominant soil type within the catchment is Cambisol, see Figure 2-12, which are freely draining-base rich soils with the optimum properties to support arable pastures and deciduous woodlands. Similarly, the Coleshill and Bannerly Pools SSSI is almost entirely dominated by Cambisol soils. Planosols, which are associated with periodically waterlogged flats, are present within the River Coles floodplain in the area of Coleshill. The channel corridor through the restoration reach is comprised mainly of Fluvisol, a soil type that is formed from sediment deposited by rivers during flood periods. The presence of Planosol and Fluvisols within the river corridor indicates that the River Cole historically had good access to its floodplains and would flood regularly.

The urban areas of Solihull and Coleshill are situated to the north and west of the study area, which are comprised of urban materials such as asphalt and concrete. These materials, unlike most soils, are impermeable, and do not directly add value to the natural environment. These materials can cause increased runoff, directing heavier flows towards waterbodies like the River Cole (Teagasc, 2014).

RIVER COLE - CATCHMENT LIDAR

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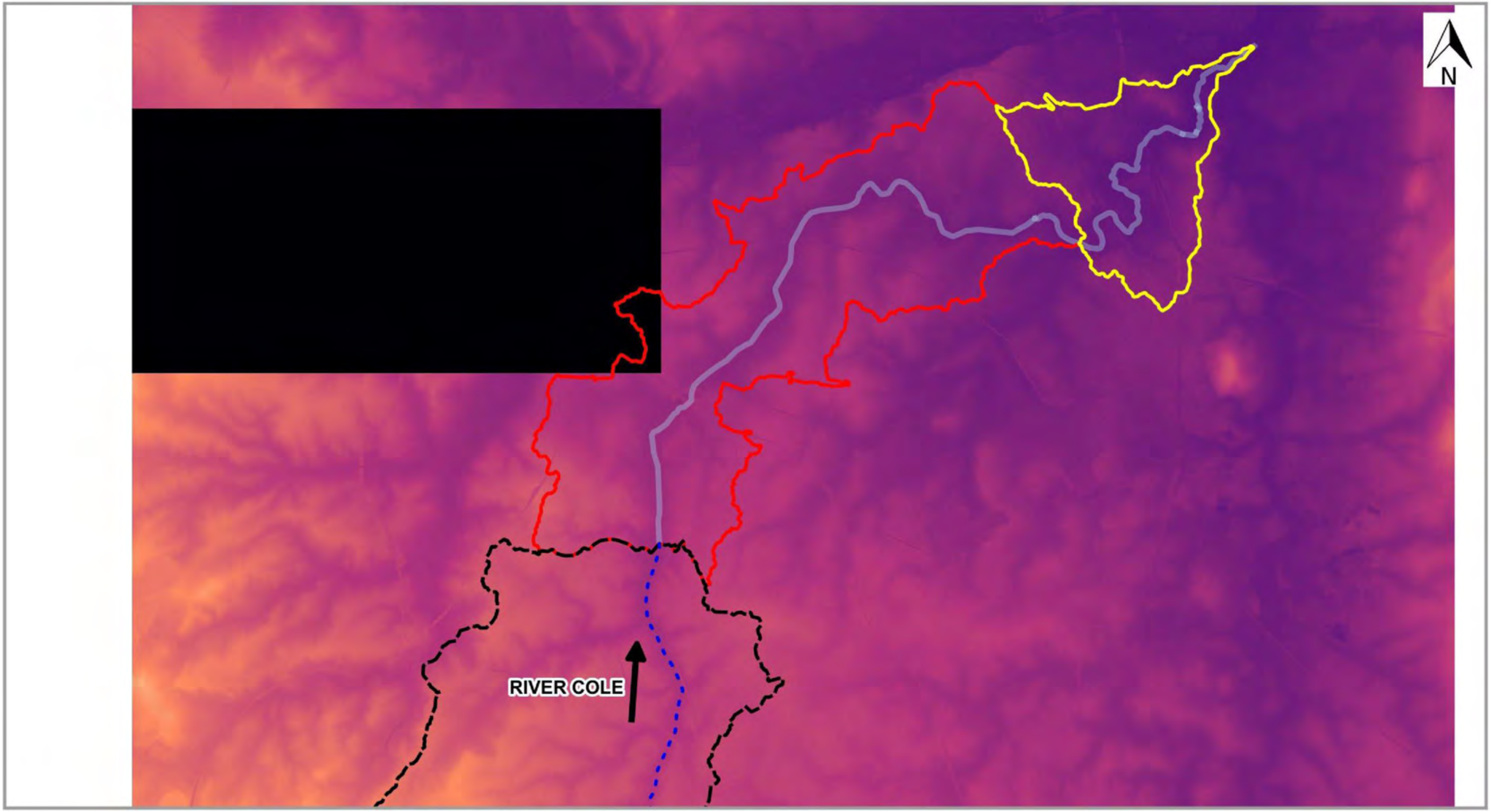
ec:o ,en91rie ring



River Cole

UpperRiverCole

Catchment Boundaries

Cole from Hatchford-Kingshurst Brook to R Blythe

D Cole from Springfield to Hatchford-Kingshurst Brook

r-, Cole from Source to Springfield

LiDAR

Band 1 (Gray)

262.155487

0

WEST MIDLANDS

CJ

CLIENT WARWICKSHIRE WILDLIFE TRUST

PROJEC, RIVER COLE FEASIBILITY AND DESIGN

0 2.5 5km

Service Crtldl5: Main maps Googe (2019), Soltut aw, s.tt'Xf-, lm.gerv: 2019 Google. OVcfilrew mao soorces - Esri. itdlGlobe. E.irUlstar Geograp 11:5, CNES/A.rbl.ls DS, GeoEyc. SD FS,l., USGS, Aerog rJ, tGN, !GP, and thi GIS US&f Community.

Project no	2150510
Date	22 NOV 2023
Drawn	RS
Surveyed	RS
Reviewed	SM

Scale@A4- 1:100,000
British National Grid
GCS OSGB 1936

Figure 2-9: Topography of the lower River Cole catchment. Source: Data.Gov,Uk.

2.6 TOPOGRAPHY, LAND USE AND LAND COVER

Catchment topography (relief) will determine how rapidly the host fluvial system responds to rainfall and controls the sediment transport regime within the system. LiDAR (obtained from Data.Gov.UK) shows that the lower River Cole sits at the bottom of a very shallow valley, and there is low relief throughout the catchment, see Figure 2-9.

Land use and land cover patterns within the catchment will provide controls over the influx of water, sediment, with urban land covers contributing to increased runoff. In order to determine both the historic and current land cover utilisation, historic and modern aerial photography were reviewed to assess changes to the catchment land cover and land use over time. Analysis of satellite imagery (Google Satellite, 2023)shows a large increase in urban/residential land cover between 1945 and 2001, with the development of Solihull and Kingshurst. Further development post 2001 was insignificant, see Figure 2-8.

Figure 2-8: Satellite imagery from 1945, 2001 and 2022, showing the increase in urban land cover within the River Cole catchment. Data: Google Earth.

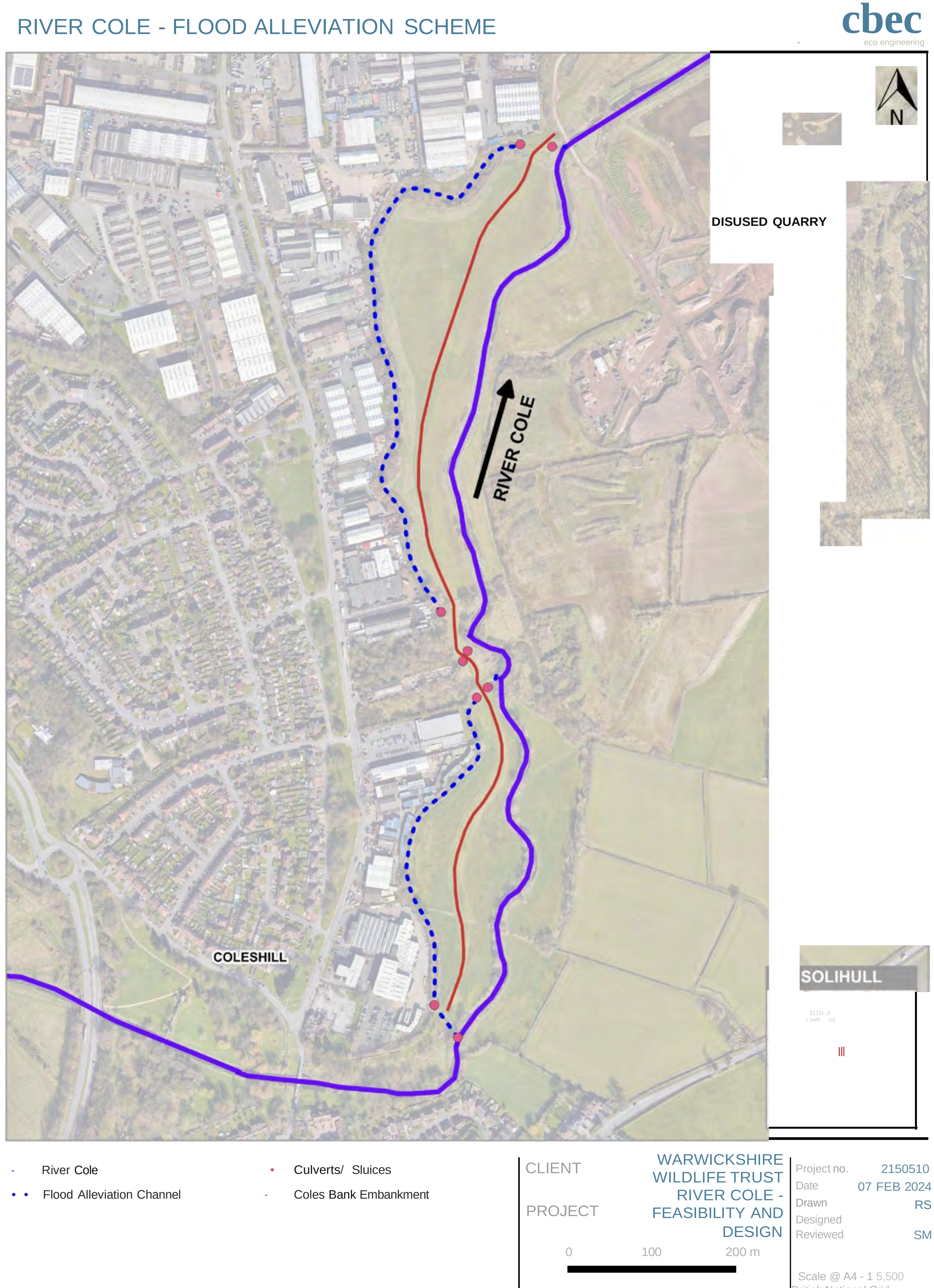
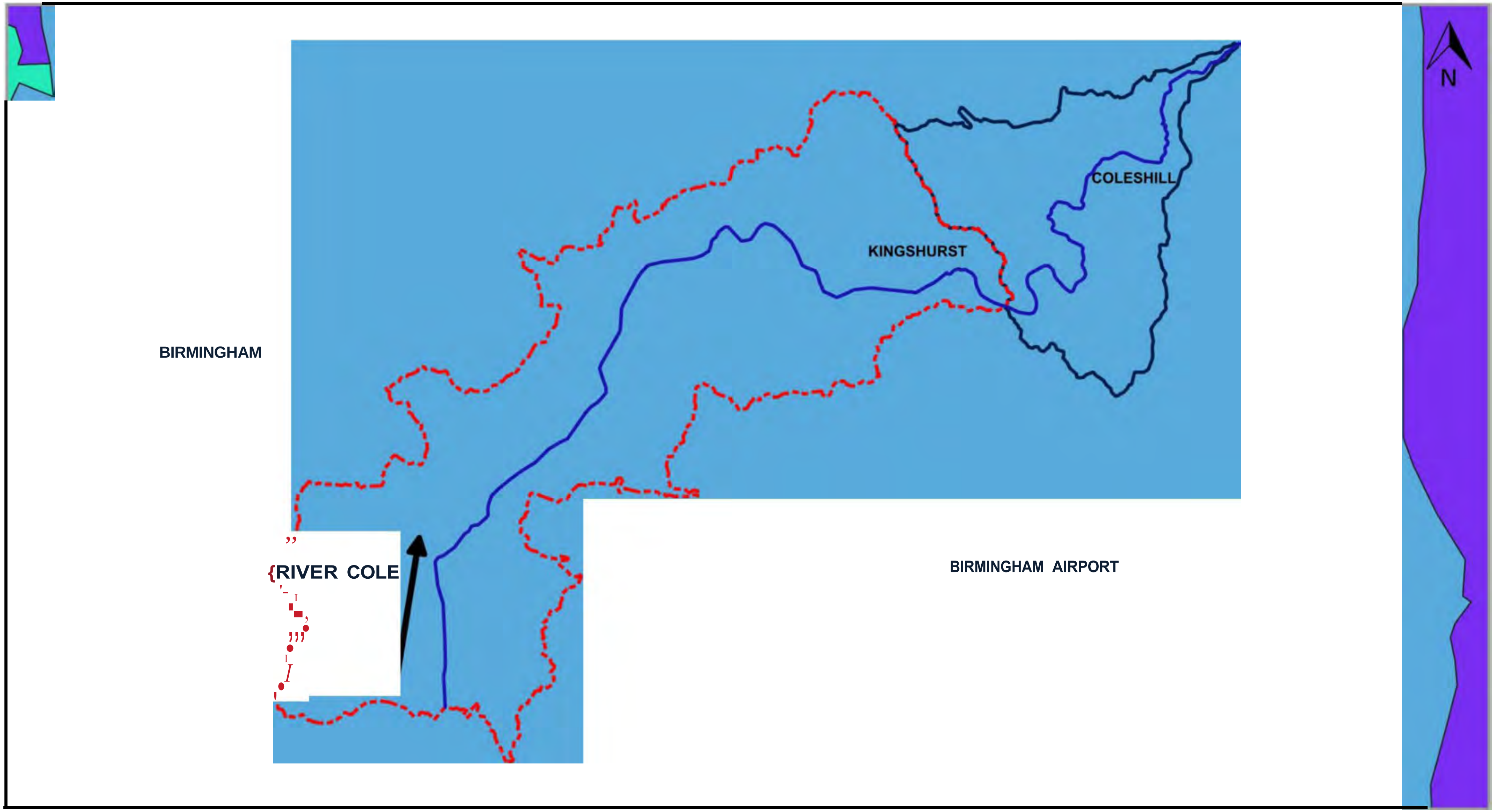


Figure 2-7: Environment Agency flood alleviation scheme at Coleshill.

RIVER COLE - BEDROCK GEOLOGY

cbe eco engineering



- River Cole
- Upper River Cole

Catchment Boundaries

Cole from Hatchford-Kingshurst Brook to R Blythe

Cole from Springfield to Hatchford-Kingshurst Brook

Bedrock Geology

Mudstone, Siltstone And Sandstone

Sandstone And Conglomerate, Interbedded

Siltstone And Sandstone With Subordinate Mudstone

WEST MIDLANDS

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
PROJECT	RIVER COLE FEASIBILITY AND DESIGN	Date	22 NOV 2023
		Drawn	RS
		Surveyed	RS
		Reviewed	SM

0 2 3 4km

Scale @ A4 - 1:75,000

British National Grid GCS OSGB 1936

Figure 2-10: Bedrock geology of the lower River Cole catchment. Source: BGS.

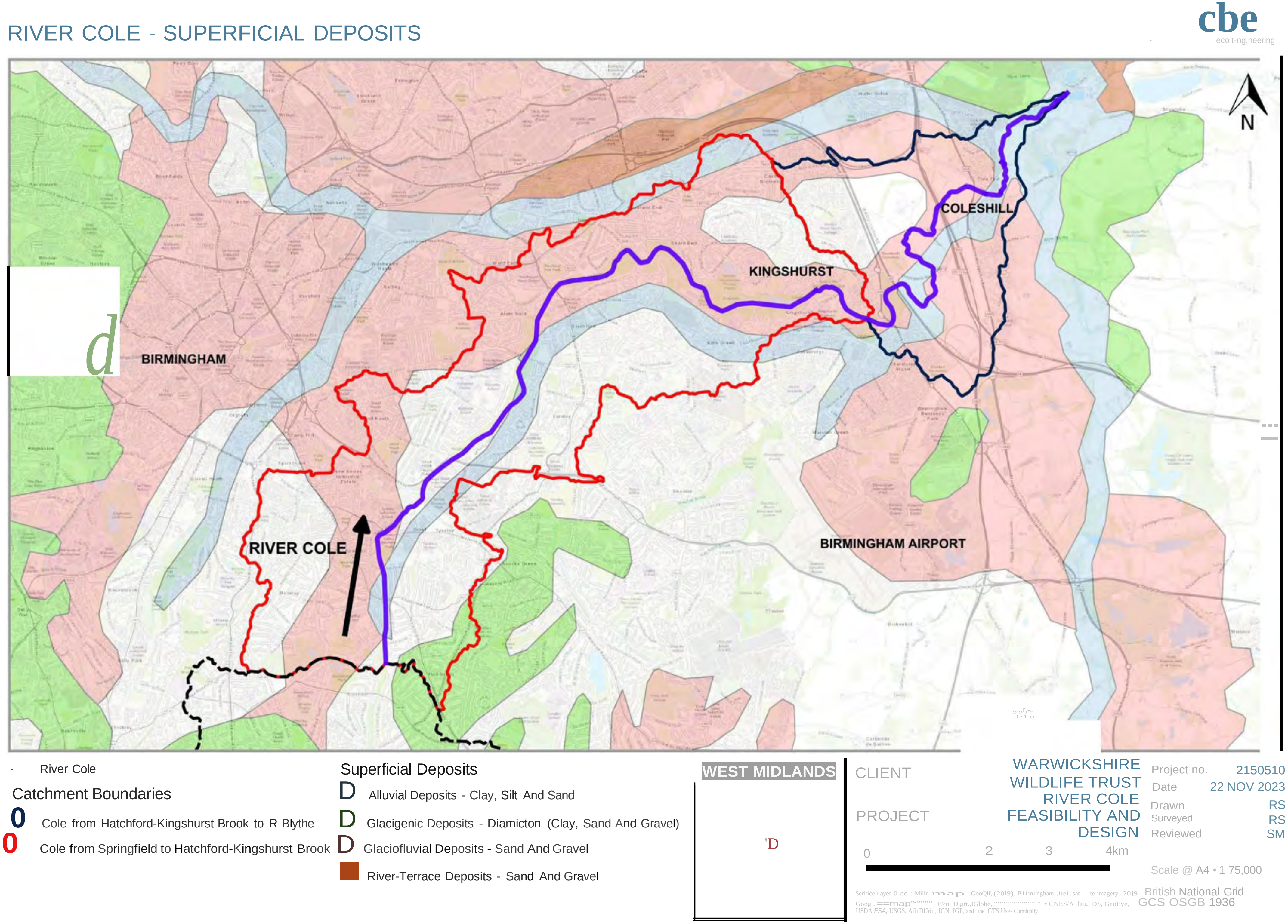
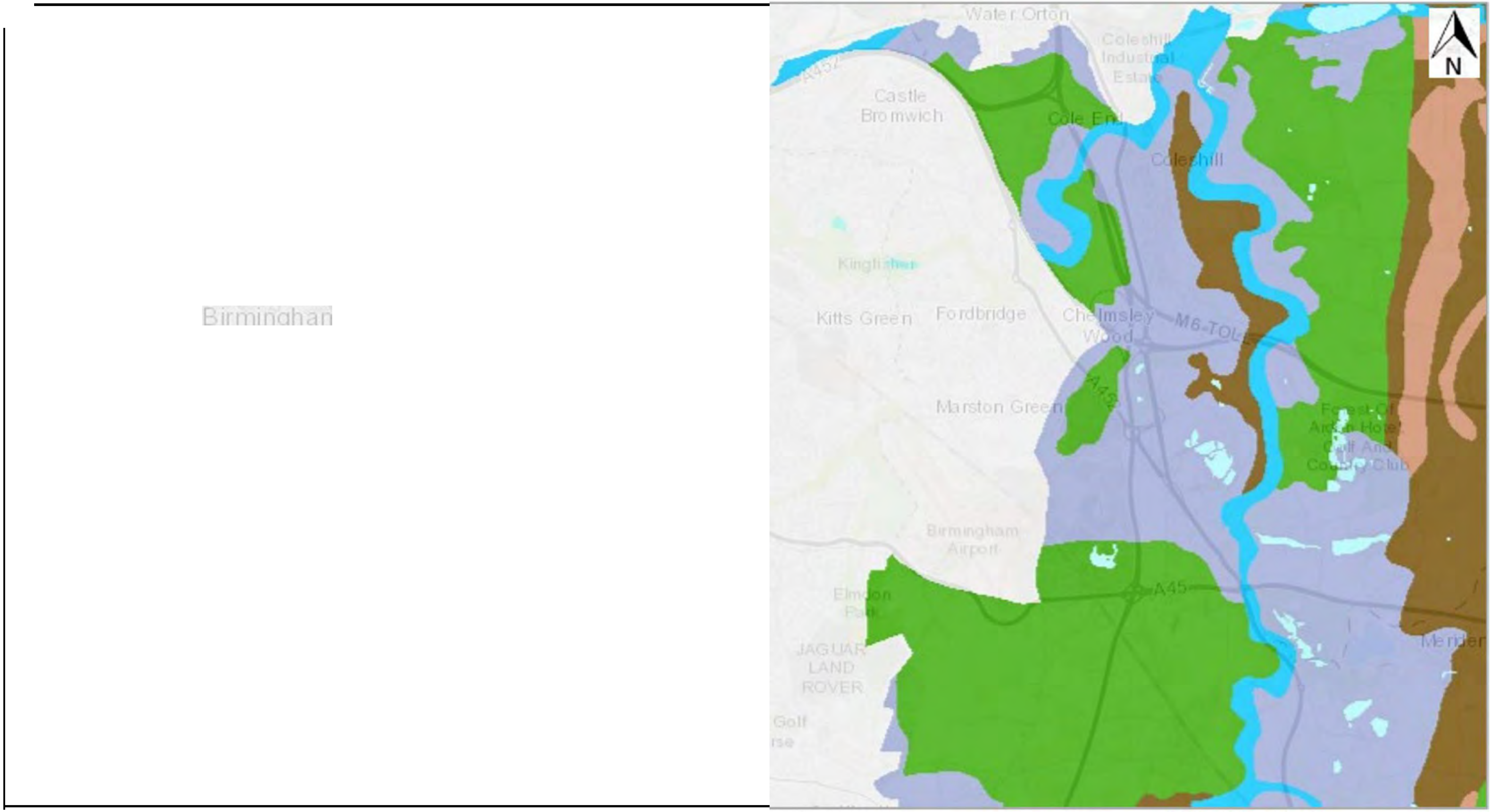


Figure 2-11: Superficial deposits within the lower River Cole catchment. Source: BGS.

cbec



NSRI Soilscapes

- Loamy and clayey floodplain soils with naturally high groundwater
- Loamy soils with naturally high groundwater
- Naturally wet very acid sandy and loamy soils
- Slightly acid loamy and clayey soils with impeded drainage
- Slowly permeable seasonally wet acid loamy and clayey soils
- Freely draining slightly acid loamy soils

WEST MIDLANDS

CLIENT	WARWICKSHIRE WILDLIFE TRUST
PROJECT	RIVER COLE FEASIBILITY AND DESIGN

0 1 2 3

Project no.	2150510
Date	22 NOV2023
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Surveyed	RS
Reviewed	SM

Scale @ A4 - 1:75,000
British National Grid
GCS OSGB 1936

Figure 2-12: Soil layers within the lower River Cole catchment. Source:

2.8 UTILITIES

A desk-based utilities search of the River Cole's corridor was undertaken between Cooks Lane and the confluence with the River Blythe (Atkins, 2023).. The search covered all potential identified utilities providers and will identify a number of those with infrastructure within the study area. A summary of the utility responses provided by the local utilities companies is provided within Table 2-4, indicating their status as to whether they are likely to be affected by future works within the River Cole and its floodplain.

Table 2-4: Summary of utilities responses provided by utility providers operating within the project area.

Utility Provider	Status	Summary
WATER& SEWER		
Severn Trent Water	Affected	Several subsurface foul and combined pipe crossings across the River Cole, numerous surface drain outfalls within the channel margins, and other subsurface pipes within the floodplain.
GTC	Not Affected	-
Leep Utilities	Not Affected	-
ELECTRICITY		
National Grid Electricity Distribution	Affected	Subsurface electrical cables centered around the urban areas within the project area.
Utility Assets	Affected	TBC
Eclipse Power	Not Affected	-
GAS		
Cadent Gas	Affected	Mains gas pipelines, situated within the residential areas within the project area. There are no pipeline crossings.
TELECOMS		
C.A Telecom UK - [Colt Technology Services]	Affected	Subsurface asset in the residential area at B37 6NT.
CityFibre	Affected	Fibre assets following the A452.
OCU Group	Affected	Cable - predominantly following the M6
BT [Openreach)	Affected	Subsurface electrical cables.
Virgin Media	Affected	Wire ducts and trenches, and cabinets. Present only in urban areas surrounding the river, no assets within the river corridor.
SKY Telecommunications Services	Not Affected	-
Verizon	Not Affected	-
Vodafone	Not Affected	-
RAIL		
Network Rail	Affected	Coleshill Parkway station and associated railway bridge.
OTHER		
ESP Utilities Group	Affected	Mains gas pipelines. No pipeline crossings.
Esso Petroleum Company Limited	Affected	Birmingham Airport Link pipeline
Highways England (AREA 9, M6 Toll)	Affected	M6 and M42 motorways
Last Mile	Affected	Low pressure mains gas pipelines adjacent to Moorend Avenue

LinesearchbeforeUdig	Affected	Underground distribution of cables and overhead high voltage cables within the surveyed area, as well as both clean and wastewater assets.
National Grid Electricity Transmission	Affected	Overhead wire and telegraph pole upstream of Coleshill.
Neos Networks	Affected	Subsurface cables.
Solihull Metropolitan Borough Council	Affected	Public highways, street lighting assets and other public rights of way.
Telent – [NTRS]	Affected	Various lighting assets, cables, cabinets and CCTV cameras throughout the residential areas in the project area.
Warwickshire County Council	Affected	Two street lamps with part-night operation, on the unnamed road at the industrial estate near Coleshill Parkway station.
Zayo Group UK Ltd c/o JSM Group Ltd	Affected	Various ducts following a large portion of the roads within the study area.
National Gas Transmission	Not Affected	-
Environment Agency	TBC	TBC

Whilst none of the proposed options presented in section 5 involve construction which will disturb these assets, where designs are in close proximity to these assets, or may impact flood risk around an asset, careful considerations should be taken. Potential risks regarding these assets should be understood and mititgated during the design process, and where required, asset owners should be consulted. Since this data provides indicative locations only, the location of buried utilities should be verified prior to construction.

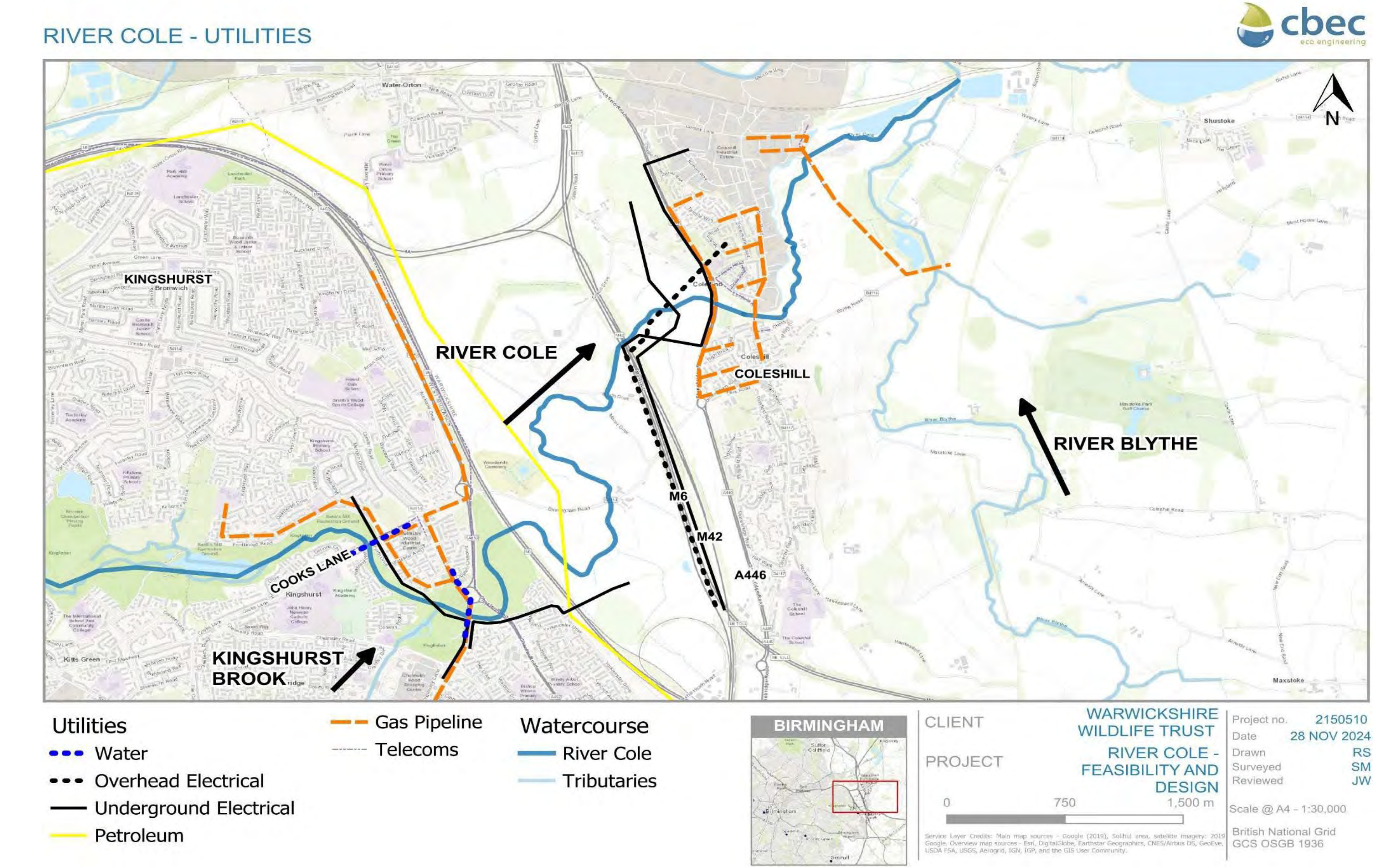


Figure 2-13: Map generated from desk-based utilities search

2.9 PREVIOUS STUDIES

Solihull Metropolitan Borough Council (SBMC) has delivered eight separate river restoration/ /wetland creation schemes along the River Cole and its tributaries since 2012. SBMC considers historical channel engineering to be a key issue for the catchment, and has sought to implement projects to address these underlying impacts, primarily through the reprofiling and remeandering of river channel, as well as by introducing LWM and gravel. Warwickshire Wildlife Trust has provided details of the in-channel habitat improvement projects that have been undertaken on the River Cole and its tributaries; these are summarised in Table 2-5.

Table 2-5. Previous projects undertaken on the River Cole.

Project Name	OSNGR	Measures Implemented	Success of measures	Future aims
Cole Bank Park LNR	SP18180 87359to SP18204 87863	• Installation of bristle tiles on the gauging weir to improve eel and fish passage • Insertion of gravel into the river to improve fish spawning and invertebrate habitat • Re-grading of the banks in 4 locations to improve access to the river for local residents	• Installation of bristle tiles has slightly improved eel and fish passage, although passage will still be poor during low and high flows. The weir itself still acts as a barrier to the transport of sediment and nutrients. • Insertion of gravel into the river has provided additional habitat diversity, although the majority of this has now washed downstream	• Remains compromised by historic channel realignment and bed lowering • Improvements to be achieved by addressing artificial nature of channel • Complete weir removal necessary to fully reinstate natural processes
Kingshurst Brook Enhancement Scheme	SP17103 86335 to SP17460 86813	• Reprofiling of 650 m of river bank • Installation of LWM • Insertion of gravel into the river to improve fish spawning and invertebrate habitat	• Insertion of gravel into the river has provided additional habitat diversity, although the majority of this has now washed downstream • Regrading of banks to a natural profile has reduced erosion, lowering sediment input	n/a
Babbs Mill Brook	SP16225 87737	• Remeandering of the Babbs Mill Brook above Babbs Mill Lake	• Creation of reedbeds has improve local ecology and habitat • Reedbeds intercept	n/a

		• Creation of reedbeds to reduce sediment and pollution input	sediment and pollution and sequester it, preventing it from moving downstream into the River Cole	
Hatchford Brook	SP 15934 82347	• A heavily engineered, concrete line channel was reverted to a natural state • Concrete bed lining removed • River remeandered and banks reprofiled • Gravel introduced	• Vast improvement to river ecology, as a channel devoid of any vegetation or natural substrate was reverted back to a natural state • Increased abundance of fish spawning and invertebrate habitat through introduction of gravels • Removal of two weirs in 2021greatly improved fish passage and natural processes	• n/a

3. FLUVIAL AUDIT

3.1 METHODOLOGY

On the 31st October 2023, CBEC undertook a field-based survey of the physical condition of ~8 km of the River Cole ('fluvial audit') to assess the distribution of morphological, sedimentary and ecological factors in combination with human impacts along the length of the studied section. This procedure is a location-specific inventory of the physical form of the river (i.e. morphology and sedimentology) that creates a template for key habitats and all likely influencing factors, providing an understanding of both form and function. This enhances understanding of the causes of ecological/habitat degradation and supports the implementation of sustainable measures to address such degradation.

Information collected includes. But is not limited to the following:

- Reach-scale channel morphology (e.g. step pool, plane bed, pool-riffle, wandering). We use a classification system that is a combination of recognised procedures (i.e. Montgomery and Buffington, 1997; Brierley and Fryirs, 2000).
- Morphological/habitat units (i.e. pools, riffles, runs). These are specific 'mesoscale' features that, together, define reach-scale morphology. Such features can be regarded as the fundamental physical 'building blocks' of river channels and are closely related to habitat patterns. Therefore, such data can provide potentially valuable information to support assessments of ecological condition and habitats.
- Indicators of the sediment transport regime (e.g. the size, form, texture, dominant particle size and vegetation cover of bar features and bed forms). This information is essential for interpreting physical process within the river and has implications for ecological condition and habitats.
- Sediment sources (e.g. from upstream on the main river, tributaries, bank/terrace erosion). These sources have been recorded in terms of severity and extent to allow an index of sediment supply to be calculated.
- In-channel sediment storage (including alluvial bar features and evidence of bed accumulation). This data also provides an indication of the rate and distribution of sediment supply to downstream areas from within-channel sources. This includes any indicators of sediment transport (e.g. the size, form, texture and vegetation cover of bar features and bed forms).
- Large wood. The incidence, location (e.g. mid-channel, bank-side) and extents of large wood within the active channel, including their physical and ecological influence, have been documented.
- Vegetation. Both in-channel vegetation (e.g. macrophytes) and riparian/bank-side cover have been recorded, as well as invasive/non-native species.
- River engineering pressures (e.g. weirs, lades, impeded side channels, bank protection, canalisation, embankments, bridge crossings). These features have been characterised in terms of their extents and the severity of their impacts on river process.
- Floodplain morphology, including drainage channels/ditches, relict natural secondary channels, wetland areas and swales.
- Other indicators of the dynamic physical behaviour of the channel (e.g. paeleo-channels, historic side channels, age structure of vegetation within the riparian corridor).

- Other land use pressures in the areas draining directly into the River Cole (e.g. urban drainage, livestock poaching, poor forestry drainage, field cultivation close to channel margins).

Data was recorded using a mobile GIS platform, Qfield, with integral GPS capability. This allowed for accurate determination of the position and extent of important features (e.g. length of bank erosion, area of sediment stored in active bar features). High-resolution georeferenced photos were also taken throughout the survey reach to capture significant features/structures and illustrate the general characteristics of specific reaches.

As discussed with WWT prior to the walkover, access was not possible between the M6 Motorway bridge and the M42 Motorway bridge due to the HS2 construction works which are currently underway. No field observations have been recorded for this section, so this reach will not be reported on further within this section of the report however, this reach will still be considered when outlining restoration options

3.2 ASSESSMENT OF PHYSICAL FORMS

Data collected during the fluvial audit are presented in a series of maps, with GIS-analysed data overlain on aerial imagery and base maps for clarity of location. The study extent has been divided into 4 reaches, delineated based on changes along the surveyed reach in dominant river form and process and in the potential restoration options available. Here, we present a summary of the overarching features of the River Cole across the study extent, followed by reach-based descriptions that include summary sheets and maps.

The River Cole between Cooks Lane and the M6 is a heavily modified river, with almost its entire length having been straightened to some degree. For most of its length through this reach, the River Cole is set within an artificial two-stage channel, with large embankments set in place to reduce flood risk to the residential area of Kingshurst. The River Cole south-east of Coleshill Parkway station to its confluence with the River Blythe follows a similar planform, with high embankments situated either side of the channel in order to restrict the river from interfering with adjacent quarries. Construction of embankments in this way has served to reduce connectivity with the natural floodplain through these reaches. Accordingly, the river has been stripped of much of its natural form and process. In some sections of the surveyed extent, in-channel structures have been installed previously in an attempt to improve in-stream habitat, particularly around the confluence with the Kingshurst Brook. These structures have been relatively successful in mimicking natural river form by introducing variation in channel with and depth and increasing morphological diversity. However, there is a lack of natural, self-sustaining fluvial processes within the remainder of the system, as such, habitat availability in the River Cole can only be improved further, by restoring both form and process. There is widespread evidence of relict meanders on the floodplain of the river, particularly between the M6 and M42 motorway bridges, and it is considered that channel remeandering in combination with floodplain reconnection are likely to offer the greatest potential for habitat improvements. The floodplain is generally at a much higher elevation than the channel bed, which will pose some logistical challenges for the options taken forward to the design stage.

This is a low-energy system, with almost 65% of the surveyed length being made up of glide morphological units. Both within and outside the glide units, short sections of shallower and faster flow are often forced by deposition of fine sediment and gravels, which are generally stabilised by vegetation. Short pool-riffle sections are present within each surveyed reach, with natural sinuosity and areas of erosion and deposition preserved. However, these relatively natural and unmodified sections make up only a small percentage of each reach, and even in their cases, there has still been a degree of floodplain disconnection resulting from incision and artificial embankments. A section of Reach 3 (see Figure 3-1), downstream of Coleshill, was the focus of restoration works during the construction of the Environment Agency flood alleviation scheme (outlined , which sought to remeander the channel and created pool riffle sequences. Whilst the results of this project are generally positive, erosion through this reach indicates the river is still adjusting to its new form – as would be expected. Whilst the river is still adjusting within this reach, it would not be advisable to undertake any major restoration works, such as remeandering or bank reprofiling. Therefore, the introduction of large wood would be a viable approach, helping to enhance the works already undertaken by promoting localised scour and subsequent deposition, allowing the River Cole to find its own equilibrium.

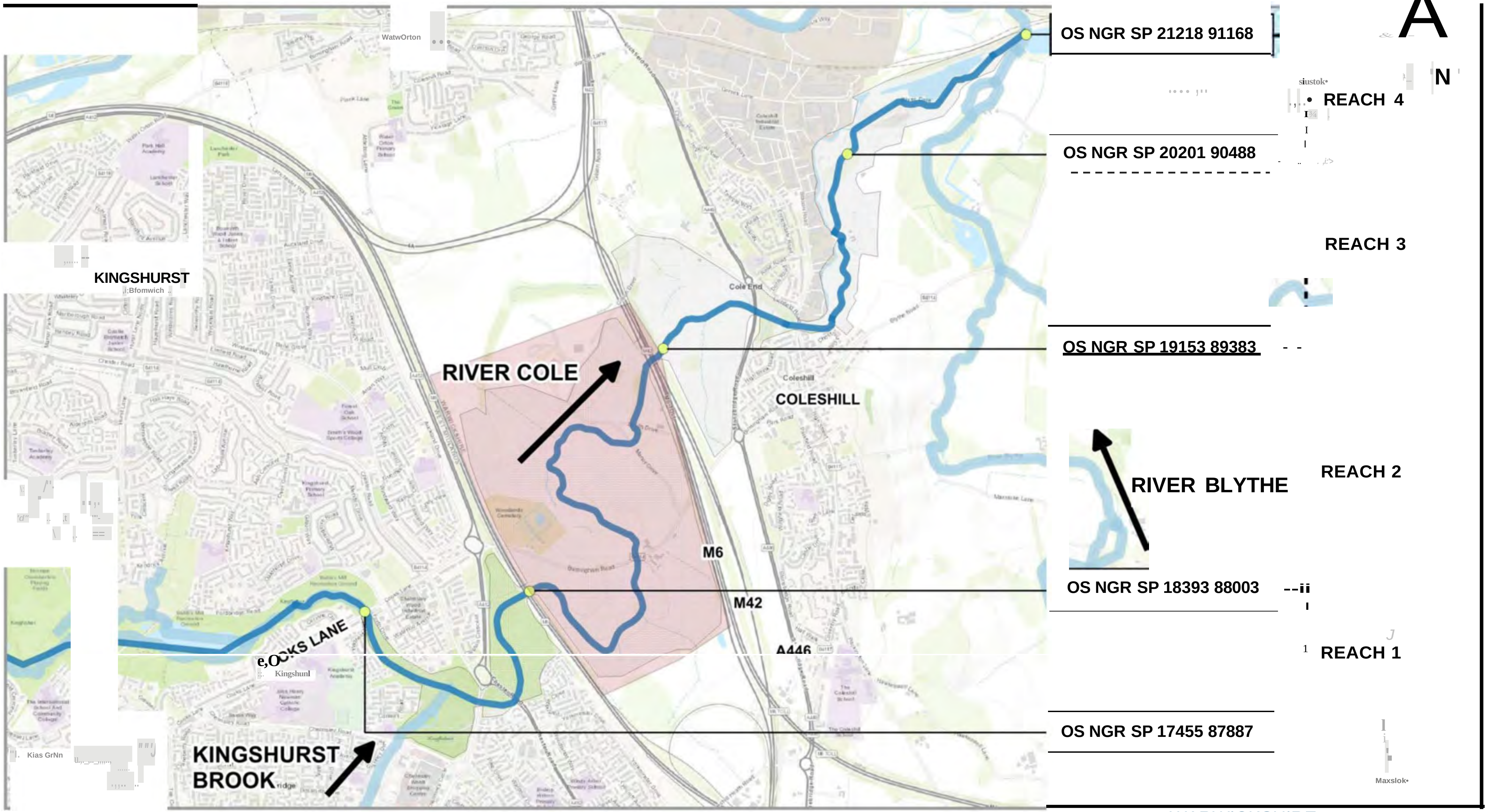
The substrate throughout the reach is predominantly a mix of gravel and fines, with clean gravels present in sections of faster flow, and on the inside of meander bends. Cobbles were observed locally in some areas. Silt was found to be widespread throughout the audit reach, covering the coarser substrate in areas of slower and/or deeper flow and locally depositing around large wood, meander bends and in-channel structures. Silt is being actively supplied to the channel in a number of locations, including sections of bank erosion and areas of poaching and ford crossings, and is having a detrimental effect on habitat. Based on observations made during the fluvial audit, it is suggested that a combination of restoring natural fluvial form and is likely to offer the greatest potential for improvements in habitat within the River Cole system. Himalayan Balsam, and invasive non-native species, is present extensively within the floodplains of the audit reach. Himalayan Balsam dominates bank top vegetation, leaving banks devoid of vegetation when it dies off during the winter months, leading to increased delivery of fine sediment into the river. Controlling the spread of Himalayan Balsam within the River Cole also presents a method of reducing fine sediment input. Regular local removlals of Himalayan Balsam could provide localised reductions in fine sediment delivery and improvements in biodiversity, although a full catchment based approach to removal would be necessary to completely remediate the issues, as Himalayan Balsam upstream of the restoration site would result in future recolonisation.

Other than the embankments installed across the project area extent and the historical modifications made to the channel (i.e. straightening, leading to incision and disconnection from the floodplain), morphological pressures are relatively few. Few in-channel structures are present, bar one gauging weir present in reach 1, which offers potential for habitat improvement through its modification or removal. A total of 15 bridges span the River Cole through the project area (the majority being road bridges, with several small footbridges also being present); these should be considered in any proposed options taken forward to the design stage.

Riparian vegetation is present throughout much of the audit extent, with in-channel vegetation present in some local areas of faster flow. There is a well-established riparian corridor in much of the upper part of the audit extent, with riparian trees and bushes present locally elsewhere. There are opportunities to enhance riparian habitat in a number of areas, predominantly through the management of the aforementioned Himalayan Balsam. Where the surrounding land is used for agriculture, efforts have been made to prevent grazing or cultivation along the bank top areas through installation of wire fencing. Emergent vegetation and macrophytes were absent from the majority of the audit reach, likely as a result from shading by dense riparian tree cover,slow flows and inappropriately steep bank gradients..

More detailed descriptions of the audit extent are provided by reach below. Maps are provided as figures to illustrate the engineering pressures, morphological units and sediment dynamics for the entire fluvial audit extent. Additionally, a fact sheet has been produced for each reach to document the dominant features in that reach.

01 - RIVER COLE - REACH OVERVIEW



- RiverCole
- Tributaries and Other Water Bodies
- Survey Extents
- Project Area
- No access due to HS2 works

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
		Date	16 DEC 2024
PROJECT	RIVER COLE- FEASIBILITY AND DESIGN	Drawn	RS
		Surveyed	SM
		Reviewed	JW

0 750 1,500 m

Scale @ A4 - 1:30,000

British National Grid
GCS OSGB 1936

Figure 3-1: Overview of reaches surveyed on the River Cole.

02 - RIVER COLE - REACH 1 - FLOW TYPES AND ENGINEERING PRESSURES

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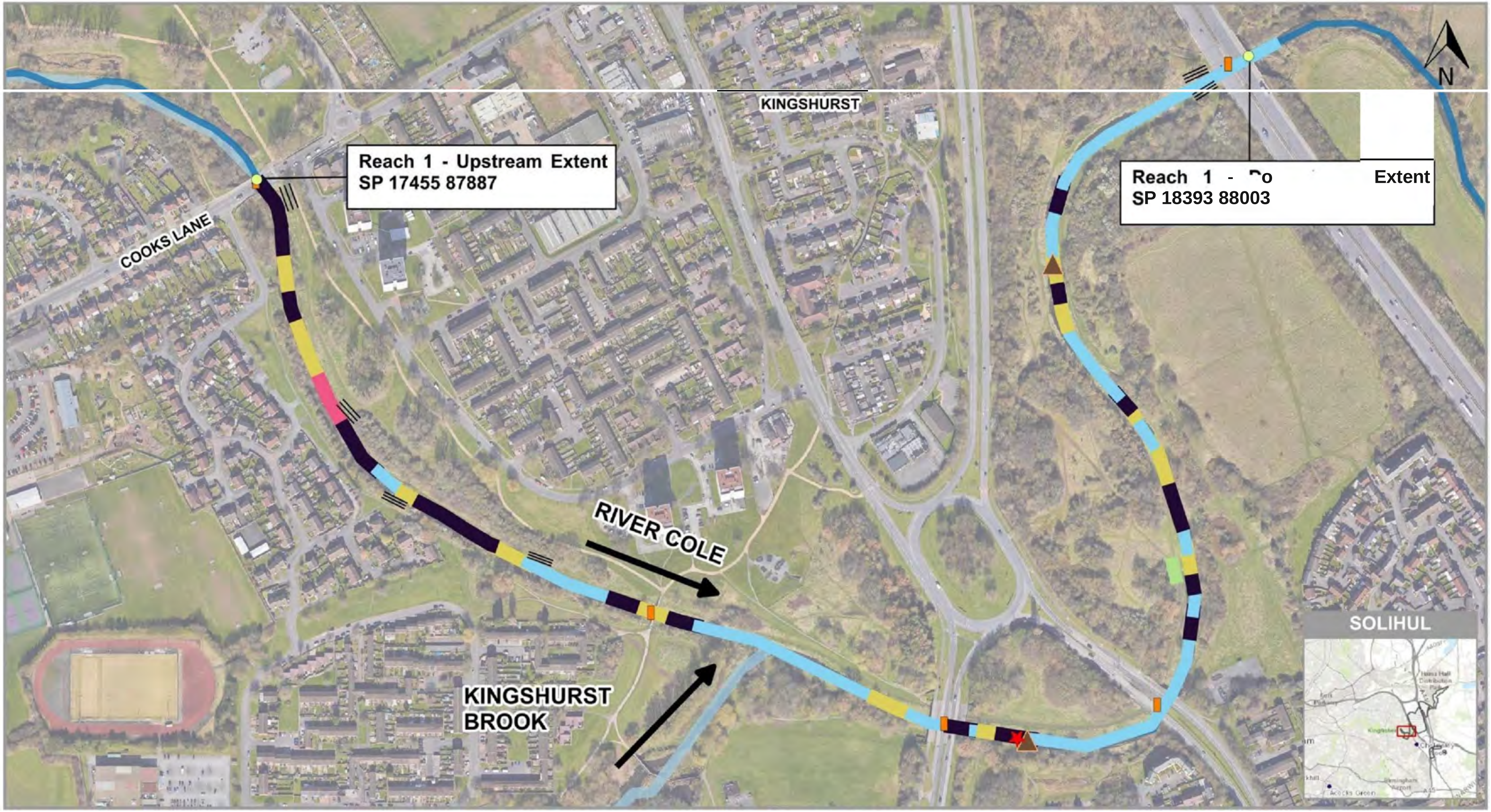

Waterbodies

- River Cole
- Tributaries and Other Water Bodies

Flow Types

- Glide
- Pool
- Riffle
- Run

Engineering Pressures

- EA Gauging Weir
- Bridges
- Impoundment
- Poaching
- Bank Protection
- Culvert

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Surveyed	SM
Reviewed	JW

0 50 100 150 200 m

Scale @ A4 - 1;5,000

British National Grid GCS OSGB 1936

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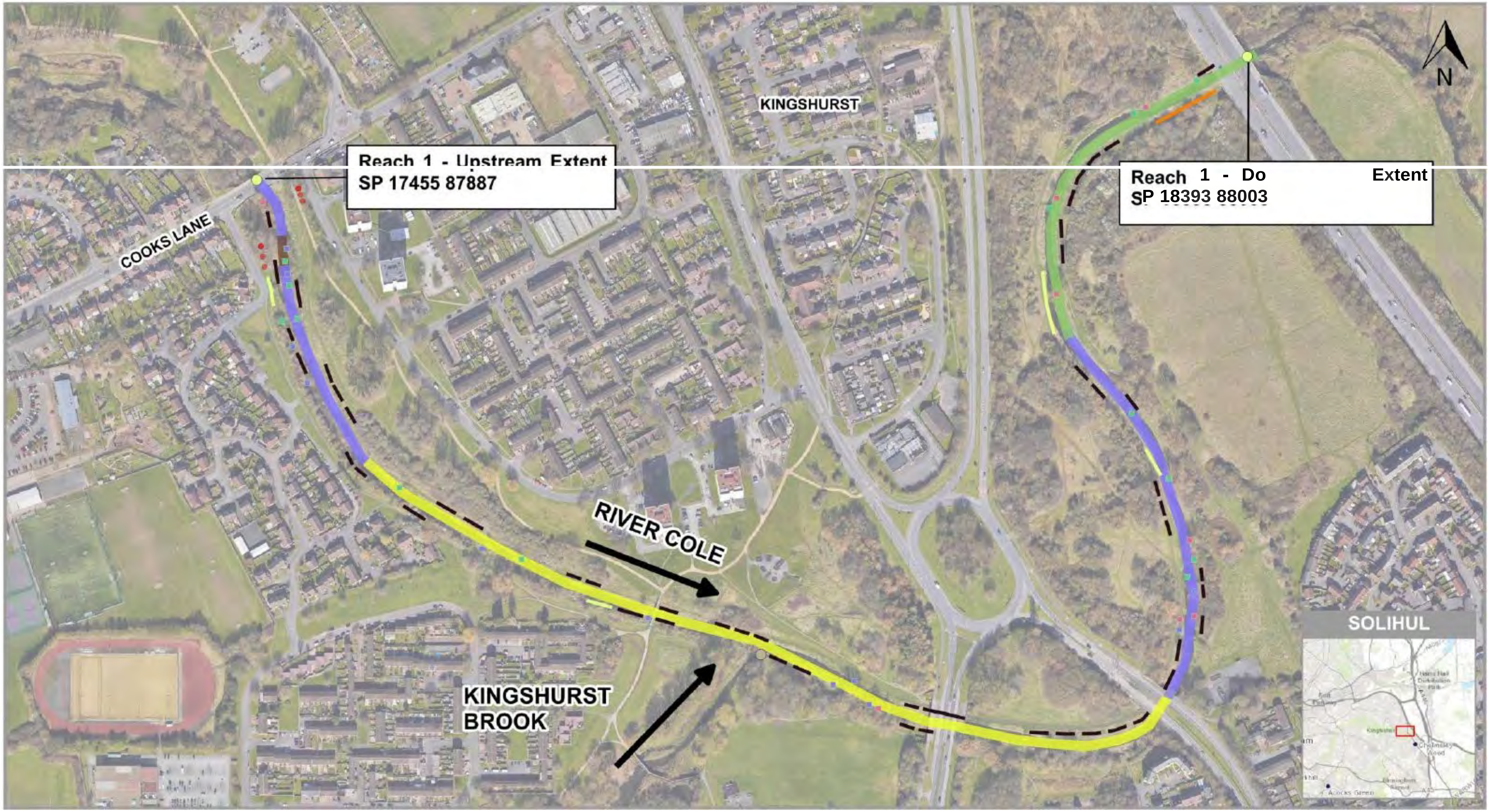
Figure 3-2: Reach 1 flow types and engineering pressures.

03 - RIVER COLE - REACH 1 - SEDIMENT DYNAMICS



- River Cole
Tributaries and Other Water Bodies -
Tributary
CI! Survey Extents

Bed Substrate
Boulder/Cobble
Gravel
Gravel/ Cobble
Gravel/ Fines

Bank Erosion
Minor
Moderate
Severe
Deposition

INNS

LWM
Overhanging branches
Tree in channel margin
Wood in channel

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PROJECT: RIVER COLE- FEASIBILITY AND DESIGN

0 50 100 150 200m

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Figure 3-3: Reach 1 sediment dynamics.

Reach 1: Cooks Lane toM6	LENGTH (m)	1,800	
	OSNGR	Upstream:	SP 1745587887
		Downstream:	SP 1839388003

Setting:	• The channel is situated within an alluvial valley with areas of lightly managed parkland and urban land uses (i.e. housing developments). Compared to the downstream reaches, this reach is more constrained laterally by local topography (i.e. valley width); as a result, channel planform is less sinuous.
Flow Conditions	• The channel was surveyed under normal to moderate flow conditions.
MORPHOLOGICAL CHARACTERISATION	
Channel Dimensions	• 4- 6m.
Planform Type	• Single thread, with relatively low sinuosity.
Bed Material	• The dominant substrate in the upper reach consisted of gravels and cobbles. • the dominant substrate type through the middle section of the reach was gravel and fines. • The upstream and downstream sections were dominated by gravels and cobbles.
Bed Morphology Units	• Alluvial deposits were observed frequently throughout the entire reach. • Large (up to 100 m in length) side bars were present throughout the reach, composed of predominantly gravels and fines. The majority of these deposits were fully stabilised by vegetation, and are likely resistant to reworking during high flows, providing a good mechanism for capture and storage of fine sediment amongst the vegetation
Bank face Materials	• Fine sediment (silts and sands) and pebbles characteristic of alluvial deposits were the dominant bank face material.
Bank Profile & Stability	• The banks are steep and predominantly vegetated. • In the upper and middle sections of the reach, the river bed is situated within an artificial two-stage channel, with large embankments set back approximately 15 m from the channel.
Flow Type & Diversity	• Throughout the length of the study area, the flow pattern alternated between riffle, pool and glide morphological units, with glide sections being on average longer than pool or riffle units.
Instream Vegetation	• The channel exhibited very limited in-channel vegetation.
RIVER CORRIDOR PRESSUREs	
Land Cover/Use	**Both Banks** • The land use bordering the majority of the project reach is council managed scrub, woodland and grassland. Management is more proactive in some areas, such as grassland, likely to improve the floodplain aesthetic for dog walkers.
Riparian Conditions	**Both Banks** • The channel is shaded in places, but the banks are fully vegetated for the vast majority of the project reach. • Throughout the project reach the channel is bordered by broadleaf

	woodland with an understorey of tall herbs, scrub and shrub.
Prior management	• There is some evidence of previous restoration works at the confluence with Kingshurst Brook, with LWM deliberately placed into the channel and fixed in place with wooden stakes. • Previous restoration works also introduced gravels and installed fish tiles on the gauging weir.
Fencing	• The channel is unfenced along the majority of its length.
Tributaries & Drainage	• A tributary (Kingshurst Brook) feeds into the River Cole within the middle of the reach.
Infrastructure & Engineering	• There are multiple road bridges that cross the River Cole within this reach, as well as numerous culverts that empty into the river. • A concrete gauging weir is also present. Fish tiles are installed on the weir.
Invasive non-native species	• Himalayan Balsam (*Impatiens glandulifera*) is present extensively at very high densities along both banks throughout the entire reach.

04 - RIVER COLE - REACH 3 - FLOW TYPES AND ENGINEERING PRESSURES

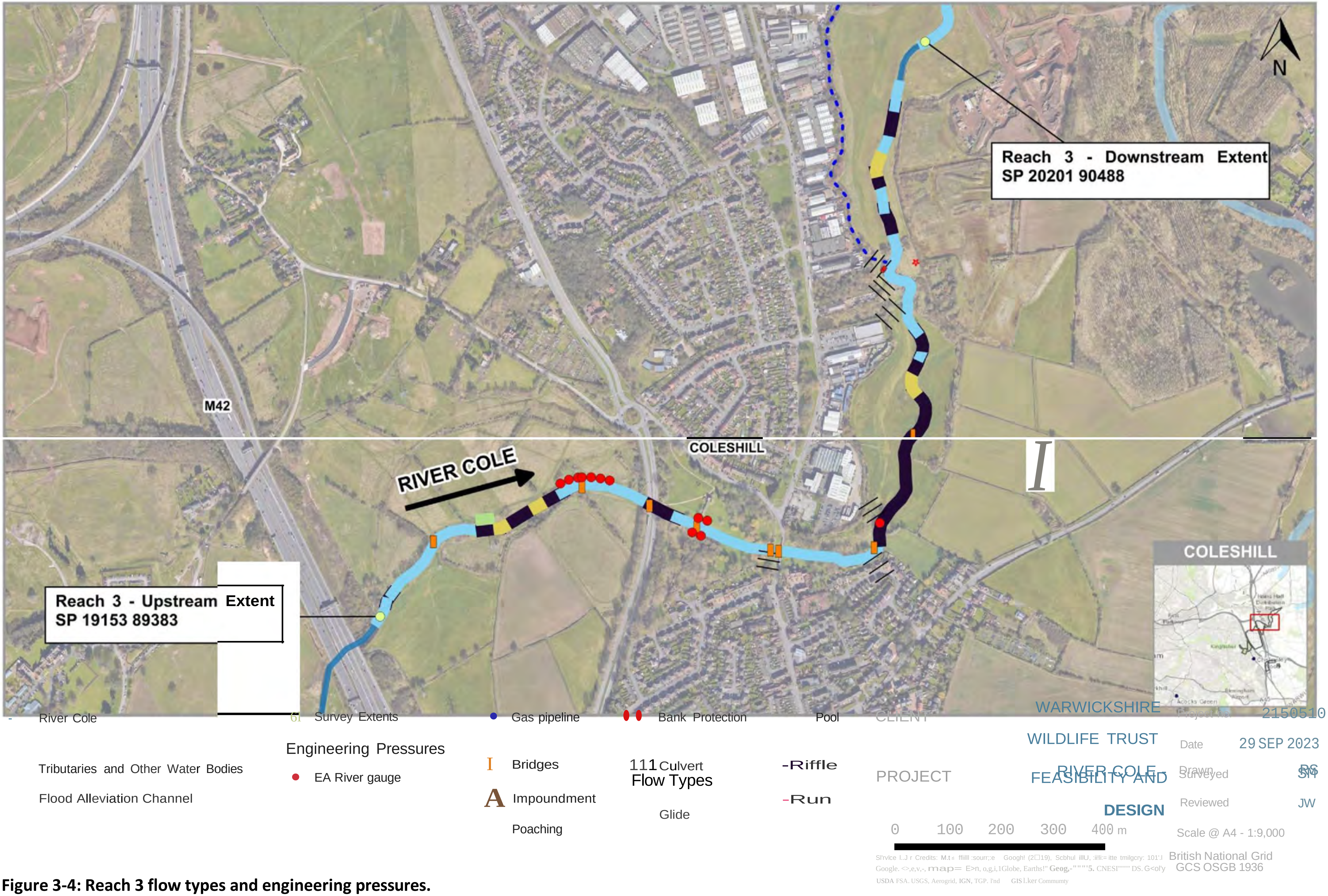
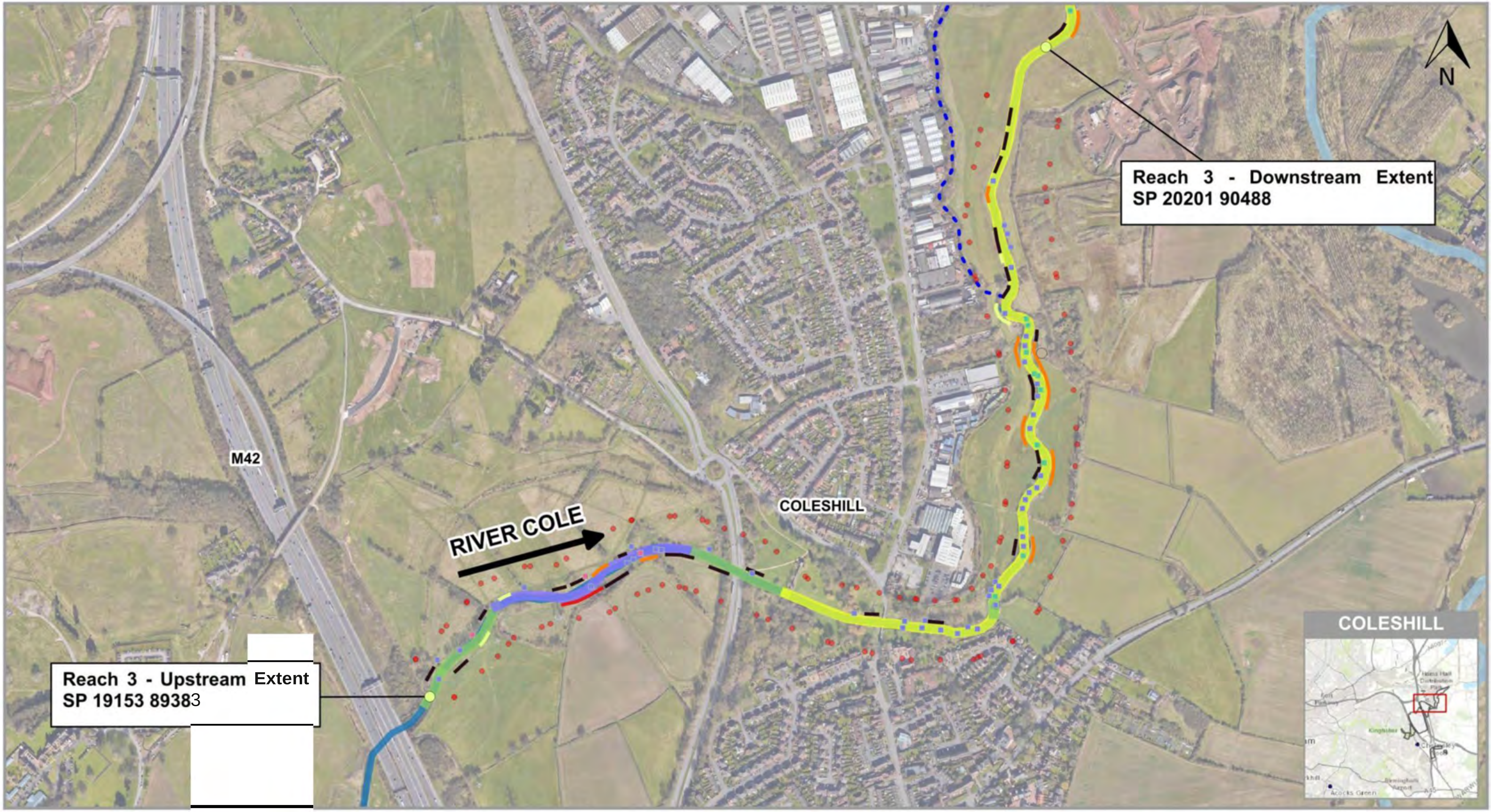


Figure 3-4: Reach 3 flow types and engineering pressures.

04 - RIVER COLE - REACH 3 - SEDIMENT DYNAMICS

cbec
eco engineering



River Cole
Tributaries and Other Water Bodies
Flood Alleviation Channel

Survey Extents

Bed Substrate
Boulder/Cobble
Gravel
Gravel/ Cobble
Gravel/ Fines

Bank Erosion
Minor
Moderate
Severe

INNS

LWM
Overhanging branches
Tree in channel margin
Wood in channel

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no	2150510
		Date	29 SEP 2023
PROJECT	RIVER COLE- FEASIBILITY AND DESIGN	Drawn	RS
		Surveyed	
		Reviewed	JW

0 100 200 300 400m

Scale @ A4 - 1:9,000

British National Grid
GCS OSGB 1936

Figure 3-5: Reach 3 sediment dynamics.

Reach 3: Coleshill	LENGTH (m)	1,900	
	OSNGR	Upstream:	SP 19153 89383
		Downstream:	SP 2020190488

Setting:	• The channel is situated within a wide alluvial valley with areas of lightly managed parkland and urban land uses (i.e. housing developments).
Flow Conditions	• The channel was surveyed under normal to moderate flow conditions.
MORPHOLOGICAL CHARACTERISATION	
Channel Dimensions	• 5- 9 m.
Planform Type	• Single thread, with relatively low sinuosity.
Bed Material	• The dominant substrate in the upper reach consisted of gravels and cobbles. • The middle and lower reaches were dominated by gravels and fines. • Through Coleshill the bed is reinforced concrete.
Bed Morphology Units	• Alluvial deposits were observed frequently throughout the entire reach. • Large (up to 100 m in length) side bars were present throughout the reach, composed of predominantly gravels and fines. The majority of these deposits were fully stabilised by vegetation, and are likely to be resistant to reworking during high flows providing a good mechanism for capture and storage of fine sediment amongst the vegetation. • Both lateral and point bars comprised of gravels were common on the inside of meander bends.
Bank face Materials	• Fine sediment (silts and sands) and pebbles characteristic of alluvial deposits were the dominant bank face material. • There are areas of bank face reinforcement upstream and downstream of Stonebridge Road, where the channel is likely artificially straightened through Coleshill.
Bank Profile & Stability	• The banks are steep and predominantly vegetated. • Moderate levels of bank erosion at the outside of meander bends was common through this reach.
Flow Type & Diversity	• Throughout the length of the study area, the flow pattern alternated between glide and riffle morphological units.
Instream Vegetation	• The channel exhibited very limited in-channel vegetation.
RIVER CORRIDOR PRESSUREs	
Land Cover/Use	**Both Banks** • The land use bordering the majority of the project reach appears to be relatively unmanaged scrub, woodland and grassland immediately downstream of the M42 Motorway bridge. • The land through Coleshill is more heavily managed in an effort to present a more manicured aesthetic. Therefore established riparian margins were absent and very few trees are present along the bank top. • Downstream of Coleshill, the channel has previously been rehabilitated in conjunction with the development of a flood alleviation scheme for Coleshill. The fields through this reach are still used for pastoral grazing.
Riparian Conditions	**Both Banks**

	• The channel is shaded in places, but the banks are fully vegetated for the vast majority of the project reach. • Throughout the project reach the channel is bordered by pockets of broadleaved trees with an understorey of tall herbs, scrub and shrub. In areas where trees are absent, short and tall grasses are present.
Prior management	• Historical realignment downstream of Coleshill. • Development of Coleshill flood alleviation scheme. • Parkland style management of river through Coleshill township.
Fencing	• The channel is unfenced along the majority of its length.
Tributaries & Drainage	• There are no major tributaries within this reach.
Infrastructure & Engineering	• There are multiple road bridges that cross the River Cole around the Coleshill area, as well as numerous culverts that empty into the river. • Infrastructure relating to the development of the Coleshill flood alleviation scheme such as sluice gates, culverts and embankments are all present downstream of Coleshill.
Invasive non-native species	• Himalayan Balsam (*Impatiens glandulifera*) is present extensively at very high densities along both banks throughout the entire reach.

06 - RIVER COLE - REACH 4 - FLOW TYPES AND ENGINEERING PRESSURES

cbe eco engineering

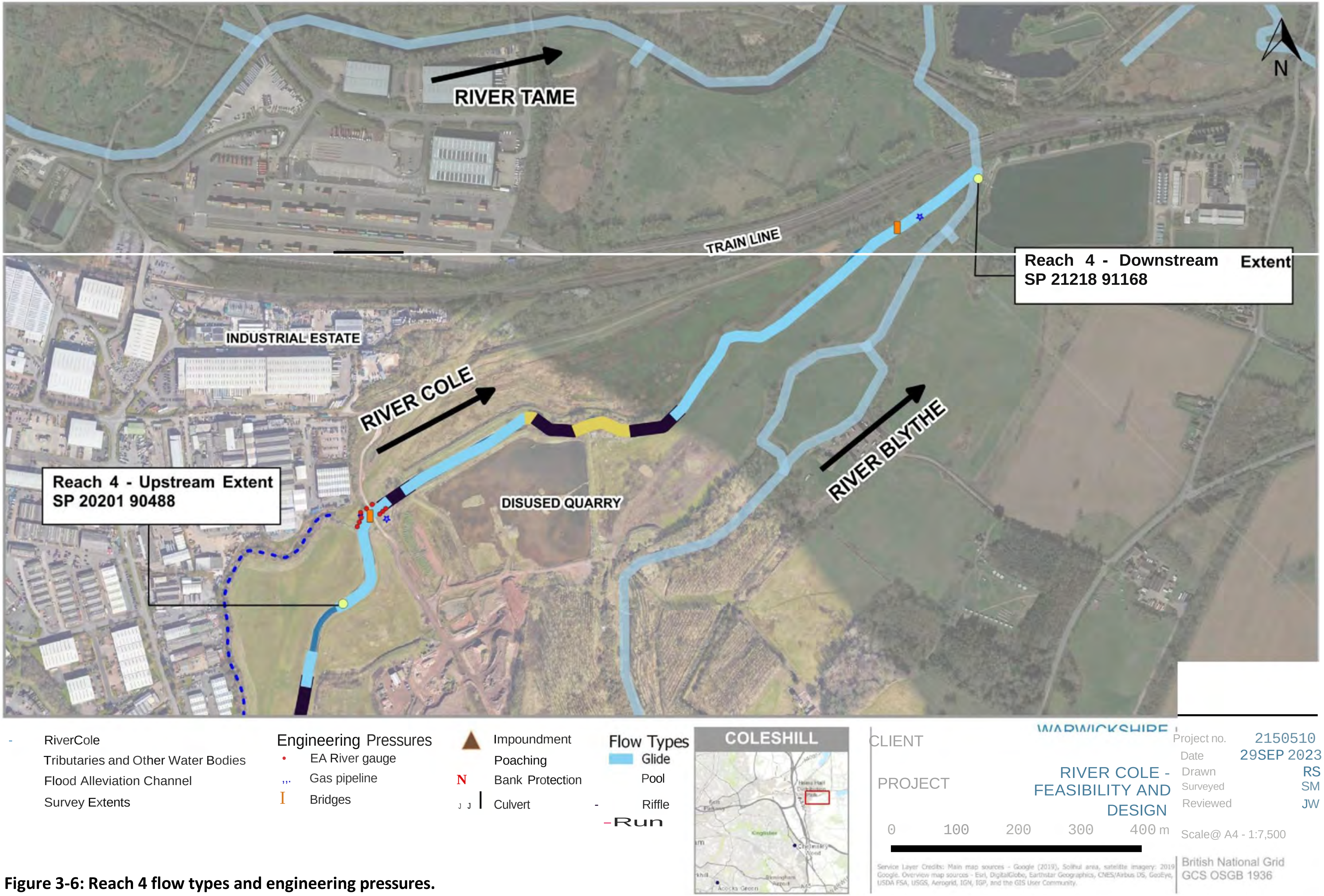
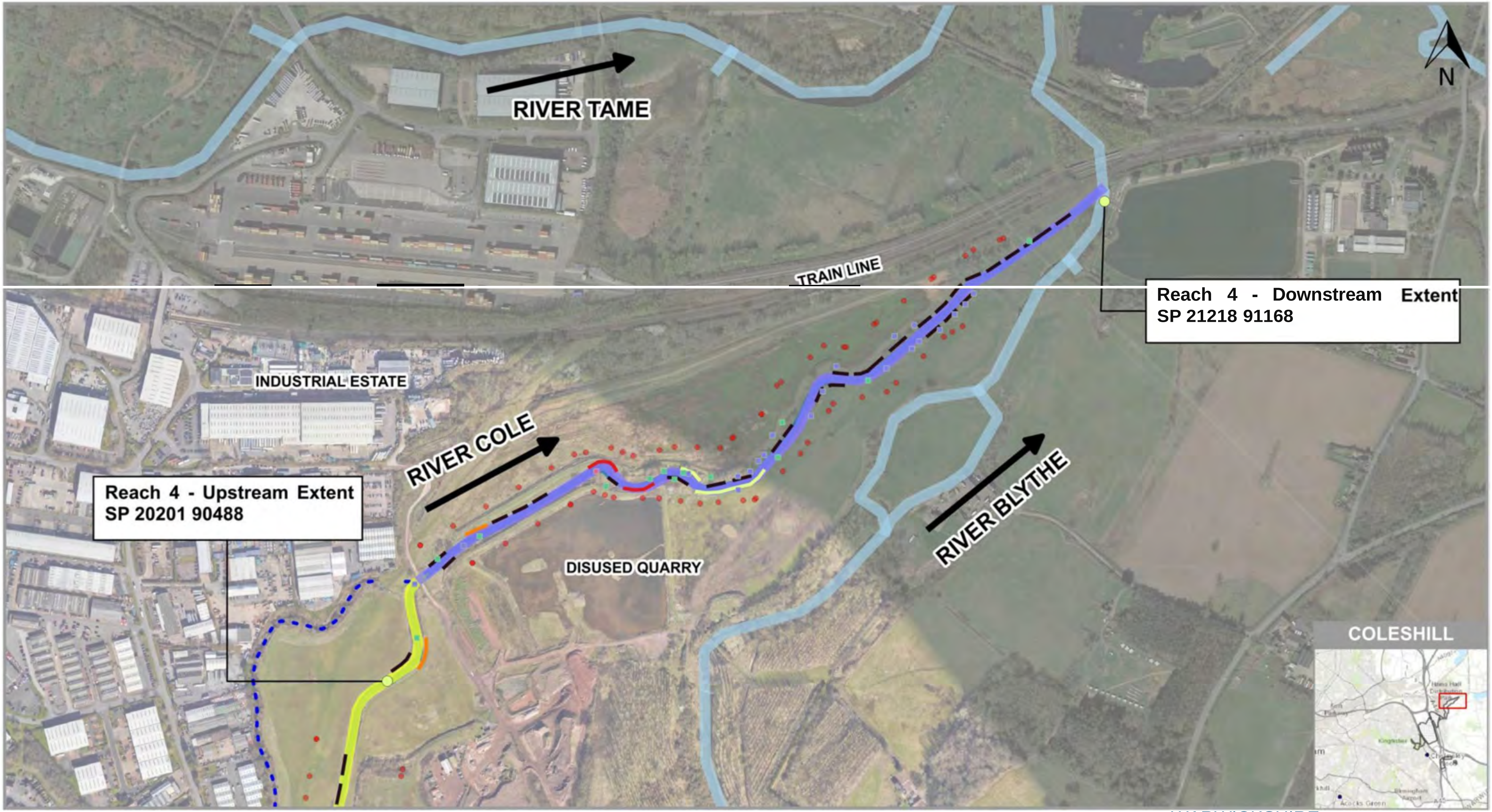


Figure 3-6: Reach 4 flow types and engineering pressures.

06 - RIVER COLE - REACH 3 - SEDIMENT DYNAMICS

cbec
eco eng neenng



River Cole
Tributaries and Other Water Bodies
Flood Alleviation Channel
Survey Extents

Bed Substrate
Boulder/Cobble
Gravel
Gravel/ Cobble
Gravel/ Fines

Bank Erosion
Minor
Moderate
Severe
Deposition

LWM
Overhanging branches
Tree in channel margin
Wood in channel
INNS

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
		Date	29 SEP 2023
PROJECT	RIVER COLE- FEASIBILITY AND DESIGN	Drawn	RS
		Surveyed	SM
		Reviewed	JW

0 100 200 300 400 m

Scale @A4 - 1 7,500

British National Grid
GCS OSGB 1936

USOA FSA, USGS, Aerogrkl. IGN, and theGIS USerCommuruty

Figure 3-7: Reach 4 sediment dynamics.

Reach 4: Quarry to confluence with the River Blythe	LENGTH (m)	1,300	
	OSNGR	Upstream:	SP 2020190488
		Downstream:	SP 21218 91168

Setting:	• The channel is situated within a wide alluvial valley with areas of lightly managed parkland and urban land uses (i.e. housing developments).
Flow Conditions	• The channel was surveyed under normal to moderate flow conditions.
MORPHOLOGICAL CHARACTERISATION	
Channel Dimensions	• 4- 8m.
Planform Type	• Single thread, with relatively low sinuosity.
Bed Material	• The entire reach is dominated by gravels and cobbles.
Bed Morphology Units	• Alluvial deposits were observed frequently throughout the entire reach. • Large (up to 100 m in length) side bars were present throughout the reach, composed of predominantly cobbles and gravels. The majority of these deposits were absent of any vegetation, indicating they're likely active and susceptible to reworking during high flows.
Bank face Materials	• Fine sediment (silts and sands) and pebbles characteristic of alluvial deposits were the dominant bank face material.
Bank Profile & Stability	• The banks are steep and predominantly vegetated. • In the middle of the reach, extreme erosion of the leh bank (formed into an artificial embankment) has resulted in the formation of a ~4 m cliff. • In the middle sections of the reach where the channel is bordered by the disused quarry, the river is set within a two-stage channel, with tall (20 m) embankments set back 10 m from the channel.
Flow Type & Diversity	• Glide morphological units dominated this reach, with a small section alternating between riffle and pool situated within the middle of the reach.
Instream Vegetation	• The channel exhibited some in-stream macrophytes.
RIVER CORRIDOR PRESSUREs	
Land Cover/Use	**Both Banks** • The entire length of this reach is within the quarry. Confirmation is required from the quarry operator, but it appears that excavation/quarrying of the floodplain is now complete within the floodplain of this reach. • The leh floodplain, which has been 'remediated' by the quarry operator, now appears to be unmanaged, with scrub and rank grassland developing. This would present a good possibility for floodplain reconnection. • The right floodplain has also been remediated, a majority of which has been returned to a mixture of pastoral grassland/bailage production. This too presents a good opportunity for floodplain reconnection/rehabilitation. •
Riparian Conditions	**Both Banks** • The channel is shaded in places, but the banks are fully vegetated for the vast majority of the project reach. • Throughout this reach the channel is bordered tall herbs, scrub and shrub, with some small trees.

Prior management	• There is some steel sheet piling and gabion baskets reinforcing the banks around the bridge crossing.
Fencing	• The channel is unfenced along the majority of its length.
Tributaries & Drainage	• The River Cole joins the River Blythe at the end of this reach.
Infrastructure & Engineering	• There are two small agricultural bridges that cross the river within this reach. • The outfall from the Coleshill flood alleviation scheme discharges immediately upstream of the quarry bridge near the upstream extent of the reach.
Invasive non-native species	• Himalayan Balsam (*Impatiens glandulifera*) is present extensively at very high densities along both banks throughout the entire reach.

4. OPTIONS APPRAISAL

As part of the Invitation to Quote, the Warwickshire Wildlife Trust provided a review of past projects, which summarised previous works undertaken and lessons learned from those works. The project review also discussed a number of potential restoration options that had been identified previously. The options outlined here have been developed based on the assessment of physical form and process described above, taking into consideration both previous restoration projects within the river and the Warwickshire Wildlife Trust's suggestions for future restoration. This section describes each option in turn, briefly summarising each option, including associated benefits, disadvantages and potential risks and mitigation measures, alongside a consideration of any further assessments required to progress the option to design/construction. An options matrix has also been produced for each reach to allow a visual comparison of the relative merits and constraints for each option.

Options were developed within the context of the issues that are present explicitly within the River Cole. A summary of the issues faced broadly across all of the restoration reaches of the River Cole are presented in Table 4-1.

Table 4-1 A summary of the issues, and their solutions, within the River Cole.

Problem	Description	Solution	Description
Canalisation and lack of connectivity	The cumulative legacy of the various ways in which the river channel has been modified presents a significant and fundamental limit on the ecological status of the River Cole.	**Restore connectivity and reverse the canalisation through a catchment wide programme of re-sculpting the channel, planform and riparian margin: reinstate or re-create meanders, allow woody debris to remain in the river, or introduce it where appropriate. Successful restoration of connectivity will involve different measures in different places.**	Restoration of connectivity from the headwaters downstream will by default go a long way to addressing other limiting pressures such as sediment deposition and excessive in-stream plant growth Connectivity can be restored wholly or partly and in different ways, but in the broadest terms, either the river needs to be brought back up, or the banks need to be taken down or a new channel needs to be cut with the correct sinuosity and morphological variety. Bringing the river back up: This is expensive and difficult. There is always a danger of imposing yet another tier of modification, an artificial staircase structure, and of the unchanged pools between the riffles becoming silt traps: natural riffles never interrupt a straight channel in a series of bars according to the model most artificial riffle insertions have followed. However along short sections of the river restoring a gravel bed may be a viable option, allowing the riverine processes, in concert with LWD structures, to shape and contour it. With sufficient funding available it would possible to entertain this idea in certain suitable reaches of the Lower Cole. Taking the banks down: A more practical option is to shape the leveed and incised banks to create low-lying flood berms. Incised berms of this sort should be three to five meters deep if possible, from the rivers edge to the lift in slope, or built on a very gentle incline. The re-shaping can involve a combination of pulling back the levees and pushing in the toe of the bank, so that as well as creating a connected riparian zone, one is also manipulating the planform of the river to create pinches and wider reaches. This option does not recreate wide-scale connectivity, but it is more easily accomplished, less expensive and poses no wider flooding risk: it is a very practical and realistic option. **Remeandering:** A third option, where the ground is available and the land-owner willing, is to carve a new channel. This may often be an easier and more cost-effective solution than 'bringing the river up', and is especially viable in some reaches of the lower river. LiDAR indicate that the middle and lower reaches of the Cole were once far more sinuous than the current channel exhibits. Using the old maps, a more natural sinuosity of the channel can be estimated and used as a starting point for realignment projects. **Embankment Removal** Within the lower reach of the Cole, immediately upstream of the confluence with the River Blythe, the channel is bordered large embankments. The surrounding land lies below the level of the top of the embankment and is predominantly used for pastoral grazing. Removal or setting back of the embankments would be challenging, expensive, and require the forfeiting of grazing rights however, giving the river freedom to occupy the floodplain would have a significant impact on morphology and ecology of the lower river.
Uniform morphology	Canalisation and other historic channel modifications have altered channel gradient and planform resulting in a loss of geomorphic units and complexity of channel structure.	**Consider in-stream works that enhance morphological variety**	Re-sculpting the channel to achieve localised connectivity is far more challenging within the confines of the steep banks such as those observed in the upstream reach. Re-sculpting within the channel: By sculpting pools and pinches in the river bed and 'planting' mats of vegetation either as shoulders pinching the flow, or as long berms which narrow the channel, it is possible to restore connectivity on a localised scale, immediately surrounding the river. Introduction of Large-Woody-Debris (LWD): Tree-fall is vital in catalysing the dynamic processes of a most UK river systems. When a tree falls across a stream, complex processes are set in motion which vastly add to the ecological richness of the river. In forcing its way past the obstruction a low energy river is energised. The river becomes gently impounded upstream but is forced to blow a deep hole in the river bed or bank to get around or under the tree. New gravel enters the

			system. Berms are thrown up along the downstream edges and often the channel is forced to braid, creating islands. All of this enhances connectivity and morphological variety. As importantly the tree fall creates a window of daylight and that light allows the colonisation and consolidation of the accreted berms around the fallen tree. Under the natural conditions which are referred to in explaining the vitality of LWD, trees fall out of mature and relatively extensive woodland, so that the old, dead tree when it falls, or the mature one blown over, opens up a broad window to the sky. This link between LWD and daylight is crucial. Flow deflectors also energise low energy rivers, forcing the water to make pools and riffles and berms. Built properly a flow deflector has a very similar impact and function to tree-fall. It is possible to make flow deflectors where there are no trees, recreating the impact of LWD in open reaches of the river. They only work well in more or less unshaded areas and they must be built properly.
Sediment Pollution	Coupled with canalisation, sediment makes a considerable impact on the ecology of the river, smothering substrate of the river bed and blocking the interstices. An excess of fine sediment changes the morphology, the plant communities and the natural flows in the river and negatively impacts fish and insect numbers	**Address fine sediment and sand pollution through a strategic farm and land-management liaison process throughout catchment.**	**Identify sources of fine sediment throughout the catchment. This will include:** - Arable fields; - Pig units (if present) - Road side verges - Aggregate works - Road crossings - Footpaths, tracks and fords - Drains and ditches - EA & IDB pumping stations and drains - Tributaries **Strategic solutions should include:** - Creation of river buffers within agricultural land - Improved connectivity to allow fine sediment to be redeposited/accreted on floodplain - Treatment of fine sediment at points of entry (i.e. installation of silt traps) - Encouragement of catchment sensitive land-use to reduce catchment wide erosion/soil loss.
Diffuse Pollution	The release of potential pollutants from a range of activities that, individually, may have no effect on the water environment, but, at the scale of a catchment, can have a significant effect. Sources include: - Runoff from farms, forestry, community and amenity green spaces; - Runoff from roads, houses, commercial areas; and - Seepage into groundwater	**Treat sources of diffuse pollution before they enter the main river**	**Strategic solutions should include:** - Stop field drains where they enter the main river, or explore to create wetlands or reedbeds to act as interceptors - Diversion of track-side drains into riparian settling ponds - Creation of wetland that will act as sediment-sinks immediately upstream of where tributaries converge with the Cole. Diffuse pollution impacts will be further minimised when undertaken in conjunction with sediment prevention solutions and improved connectivity with the floodplain.
Overshading	The shading effect imposed by dense forestry plantations or homogenous woodlands can limit the ecological potential of a river. Diverse woodlands with successional growth are required to allow varying light levels into the woodland floor, creating a diverse mosaic between shade and light.	**Selective vegetation/canopy thinning**	Create a more even distribution of light and shade, by careful planting in the wide open reaches and careful felling in the densely shaded reaches. Mimicry of natural woodland succession (i.e., old trees die/fall and are replaced by younger trees) is a desirable outcome allowing variety in light levels as well as the recruitment of large woody debris to the channel for added complexity. Consideration of urban lighting can also be made during creation of planting / selective tree thinning, helping to reduce urban light reaching the river channel, which can have negative impacts on nocturnal animals.
Lack of Shade	Complete absence of riparian woodland	**Creation of wet woodland habitat**	Planting of riparian margin with desirable species such as Alder, Maple, Willow, Hornbeam and Oak to re-establish/encourage the regeneration of diverse woodland.
Excessive in-stream and	Overgrown monocultures of	**Change in management of watercourse:**	Examine the weed-cutting and bank-maintenance regime to explore ways in which changes of practice can

channel margin plant growth	vegetation such as glyceria likely arising from excessive nutrient loads are present at specific locations within the project area.	1. **Review weed cutting regime;** 2. **Establishment of riparian vegetation** (see above)**; and** 3. **Reduce nutrient enrichment (**see below)	enhance the in-stream and riparian habitat, replacing monocultures with diverse mosaics of plant cover. Identify areas of high vegetation that are perceived as negative to channel flows and review their ecological values before considering options for their removal. Plants removed from the channel and bank faces could be used to re-colonise areas denuded by INNS.
Control Structures/Barriers to Fish Passage	Manmade structures such as flow gauging weirs which cause impoundment and impede migratory fish passage as well as disruption to sediment transport continuity.	**Removal of Structures**	Mitigate impoundments, by removal or by-pass.
Invasive Non-Native Species	Himalayan Balsam is present in the upper valley and is a major threat to the ecology of the river. Himalayan balsam spreads quickly, especially along the edges of a river. Once established Himalayan balsam dominates almost all native vegetation, creating a riparian mono-culture. Moreover it dies away in winter leaving nothing to protect the fragile, bare banks below. Himalayan balsam causes severe erosion and siltation comparable in scale and impact with heavy overgrazing by livestock, but more difficult to contain. Large numbers of Signal Crayfish were seen alive and swimming during the topographic survey and fluvial audit walkover, particularly between Cooks lane and HS2 land. Signs of Signal Crayfish were also observed in other reaches however they were less prolific.	**Instigate a stakeholder-led invasive plant eradication programme, approached strategically, starting at the top of the catchment**	The most reliable control strategy is the total eradication from the top of the valley working downstream. This is a labour intensive exercise. **Himalayan Balsam** The plant is best strimmed or pulled as it starts to grow in spring, but before it flowers. Once it flowers the seed pods burst open when the plants is touched. The seeds last for some time in the ground and patches dealt with will need to be revisited even as the eradication is unrolled downstream **Signal Crayfish** A signal crayfish eradication plan could be developed whereby crayfish are captured and dispatched humanely. A catchment based approach to eradication utilising current best approaches would be most effective.
Nutrient Enrichment	Excessive supply of the inorganic nutrients nitrogen (N) and phosphorus (P) causing excessive algae and plant growth causing excessive algae and plant growth. Eutrophication is nearly always a result of land use activities or from direct discharges from industry.	**Investigate the impact of nutrient enrichment and reduce its impact through a strategic farm and land-management liaison process.**	Excess sediment can disrupt ecosystems through: - Blocking light, reducing algae growth; - Harming of fish; and - Degrading of habitat quality. To minimise the impact of nutrient enrichment within the catchment, land use activity maps should be reviewed to identify areas with high potential impact on waterways (e.g. areas of erosion, stock crossings, fertiliser runoff). Catchment stakeholders should then work with landowners to reduce the impacts through sensitive management.

4.1 CRITERIA ASSESSED

Each potential option for restoration of the reach was developed and assessed against a range of criteria. This assessment is intended to provide an objective and comprehensive data set to allow the Warwickshire Wildlife Trust and stakeholders/landowners to assess option feasibility and select a preferred option for the reach. The criteria considered included the following.

- *Benefit to fluvial process and habitat (within and adjacent to river).* Given that the restoration reach has been straightened significantly and has generally limited morphological diversity and a lack of dynamic fluvial process, most restoration options are likely to offer improvements. However, restoration options that can move the river closer to its reference condition can be considered to offer greater benefits.
- *Flood risk.* The proposed options have potential to both increase and decrease flood risk, both locally and downstream.
- *Impact on landscape and amenity value.* This criterion is somewhat subjective, as stakeholders and landowners are likely to have differing views as to what constitutes 'value' in this context. Accordingly, both positive and negative influences were considered. Consultation with landowners, stakeholders and local residents is recommended to gauge opinion on the various options.
- *Degree of disruption/disturbance required for construction.* Although construction is likely to create only short-term disruption, many of the proposed options will require some level of disruption to infrastructure and agricultural land.
- *Complexity of construction and 'buildability'.* Although this criterion is reflected broadly in the overall cost, its consideration here highlights any specific issues with the proposed options that may increase the complexity of the construction.
- *Cost.* Cost estimates should be considered approximate at this stage. Accordingly, they should be considered a guide only and are presented here to allow comparison of options via a qualitative cost benefit assessment.

The general philosophy underpinning the development of restoration options for the River Cole is the restoration, as far as is practicable, of natural fluvial form and process. This approach aims to promote a self-sustaining river system that requires minimal long-term management. This concept of 'process restoration' seeks to tackle the cause of a specific problem (e.g. historic straightening) rather than tackling the site-specific symptom (e.g. lack of morphological diversity).

4.2 Reach 1: Cooks Lane To M6

The River Cole between Cooks Lane and the M6 is heavily modified, with almost its entire length having been straightened to some degree. For most of this reach the River Cole is set within an artificial two-stage channel, with large embankments set in place to reduce flood risk to the residential areas of Kingshurst. These embankments successfully reduce connectivity with the natural floodplain. In-channel structures have been installed previously in an attempt to improve in-stream habitat, particularly around the confluence with the Kingshurst Brook; these structures have been relatively successful in mimicking natural river form by introducing variations in channel width and depth and increasing morphological diversity.

Throughout the length of Reach 1 the flow type alternates between riffle, pool and glide morphological units, with glide sections being on average longer than pool or riffle units. The dominant substrate in the upper ~300m consisted of gravels and cobbles, shifting to gravel and fines through the middle section of the reach and then back to cobble and gravels downstream of the Chester Road (A452) bridge. Alluvial deposits were observed throughout the entire reach, including large (up to 100 m in length) side bars composed of predominantly gravels and fines. The majority of these deposits were fully stabilised by vegetation and are likely resistant to reworking during high flows, providing a good mechanism for capture and storage of fine sediment amongst the vegetation. Where substrate was exposed on the vegetated and relatively steep banks it comprised fine sediments (silts and sands) and pebbles characteristic of alluvial deposits.

The land use bordering most of Reach 1 is council-managed, comprising scrub, woodland and grassland. Management is more proactive in some areas, such as grassland, likely to improve the floodplain aesthetic for dog walkers. Throughout the project reach the channel is bordered by broadleaf woodland with an understorey of tall herbs, scrub and shrub. The channel is shaded by large trees in places, but the banks are fully vegetated along most of the project reach. Himalayan Balsam *(Impatiens glandulifera)* is present extensively at high densities along both banks throughout the entire reach.

The channel is unfenced along the majority of its length. There are multiple road bridges that cross the River Cole within this reach, as well as numerous culverts that empty into the river. A concrete gauging weir is also present. Fish tiles are installed on the weir.

The presence of large embankments either side of the channel limit the cost-effectiveness of any out of channel works through this reach. However, previous in-channel improvements have resulted in localised habitat improvement in this reach, which sets a precedent for future options. A concrete gauging weir is also present within this reach Four potential options are described here, with varying degrees of potential improvement to the existing channel. Fact sheets describing each option are presented below. A map illustrating the recommended option is presented in Figure 4-1.

- **Option 1: Do nothing.** Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- **Option 2: Minimal intervention.** Retain flow through existing channel. Introduce alternating large wood structures (LWS) at carefully targeted locations to further improve habitat diversity in main channel.
- **Option 3: Partial intervention.** Retain flow through existing channel. Introduce gravels and augment existing gravels to form alternating bar and berm features. Introduce alternating LWS at carefully targeted locations to further improve habitat diversity in channel.
- **Option 4. Full-scale intervention.** Retain flow through existing channel. Removal of the gauging weir. Introduce gravels and augment existing gravels to form alternating bar features. Introduce alternating LWS at carefully targeted locations to further improve habitat diversity in channel. Full connection of the pond adjacent to the M6 overpass, as was suggested within the PEA.

RECOMMENDATION*: *Option 4 *Full-scale intervention*

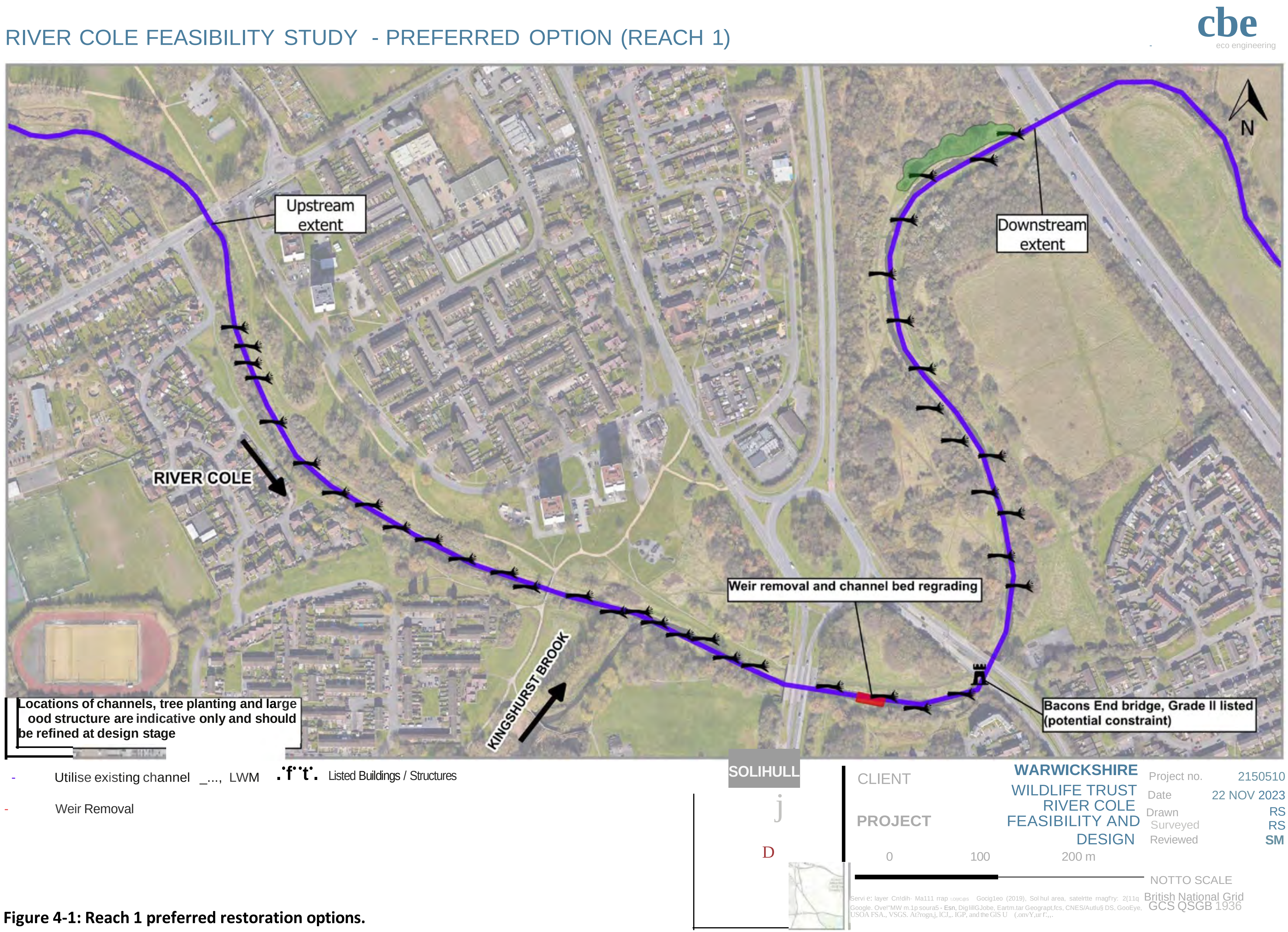


Figure 4-1: Reach 1 preferred restoration options.

Table 4-2: Options matrix for Reach 1.

Factor	Option 1 (Do nothing)	Option 2 (Minimal intervention)	Option 3 (Partial intervention)	Option 4 (Full-scale intervention)
Benefit to geomorphic process	Due to current morphological pressures and pollution (particularly fine sediment), without any intervention, geomorphic processes are likely to decline over time.		Introduction of LWS will kickstart natural geomorphic processes, although the weir still presents a barrier to natural processes.	Removal of weir will full reinstate natural geomorphic processes.
Impact on flood risk (to upstream and downstream areas)	Proposed designs will be developed in a way in which they do not negatively impact on flood risk	Proposed designs will be developed in a way in which they do not negatively impact on flood risk.	Proposed designs will be developed in a way in which they do not negatively impact on flood risk.	Proposed designs will be developed in a way in which they do not negatively impact on flood risk.
Impact to in-stream habitat (longer term)				
Impact on wider biodiversity			LWS and gravels to improve flow and habitat diversity.	Improved fish passage and refuge.
Impact on landscape/amenity value				Removal of the weir will remove concrete from the environment, returning the area to a natural landscape
Ease of construction (short term)				Weir removal will increase complexity of construction
Cost of design/construction (short term)				Weir removal will increase cost of construction
Cost of maintenance (longer term)		Proposed designs will be developed in a way in which they require minimal long-term maintenance.	Proposed designs will be developed in a way in which they require minimal long-term maintenance.	Proposed designs will be developed in a way in which they require minimal long-term maintenance.

Significantly Positive; Slightly Positive; Neutral; Slightly Negative; Significantly Negative

Reach	Cooks Lane to M6	Option	1. Do nothing

Description

- Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- Very occasional 'emergency' measures may still be permissible, under extreme circumstances.

Indicative cross-section

n/a

Benefits

- No short-term costs associated with construction.
- No short-term disruption to services or farmland.
- No disturbance to existing in-stream and riparian habitats.
- Existing habitat relatively good in this reach, retaining many natural features.

Disadvantages

- Risk of continued incision and further channel deepening.
- Risk of continued erosion of steep banks and enhanced supply of fine sediment to channel.
- No benefits for channel/floodplain connectivity.

Risk appraisal and mitigation measures

n/a

Additional work required

n/a

Approximate design and build costs

None, but may be associated with cost benefit since any ongoing, routine channel management is likely to incur some cost

Reach	Cooks Lane to M6	Option	2. Minimal intervention

Description

- Retain flow through existing channel.
- Introduce alternating large wood structures (LWS) at carefully targeted locations to further improve habitat diversity in main channel, with placement guided by detailed physical assessments.

Indicative cross-section

Benefits

- Some benefit to **biodiversity** and **geomorphic process** through improved in-stream habitat in association with LWS.
- **Minimal disruption** during construction, with existing in-stream and floodplain habitats being largely retained.
- **Limited cost** associated with this option in comparison with others.

Disadvantages

- Risk of continued incision and further channel deepening.
- Limited benefit for channel/floodplain connectivity.
- Further natural recovery unlikely given the low-energy, incised nature of the river.
- Limited benefit to riparian and floodplain habitat.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Potential for increased local flood risk due to reduced channel conveyance*: Can be mitigated through appropriate design and flood risk assessment.

Additional work required

Physical assessment to guide LWS placement, regulatory requirements

Approximate design and build costs

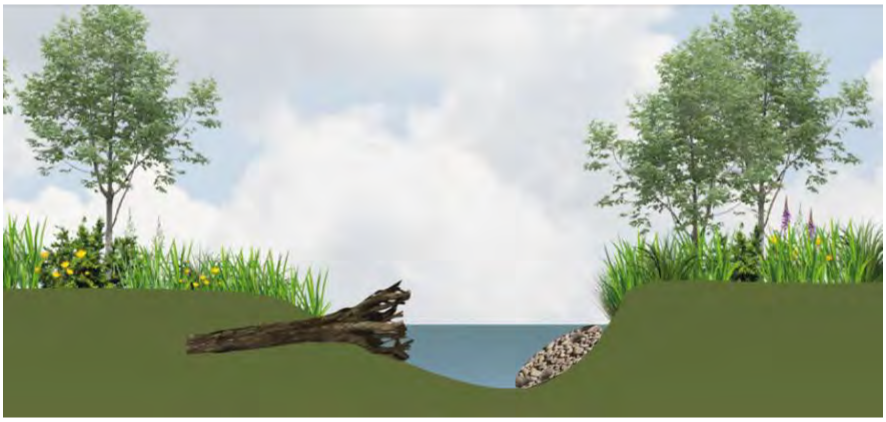
£30k to £60k

Reach	Cooks Lane to M6	Option	3. Partial intervention

Description

- **Option 2, plus:** Introduce gravels to create bar and berm features, and augment existing berms to improve geomorphic variability. Manage existing vegetation to improve the stability of existing berms.

Indicative cross-section



Benefits

- Benefit to **geomorphic process** through increased in-channel morphological diversity.
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Positive impact on **landscape** through creation of more natural habitat and river corridor environment.

Disadvantages

- **Some disruption** to recreational land during construction, although much of existing in-stream and floodplain habitats can be retained.
- **Increased cost** relative to other proposed options.
- Minimal benefit to riparian and floodplain habitat.

No benefits for channel/floodplain connectivity.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Risk of encountering contaminated land or impacting utilities*: Considered to be low but can be better constrained during design phase.

Additional work required

Physical assessment to guide LWS placement, flood risk assessment, outline/detailed design, regulatory requirements, ecological assessment, landowner consultation

Approximate design and build costs

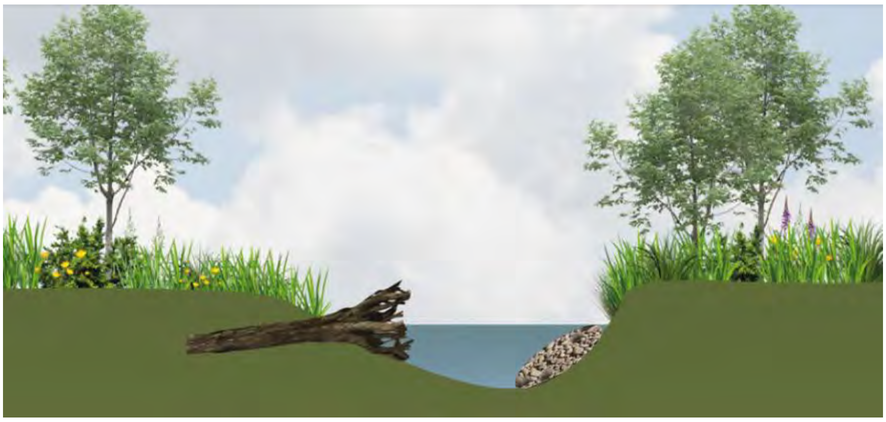
£60k to £120k

Reach	Cooks Lane to M6	Option	4. Full intervention

Description

- Retain flow through existing channel.
- Introduce alternating LWS at carefully targeted locations to further improve habitat diversity in channel, with placement guided by detailed physical assessments.
- Introduce gravels to create bar and berm features, and augment existing berms to improve geomorphic variability. Manage existing vegetation to improve the stability of existing berms.
- Complete removal of the gauging weir to fully restore fish passage, transfer of sediment and nutrients, and reinstate natural form and processes. If permissions for removal of the weir are difficult to obtain, installation of a fish pass could also be considered.

Indicative cross-section



Benefits

- Significant improvement to **geomorphic process** by reinstating the natural form of the river through the removal of the weir
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Benefits to **wider biodiversity** through improvements to fish passage and movement of sediment and nutrients.
- Significant positive impact on **landscape** by replacing the weir and associated concrete protection with more natural habitat and river corridor environment.

Disadvantages

- **Short-term disruption** to recreational land during construction, although much of existing in-stream and floodplain habitats can be retained.
- **Increased cost** associated with more extensive restoration measures.
- Greater **complexity of construction** relative to other options.
- Removal of an Environment Agency gauging weir will require extended consultation period.
- Significant cut likely required to balance differences in bed levels around the point of weir removal.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Risk of encountering contaminated land or impacting utilities:* Considered to be low but can be better constrained during design phase.

• *Complexity associated with matching bed levels around site of weir removal.:* Can be mitigated by careful design. • *Risk of avulsion and head cut:* Can be mitigated by infilling upstream downstream of weir and careful design of tie-in points. • *Risk of significant pushback from Environment Agency around the removal of the gauging weir.*
Additional work required Outline/detailed design, morphodynamic modelling, flood risk assessment, regulatory requirements, detailed topographic survey, ground investigation, landowner consultation, ecological assessment
Approximate design and build costs £80k to £140k

4.3 REACH 2: HS2 LAND

Walkover access was not possible between the M6 bridge and the M42 bridge due to the HS2 construction works currently underway. Consequently, no field observations were recorded for this section, although a desk-based assessment of LiDAR data indicated the presence of relict relict meanders on the floodplain throughout this reach

As discussed with WWT prior to the walkover, access was not possible between the M6 Motorway bridge and the M42 Motorway bridge due to the HS2 construction works which are currently underway. No field observations have been recorded for this section, although a desk-based assessment of LiDAR data indicated the presence of relict channels throughout this reach. Aerial imagery indicates that surrounding land-use is also undeveloped, recent HS2 construction activity notwithstanding, and that existing conditions in Reach 2 are likely to be similar to those in Reach 3 upstream of Stonebridge Road (A446). For these reasons, full scale floodplain restoration is still considered a viable option for this reach.

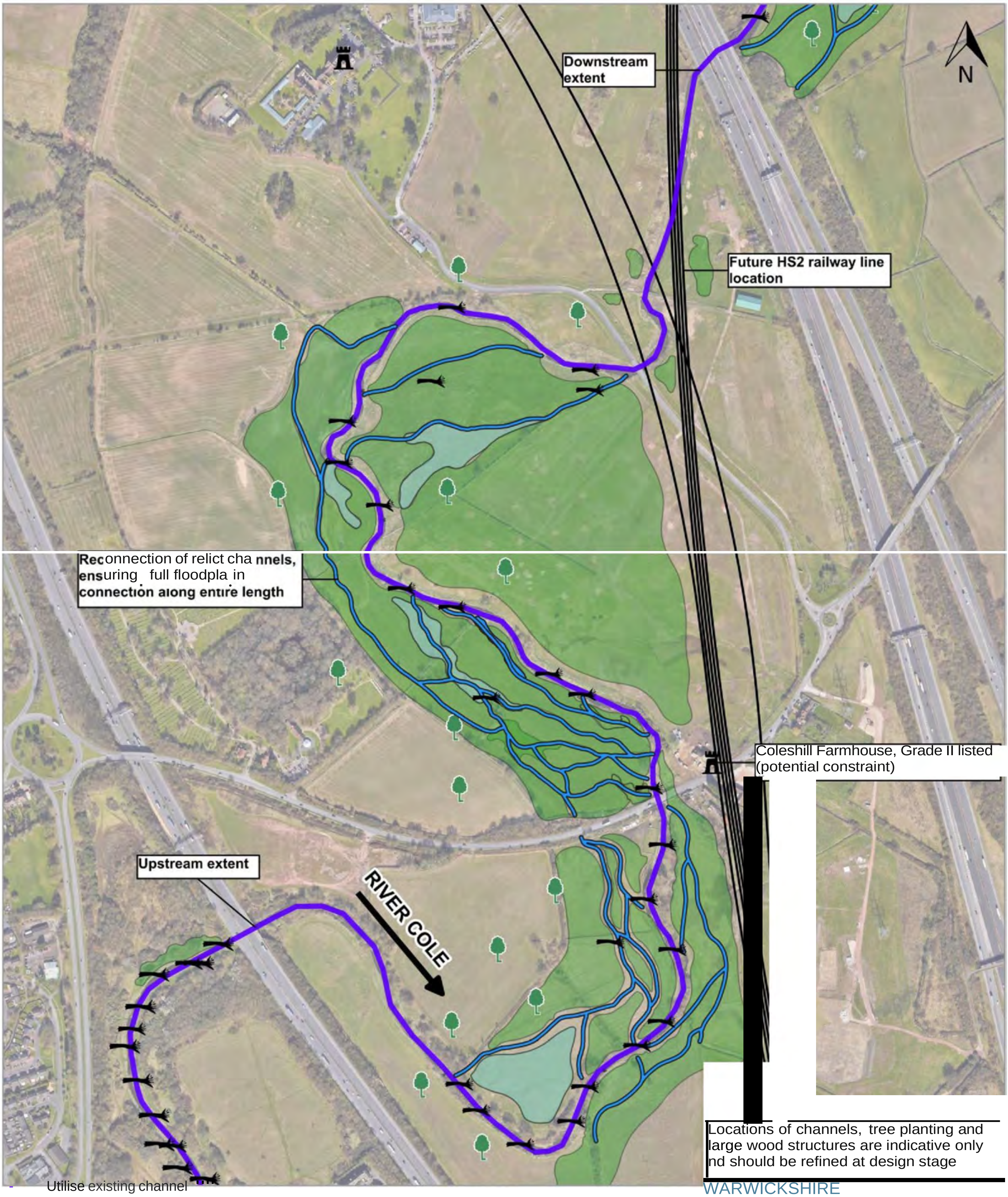
Four potential options are described here, with varying degrees of potential improvement to the existing channel. Fact sheets describing each option are presented below. A map illustrating the recommended option is presented in Figure 4-2.

- **Option 1: Do nothing.** Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- **Option 2: Minimal intervention.** Retain flow through existing channel and utilise relict channels as floodplain features. Introduce alternating large wood structures (LWS) at carefully targeted locations, structures, to further improve habitat diversity in main channel.
- **Option 3: Partial intervention.** Retain flow through existing channel and reprofile banks to improve channel/floodplain connectivity (potentially incorporating bed raising and/or creation of two-stage channel). Utilise relict channels as floodplain features. Introduce alternating LWS at carefully targeted locations, complementing existing structures to further improve habitat diversity in channel.
- **Option 4. Full-scale intervention.** Reconnect relict channels (and realign channel across floodplain in areas where no relict channels) to create more sinuous planform, potentially incorporating woodland/wet woodland habitat. Ensure channel/floodplain reconnection throughout entire reach which may require some partial infilling of the current channel. Introduce alternating LWS at carefully targeted locations in realigned channel to further improve habitat diversity. Create floodplain scrapes for further habitat diversity.

***RECOMMENDATION*:**	***Option 4***	*Full-scale intervention*

RIVER COLE FEASIBILITY SYUDY - PREFERRED OPTION (REACH 2)

cbec
eco engineering



Utilise existing channel

Listed buildings

LWM

Create New Channel

Native tree planting

Floodplain Scrapes

SOLIHULL

Birminqh1m

CLIENT	WARWICKSHIRE WILDLIFE TRUST
PROJECT	RIVER COLE FEASIBILITY AND DESIGN

0 100 200 300 m

Project no.	2150510
Date	22 AUG 2023
Drawn	RS
Designed	SM
Reviewed	MK

NOTTO SCALE
British National Grid
GCS OSGB 1936

Figure 4-2: Reach 2 preferred restoration option.

Table 4-3: Options matrix for Reach 2.

Factor	Option 1 (Do nothing)	Option 2 (Minimal intervention)	Option 3 (Partial intervention)	Option 4 (Full-scale intervention)
Benefit to geomorphic process	[Slightly Negative] Due to current morphological pressures and pollution (particularly fine sediment), without any intervention, geomorphic processes are likely to decline over time.		[Significantly Positive]	[Significantly Positive] Introduction of LWS will kickstart geomorphic processes
Impact on flood risk (to upstream and downstream areas)			[Slightly Positive]	[Significantly Positive] Retaining more water on the floodplain will reduce flood risk downstream
Impact to in-stream habitat (longer term)			[Slightly Positive]	[Significantly Positive] Reconnecting paleo-channels will provide missing backwater habitat
Impact on wider biodiversity			[Slightly Positive]	[Significantly Positive] Full floodplain reconnection will greatly increase habitat niches
Impact on landscape/amenity value			[Slightly Positive]	[Significantly Positive] Creation of wetlands – a habitat not present in the wider area – unique habitat will improve amenity value
Ease of construction (short term)			[Slightly Negative]	[Significantly Negative]
Cost of design/construction (short term)			[Slightly Negative]	[Significantly Negative]
Cost of maintenance (longer term)			[Neutral]	[Neutral] Proposed designs will be developed in a way in which they require minimal long-term maintenance.

Significantly Positive; Slightly Positive; Neutral; Slightly Negative; Significantly Negative

Reach	HS2 Land	Option	1. Do nothing

Description

- Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- Very occasional 'emergency' measures may still be permissible, under extreme circumstances.
- Channel would still benefit from effects of previous restoration efforts for as long as in-channel structures persist.

Indicative cross-section

n/a

Benefits

- No short-term costs associated with construction.
- No short-term disruption to services or farmland.
- No disturbance to existing in-stream and riparian habitats.

Disadvantages

- Risk of continued incision and further channel deepening and canalisation.
- No benefits for channel/floodplain connectivity.
- Potential for benefits of previous restoration efforts to reduce with time without restoration of natural fluvial processes.

Risk appraisal and mitigation measures

n/a

Additional work required

n/a

Approximate design and build costs

None, but may be associated with cost benefit since any ongoing, routine channel management is likely to incur some cost

Reach	HS2 Land	Option	2. Minimal intervention

Description

- Retain flow through existing channel.
- Utilise relict channels as floodplain features.
- Introduce alternating large wood structures (LWS) at carefully targeted locations to further improve habitat diversity in main channel, with placement guided by detailed physical assessments and designed to complement existing structures.

Indicative cross-section

Benefits

- Benefits to **wider biodiversity** through improvements to floodplain.
- Potential improvements to **flood risk** by enhancing/formalising floodplain storage.
- **Minimal disruption** during construction, with existing in-stream and floodplain habitats being retained.
- **Limited cost** associated with this option in comparison with others.
- Limited additional benefit to **biodiversity** and **geomorphic process** through improved in-stream habitat in association with LWS, owing to existing structures.

Disadvantages

- Risk of continued incision and further channel deepening and canalisation.
- Limited benefit for channel/floodplain connectivity.
- Potential for benefits of previous restoration efforts to reduce with time without restoration of natural fluvial processes.
- Further natural recovery unlikely given the low-energy, incised nature of the river.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Potential for increased local flood risk due to reduced channel conveyance:* Can be mitigated through appropriate design and flood risk assessment.

Additional work required

Physical assessment to guide LWS placement, regulatory requirements

Approximate design and build costs

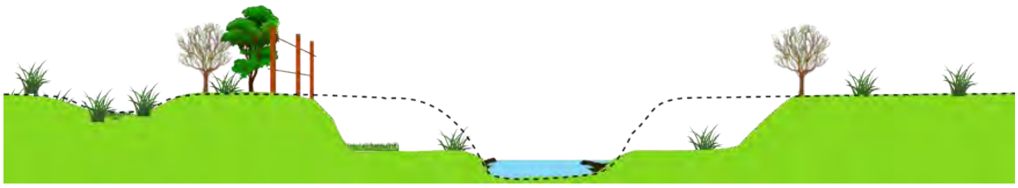
£60k to £80k

Reach	HS2 Land	Option	3. Partial intervention

Description

- Retain flow through existing channel.
- Reprofile banks (potentially incorporating bed raising and/or creation of two-stage channel) and remove localised embankments to improve channel/floodplain connectivity.
- Utilise relict channels as floodplain features.
- Introduce alternating LWS at carefully targeted locations to further improve habitat diversity in channel, with placement guided by detailed physical assessments and designed to complement existing structures.
- Maintain natural riparian woodland vegetation where already present (particularly around the reaches upstream extent) and enhance vegetation along reprofiled banks for additional stability.

Indicative cross-section



Benefits

- Benefit to **geomorphic process** through improved channel geometry and floodplain reconnection.
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Limited potential improvements for **in-channel diversity** owing to effects of existing structures.
- Benefits to **wider biodiversity** through improvements to riparian zone and floodplain.
- Potential improvements to **flood risk** by enhancing/formalising floodplain storage.
- Positive impact on **landscape** through creation of more natural habitat and river corridor environment.

Disadvantages

- **Some disruption** to agricultural land during construction, although much of existing in-stream and floodplain habitats can be retained.
- **Increased cost** associated with more extensive restoration measures.
- Further natural recovery towards reference state unlikely given the low-energy, incised nature of the river.
- Effects of previous works (including installation of in-channel structures) likely to be affected by bank reprofiling.
- Some land take required to achieve more stable bank configuration.
- Considerable cut may be required to achieve appropriate bank configuration.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Risk of encountering contaminated land or impacting utilities:* Relatively low but can be better constrained during design phase.

Additional work required

Physical assessment to guide LWS placement, flood risk assessment, outline/detailed design, regulatory

requirements, ecological assessment, landowner consultation
Approximate design and build costs £120k to £200k

Reach	HS2 Land	**Option**	4. Full intervention

Description

- Reconnect relict channels (and realign channel across floodplain in areas where no relict channels) to create more sinuous planform, potentially with additional woodland/wet woodland habitat.
- Ensure channel/floodplain connectivity throughout entire reach, reprofiling banks where necessary where existing channel is utilised.
- Introduce alternating LWS at carefully targeted locations in realigned channel to further improve habitat diversity, with placement guided by detailed physical assessments.
- Utilise existing channel to include backwater features and infill channel elsewhere.
- Maintain natural riparian woodland vegetation where already present and plant native vegetation along realigned channel.

Indicative cross-section

Benefits

- Significant improvement to **geomorphic process** through design of more sinuous channel, introduction of LWS and enhanced floodplain connectivity.
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Benefits to **wider biodiversity** through improvements to riparian zone and floodplain.
- Potential improvements to **downstream flood risk** by flow attenuation within reconnected floodplain.
- Significant positive impact on **landscape** through creation of more natural habitat and river corridor environment.

Disadvantages

- **Short-term disruption** to agricultural land during construction, although much of existing in-stream and floodplain habitats can be retained.
- Increased **local flood risk** due to retention of flood waters on floodplain.
- **Increased cost** associated with more extensive restoration measures.
- Greater **complexity of construction** relative to other options.
- Land take required to achieve realigned channel.
- Significant cut likely required to balance differences in floodplain and bed levels.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Risk of encountering contaminated land or impacting utilities:* Relatively low except in downstream part of reach (where electricity infrastructure and urban areas present) but can be better constrained during design phase.
- *Risk of local increase in flood risk:* Can be mitigated as part of design phase.
- *Complexity associated with floodplain levels relative to bed levels:* Can be mitigated by careful design.
- *Risk of avulsion and head cut:* Can be mitigated by infilling upstream end of existing channel and careful design of tie-in points.

Additional work required

Outline/detailed design, morphodynamic modelling, flood risk assessment, regulatory requirements, detailed topographic survey, ground investigation, landowner consultation, ecological assessment

Approximate design and build costs

£200k to £300k

4.4 REACH 3: COLESHILL TO QUARRY

From the M42 crossing to Stonebridge Road the River Cole follows a moderately sinuous path through relatively unmanaged scrub, woodland and grassland. The river then follows an easterly course through managed parkland in Coleshill between Stonebridge Road and Lichfield Road (B4117), whereupon it turns to the north and enters a section that was the focus of restoration works during the construction of an Environment Agency flood alleviation scheme. The restoration works sought to remeander the channel and created pool riffle sequences. The final ~650m of the River Cole in Reach 3 consists of a simplified constructed channel with undeveloped land on either side. Throughout the project reach the channel is bordered by pockets of broadleaved trees with an understorey of tall herbs, scrub and shrub. In areas where trees are absent, short and tall grasses are present.

The flow type along Reach 3 alternates between glide and riffle morphological units. The dominant substrate in the upper reach consisted of gravels and cobbles; the middle and lower reaches were dominated by gravels and fines. Through Coleshill the bed is reinforced concrete. Alluvial deposits were observed throughout the entire reach, including large (up to 100 m in length) side bars composed of predominantly gravels and fines. The majority of these deposits were fully stabilised by vegetation and are likely resistant to reworking during high flows, providing a good mechanism for capture and storage of fine sediment amongst the vegetation. There are areas of bank face reinforcement upstream and downstream of Stonebridge Road, where the channel is artificially straightened through Coleshill. Where substrate was exposed on the banks it comprised fine sediments (silts and sands) and pebbles characteristic of alluvial deposits.

Previous works have been undertaken in this reach, but these have been confined to in-channel works only, to the portion of the channel downstream of Coleshill. The channel in this shows sign of erosion, indicating it is still adjusting to the new channel morphology. The urban area of Coleshill also restricts the level of restoration achievable for the section of river flowing directly through the town. Four potential options are described here, with varying degrees of potential improvement to the existing channel. Fact sheets describing each option are presented below. A map illustrating the recommended options is presented in Figure 4-3.

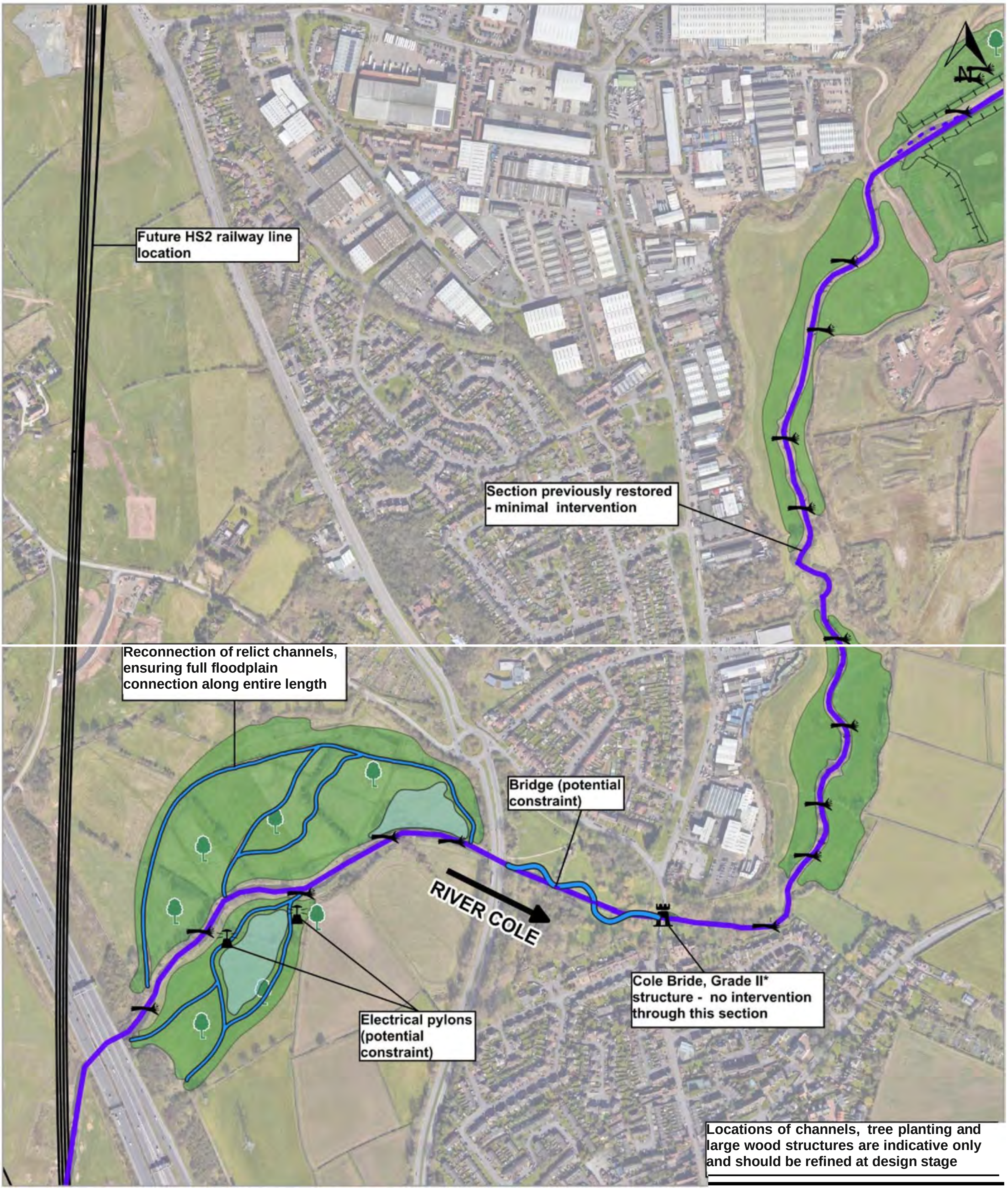
- **Option 1: Do nothing.** Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- **Option 2: Minimal intervention.** Retain flow through existing channel (in upstream extent only) and utilise relict channels as floodplain features. Introduce alternating large wood structures (LWS) and introduce, or augment existing, gravels at carefully targeted locations, to further improve habitat diversity in main channel.
- **Option 3: Partial intervention.** Retain flow through existing channel (in upstream extent only) and utilise relict channels as floodplain features, as well as reprofiling the banks to increase floodplain connection. Remeandering of the channel through the parkland area in Coleshill. Introduce alternating large wood structures (LWS) and introduce, or augment existing, gravels at carefully targeted locations, structures, to further improve habitat diversity in main channel.
- **Option 4. Full-scale intervention.** Reconnect relict channels (and realign channel across floodplain in areas where no relict channels) in the upstream reach to create more sinuous planform, potentially incorporating woodland/wet woodland habitat. Ensure channel-

floodplain reconnection throughout entire section. Remeandering of the channel through the parkland area in Coleshill. Introduce alternating LWS and gravels at carefully targeted locations in realigned channel to further improve habitat diversity.

***RECOMMENDATION*:**	***Option 4****	*Full-scale intervention*

RIVER COLE FEASIBILITY SYUDY - PREFERRED OPTION (REACH 3)

cbec
eco engineering



-utilise existing channel ==/==Electrical Pylon
- • Infill existing channel
Listed buildings/ structures
Create New Channel
Wet Woodland
LWM
D Ponds
• Native Tree Planting

SOLIHULL

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
PROJECT	RIVER COLE FEASIBILITY AND DESIGN	Date	22 AUG 2023
		Drawn	RS
		Designed	SM
		Reviewed	MK

0 100 200 300 m

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Figure 4-3: Reach 3 preferred restoration option.

Table 4-4: Options matrix for Reach 3.

Factor	Option 1 (Do nothing)	Option 2 (Minimal intervention)	Option 3 (**Partial** intervention)	Option 4 (Full-scale intervention)
Benefit to geomorphic process	Due to current morphological pressures and pollution (particularly fine sediment), without any intervention, geomorphic processes are likely to decline over time.	LWS will kickstart geomorphic processes.	LWS and gravels will kickstart geomorphic processes	Full floodplain reconnection with LWS will fully restore geomorphic processes .
Impact on flood risk (to upstream and downstream areas)		Proposed design will developed in a way that does not negatively impact flood risk.	Proposed design will developed in a way that does not negatively impact flood risk.	Retaining more water on the floodplain will reduce flood risk downstream.
Impact to in-stream habitat (longer term)				Reconnecting relict channels will create backwater habitat, increasing stream habitat diversity.
Impact on wider biodiversity		In-stream biodiversity improved only	In-stream biodiversity improved only	Full floodplain reconnection greatly improves river and floodplain biodiversity.
Impact on landscape/amenity value				Improved amenity value by creating mosaic of habitat.
Ease of construction (short term)				Excavation of new and paleo channels will increase construction difficulty.
Cost of design/construction (short term)				Excavation of new and paleo channels will increase construction cost.
Cost of maintenance (longer term)				

Significantly Positive; Slightly Positive; Neutral; Slightly Negative; Significantly Negative

Reach	Coleshill to Quarry	Option	1. Do nothing

Description

- Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- Very occasional 'emergency' measures may still be permissible, under extreme circumstances.

Indicative cross-section

n/a

Benefits

- No short-term costs associated with construction.
- No short-term disruption to services or farmland.
- No disturbance to existing in-stream and riparian habitats.

Disadvantages

- Risk of continued incision and further channel deepening and widening.
- No benefits for channel/floodplain connectivity.

Risk appraisal and mitigation measures

n/a

Additional work required

n/a

Approximate design and build costs

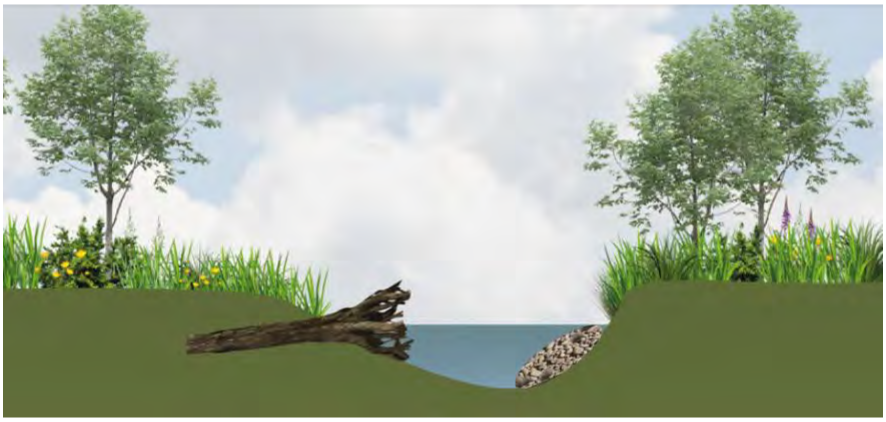
None, but may be associated with cost benefit since any ongoing, routine channel management is likely to incur some cost

Reach	Coleshill to Quarry	Option	2. Minimal intervention

Description

- In the upstream extent, use relict channels as floodplain features.
- Introduce alternating large wood structures (LWS) and introduce, or augment existing, gravels at carefully targeted locations, to further improve habitat diversity in main channel.

Indicative cross-section



Benefits

- Enhancement of **habitat** through introduction of floodplain features.
- Improvements to **geomorphic process** by enhancement of morphological diversity.
- Potential improvements to **flood risk downstream** by helping reconnect channel with floodplain at higher flows.
- **Lower cost** associated with this option in comparison with others.

Disadvantages

- **Some disruption** during construction, although existing floodplain habitats can be retained.
- Potential for benefits of restoration efforts to reduce with time without full restoration of natural fluvial form and process.
- Further natural recovery unlikely given the low-energy nature of the river.
- Potential increases in **flood risk** locally due to reduced channel conveyance during moderate to high flows.
- Risk of LWM destabilisation during high flows.

Risk appraisal and mitigation measures

- *Potential for increased local flood risk due to reduced channel conveyance resulting from introduction of LWS :* Can be mitigated through appropriate design and flood risk assessment.
- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.

Additional work required

Flood risk assessment, landowner consultation, outline/detailed design, regulatory requirements

Approximate design and build costs

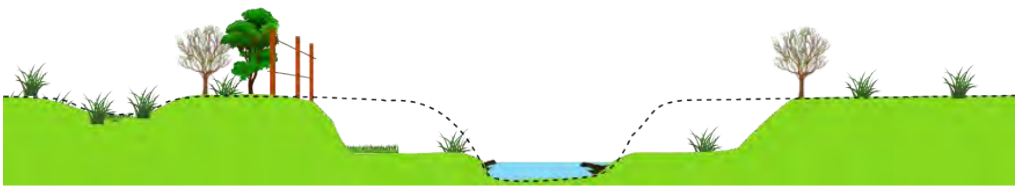
£40k to £80k

Reach	Coleshill to Quarry	Option	3. Partial intervention

Description

- In the upstream extent, use relict channels as floodplain features as well as reprofiling the banks to increase floodplain connection.
- Remeandering of the channel through the parkland area in Coleshill to improve geomorphic variability.
- Introduce alternating large wood structures (LWS) and introduce, or augment existing, gravels at carefully targeted locations, to further improve habitat diversity in main channel.

Indicative cross-section



Benefits

- Benefit to **geomorphic process** through improved channel morphology for the remeandered section in Coleshill.
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Positive impact on **landscape and amenity value** through creation of more natural habitat and river corridor environment.
- Enhancement of fish **habitat** through flushing of fine sediments by narrower, faster flow around areas of gravel augmentation.
- Potential improvements to **flood risk downstream** by helping reconnect channel with floodplain at higher flows.
- Potential for greater floodplain inundation locally during higher flows.

Disadvantages

- **Disruption** during construction, although much of existing floodplain habitat can be retained.
- **Increased cost** associated with more extensive restoration measures.
- Potential increases in **flood risk** locally due to reduced channel conveyance during moderate to high flows.
- Risk of LWM becoming destabilised during high flows.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising or benches eroding during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing appropriate design of stabilising measures.
- *Risk of encountering contaminated land or impacting utilities:* Relatively low, except where electricity infrastructure in place on floodplain, but can be better constrained during design phase.
- *Potential increases in flood risk:* Can be assessed during design phase based on hydraulic modelling and flood risk assessment.

Additional work required

Flood risk assessment, landowner consultation, outline/detailed design, regulatory requirements, , ecological assessment, physical assessment to guide LWS placement, morphodynamic modelling.

Approximate design and build costs

£150k to £200k

Reach	Coleshill to Quarry	**Option**	4. Full intervention

Description

- Reconnect relict channels (and realign channel across floodplain in areas where no relict channels) in the upstream reach to create more sinuous planform, potentially incorporating woodland/wet woodland habitat. Ensure channel/floodplain reconnection throughout entire section.
- Remeandering of the channel through the parkland area in Coleshill.
- Introduce alternating LWS and gravels at carefully targeted locations in realigned channel to further improve habitat diversity.

Indicative cross-section

Benefits

- Significant improvement to **geomorphic process** through design of more sinuous channel, introduction of LWS and enhanced floodplain connectivity.
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Benefits to **wider biodiversity** through improvements to riparian zone and floodplain.
- Potential improvements to **downstream flood risk** by flow attenuation within reconnected floodplain.
- Significant positive impact on **landscape** through creation of more natural habitat and river corridor environment.

Disadvantages

- Increased **local flood risk** due to retention of flood waters on floodplain.
- **Increased cost** associated with more extensive restoration measures.
- Greater **complexity of construction** relative to other options.
- Land take required to achieve realigned channel.
- Significant cut likely required to balance differences in floodplain and bed levels.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Risk of encountering contaminated land or impacting utilities:* Relatively low except in upstream part of reach (where extensive electricity infrastructure present) but can be better constrained during design phase.
- *Risk of local increase in flood risk:* Can be mitigated as part of design phase.

• *Complexity associated with floodplain levels relative to bed levels:* Can be mitigated by careful design. • *Risk of avulsion and head cut:* Can be mitigated by infilling upstream end of existing channel and careful design of tie-in points.
Additional work required Outline/detailed design, morphodynamic modelling, flood risk assessment, regulatory requirements, detailed topographic survey, ground investigation, ecological assessment, landowner consultation, structural assessment
Approximate design and build costs £200k to £300k

4.5 REACH 4: QUARRY TO CONFLUENCE WITH RIVER BLYTHE

The River Cole south-east of Coleshill Parkway station to its confluence with the River Blythe follows a highly modified planform, with high embankments situated either side of the channel in order to restrict the river from interfering with adjacent quarries. This reach is has been historically straightened and embanked on either side to protect the adjacent quarries. The areas of quarry on the left bank and downstream section of the right bank are no longer in use, and have been allowed to recover naturally, forming areas of scrub, grassland and wetland.

Glide morphological units are dominant in Reach 4, with a small section of alternating riffles and pools situated within the middle of the reach. The entire reach substrate is dominated by gravels and cobbles. Alluvial deposits were observed frequently throughout the entire reach. Lateral bars were present throughout the reach, composed of predominantly cobbles and gravels. The majority of these deposits were absent of any vegetation, indicating they're likely active and susceptible to reworking during high flows. The banks are steep and predominantly vegetated, but in the middle of the reach, extreme erosion of the left bank (formed into an artificial embankment) has resulted in the formation of a ~4 m cliff. In the middle sections of the reach where the channel is bordered by the disused quarry, the river is set within a two-stage channel, with tall embankments set back ~10 m from the channel.

The entire length of Reach 4 is within the quarry. It appears that excavation/quarrying of the floodplain is now complete. The left floodplain, which has been 'remediated' by the quarry operator, now appears to be unmanaged, with scrub and rank grassland developing. The right floodplain has also been remediated, a majority of which has been returned to a mixture of pastoral grassland/bailage production. Throughout this reach the channel is bordered tall herbs, scrub and shrub, with some small trees.

Four potential options are described here, with varying degrees of potential improvement to the existing channel. Fact sheets describing each option are presented below. A map illustrating the recommended options is presented in Figure 4-4.

- **Option 1: Do nothing.** Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- **Option 2: Minimal intervention.** Retain flow through existing channel , introduce alternating large wood structures (LWS) and introduce, or augment existing, gravels at carefully targeted locations, to further improve habitat diversity in main channel.
- **Option 3: Partial intervention.** Retain flow through existing channel , introduce alternating large wood structures (LWS) and introduce, or augment existing, gravels at carefully targeted locations, to further improve habitat diversity in main channel. In selected locations, set back flood embankments to create areas of inset floodplain.
- **Option 4. Full-scale intervention.** Complete infilling of the existing channel and removal of flood embankments whilst also adding LWS across the floodplain, in order to create a 'Stage 0' restoration approach. This would involve completely restoring natural processes within the River Cole, allowing the river to naturally forge its own path across the floodplain, leading to the development of a rich mosaic of habitats, such as ponds and wet woodland. As was identified within the PEA, Willow Tit (a priority species under the UK Biodiversity Framework) favour early successional habitats, large areas of which would be formed via a stage 0 restoration approach.

***RECOMMENDATION*:**	***Option 4***	*Full-scale intervention*

RIVER COLE FEASIBILITY STUDY - PREFERRED OPTION (REACH 4)

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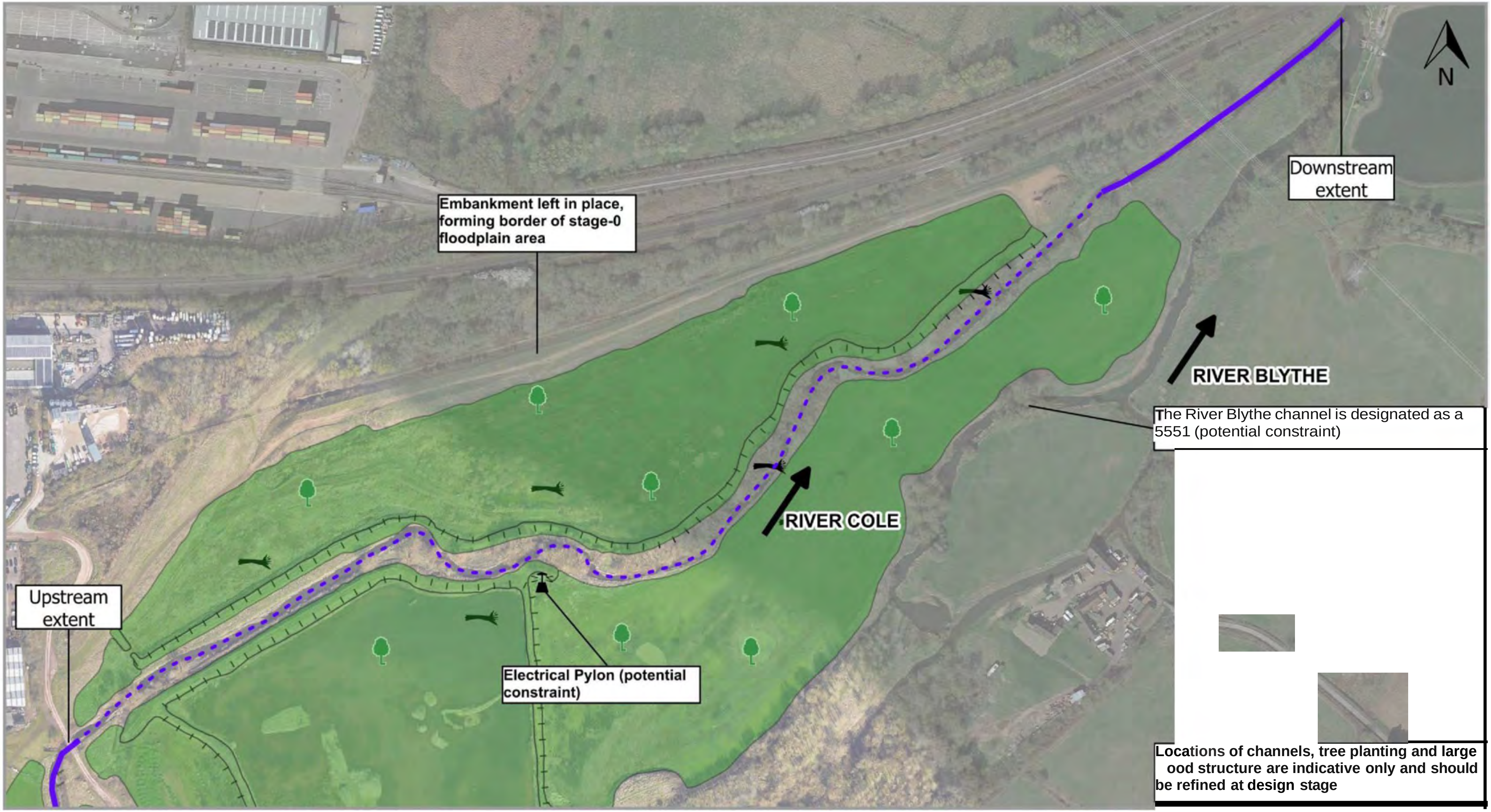

- utilise Existing Channel

Infilling of Existing Channel

LWM

Native Tree Planting

Listed Buildings / Structures

Electrical Pylon

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
PROJECT	RIVER COLE FEASIBILITY & DESIGN	Date	22 NOV 2023
		Drawn	RS
		Surveyed	RS
		Reviewed	SM

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Figure 4-4: Reach 4 preferred restoration option.

Table 4-5: Options matrix for Reach 4.

Factor	Option 1 (Do nothing)	Option 2 (Minimal intervention)	Option 3 (**Partial** intervention)	Option 4 (Full-scale intervention)
Benefit to geomorphic process	Due to current morphological pressures and pollution (particularly fine sediment), without any intervention, geomorphic processes are likely to decline over time.	LWS will kickstart geomorphic processes.	LWS and gravels will kickstart geomorphic processes	Full floodplain reconnection with LWS will fully restore geomorphic processes .
Impact on flood risk (to upstream and downstream areas)		Proposed design will developed in a way that does not negatively impact flood risk.	Proposed design will developed in a way that does not negatively impact flood risk.	Retaining more water on the floodplain will reduce flood risk downstream.
Impact to in-stream habitat (longer term)				Reconnecting relict channels will create backwater habitat, increasing stream habitat diversity.
Impact on wider biodiversity		In-stream biodiversity improved only	In-stream biodiversity improved only	Full floodplain reconnection greatly improves river and floodplain biodiversity.
Impact on landscape/amenity value				Improved amenity value by creating mosaic of habitat.
Ease of construction (short term)				Excavation of new and paleo channels will increase construction difficulty.
Cost of design/construction (short term)				Excavation of new and paleo channels will increase construction cost.
Cost of maintenance (longer term)				

Significantly Positive; Slightly Positive; Neutral; Slightly Negative; Significantly Negative

Reach	Coleshill to Quarry	Option	1. Do nothing

Description

- Cease all regular channel management activities and do not undertake any additional in-channel habitat improvement works.
- Very occasional 'emergency' measures may still be permissible, under extreme circumstances.

Indicative cross-section

n/a

Benefits

- No short-term costs associated with construction.
- No short-term disruption to services or farmland.
- No disturbance to existing in-stream and riparian habitats.

Disadvantages

- Risk of continued incision and further channel deepening and widening.
- No benefits for channel/floodplain connectivity.

Risk appraisal and mitigation measures

n/a

Additional work required

n/a

Approximate design and build costs

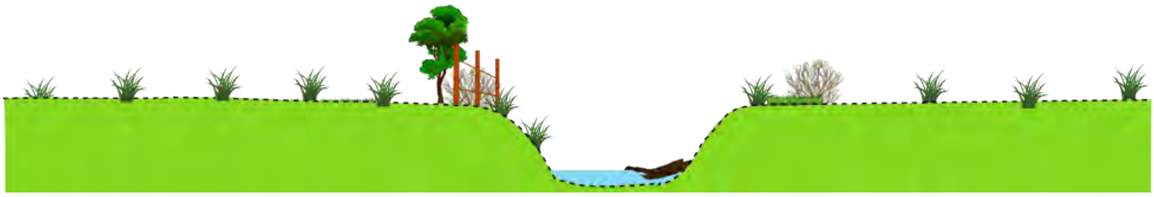
None, but may be associated with cost benefit since any ongoing, routine channel management is likely to incur some cost

Reach	Coleshill to Quarry	Option	2. Minimal intervention

Description

- Retain flow through existing channel.
- Introduce alternating large wood structures (LWS) at carefully targeted locations to further improve habitat diversity in main channel, with placement guided by detailed physical assessments.

Indicative cross-section



Benefits

- Some benefit to **biodiversity** and **geomorphic process** through improved in-stream habitat in association with LWS.
- **Minimal disruption** during construction, with existing in-stream and floodplain habitats being largely retained.
- **Limited cost** associated with this option in comparison with others.

Disadvantages

- Risk of continued incision and further channel deepening.
- Limited benefit for channel/floodplain connectivity.
- Further natural recovery unlikely given the low-energy, incised nature of the river.
- Limited benefit to riparian and floodplain habitat.
- No benefits for channel/floodplain connectivity.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
  Potential for increased local flood risk due to reduced channel conveyance: Can be mitigated through appropriate design and flood risk assessment.

Additional work required

Physical assessment to guide LWS placement, regulatory requirements

Approximate design and build costs

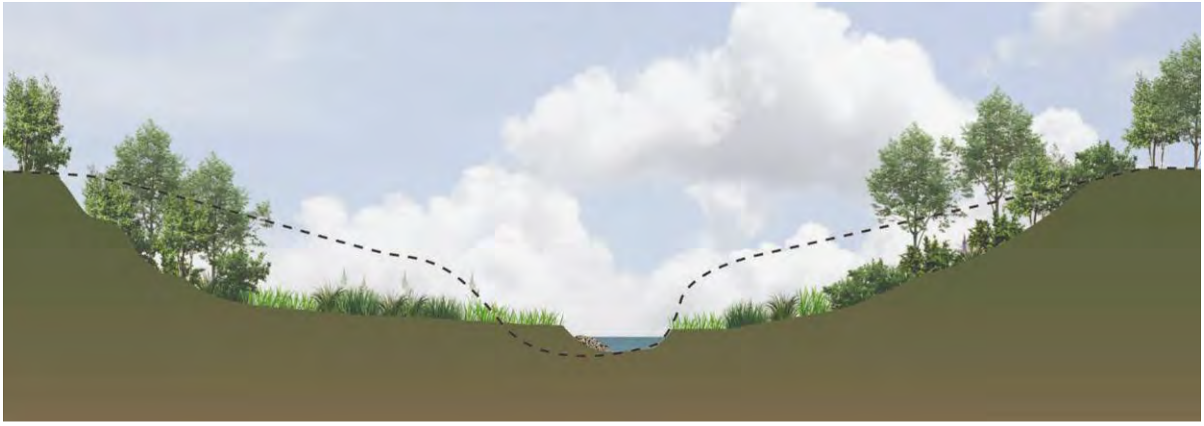
£40k to £80k

Reach	Coleshill to Quarry	Option	3. Partial intervention

Description

- Retain flow through existing channel.
- Introduce alternating LWS and gravels at carefully targeted locations to further improve habitat diversity in channel, with placement guided by detailed physical assessments.
- Introduce gravels to create bar and berm features, and augment existing berms to improve geomorphic variability. Manage existing vegetation to improve the stability of existing berms.
- In selected areas, set back the embankments to create in-set floodplain/wetland areas.

Indicative cross-section



Benefits

- Benefit to **geomorphic process** through increased in-channel morphological diversity.
- Improvement to **ecological condition/habitat** through the introduction of LWS.
- Positive impact on **landscape** through creation of more natural habitat and river corridor environment.
- Partial improvement in **ecological condition/habitat** through creation of localised inset floodplain areas.

Disadvantages

- **Increased cost** relative to other proposed options.
- Minimal benefit to riparian and floodplain habitat.
- No benefits for channel/floodplain connectivity.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.

Additional work required

Physical assessment to guide LWS placement, flood risk assessment, outline/detailed design, regulatory requirements, ecological assessment, landowner consultation

Approximate design and build costs

£80k to £200k

Reach	Coleshill to Quarry	Option	4. Full intervention

Description

- Full removal of embankments and infilling of current channel to create a 'stage-0' restoration approach, allowing full reconnection between the river and disused quarry land.
- Introduce alternating LWS at carefully targeted locations across the floodplain area to force channel natural geomorphic processes, leading to unassisted channel development over an extended time period.
- Extensive planting of native trees and vegetation to create a floodplain mosaic across which the river will meander freely.

Indicative cross-section

Benefits

- Significant improvement to **geomorphic process** through creation of floodplain mosaic with full connection to the river.
- Improvement to **ecological condition/habitat** through the introduction of LWS and native vegetation.
- Benefits to **wider biodiversity** through improvements to riparian zone and floodplain.
- Potential improvements to **downstream flood risk** by flow attenuation within reconnected floodplain.
- Significant positive impact on **landscape** through creation of more natural habitat and river corridor environment.

Disadvantages

- Increased **local flood risk** due to retention of flood waters on floodplain.
- **Increased cost** associated with more extensive restoration measures.
- Greater **complexity of construction** relative to other options.
- Land take required to achieve realigned channel.
- Significant cut likely required to balance differences in floodplain and bed levels.

Risk appraisal and mitigation measures

- *Risk of LWS mobilising during high flows*: Can be minimised through careful design that assesses the maximal forces likely to act on the structures, allowing for measures that optimise their stability, potentially employing stabilising measures in extreme cases.
- *Risk of encountering contaminated land or impacting utilities:* Relatively low except in upstream part of reach (where extensive electricity infrastructure present) but can be better constrained during design phase.
- *Risk of local increase in flood risk:* Can be mitigated as part of design phase.
- *Complexity associated with floodplain levels relative to bed levels:* Can be mitigated by careful design.
- *Risk of avulsion and head cut:* Can be mitigated by infilling upstream end of existing channel and

careful design of tie-in points.
Additional work required Outline/detailed design, morphodynamic modelling, flood risk assessment, regulatory requirements, detailed topographic survey, ground investigation, ecological assessment, landowner consultation, structural assessment
Approximate design and build costs £250k to £350k

4.6 ADDITIONAL RESTORATION OPTIONS

In addition to the options proposed in detail above, it is also recommended that further work be undertaken to reduce the amount of fine sediment entering the watercourse. This sediment was observed to blanket the bed substrate, both immediately downstream of the point of entry and elsewhere in the watercourse. Reducing the amount of fine sediment entering the river from areas of poaching, fords and bank erosion will offer potential for improvement in in-stream habitat.

Previous work is known to have been undertaken to improve bank stability upstream of Cooks Lane. However, in the project area, severe bank erosion was observed in several locations, supplying fines and small amounts of gravel. It is recommended that these areas are stabilised, e.g. by reprofiling and protecting the banks in conjunction with further stoning up of the approaches and even the bed of the crossing points.

There were many locations in which riparian vegetation was absent, greatly exacerbated by the presence of the non-native invasive species Himalayan Balsam (Figure 3-5) It is recommended that consideration be given to enhancing the riparian zone in areas where the proposed options are not progressed to the design phase.

4.7 REACH RESTORATION POTENTIAL RANKING

The options described above were presented to the Warwickshire Wildlife Trust and the Environment Agency for feedback, in order to rank the preferred options for each reach and select an option to take forward to detailed design stage in the near future. A number of factors were considered in the ranking process, and adjacent reaches with similar proposed measures have been ranked together to maximise restoration potential. The options are ranked in Table 4-6 and are colour coded to indicate their overall feasibility in terms of constraints. Options coloured in *green* indicate those with few constraints to be overcome; those in *orange* indicate the presence of considerable constraints that can potentially be mitigated as part of a concept design or detailed design study; and those in *red* indicate that the constraints present are likely to be showstoppers for any restoration proposals.

The restoration reaches above were ranked based on their restoration potential, that is the opportunity to make the biggest improvement to the morphology and ecology of the reach, with the greatest return on investment. It is hoped that all of the proposed restoration packages can be delivered in future. However, if this is not the case, packages with the greatest potential for morphological, ecological and community gain should be prioritised. In this context, Restoration Reach 1 can be considered to be the lowest priority work package owing to the existing relatively good morphology and large constraints imposed by the adjacent residential developments, meaning there is smaller scope for improvement. Restoration Reach 3 is also considered to be lower priority than other reaches owing to the good morphology present resulting from previous restoration works undertaken by the Environment Agency. Restoration Reaches 4 and 2 offer the greatest scope for improvements in morphology and ecology. Given the scope for improvements in ecology, floodplain connection and amenity value relative to existing conditions, Restoration Areas 4 and 2 should be considered the highest priority sites for restoration, although it is recognised that there are likely to be more technical and regulatory challenges for Restoration Area 2 in particular due to the close proximity of the residential area of Coleshill.

In addition to specific restoration work packages, recommendations have also been provided for catchment-wide measures that will help meet the above project objectives and could be undertaken in advance of additional design work, potentially by volunteers, interns or local community groups.

Table 4-6 Restoration reach prioritisation

Restoration Potential	Reach Number	Comments
High	4	• Reach 4 has the greatest restoration potential due to there being no floodplain constraints, and a wide-open **area** to work with. The river through this reach is heavily embanked and straightened, meaning **large benefit to fluvial processes and habitat can be achieved here.** • The disused quarry that is situated on the right floodplain has also already begun the process of natural succession since it was abandoned. • This reach also presents an exciting opportunity for Warwickshire Wildlife Trust to undertake a novel 'stage O' style restoration approach. • This reach ends with the confluence to the River Blythe, which is designated as a SSSI. Improvements to the River Cole have the opportunity to create a corridor of high-quality habitat. • This reach is furthest from any residential areas and so will have the lowest social benefits. • Construction will likely be more complex and time consuming than within the other reaches, but the large distance from residential areas will limit disruption.
	2	• This reach has good restoration potential due to there being few floodplain constraints, meaning full floodplain reconnection would be possible, **resulting in large benefit to fluvial processes and habitat.** • There are many relict meanders present in the floodplain that can be reconnected, which would improve the ease of construction. Being in close proximity to HS2 land could present logistical issues.
	3	This reach has good restoration potential in its upper reaches, where full floodplain reconnection will bepossible. Options are limited as it flows through Coleshill, due to constraints on flood risk, as well as listed bridges. The section downstream of Coleshill was restored relatively recently by the Environment Agency, and for the most part follows a natural morphology. Only minor improvements, such as introduction of LWM, would be necessary here. This means that there is less opportunity for improvement to fluvial processes and habitat. • The River Cole through this reach already follows a relatively natural meandering course, meaning there are fewer opportunities for improvement.

Restoration Potential	Reach Number	Comments
Low	1	▪ This reach is constrained by embankments for most of its length, due to the residential area of Kingshurst. This presents a barrier to any full-scale restoration. Several bridges cross this reach too, again acting as barriers to restoration. ▪ Because full scale restoration would not be feasible within this reach, there is less opportunity to improve fluvial processes and habitat. ▪ Although the removal of the gauging weir is proposed and would have a large benefit on fish passage, this presents a large construction cost, and would also result in disruption to adjacent residential areas.

5. PROPOSED RESTORATION DESIGN

5.1 DETAILED DESIGN CONTEXT

2022 Water Framework Directive (WFD) assessments indicate that the River Cole (From Hatchford-Kingshurst Brook to River Blythe) is rated poor for macrophytes, while the upstream reach from Springfield to Hatchford-Kingshurst Brook is rated poor for invertebrates. Historically, the River Cole has been subject to channel deepening, straightening and widening and disconnection of the channel from its floodplain. This historical channel engineering is considered to have had a detrimental impact on river habitat, including the destruction of the natural pool-riffle habitat. The River Cole also has naturally low energy and a limited supply of coarse sediment, which means that the recovery of natural characteristics within the river will be slow. A number of in-channel habitat improvement projects have been undertaken in the River Cole in recent years, with some projects attempting to address the historical modifications made to the watercourse, although these modifications remain a key issue for much of the watercourse.

Key findings from a Preliminary Ecological Appraisal (PEA) conducted by RSK Biocensus between November 2023 and January 2024 indicate that there is a lack of backwater habitat, which forms crucial habitat for fish at various stages within their lifecycle. The PEA also indicated that INNS are present throughout the project area in varying densities, with Himalayan Balsam being relatively extensive throughout the site.

The River Cole is a low-energy system, with almost 65% of the surveyed length being made up of glide morphological units. Both within and outside the glide units, short sections of shallower and faster flow are often forced by deposition of fine sediment and gravels, which are generally stabilised by vegetation. Naturally occurring short pool-riffle sections have been preserved in isolated areas within each reach, coinciding with natural sinuosity and areas of erosion. However, these relatively natural and unmodified sections make up only a small percentage of each reach, and even in these locations, there has still been a degree of floodplain disconnection resulting from incision and artificial embankments.

5.2 DESIGN OVERVIEW

As outlined in Section 4, it is recommended that full-scale intervention is the best option for Reaches 1 - 4 of the River Cole. Given the unpredictable timing and effects of HS2 construction and restoration works in Reach 2, it has been agreed with the client to progress restoration designs for Reaches 1, 3, and 4, and as such, Reach 2 is not considered going forward. At the options appraisal stage the full-scale intervention concepts for these reaches were described as follows:

- ***Reach 1:*** Retain flow through existing channel. Removal of the gauging weir. Introduce gravels and augment existing gravels to form alternating bar features. Introduce alternating LWS at carefully targeted locations to further improve habitat diversity in channel. Full connection of the pond adjacent to the M6 overpass, as was suggested within the PEA.

- ***Reach 3:*** Reconnect relict channels (and realign channel across floodplain in areas where no relict channels) in the upstream reach to create more sinuous planform, potentially incorporating woodland/wet woodland habitat. Ensure channel-floodplain reconnection throughout entire section. Remeandering of the channel through the parkland area in Coleshill. Introduce alternating LWS and gravels at carefully targeted locations in realigned channel to further improve habitat diversity.

- ***Reach 4:*** Complete infilling of the existing channel and removal of flood embankments whilst also adding LWS across the floodplain, in order to create a 'Stage 0' restoration approach. This would involve completely restoring natural processes within the River Cole, allowing the river to naturally forge its own path across the floodplain, leading to the development of a rich mosaic of habitats, such as ponds and wet woodland.

CBEC has subsequently designed a set of restoration measures for Reaches 1, 3, and 4 of the River Cole from Cooks Lane to the River Blythe. These restoration measures are intended to achieve the objectives of the recommended interventions while taking into account additional constraints and opportunities discovered during the design development process. A schematic plan of the design is shown in Figure 5-1 through Figure 5-3; full design drawings are presented in Appendix A. The proposed restoration measures include:

- Increasing in-channel complexity by placing lateral bar-apex large wood structures (LWS);
- Increasing the river-floodplain connectivity by excavating floodplain distributary channels;
- Enhancing longitudinal connectivity over the gauging weir by means of a rock ramp fish pass;
- Increasing channel width to depth ratio by reprofiling banks where feasible;
- Remeandering sections of the main channel in Reaches 3 and 4;
- Constructing floodplain mounds in Reach 4; and
- Removal of INNS, revegetation of disturbed areas, and planting of riparian trees.

5.3 RESTORATION MEASURES

5.3.2. Reach 1

Bar apex LWS

A total of 20 LWS are proposed in Reach 1 to create local physical and habitat diversity in the channel. LWS are to be attached to alternating banks at approximately 5 – 7 channel widths spacing, or aligned with the head of existing bars, where they will be effective at encouraging both gravel deposition and pool formation. Each structure should comprise one tree of trunk diameter 250 mm – 400 mm, length approximately 4 m, with root plate still attached, anchored at least half of the trunk length into the bank, angled with the root plate facing upstream so that approximately one third of the channel width is (partially) obstructed, fixed to the bed by inclined chestnut stakes, and ballasted with boulders.

Gauging weir rock ramp
A full-width rock ramp is proposed downstream of the EA gauging weir to facilitate fish passage. A pre-barrage was previously recommended for this location (Black & Veatch Limited 2013), but CBEC's experience suggests that rock ramps can be an equally effective, more natural and sustainable solution to fish passage issues.

Bank reprofiling
Where feasible, riverbanks are to be regraded and subsequently revegetated with appropriate native plants. Reprofiling will entail setting back the top of the bank so that the reprofiled bank slope is 2H:1V.

Tree planting
Riparian revegetation is specifically to include large tree species planted near bar apex LWS to enhance long term in-channel complexity by contributing woody material to the river upon maturity and/or senescence. Species planted should include *Salix alba* (white willow) and *Alnus glutinosa* (alder).

5.3.3. Reach 3

Floodplain channels
Sinuous distributary channels are to be excavated to connect the main channel to the floodplain space over a wider range of flow. A stable cross-sectional form is proposed that will enhance channel/floodplain connectivity and result in more graduated and variable inundation.

Bar apex LWS
A total of 33 LWS are proposed in Reach 3. The specification for these features and associated benefits are as per those outlined for Reach 1.

Bank reprofiling
Where feasible, riverbanks are to be reprofiled and subsequently revegetated with appropriate native plants. Reprofiling will entail setting back the top of the bank so that the reprofiled bank slope is 2H:1V.

Remeandered main channel
The straight section of channel within Cole End Park is to be remeandered. In addition to the creation of gentle meander bends, a more natural cross-sectional form is proposed that will enhance channel/floodplain connectivity and result in more varied and widespread inundation within the channel footprint. Portions of the existing channel are to be infilled to dispose of cut material generated through excavation of the new channel.

Tree planting
Riparian revegetation is specifically to include large tree species planted in the vicinity of bar apex LWS to enhance long term in-channel complexity by eventually contributing woody material to the river upon maturity and/or senescence. Species planted should include *Salix alba* (white willow) and *Alnus glutinosa* (alder).

5.3.4. Reach 4

Embankment removal

The river left floodplain embankment is to be removed to facilitate connection between the main channel and the floodplain.

Floodplain channels

A network of sinuous channels is to be excavated on the left floodplain. A stable cross-sectional form is proposed that will enhance channel/floodplain connectivity and result in more graduated and variable inundation. Portions of the existing channel are to be infilled to dispose of cut material generated through excavation of the new channel.

Floodplain mounds

Spoil from excavation of the floodplain channel network is to be used to build up mounds within the floodplain that will provide appropriate and varied habitat for a variety of riparian and wet woodland plants.

Bar apex LWS

A total of 15 LWS are proposed in Reach 4. The specification for these features and associated benefits are as per those outlined for Reach 1.

Tree planting

Riparian revegetation is specifically to include large tree species planted in the vicinity of bar apex LWS to enhance long term in-channel complexity by eventually contributing woody material to the river upon maturity and/or senescence. Species planted should include *Salix alba* (white willow) and *Alnus glutinosa* (alder).

5.4 ANTICIPATED BENEFITS

In combination, the restoration measures proposed are expected to result in:

- Enhanced morphological, flow, and habitat diversity resulting from the local effects of LWS and the variability in wetted channel area at different flow levels that sections of wider channel with reprofiled banks will allow.
- Enhanced fish passability at the gauging weir.
- Enhanced riparian and floodplain habitat.
- Enhanced flood storage in distributary channels and on the floodplain, with corresponding reductions in adjacent and downstream flood risk.
- Self-sustaining morphological, flow, and habitat diversity eventually resulting from the growth of additional large trees to be planted in the riparian area.
- Better community access to the river resulting from INNS removal, bank reprofiling, and eventual understory suppression by additional large trees in the riparian area.

The relationships between proposed restoration actions and anticipated benefits are illustrated in Table 5-1.

5.5 DESIGN RISKS AND UNCERTAINTIES

The feasibility and effectiveness of this set of restoration measures for the River Cole is contingent upon a number of uncertain risks, including:

- Landowner consent;
- Community engagement;
- Permissibility of the gauging weir rock ramp;
- Availability of wood for LWS;
- Construction access;
- Hydraulic effects of HS2 restoration works; and
- Impediments to riparian vegetation establishment, including competition from established INNS (e.g., Himalayan Balsam, Japanese Knotweed).

Table 5-1. Anticipated Benefits of Proposed Restoration Measures

Restoration Measure	Anticipated Benefit					
	Immediate Morpholocical & Flow Type Diversity	Fish Passace Improvement	Riparian & Floodplain Habitat	Flood Risk	Sustained Morpholocical & Flow Type Diversity	Community Access to the River
All Reaches						
Bar Apex LWS	Gravel deposition; Wetted width variation; Bar &and pool formation					
Bank Reprofiling	Wetted width variation with varying flows; Shallow marllinal flow area			Increased conveyance		Shallow bankslopes allow safer approach to river
Riparian Planting			Growth of native spp.; Suppression of INNS; Increase in large tree numbers		Large trees interact with river at maturity and in senescence; Tree hinging potential	Shade suppression of undergrowth allows river approach
Reach 1						
Gauging Weir Rock Ramp		Suitable flow depths/ velocities				
Reach 3						
Floodplain Channels	New floodplain channels; Flow-varying inundation			Increased floodplain storage		
Remeandered Main Channel	New meander bends; Width variability; Wetted width variation; Bar &and pool formation				New meander bends; Width variability; Wetted width variation; Bar &and pool formation	Added bank length; meander bends facilitate viewing of channel
Reach 4						
Embankment Removal			More frequent floodplain inundation	Increased floodplain access		
Floodplain Channels	New floodplain channels; New meander bends; Wetted width variation; Bar &and pool formation			Increased floodplain storage		
Floodplain Mounds			Growth of native spp.; Suppression of INNS; Increase in large tree numbers			

RIVER COLE - DETAIL DESIGN SCHEMATIC (REACH 1)

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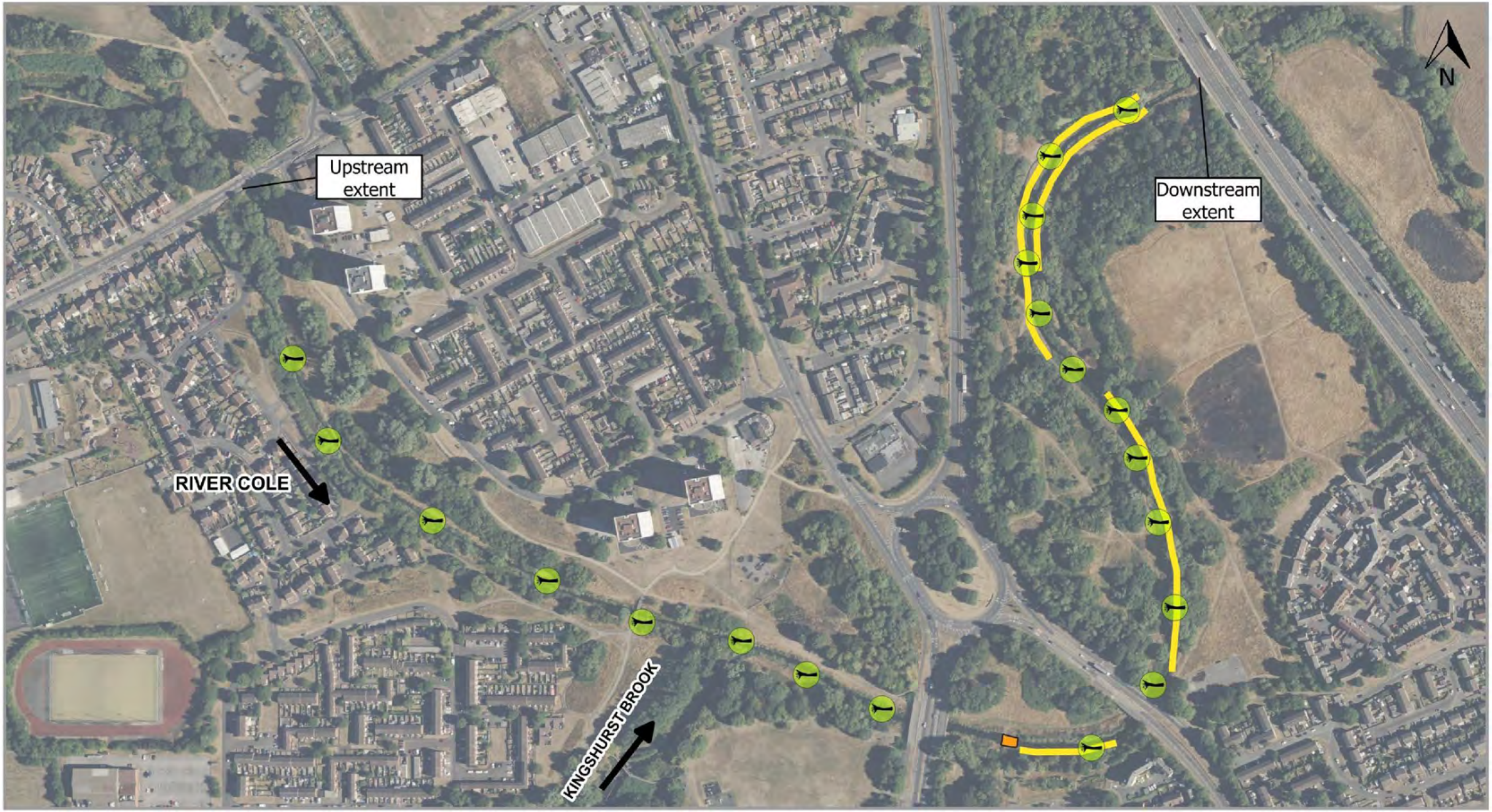
eco engineering



Design Features

Large Wood Structures

8 Lateral Bar Apex LWS

Reprofiled Banks

D Gauging Weir Rock Ramp

Basemap

Bing Maps

SOLIHULL

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
		Date	29 NOV 2024
PROJECT	RIVER COLE FEASIBILITY AND DESIGN	Drawn Designed	JB SM/JB
		Reviewed	SM

0 100 200 m

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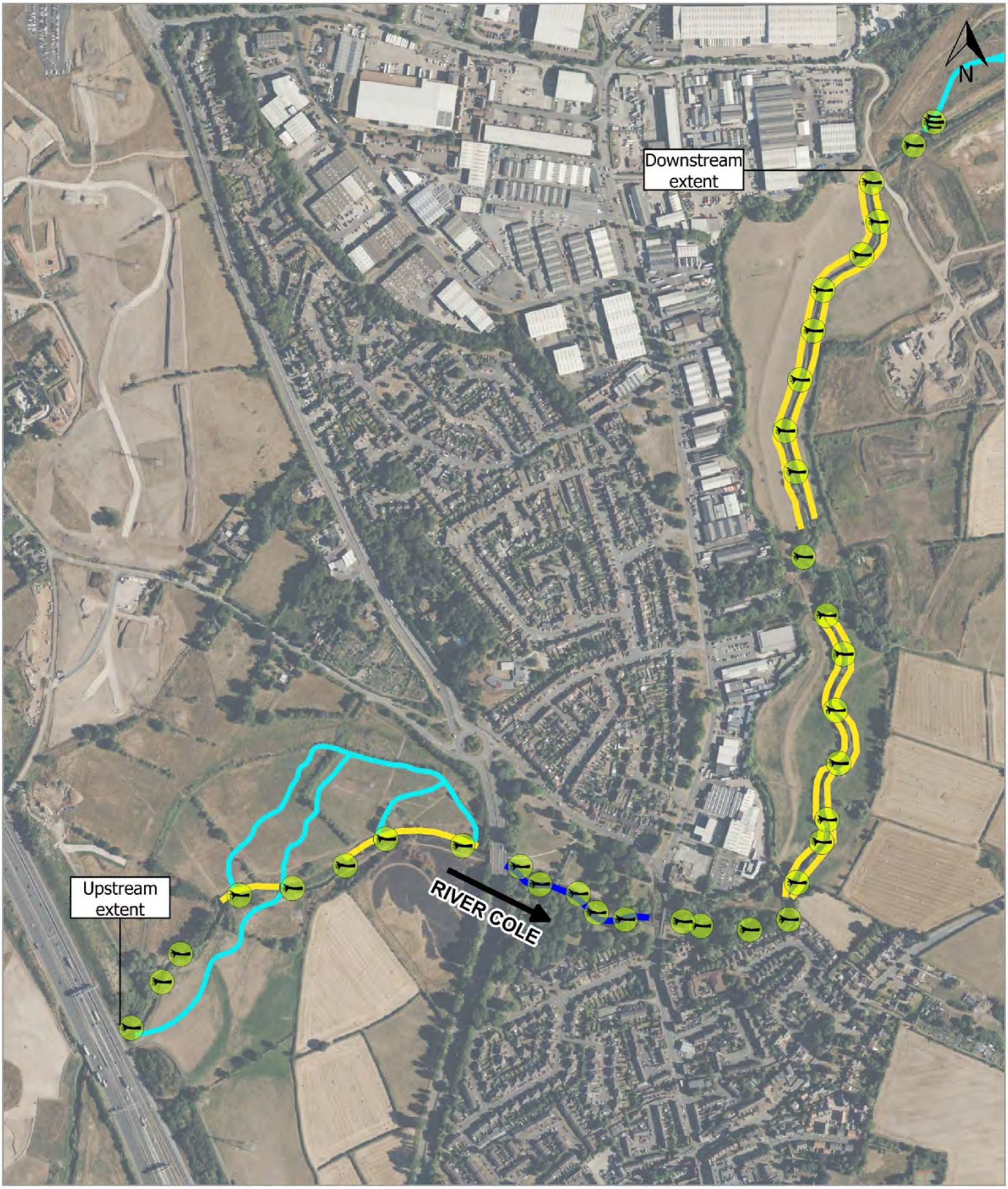
British National Grid GCS QSGB 1936

Figure 5-1: Reach 1 Design Schematic.

cbec
eco engineering



Design Features

Large Wood Structures

8 Lateral Bar Apex LWS

Reprofiled Banks

-Mainstem Meander

- Reach 3 Floodplain Channel

Basemap

Bing Maps

SOLIHULL

CLIENT	WARWICKSHIRE WILDLIFE TRUST
PROJECT	RIVER COLE FEASIBILITY AND DESIGN

0 100 200 300 m

Project no.	2150510
Date	29 NOV 2024
Drawn	RS/ JB
Designed	SM/ JB
Reviewed	SM

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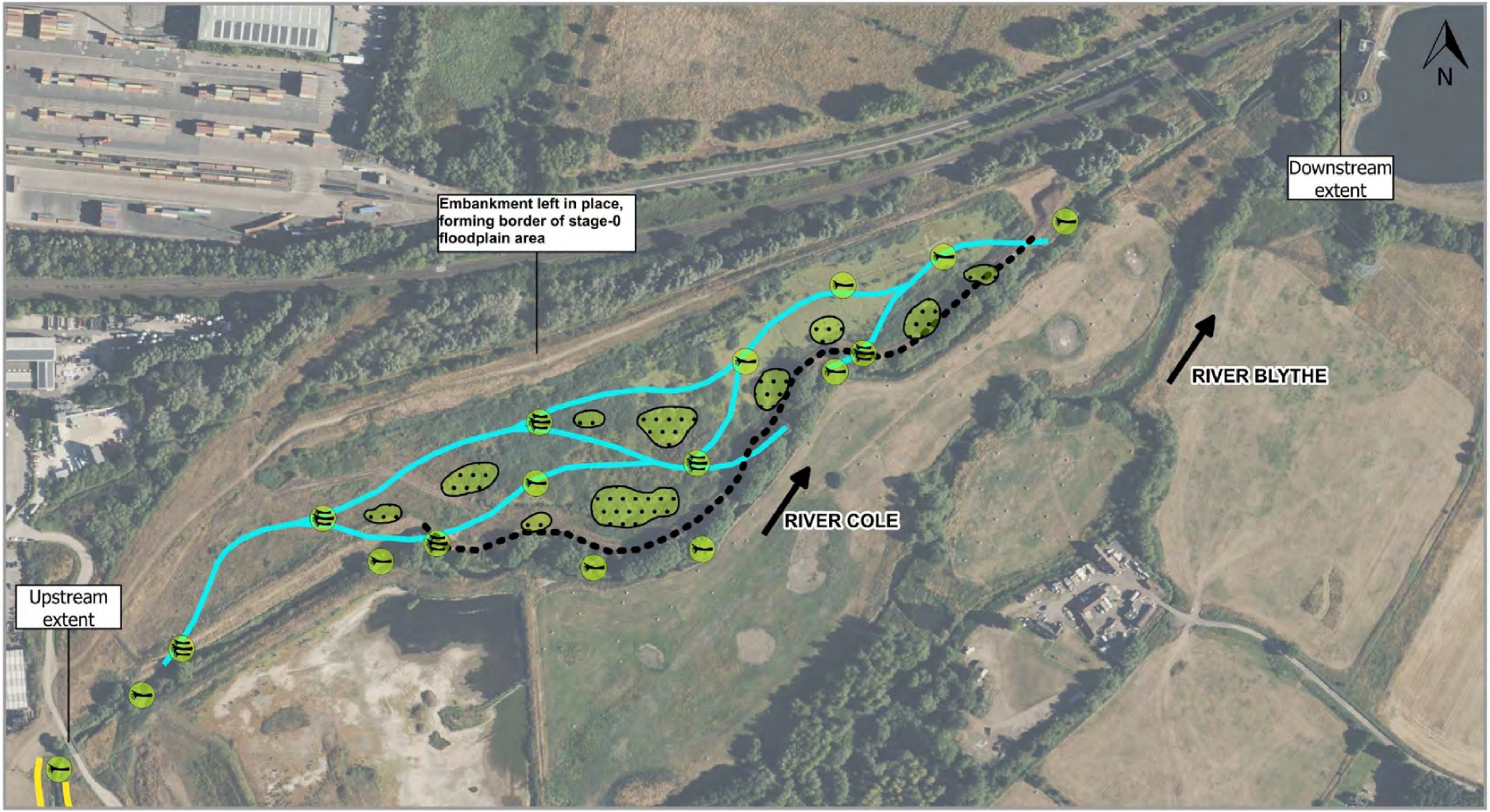
British National Grid

Serviee Layer Credts: Main map sources: Google (2019), ColeshIU area, satefite Imagery: s,:e.os ; cesusGs. r:\ iGP a h/ t GCSOSGB 1936 Community.

Figure 5-2: Reach 3 Design Schematic.

RIVER COLE - DETAIL DESIGN SCHEMATIC (REACH 4)

cbe
eco engineering



Design Features

Large Wood Structures

Lateral Bar Apex LWS

Medial Bar Apex LWS

Reach **4** Floodplain Islands

Reach **4** Embankment Removal

Reach **4** Floodplain Channels

Basemap

Bing Maps

SOLIHULL

CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150510
		Date	29 NOV 2024
PROJECT	RIVER COLE FEASIBILITY & DESIGN	Drawn	RS/ JB
		Designed	SM/ JB
		Reviewed	SM

0 100 200 m

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British National Grid
GCS QSGB 1936

Service Layer Credits: Man mdp sources Google (2019), Solltiul 3tf'a, telitte IMge'r', 2019 Google, O'lerv.ew map sources- Esn, 0191talGlobe, Eart:tlstar Geographies, CNES/Airbus DS, GeoEye, USDA FSA, USGS, Aerogrid, IGN, IGP, and the GIS User Community

Figure 5-3: Reach 4 Design Schematic.

6. HYDRAULIC MODELLING

6.1 MODEL SCOPE

As agreed with WWT during a meeting on 25th July, CBEC has produced a design model for Reach 3 although, given this runs into Reach 4, we have also included the proposed designs as part of the modelling. We recognise the Reach 4 designs are likely to be the subject of further discussion with the landowners and other stakeholders. As agreed, the modelling undertaken is focused on assessing design performance and not (currently) for submission of a Flood Risk Activities environmental Permit (FRAP).

6.2 HYDROLOGY

As part of the study, CBEC carried out a hydrological assessment of the River Cole for the project site. The resulting flow estimates are shown in Table 6-1. These were derived using ReFH 2.3. The full assessment is presented in the accompanying hydrology report.

Table 6-1. **Peak** flow estimates used in modelling.

Return period (yrs)	ReFH peak flow (m^3/s)
2	22.989
10	38.624
30	48.672
50	54.201
75	59.109
100	62.881
100 + 22% **CC**	76.715
1000	99.961

6.3 MODELLING RATIONALE

Two approaches were considered for the hydraulic modelling: a linked 1D/2D, or a fully 2D model. Using a linked 1D/2D approach (i.e. Flood Modeller/TUFLOW) would have been more aligned with the Environment Agency's (EA) flood model of the Cole. While this type of model is useful for modelling large rivers/catchments, it is not always the best method for quantifying the benefits associated with in-channel enhancements under consideration for this project.

A fully 2D approach allows for better representation of the design options, as such, this was the approach selected for the model. A 2D model can take longer to run for larger river reaches, but allows for easier floodplain connection, braided channels and representation of in-channel elements, such as large wood structures.

6.3.5. <u>Software Used</u>

The model was developed using HEC-RAS version 6.3.1.

6.3.6. <u>Data Used</u>

The model was developed using the following data:

- Topographic survey, carried out by CBEC for this project.
- LiDAR, available online.
- Existing EA flood model of the River Cole.
- Flood defence asset records from the EA.

6.4 MODELLING METHODOLOGY

6.4.7. Model Extents

The model extents are shown in Figure 6-1.

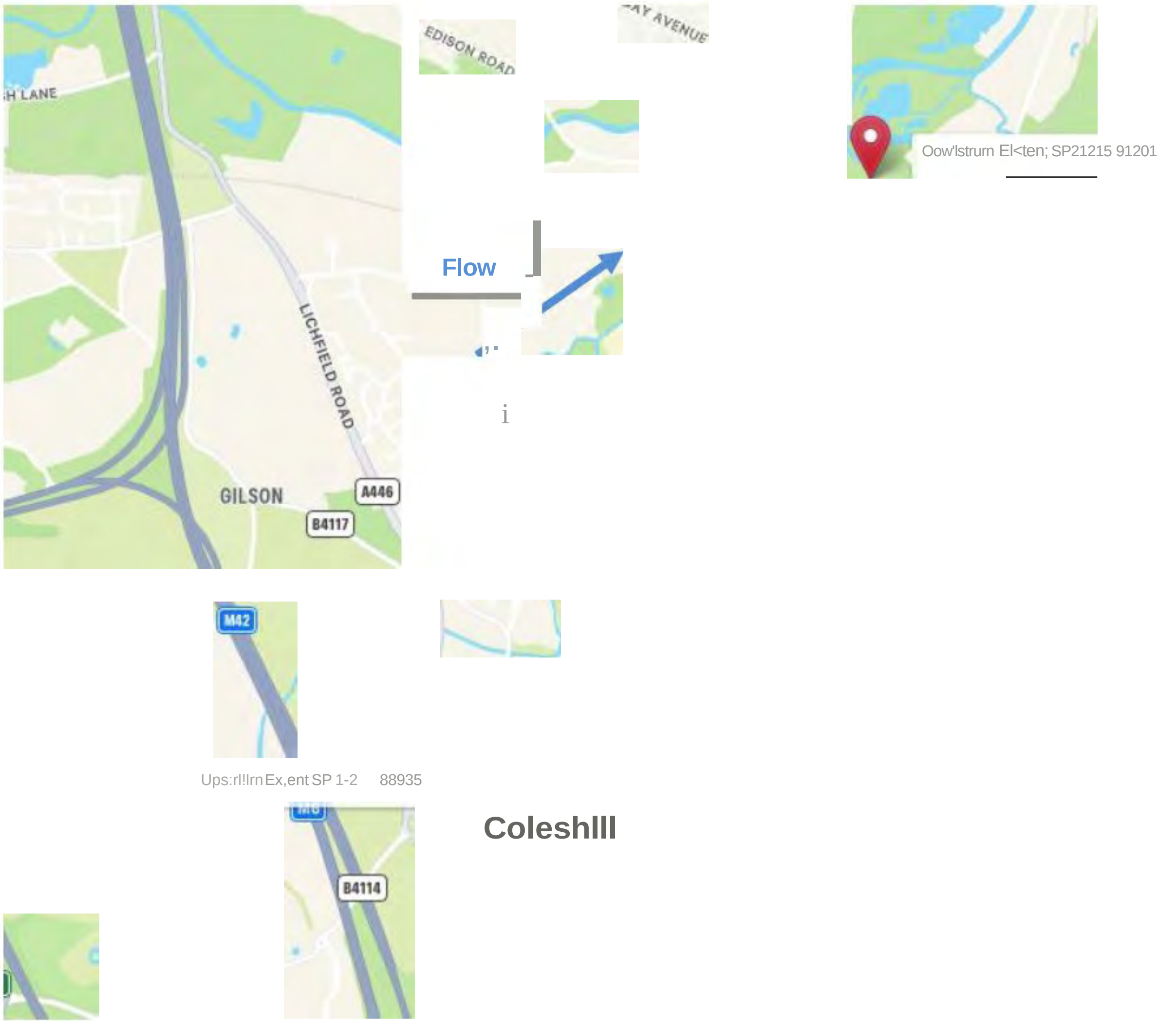

Figure 6-1. Model extents.

6.4.8. Model Domain

The model domain is fully 2D, using HEC-RAS' flexible mesh system with a 4 m cell size. A 2 m mesh refinement region was applied along the channel and immediate floodplain, to provide greater resolution in the riverbed and banks.

Breaklines were applied to help define the channel banks, as well as any other significant terrain features, such as embankments.

6.4.9. Model Boundaries

There are four boundaries used in the model: one at the upstream end for the channel inflow, and three at the downstream end. These cover outflows for the main channel, as well as the floodplain either side.

The inflow boundary is used to apply in the input flow hydrograph. The outflow boundaries are normal depth boundaries. Energy slopes for the boundaries were derived from the terrain.

6.4.10. Model Roughness

Varying roughness in the model, e.g. for floodplain and channel bed, was defined using Manning's n values. The values used are summarised in Table 6-2.

Table 6-2. Manning's n values used in the model.

Feature	Manning's n value
Channel	0.035
Floodplain	0.055
Buildings	0.3

6.4.11. Structures

There are several bridges in the model area, shown in Figure 6-2 and Figure 6-3. The bridges were reviewed to determine whether they would impact the channel flow. The large road bridges for the M42 and A446 are significantly larger than the channel and the decks would not affect the channel flow. The abutments do present a narrowing of the flow path (out of bank), but these are included in the model terrain.

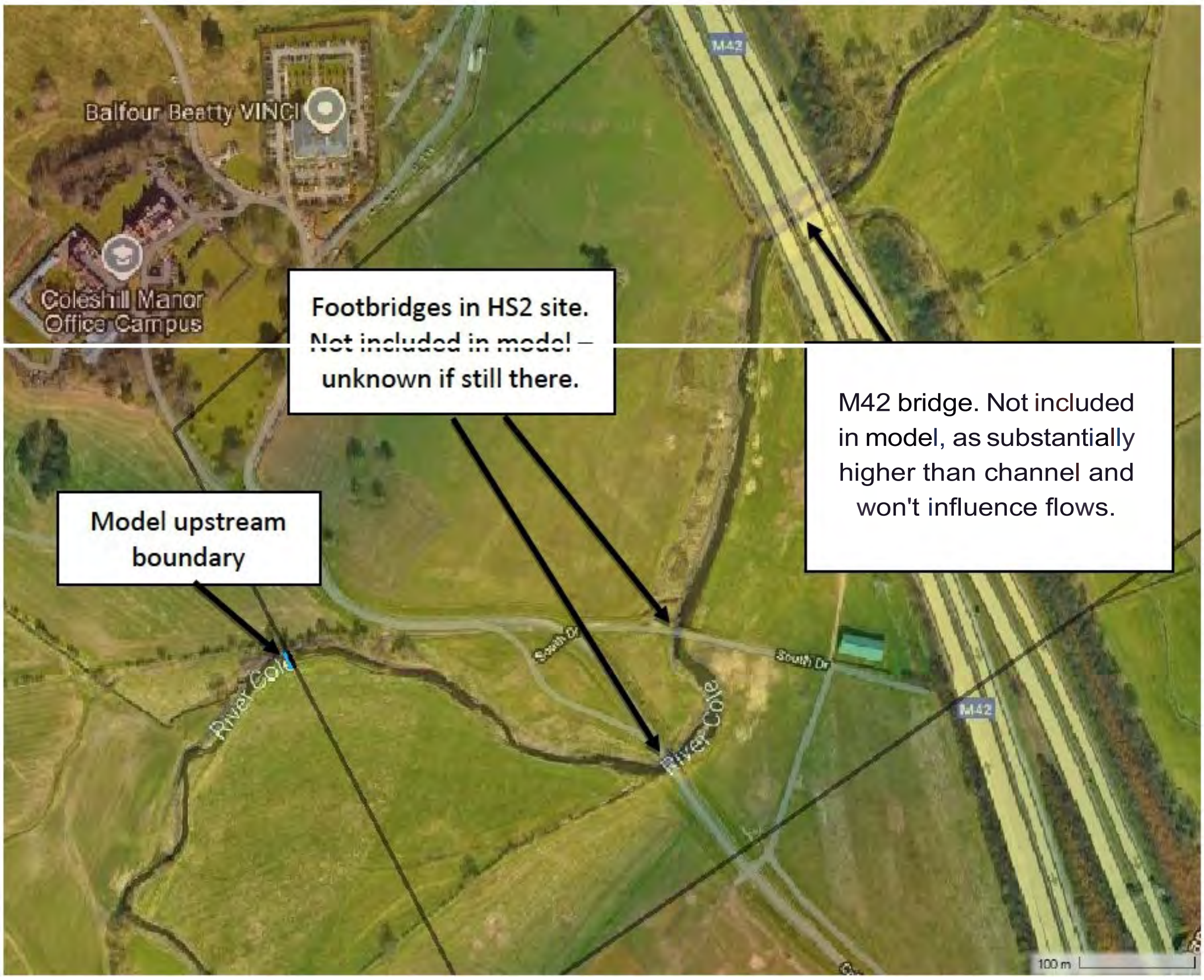

Figure 6-2. Bridges at upstream extent.

Figure 6-3. **Bridges** included in the model.

The two bridges that do affect the flow (Lichfield Road bridge and the footbridge upstream) are included in the model as 1D bridge structures.

There are two flood relief channels to the west of the main river channel. These are connected to the main channel via pipe culverts. The EA confirmed the culverts are only open during low flows and are closed during flood events to prevent flow from the main channel entering them. The relief channels are designed to contain surface water runoff from the adjacent roads and buildings.

The culverts are included in the model as 1D structures.

Figure 6-4. Culverts connecting relief channels to main channel.

There is an EA flood defence asset, a wall located behind the car park behind the Harvester, on the left of the channel (see Figure 6-5). The EA was contacted for information about this wall and confirmed the crest elevation is 74.4 mAOD. This was incorporated into the model using the terrain modification functionality in HEC-RAS.

Figure 6-5. Location of flood defence wall.

6.4.12. Design Elements

The restoration design includes the following features:

- Floodplain reconnection with braided channels.
- Channel redirection into new braided channels.
- Channel widening / reprofiling.
- Large wood structures in the channel.

All of these were incorporated into a new terrain surface.

6.5 MODEL ASSUMPTIONS

Limited information was available on the relief channels and connecting culverts. CBEC was only able to survey limited levels in the area, partially due to access difficulties. The channels were visible in the LiDAR data, but not at sufficient resolution for modelling. Greater detail was added by using available level data to interpolate the channels into the model surface. Some assumptions had to be made on the culvert invert levels, e.g. by using ground levels, diameters and soffit levels. It’s assumed there’s sufficient detail for the model purpose.

6.6 LIMITATIONS

CBEC is aware there have been changes in the channel in the HS2 section of river, due to realignment work being carried out there by another consultant s part of the construction of the HS2 rail link. We attempted to get details of the changes, to incorporate into our model, but this was not possible. As such, this section will likely be outdated.

The model doesn’t include the River Blythe, except for the limited representation of the channel in the LIDAR. Given the Blythe’s proximity to the Cole in the lower reach, there will be an interaction between the two if flooding occurs on both rivers. In some cases, the flooding in design reach 4 may be dominated by the Blythe. Assessing the impact of the Blythe though was outside the scope of this study. Instead, the focus was maintained on the River Cole and how the design performs based on flows within it.

6.7 MODELLING RESULTS

6.7.1. Map Outputs

The model results are presented in Figure 6-6 to Figure 6-13. These show two low flow events (Q50 and Q10) and flood events from 1 in 2 years up to 1 in 1,000 years.

The braided channels are functioning in the low flow events. They are also apparent in the flood events. For the 1 in 2 years event, the design reduces flood extents in some areas, while increasing it in the design braided channel areas.

In the 1 in 10 years event, the design reduces flooding to the industrial area left of the river (e.g. along Station Road). This is also apparent in the 1 in 30 years event. For the 1 in 100, 100 plus climate change and 1,000 years events, this improvement is no longer seen. For the 1 in 100 and higher events, the design shows reduced flooding in the Coleshill Quarry, on the right bank of the river.

For all events, the design shows increased flood extents in the floodplain on the right bank of the River Blythe. The Blythe was not included in the model, though the channel is present to some degree in the LIDAR. Based on EA flood maps of the area though, this will be dominated by the Blythe flooding. As previously noted, it was outside the scope of this assessment to carry out joint analysis of flooding on both rivers interacting. The focus for this assessment was solely on the River Cole and how the design performs there.

Maximum Depth Results Comparison - Q50

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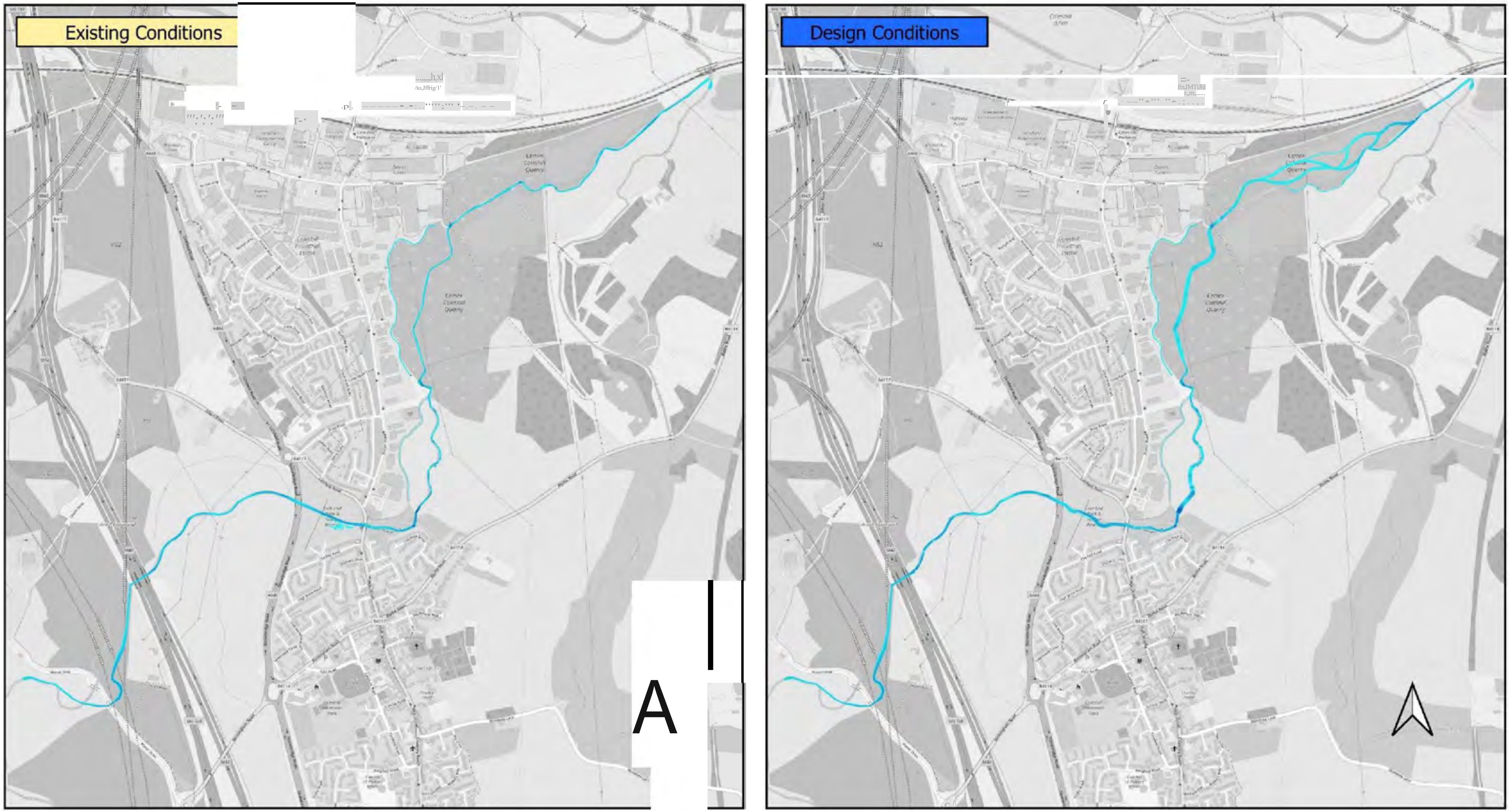

Maximum Depth (m)

0.00	1.00
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□.40	1.40
□.60	1.60
□.80	1.80
	2.00

CLIENT WARWICKSHIRE WILDLIFE TRUST

PROJECT RIVER COLE

O 200 400 600 800 1,000 m

Project no"	2150520
Date	16 DEC 2024
Drawn	ED
Modelled	DP
Reviewed	SM

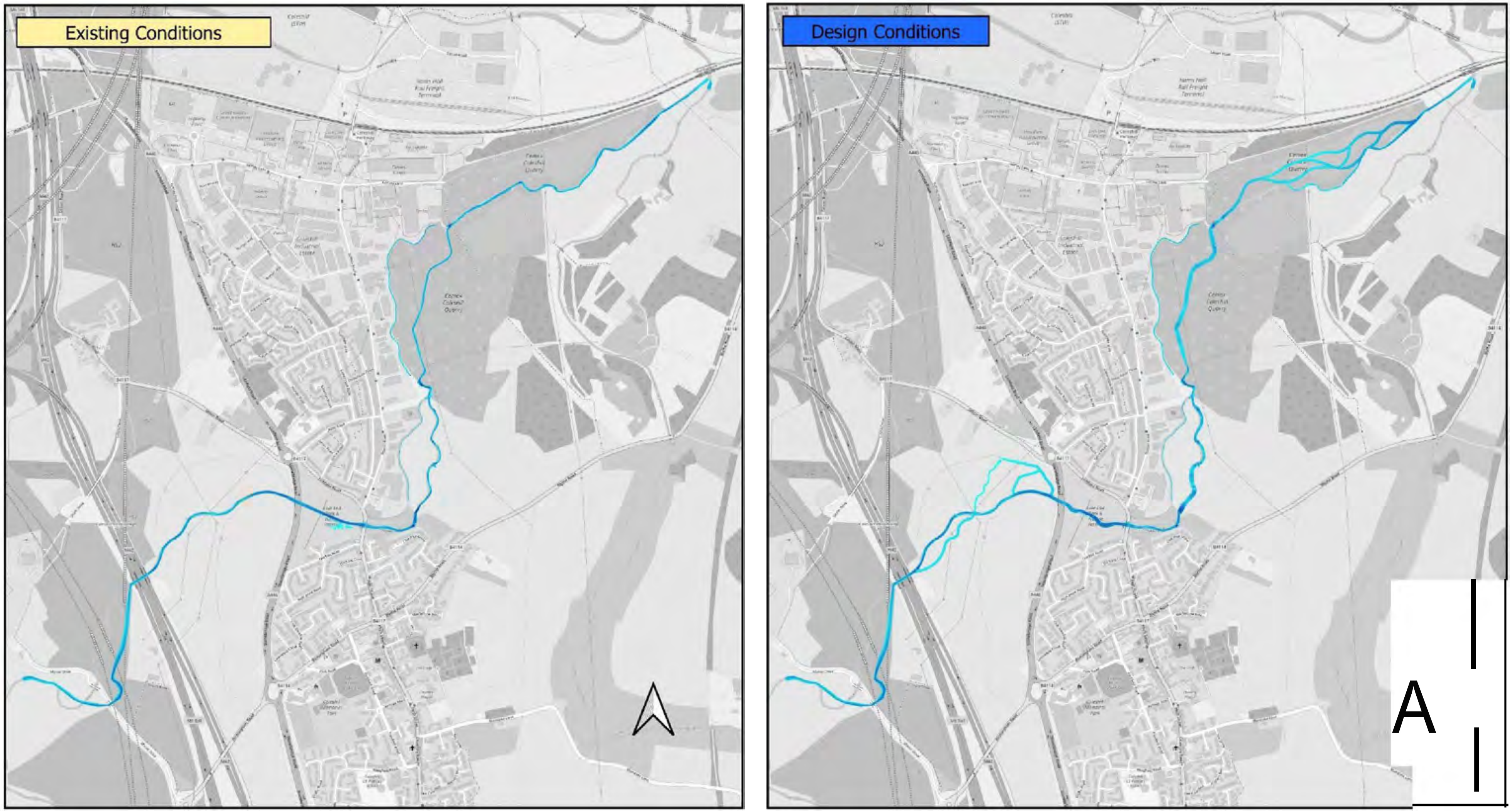
Scale @ A4 - 1:20,000

British National Grid GCS OSGB 1936

Figure 6-6 Maximum depth results, Q50 event.

Maximum Depth Results Comparison - Q10

cbec
eco engineering



Maximum Depth (m)

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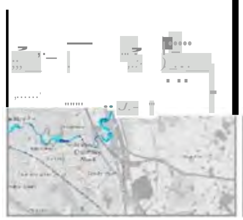

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PROJECT RIVER COLE

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Pro1ect no. 2150520
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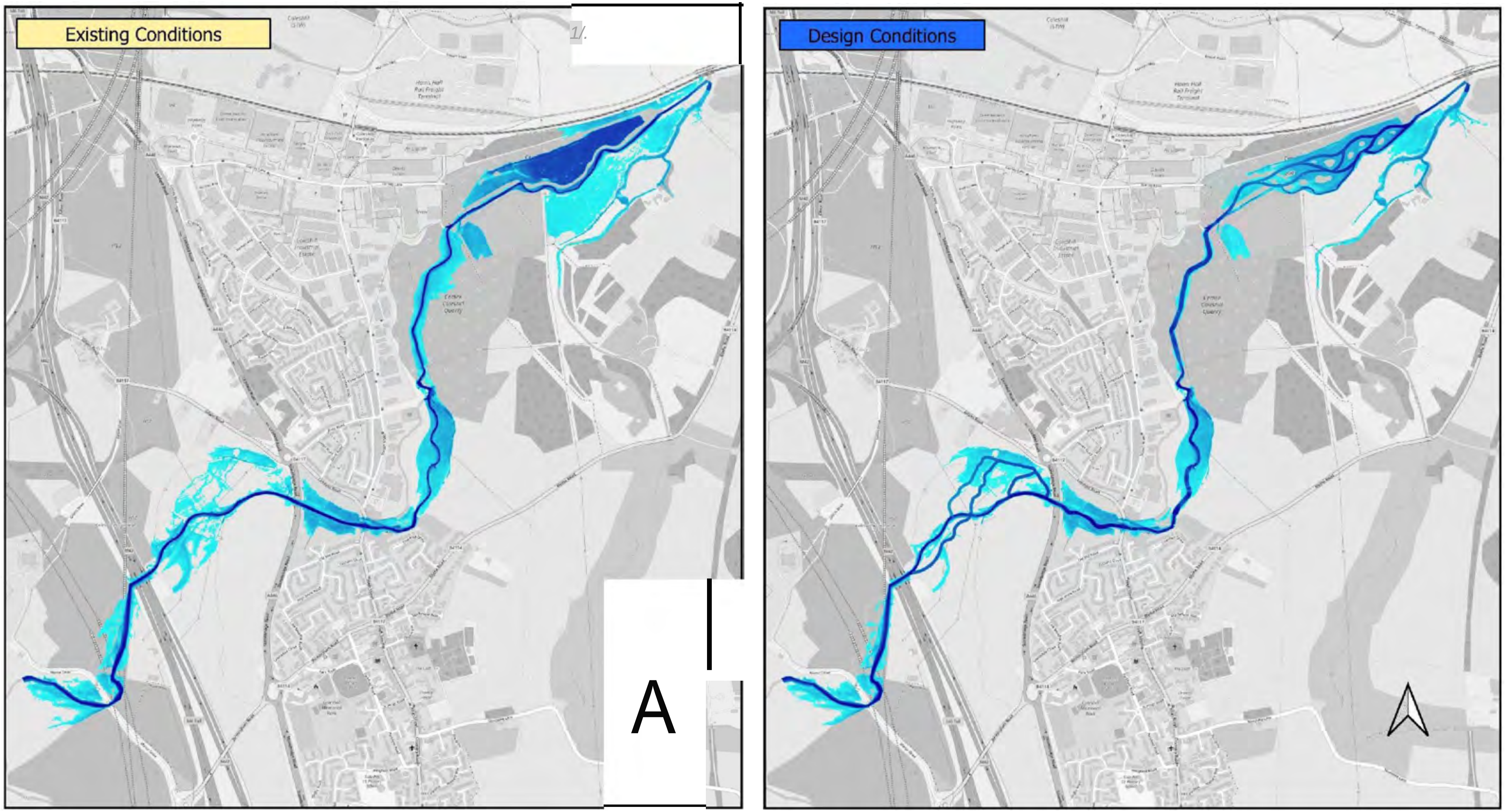
British National Grid
GCS OSGB 1936

Figure 6-7 Maximum depth results, Q10 event.

Maximum Depth Results Comparison - 1 in 2 Years

cbe
eco engineering



Maximum Depth (m)

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0.20	1.20
0.40	1.40
0.60	1.60
0.80	1.80
	2.00

CLIENT WARWICKSHIRE WILDLIFE TRUST

PROJECT RIVER COLE

0 200 400 600 BOO 1,000 m

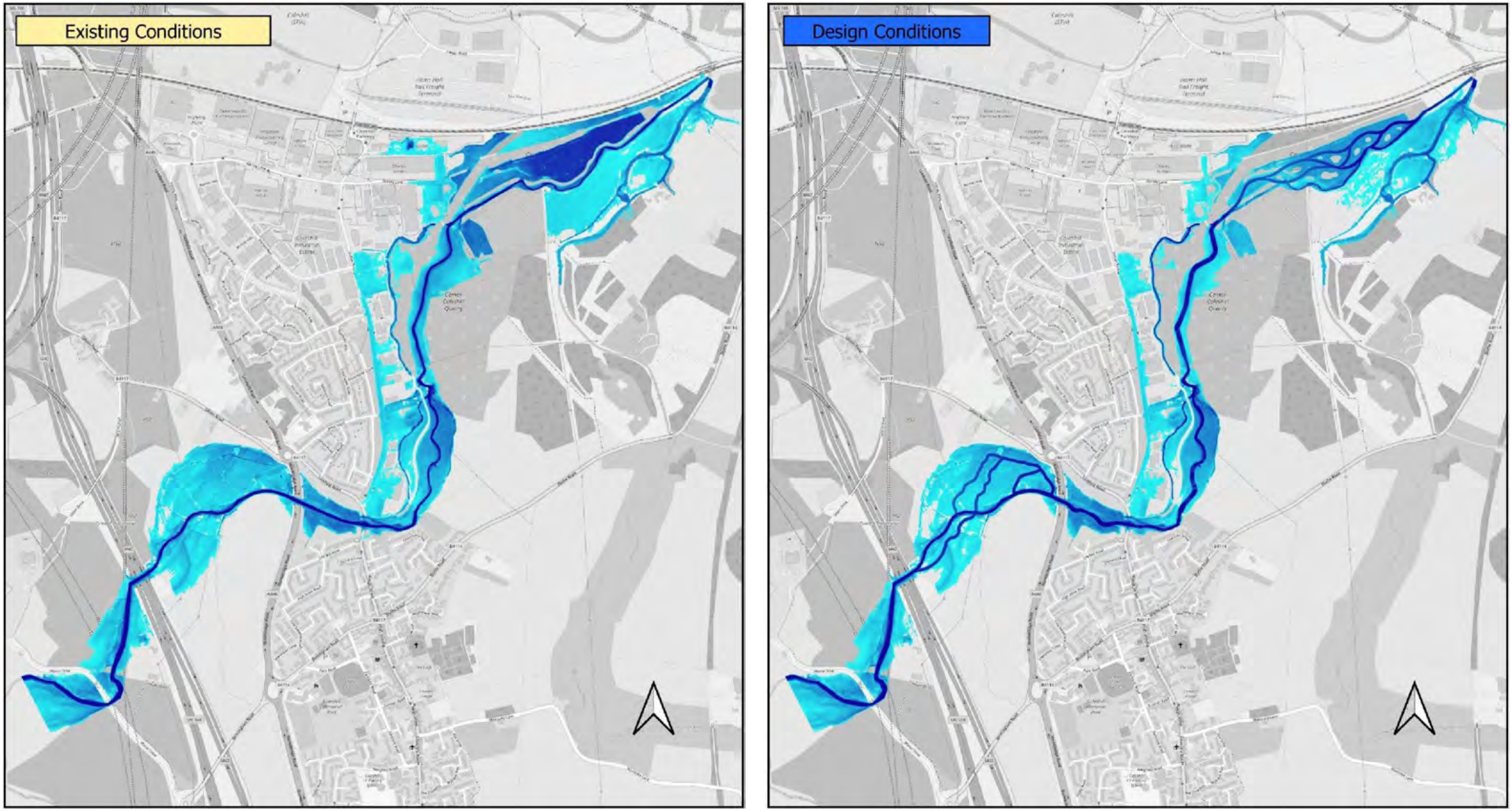
Project no 2150520
Date 16 DEC 2024
Drawn ED
Modelled DP
Reviewed SM

Scale @ A4 - 1:20,000
British National Grid
GCS OSGB 1936

Figure 6-8 Maximum depth results, 1 in 2 years event.

Maximum Depth Results Comparison - 1 in 10 Years

cbe eco engineering



Maximum Depth (m)

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0.20	1.20
0.40	1.40
0.60	1.60
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PROJECT	RIVER COLE	Date	16 DEC 2024
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		Reviewed	SM

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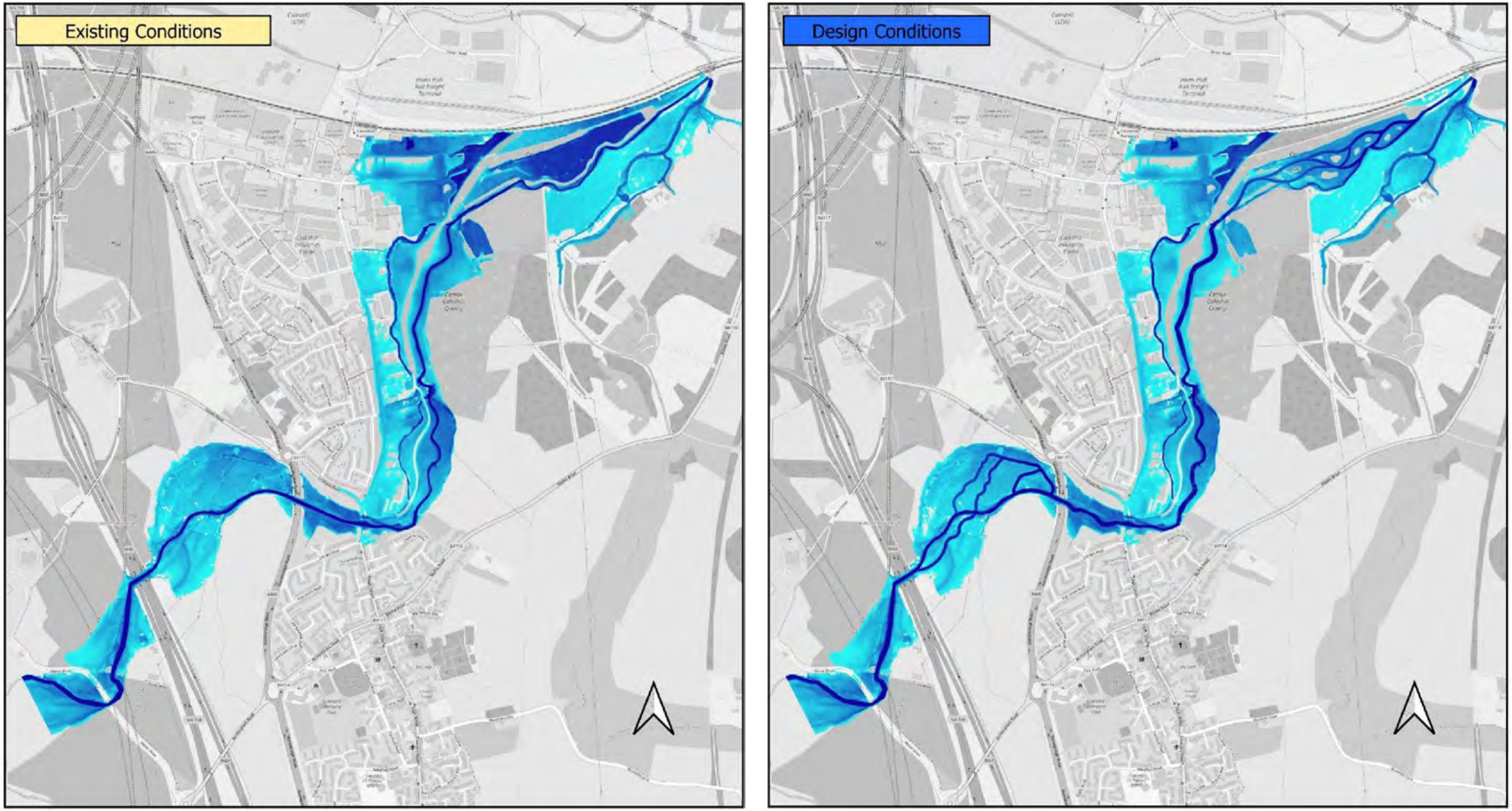
British National Grid GCS OSGB 1936

Figure 6-9 Maximum depth results, 1 in 30 years event.

Maximum Depth Results Comparison - 1 in 30 Years

cbec
eco engineering



Maximum Depth (m)

0.00	1.00
0.20	1.20
0.40	1.40
0.60	1.60
0.80	1.80
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CLIENT	WARWICKSHIRE WILDLIFE TRUST
PROJECT	RIVER COLE

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Project no.	2150520
Date	16 DEC 2024
Drawn	ED
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British National Grid
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Figure 6-10 Maximum depth results, 1 in 30 years event.

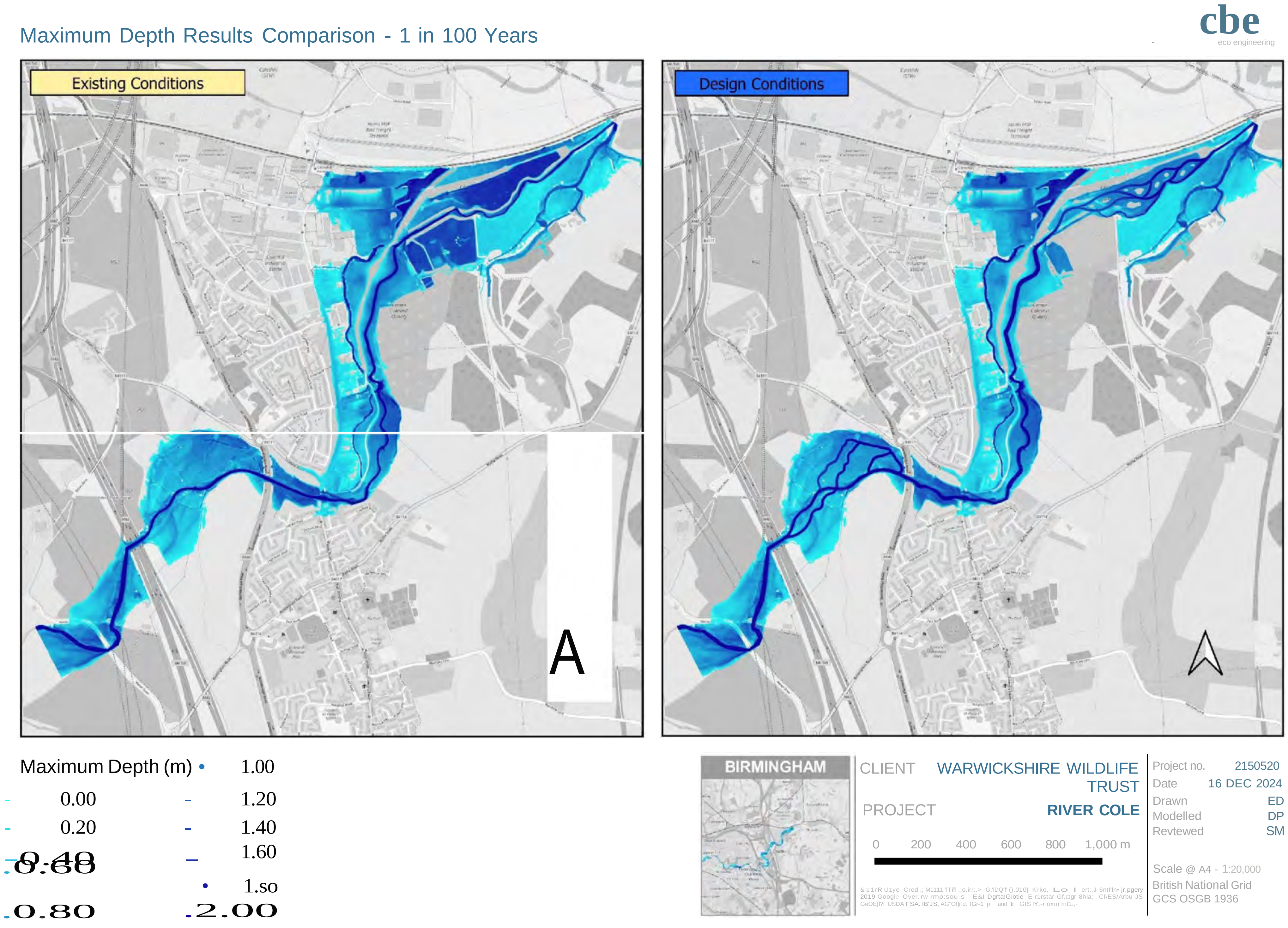
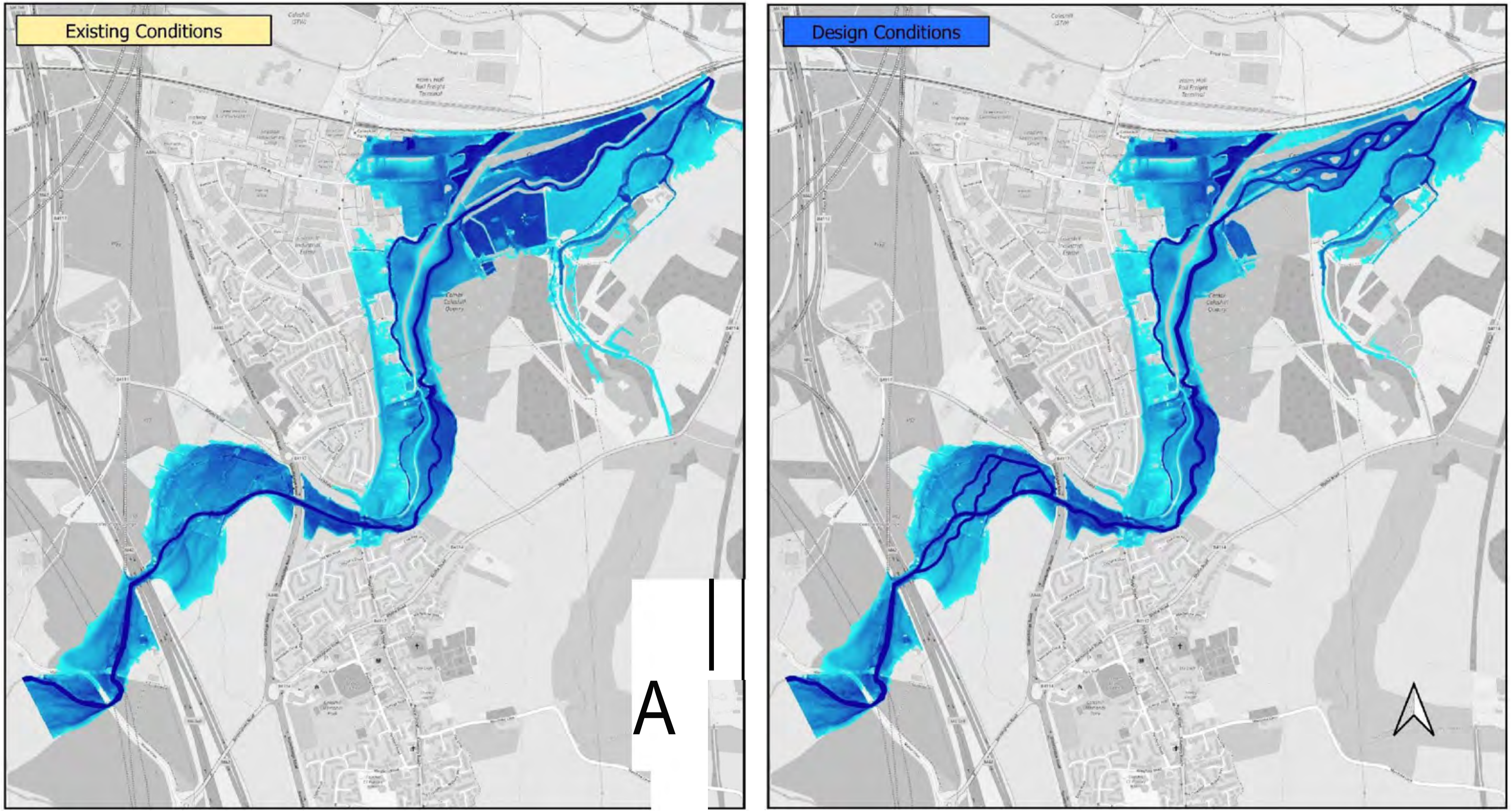
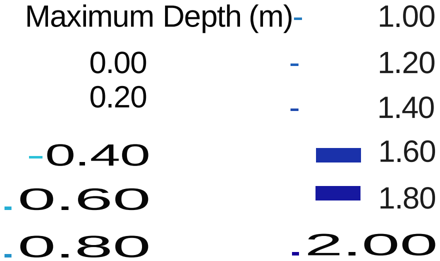


Figure 6-11 Maximum depth results, 1 in 30 years event.

Maximum Depth Results Comparison - 1 in 100 Years plus Climate Change

cbec eco engineering





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PROJECT	RIVER COLE	Drawn	ED
		Modelled	DP
		Reviewed	SM

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British National Grid
GCS OSGB 1936

Figure 6-12 Maximum depth results, 1 in 100 years plus climate change event.

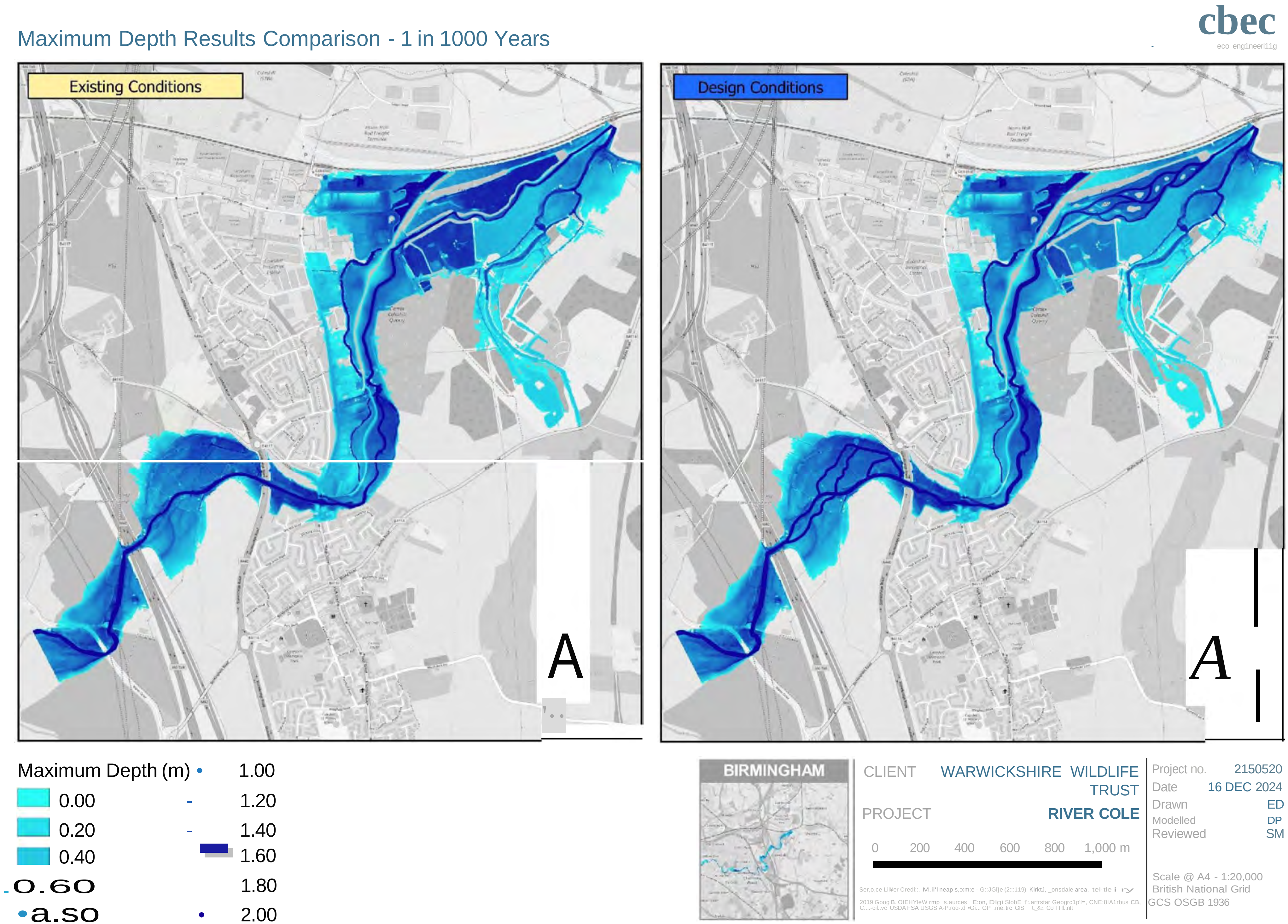


Figure 6-13 Maximum depth results, 1 in 1,000 years event.

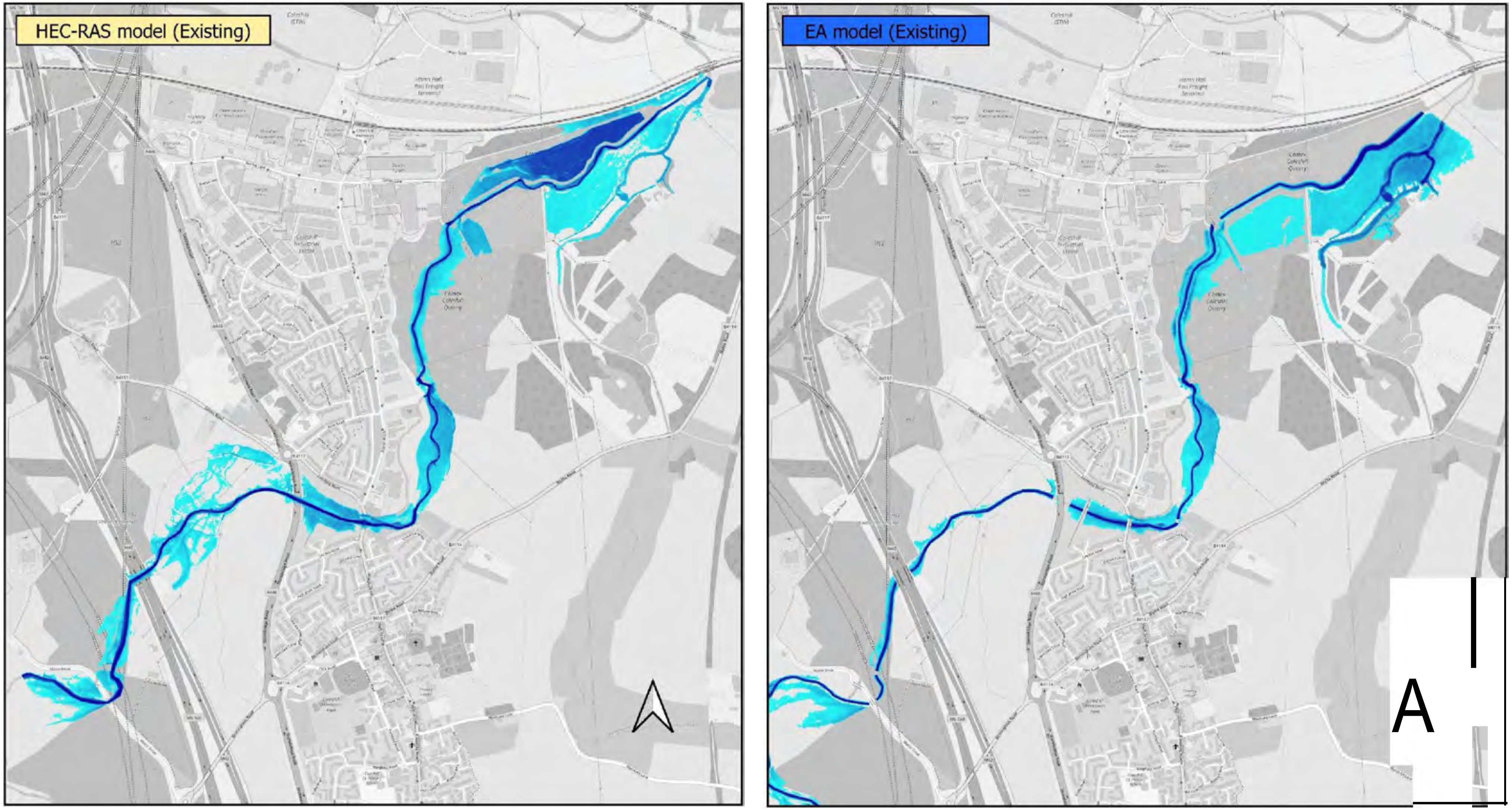
6.8 MODEL COMPARISON WITH EA RESULTS

The results from the HEC-RAS model were compared to the EA flood model outputs, for the 1 in 2, 10, 30 and 100 years events. These are shown in Figure 6-14 to Figure 6-17.

The results show the HEC-RAS model produces more extensive flood extents. This is most notable on the left side of the river. This might be attributed to differences in the schematisation of the 1D/2D model vs. the fully 2D one. It's unknown how terrain features, e.g. embankments, are represented in the EA model. It might also be differences in the hydrology.

For further modelling, e.g. for detailed design or FRAP purposes, it could be beneficial to look at the two models in further detail.

Maximum Depth EA Model Comparison - 1 in 2 Years



Maximum Depth (m)	
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0.20	1.20
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0.80	1.80
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PROJECT RIVER COLE

0 200 400 600 800 1,000 m

Project no. 2150520
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Reviewed SM

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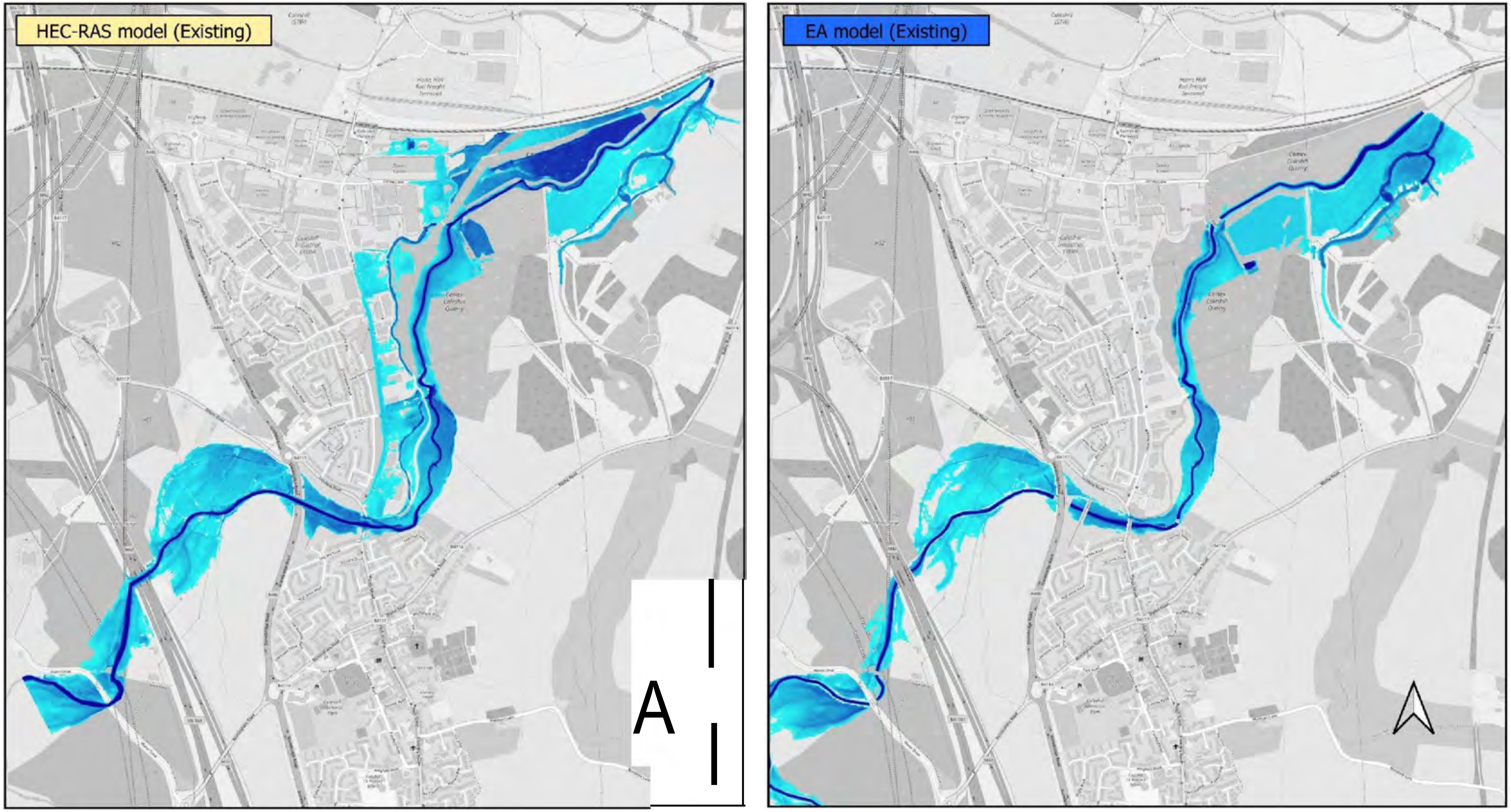
Figure 6-14 Model comparison with EA results, 1 in 2 years.

Maximum Depth EA Model Comparison - 1 in 10 Years

cbec



Maximum Depth (m)

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0.20	1.20
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CLIENT	WARWICKSHIRE WILDLIFE TRUST	Project no.	2150520
PROJECT	RIVER COLE	Date	16 DEC 2024
		Drawn	
		Modelled	
		Reviewed	SM

0 200 400 600 800 1,000 m

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British National Grid
GCS OSGB 1936

Figure 6-15 Model comparison with EA results, 1 in 10 years.

Maximum Depth EA Model Comparison - 1 in 30 Years

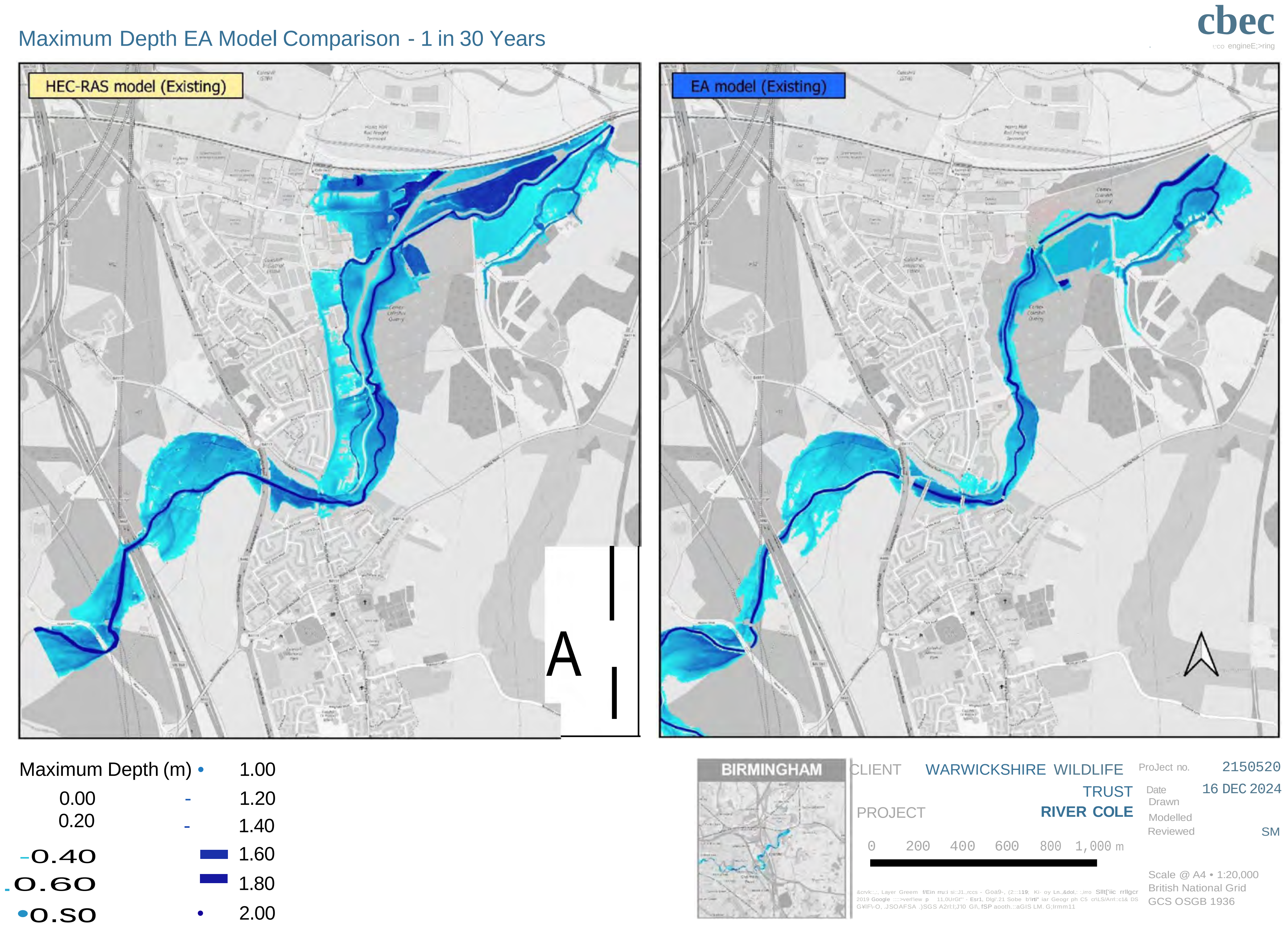

Figure 6-16 Model comparison with EA results, 1 in 30 years.

Maximum Depth EA Model Comparison - 1 in 100 Years

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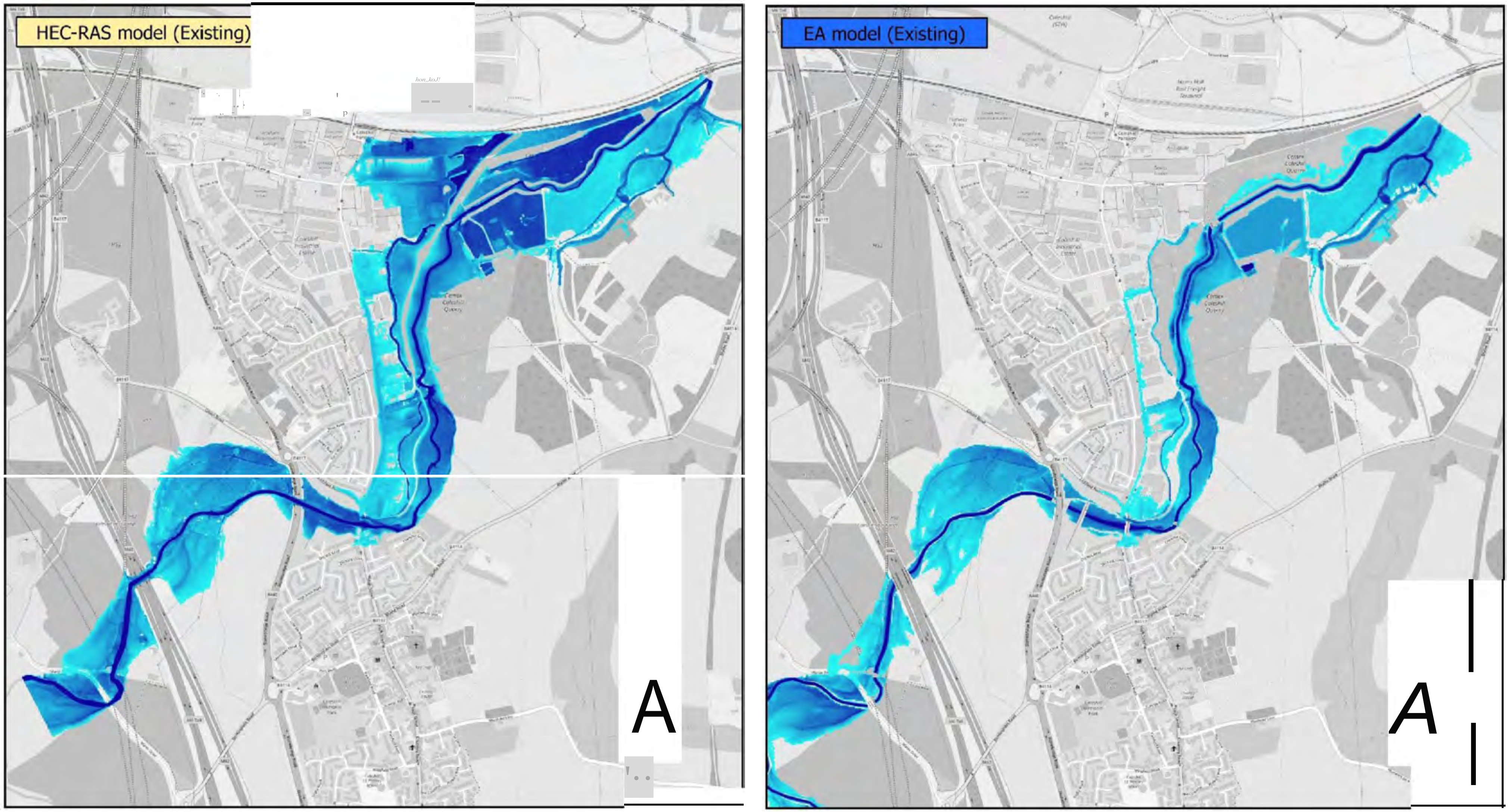

Maximum Depth (m)	
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0.20	1.20
0.40	1.40
0.60	1.60
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CLIENT WARWICKSHIRE WILDLIFE TRUST

PROJECT RIVER COLE

0 200 400 600 800 1,000 m

Project no.	2150520
Date	16 DEC 2024
Drawn	ED
Modelled	DP
Reviewed	SM

Scale @ A4 - 1:20,000
British National Grid
GCS QSGB 1936

Figure 6-17 Model comparison with EA results, 1 in 100 years.

6.9 MODELLING CONCLUSIONS

The design includes braided channels, connecting the main channel to the floodplain in two areas. These are shown to be effective in the low flows, as well as the flood events. There is also a reduction in flooding in various areas, including the industrial development along Station Road, for up to the 1 in 30 years event. The effect is diminished for the higher return period events modelled (1 in 100, 100 cc and 1,000 years), as the floodplain becomes more extensively inundated.

Outputs were also compared to some of the events from the EA 1D/2D flood model. This was done as a check against these previous modelling results. The comparison shows the HEC-RAS model generally produces more extensive flooding. This most notably affects the properties along Station Road and Gorsey Road. It was outwith the scope of this feasibility study to investigate this in more detail though.

6.10 RECOMMENDATIONS

The modelling work presented here supports the design feasibility assessment for the River Cole. For detailed design and FRAP purposes, it may be advisable to carry out more detailed modelling. This would include greater topographic resolution in the flood relief channels. It would also be beneficial to carry out a more detailed assessment of the EA flood model and how it compares to the HEC-RAS model. This would involve a detailed review of the EA model, with the aim to determine why there are differences in the flood extents, particularly behind the flood defence wall that affects flooding to Station Road.

CBEC is aware that there are changes in the river channel in the HS2 site. It was not possible to obtain details of the changes though for inclusion in the model. For future modelling work, it may be necessary to include these changes.

7. CONSTRUCTION CONSIDERATIONS

7.1 COSTS

Salix, employed on the Project to provide Early Contractor Involvement produced a breakdown of indicative costs associated with design implementation using a bill of quantities approach. As agreed during course of the project, CBEC has developed a highly aspirational detailed design involving full restoration, particularly in Reach 3. Here, significant bank reprofiling is proposed, together with creation of floodplain channels and a remeandered section. This generates a significant amount of spoil which, Salix has assumed, will need to be removed. Should designs be revised to reduce the cut / fill imbalance, costs would be reduced accordingly.

A costed activity schedule is presented below (Table 7-1), separating Reaches 1, 3 and 4, together with a bill of quantities (on which the costs were based).

Costs are based on the following assumptions

- Number of days construction Reach 1 = 9
- Number of days construction Reach 3 = 104
- Number of days construction Reach 4 = 139
- Number of days for removal of material off site Reach 1 = 4
- Number of days for removal of material off site Reach 3 = 114
- Number of days for removal of material off site Reach 4 = 84
- Enabling works include vegetation clearance (equipment)
- Prelims include fuel costs (materials)
- Assumes all material from vegetation clearance is left on site
- Assumes all excess spoil is taken off site to landfill (materials cost)
- Assumes all excess spoil is inert
- Assumes all tree planting is undertaken by volunteers
- Assumes all quantities in BoQ (below) are correct;

The cost of removal of spoil off site includes both the cost of moving material to the trucks that would be used to take the material off site (labour and equipment and this is reflected in the number of days required to take material off site) and the cost of disposal at landfill which includes transportation costs (materials). There is also a fuel cost associated with this which is included in the prelims line item.

If a local site was available for spoil disposal there would still be a cost for transporting material to this alternative site. However, the cost would be less if there was no charge for disposal.

From a design perspective, the most efficacious option would be to minimise the cut fill balance within the design and then look to reuse any spoil within the scheme and in close proximity to the excavation works in the first instance before looking to take material further afield or off site and then use disposal to landfill as a last option.

8. CONCLUSION

CBEC conducted a desk-based assessment, fluvial audit, and restoration options appraisal for the River Cole from Cooks Lane to the River Blythe. Recommended options were developed into designs for Reaches 1, 3, and 4 with the aim of improving habitat conditions and increasing biodiversity without adversely affecting flood risk.

Aquatic/ riparian habitat and geomorphic walkover surveys conducted in 2023 and 2024 by RSK Biocensus and CBEC found fairly uniform flow conditions, with localised flow heterogeneity where present in surveyed areas largely driven by relatively sparse large woody material. RSK Biocensus also noted an apparent lack of fry/ juvenile fish habitat away from the main flow of river, and very little juvenile lamprey habitat (i.e., stable fine sediment or sand with presence of organic detritus and low water velocities).

The Warwickshire Biodiversity Action Plan lists the following habitats as targets for retention/ enhancement: lakes/ reservoirs, ponds, marsh/ swamp, wet grassland, wet woodland, quarries/ gravel pits. Based on review of background information and walkover surveys, the RSK Biocensus report suggested habitat enhancements including weir removal, installation of flow deflectors throughout all reaches, creation of permanently-inundated and high-flow backwater channels, and re-meandering of the straightened channel, especially where it runs through the quarry lands at the downstream end of the project area.

If implemented, the proposed designs would result in the following improvements to river morphology and aquatic and riparian habitat conditions:

- Localised pool and bar formation in the vicinity of 66 LWS flow deflectors: 18 in Reach 1, 32 in Reach 3, and 16 in Reach 4;
- INNS removal and native riparian tree planting in the vicinity of each of the 66 LWS.
- Enhanced fish passability resulting from rock ramp and pools constructed below the weir, whilst retaining its flow gauging function.
- More than 2900 m length of gently sloping reprofiled banks creating low velocity zones at the margins of the main current, across a wide range of flows: over 700cm in Reach 1 and more than 2100 m in Reach 3;
- Over 1200 m length of intermittently inundated backwater channels connecting the main channel to the floodplain in Reach 3;
- Over 1700 m of re-meandered channel with gently sloping banks and consequent variability in wetted width and associated hydraulic diversity across a wide range of flows: 220 m of re-

meandered mainstem channel in Reach 3 and over 1500 m of permanently inundated interweaving floodplain channels in Reach 4; and

- Over 5800 m^2 of floodplain mounds in Reach 4, planted with native riparian woodland species suited to a range of soil moisture and inundation frequency conditions resulting from variations in mound height.

The design for Reaches 3 and 4 was hydraulically modelled to determine its influence on the river during low flows as well as on flooding. The design was shown to be effective at low flows and to reduce flooding in several areas, with less reduction at higher return period events. These hydraulic modelling results reflect one design – modelling iteration. Since the goal of restoration design is to get the most morphological and habitat benefit at the lowest construction cost, these initial results suggest that is likely that the extents of bank reprofiling and the dimensions of floodplain channels could be reduced substantially without having a negative effect on flood risk; this could provide essentially the same ecological/ morphological benefits at considerably lower cost.

8.1 NEXT STEPS

It is our recommendation that one or more additional design – modelling iterations be performed to optimise the trade-offs between the size/ extent of restoration elements, habitat and biodiversity gains, the estimated costs of construction, and reductions in flood risk.

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