



flood risk assessment

Boulton Moor District Centre
and Residential Development,
Derby

CCE/E702/BM1-FRA-03

October 2021

For
JSC Farming and Central Land
Holdings Ltd

Document Review Sheet

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Reference	Date	Author	Checked
CCE/E702/BM1-FRA-01	September 2021	JH	RT
CCE/E702/BM1-FRA-02	October 2021	JH	RT
CCE/E702/BM1-FRA-03	October 2021	JH	RT

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Site location	Land between Chellaston Lane and the A6, Boulton Moor, Derby, DE72 3UX. Grid reference – 440009, 331947
Planning application	Outline
Existing site	Agricultural
Site area	Approximately 12.68 ha
Proposed development	Mixed use
Flood Zone	Predominantly 1, small area of 2 in the east
Reservoir Inundation Zone	None
Surface water flooding	None
Surface water management	Greenfield discharge (Q_{BAR}) to the local watercourse/ditch network.

1.0 Introduction

- 1.1 This Flood Risk Assessment (FRA) has been prepared for the use of JSC Farming and Central Land Holdings Ltd to support an outline planning application for a mixed use development on land between Chellaston Lane and the A6 in Boulton Moor, Derby, Derbyshire (refer to Figure 1 for the site location).
- 1.2 The proposed development comprises:
- A District Centre comprising the erection of new buildings to accommodate Use Classes E (a)-(f), a Transport Mobility Hub and Petrol Filling/Electric Charging Station. Residential dwellings, a retirement home, a care home, a community facility, and associated road infrastructure, landscaping, services, and engineering works. Outline application with all matters reserved except the northern access.*
- 1.3 The southern part of the site forms part of the wider Boulton Moor 1 (BM1) site, which received outline planning permission (for mixed use development) as the result of a successful appeal in 2009 (South Derbyshire planning reference 9/2005/0611) with an application to extend the time limit for the implementation of this outline application approved in November 2011 (LPA reference 9/2010/1134)..
- 1.4 This assessment takes account of the National Planning Policy Framework (NPPF) and the definitions of sources of flooding within the Flood and Water Management Act (FWMA) 2010. This report has been prepared following several site visits, a site specific flood modelling exercise, and the granting of a flood risk activity environmental permit for realignment of a section of the Thulston Brook (the watercourse which runs south-eastwards through the site).
- 1.5 Policies SD2 and SD3 of the South Derbyshire Local Plan (SDLP) Part 1 reference flood risk and surface water management. In line with the NPPF, the policies promote the avoidance of development in areas of flood risk and the management of development runoff to avoid an increase in post development runoff rates. Both policies promote the inclusion of Sustainable Drainage Systems (SuDS) for the treatment and storage of runoff.
- 1.6 The site extends to some 12.68 ha and is approximately centred on Ordnance Survey grid reference 545144, 112823. The majority of the site is currently undeveloped agricultural land. The exception to this is the recently constructed access road in the south-western corner of the site. This road, roundabout and associated drainage are therefore extant and do not form part of the proposals supported by this FRA.
- 1.7 The site is divided into two parcels/catchments by the Thulston Brook. The Thulston Brook is a designated Main River which flows in from the west, beneath Chellaston Lane, follows a broad south-easterly route through the site and then exists beneath the A6. The Thulston Brook has a notable kink towards the middle of the site. This kink will be removed as part of

the realignment of the Thulston Brook as per the environmental permit issued by the Environment Agency (EA), permit reference EPR/LB3758XJ. The proposed route of the Thulston Brook is shown on the illustrative layout in Appendix B. The realignment of the brook will also involve improving the cross sectional form of the channel to add a low flow channel with a slight meander. To support the environmental permit the proposed brook was tested with a hydraulic model to make sure that the proposed works did not increase flooding elsewhere. A copy of the model and a drawing showing the proposed route of the realignment which supported the permit application are included in Appendix A.

- 1.8 The overall shape of the site is a semi ovoid. The western boundary is marked by Chellaston Lane, with residential development beyond, the eastern boundary is marked by the A6, and the northern (curved) boundary is marked by Shardlow Road and Chellaston Lane. The southern boundary is formed by the Southern Brook, an ordinary watercourse which flows eastwards for approximately 380 m before turning northwards and joining the Thulston Brook before it flows beneath the A6. The land to the south of the site benefits from planning permission for residential development, construction of which is currently underway by Persimmon under the name Buttercup Leys. The permitted and partly complete development is shown on the illustrative layout in Appendix B.
- 1.9 Although the site is best located using the surrounding roads it is worth noting that the site boundary does not extend all of the way to the roads and is set back by several metres.
- 1.10 The dominant slope direction of the part of the site to the north of the Thulston Brook is southwards (toward the brook) with a cross fall to the east. The dominant slope of the southern part of the site is eastwards, falling towards the A6. Levels across the site range between approximately 42.0 (in the north) and approximately 39.9 m AOD (in the east, adjacent the Thulston Brook). A topographical survey is included in Appendix A.
- 1.11 The site is separated from Chellaston Lane by a road drainage ditch. The ditch is in the order of 900 mm deep and runs parallel to the road from the roundabout to the north of the site and continues southwards, beyond the site. Site levels suggest that the ditch does not receive any overland flow from the site itself. Road runoff is conveyed to the ditch via several gullies which are evident at regular intervals. The ditch is open save for a field access at the north-western 'corner' of the site. The ditch appears to discharge directly to the Thulston Brook or Southern Brook as applicable. The ditch lies outside of the redline boundary for the majority of its run. Where the proposals do interact with the ditch (which appears to be limited to the northern site access) permission will be sought from the Lead Local Flood Authority (LLFA) for its diversion and/or replacing section of it with a suitable pipe/culvert.
- 1.12 British Geological Survey (BGS) mapping shows that the site is underlain by the sands and gravels of the Allenton Terrace Deposits, over the Branscombe Mudstone. Intrusive investigations (including infiltration testing) have been undertaken at the site.

1.13 The site does not lie in a groundwater source protection zone (refer to Figure 3).

2.0 Forms of Flooding

Watercourses

- 2.1 The majority of the site lies in Flood Zone 1 (the low probability area) and is not therefore considered to be at risk of inundation from a tidal source, a named river, or other significantly sized watercourse (refer to Figure 2). A small area of zone 2 is indicated in the east of the site (associated with the low lying land where the Southern Brook meets the Thulston Brook upstream of the A6 but this has been kept free of development.
- 2.2 The proposed development falls either within the more vulnerable or less vulnerable flood vulnerability categories as defined by the flood risk and coastal change section of the Planning Practice Guidance. The recently updated climate change guidance suggests that an increase of 29 % should be applied to peak river flows when testing a flood model for climate change for more and less vulnerable land uses. The flood modelling of the Thulston Brook and Southern Brook includes an increase in peak river flow of 30 % to allow for climate change and is therefore applicable to the proposals.

Surface water flooding

- 2.3 Surface water flood mapping (Figure 4) does not show any notable flooding on the site. This is in line with expectations given that the site is effectively separated from the surrounding land by the surrounding roads, ditches, and watercourses which will all act to intercept overland flow from outside of the site.
- 2.4 The highway drainage ditch which serves Chellaston Lane is not considered to pose a notable threat to the proposed development given the limited size of the catchment, the capacity of the ditch (it has an approximate cross section of 1.0 m²) and effectively free discharge to either the Thulston or Southern Brooks. Were the ditch to become overloaded by an extreme storm event to the point where it broke its banks then flows would tend to be routed around the edges of the development into the Thulston or Southern Brook (in the various landscaping strips).

Surface Water Sewers

- 2.5 Severn Trent sewer plans (included in Appendix A) show surface water sewers serving the residential development to the west of the site. The network is not considered to pose a particular risk of flooding to the proposal. Any flows arising from overloading of the network would be unlikely to reach the site as overland flow without first being intercepted by the Chellaston Lane and its associated drainage ditches.

Groundwater

- 2.6 The ground investigation suggests that the underlying geology may support seasonal waterlogging and shallow groundwater levels. The outline layout allows for any groundwater which emerges at the surface to be routed (as shallow sheet flow) towards the two watercourses running through/around the site. The detailed level design process will set appropriate external levels to help any emerging groundwater to exit the site and/or be directed around the proposed buildings rather than entering them.

Reservoirs

- 2.7 The site is not within a reservoir inundation zone (refer to Figure 2).

3.0 Surface Water Management

- 3.1 Intrusive ground investigations and infiltration testing at the site show that infiltration rates are low, but within a range which may support the disposal of site runoff via infiltration. In light of the potentially shallow groundwater however the outline attenuation scheme (in Appendix B) is based on the precautionous assumption that an attenuated discharge will be required, and secures sufficient space for said attenuation. If the results of groundwater monitoring show that groundwater levels are consistently low enough to support a shallow infiltration scheme then this will be revisited at the Discharge of Conditions stage.
- 3.2 Runoff from the proposed impermeable catchment will be managed in various sub-catchment attenuation facilities and discharged at the calculated annual greenfield rate of 3.5 l/s.
- 3.3 The outline surface water management scheme is shown on the drawing in Appendix B and comprises open basins for the residential parcels, and a mix of open basins and tanks for the commercial parcels to the north of Thulston Brook.
- 3.4 The impermeable catchment plan in Appendix B shows the location of the various catchments and their respective attenuation facilities. It also includes a table of the approximate volumes of each facility.
- 3.5 Attenuation calculations for each sub catchment are included in Appendix B and show the performance of each facility during the 1 in 100 annual probability event with a 40 % allowance for climate change. The impermeable area for the residential catchments assumes that 65 % of each area will be developed as impermeable cover. Typically an assumption of 65 % inherently includes an allowance for urban creep. The impermeable areas for the commercial catchment have been measured from the illustrative layout (for which urban creep is not relevant).
- 3.6 Although the application is in outline, the commercial parcel includes space for roadside SuDS features (grassed filter drains, SuDS planters etc). The illustrative commercial layout therefore allows space to include treatment for road runoff before it enters the proposed basins (these features are indicated on the outline surface water management plan in Appendix B).
- 3.7 All car parks will drain into the network and/or attenuation via permeable paving.
- 3.8 All flow controls will be housed in a control chamber with appropriate in-chamber protection provided. Upstream filter boxes (stone filled gabion baskets) to prevent debris from entering the control chamber will also be included for all basins.

Treatment

- 3.9 Based on Table 26.2 in the SuDS Manual the highest pollution hazard level for the site would be 'medium' (based on the busier roads) with scores/ratings of 0.7, 0.6 and 0.7 for total suspended solids (TSS), metals, and hydrocarbons respectively.
- 3.10 The combination of proposed roadside SuDS (which can be considered as less effective bio-retention areas with regards to the treatment of runoff) for the busier roads and basins is considered to provide a suitable level of treatment for the development runoff.
- 3.11 As discussed above the roadside SuDS are more analogous to bio-retention facilities than swales. Assigning the roadside SuDS scores listed for a swale in Table 26.3 of the SuDS Manual is therefore a suitably conservative approach. The combined treatment scores for water passing through the roadside SuDS, then the basins are therefore:
- TSS – swale 0.5 + basin (0.5 x 0.5) = 0.75
Metals – swale 0.6 + basin (0.5 x 0.5) = 0.85
Hydrocarbons – swale 0.6 + basin (0.5 x 0.6) = 0.9
- 3.12 Runoff from the commercial car parks will pass through permeable paving prior to entering the proposed tanks. The treatment scores for permeable paving are 0.7, 0.6, and 0.7 respectively. Permeable paving is therefore able to provide sufficient treatment for the proposed land uses.
- 3.13 Roadside SuDS for the residential parcel will be determined at the Discharge of Condition stage. Given the various options available for providing SuDS features upstream of an attenuation facility (permeable paving, tree pit 'gullies', grassed filter drains, SuDS planters etc) the appropriate treatment should be readily achievable.

Maintenance

- 3.14 Maintenance of the surface water system serving the commercial parcels will be undertaken by a private management company and remain the responsibility of the site owner operator.
- 3.15 Maintenance of the surface water system serving the residential parcels would be offered to Severn Trent Water (as part of the evolving national stance on SuDS adoption). Any elements which do not fall under Severn Trent's responsibility will be maintained by a communally funded private management company.
- 3.16 Suggested maintenance activities for the various elements of the outline strategy are shown on the maintenance plan in Appendix B.

Miscellaneous

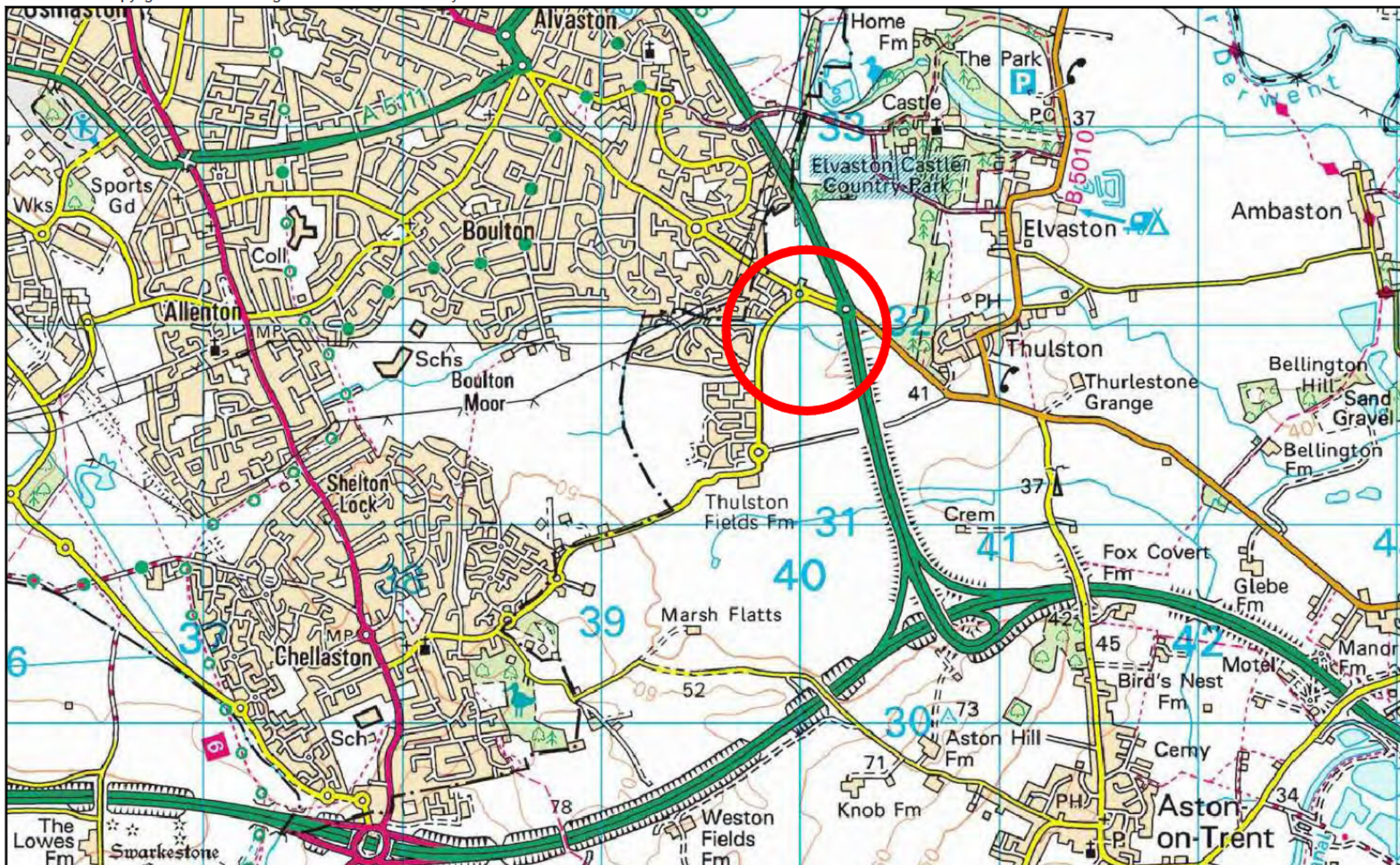
- 3.17 Potential water pollution associated with the proposed the filling station/electric charging station will be managed in the usual way by providing a canopy to separate 'clean' rainfall runoff from mixing with/mobilising pollutants (oil and fuel spills etc) within the forecourt. Forecourt drainage will be designed at the detailed design stage.
- 3.18 Any separate drainage scheme for service yards, washdown areas etc (which may require connection to a wastewater network or specialist treatment) will be designed at the appropriate detailed design stages. The outline attenuation calculations are suitably precautionous as they assume that runoff from all of the established commercial catchments will drain to the surface water management scheme.

4.0 Conclusions

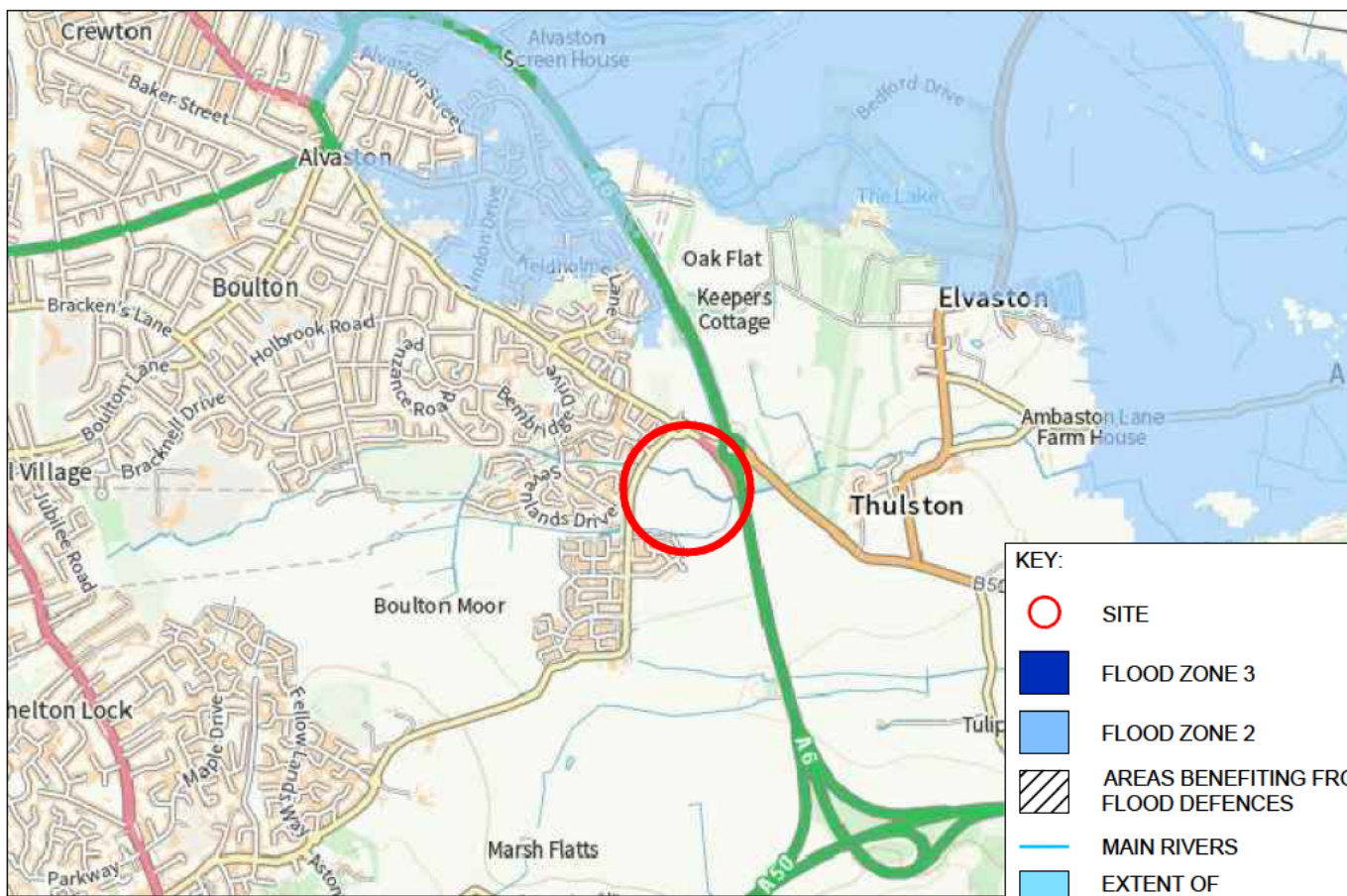
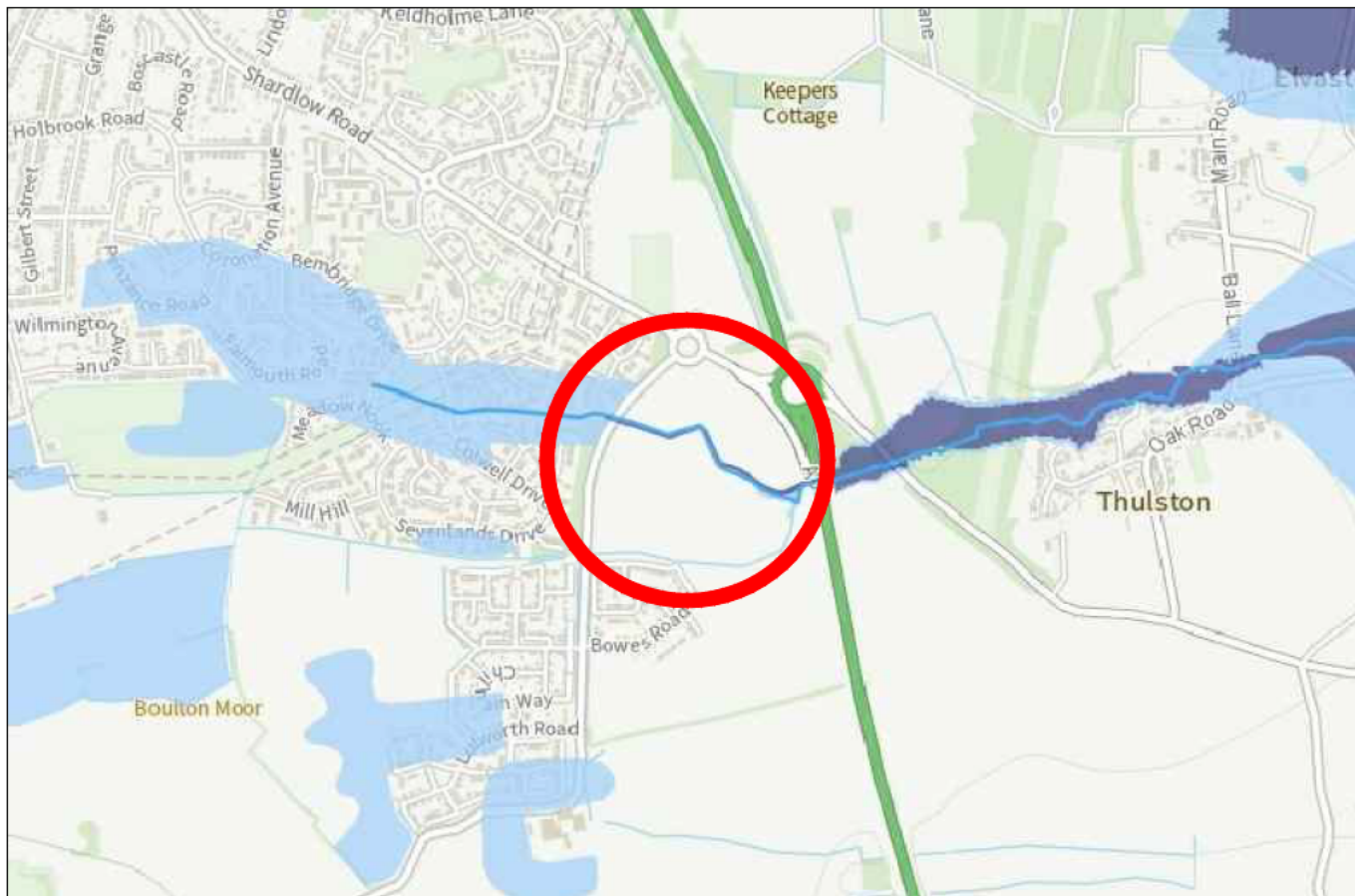
- 4.1 The proposed development is not considered to be subject to significant or unmanageable flooding from the sources identified in the Flood and Water Management Act 2010 (FWMA).
- 4.2 Surface water runoff from the proposals will be discharged to the Thulston Brook or Southern Brook at a rate of 3.5 l/s/ha.
- 4.3 The proposed surface water attenuation provides sufficient on-site storage to manage the 1 in 100 annual probability storm plus 40 % climate change allowance.
- 4.4 The proposed surface water management facilities provide a suitable level of treatment, or allow for a suitable level of treatment to be provided at the later Discharge of Condition stage.
- 4.5 Maintenance of the surface water management facilities would be determined at the appropriate later stages.
- 4.6 The proposed attenuation scheme accords with the general principles promoted by national and local policy.

Figures

1. Site Location Plan
2. Flood Zone & Reservoir Inundation Map
3. Groundwater Source Protection Zone Map
4. Surface Water Flood Map



DATE 10/09/2021	PROJECT TITLE BM1	FIGURE NUMBER 1	PROJECT NO. E702	CANNON CONSULTING ENGINEERS Highways, Transport & Infrastructure Planning
DRAWN BY DP	FIGURE TITLE SITE LOCATION PLAN			
SCALE @ A4 SIZE D.N.S.				



- KEY:**
- SITE
 - FLOOD ZONE 3
 - FLOOD ZONE 2
 - AREAS BENEFITING FROM FLOOD DEFENCES
 - MAIN RIVERS
 - EXTENT OF RESERVOIR FLOODING

DATE
10/09/2021

PROJECT TITLE

BM1

DRAWING NUMBER

2

PROJECT NO.

E702

DRAWN BY
DP

FIGURE TITLE

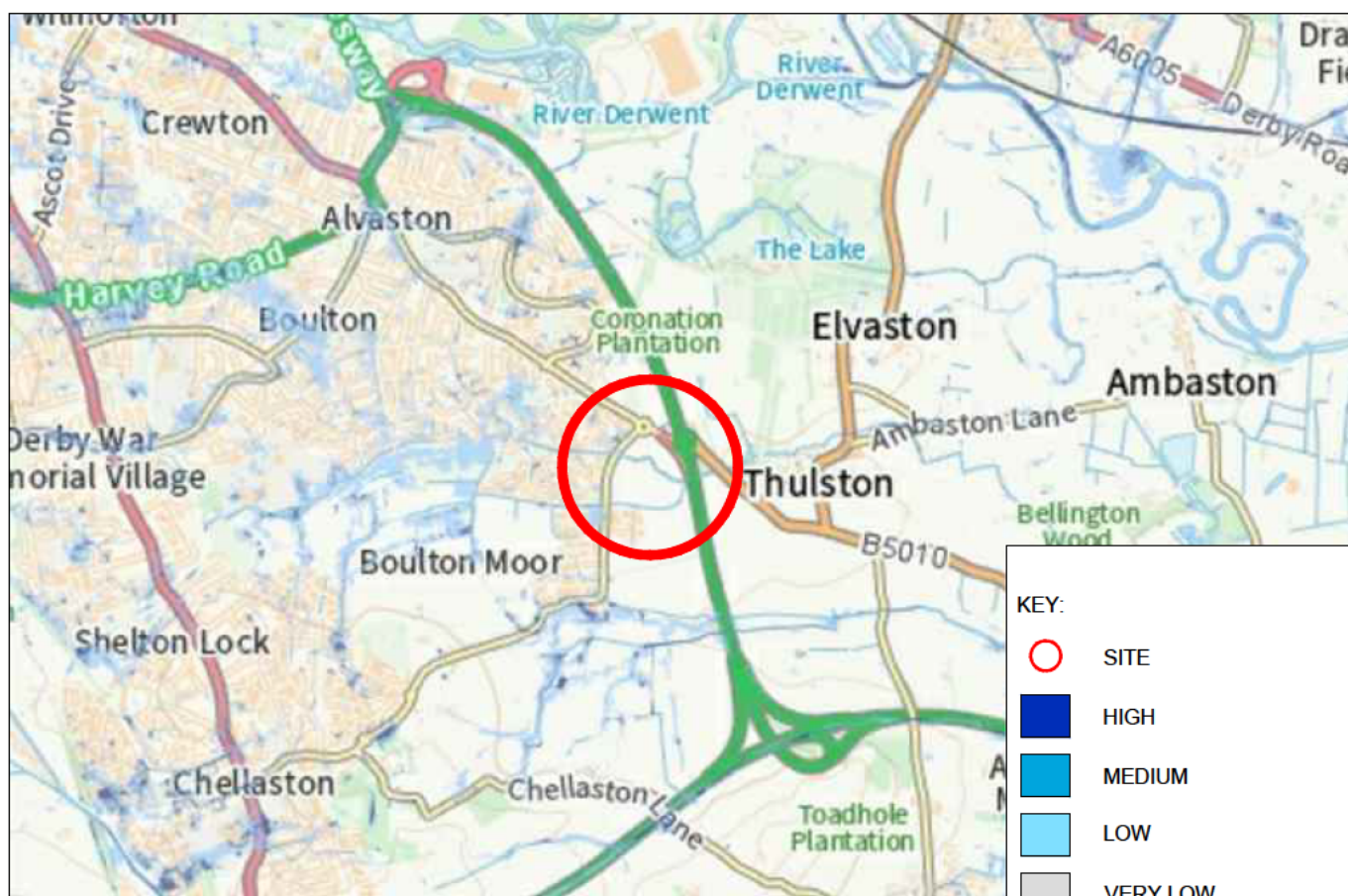
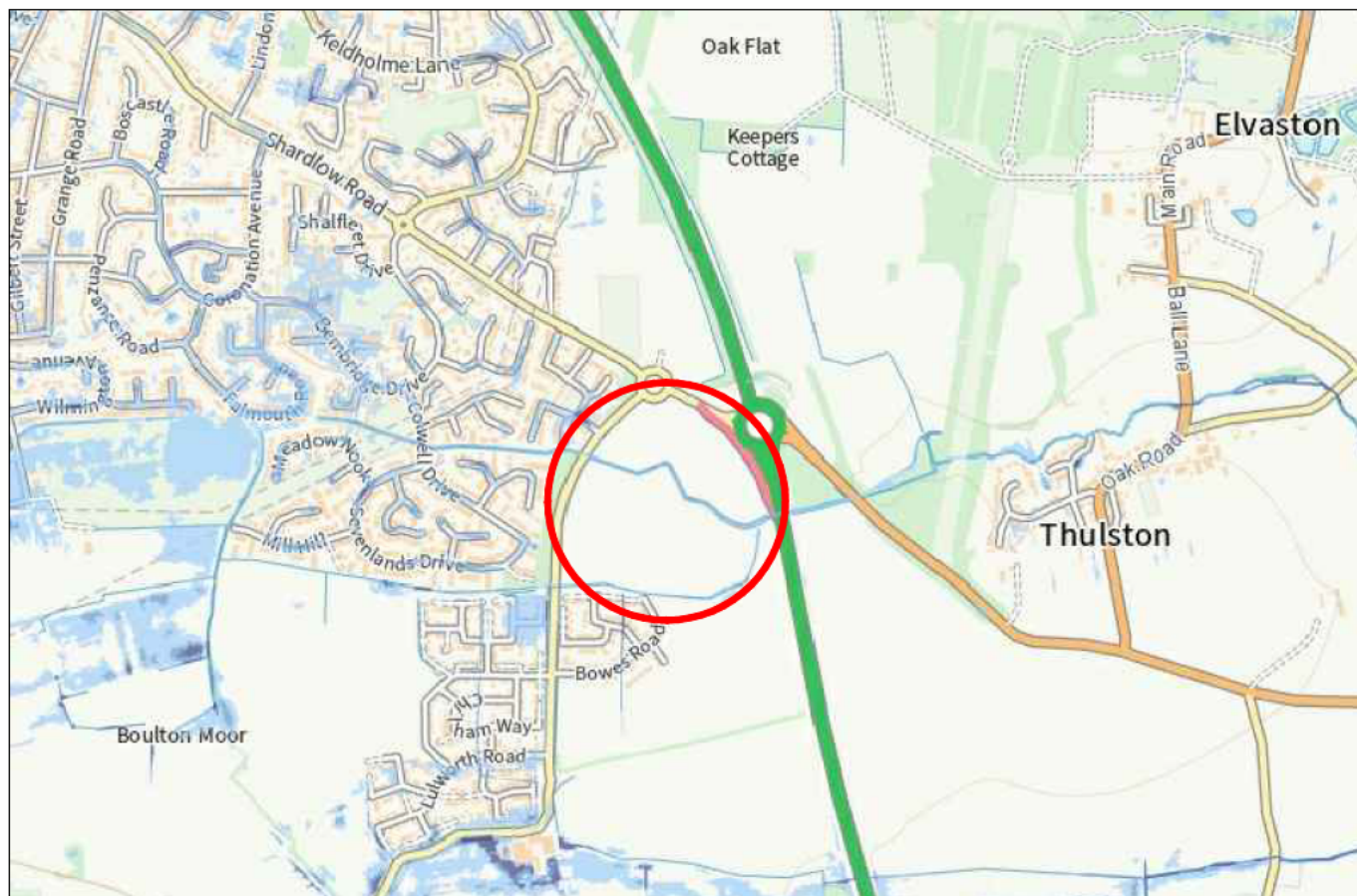
FLOOD ZONE & RESERVOIR INUNDATION PLAN

SCALE @ A4 SIZE
D.N.S.

CANNON
CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning



DATE 10/09/2021	PROJECT TITLE BM1	FIGURE NUMBER 3	PROJECT NO. E702	
DRAWN BY DP	FIGURE TITLE GROUNDWATER SOURCE PROTECTION ZONE PLAN			
SCALE @ A4 SIZE D.N.S.				



DATE 10/09/2021	PROJECT TITLE BM1	DRAWING NUMBER 4	PROJECT NO. E702	CANNON CONSULTING ENGINEERS Highways, Transport & Infrastructure Planning
DRAWN BY DP	FIGURE TITLE SURFACE WATER FLOOD MAP			
SCALE @ A4 SIZE D.N.S.				

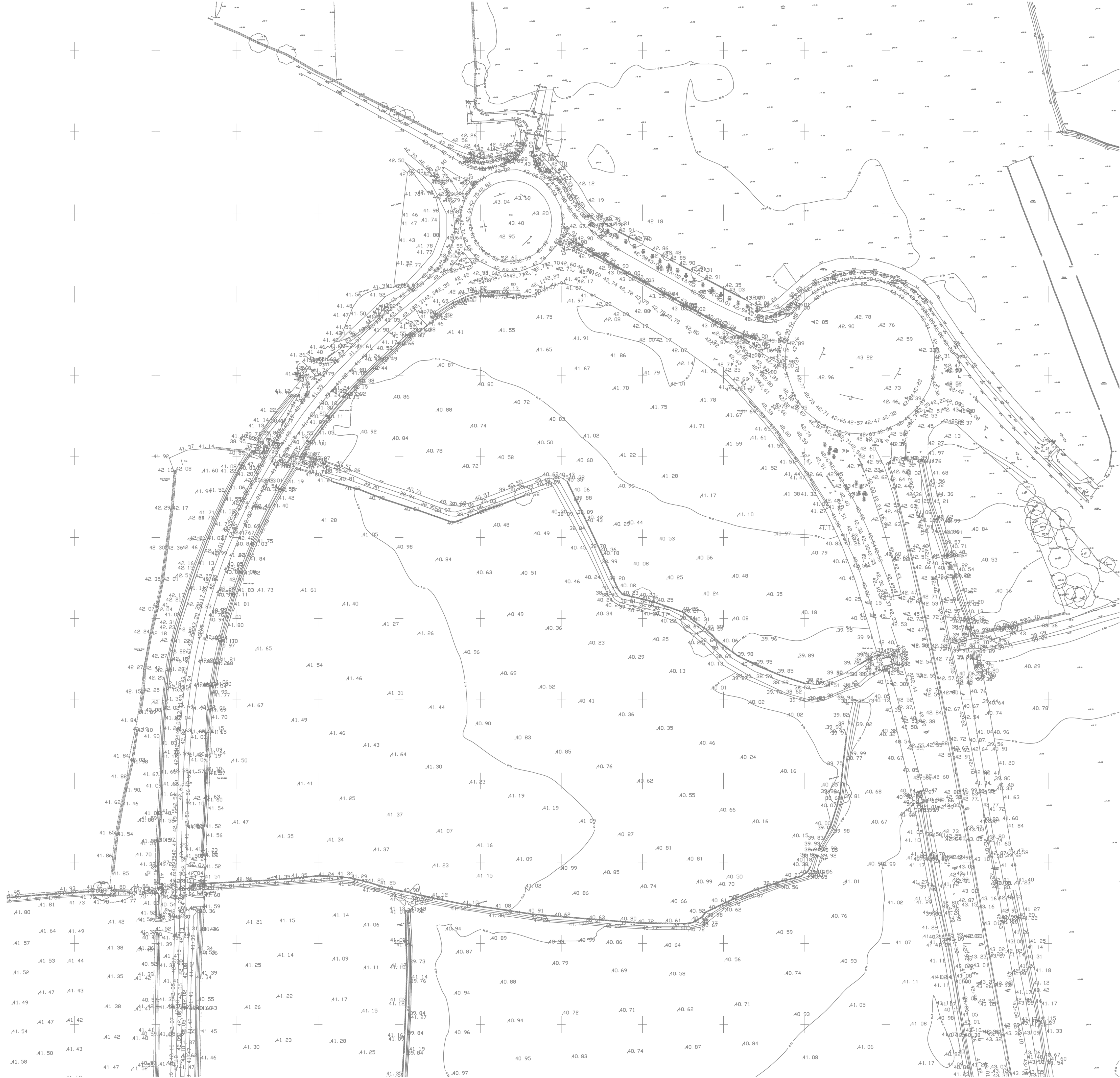
Appendix A – Existing Site

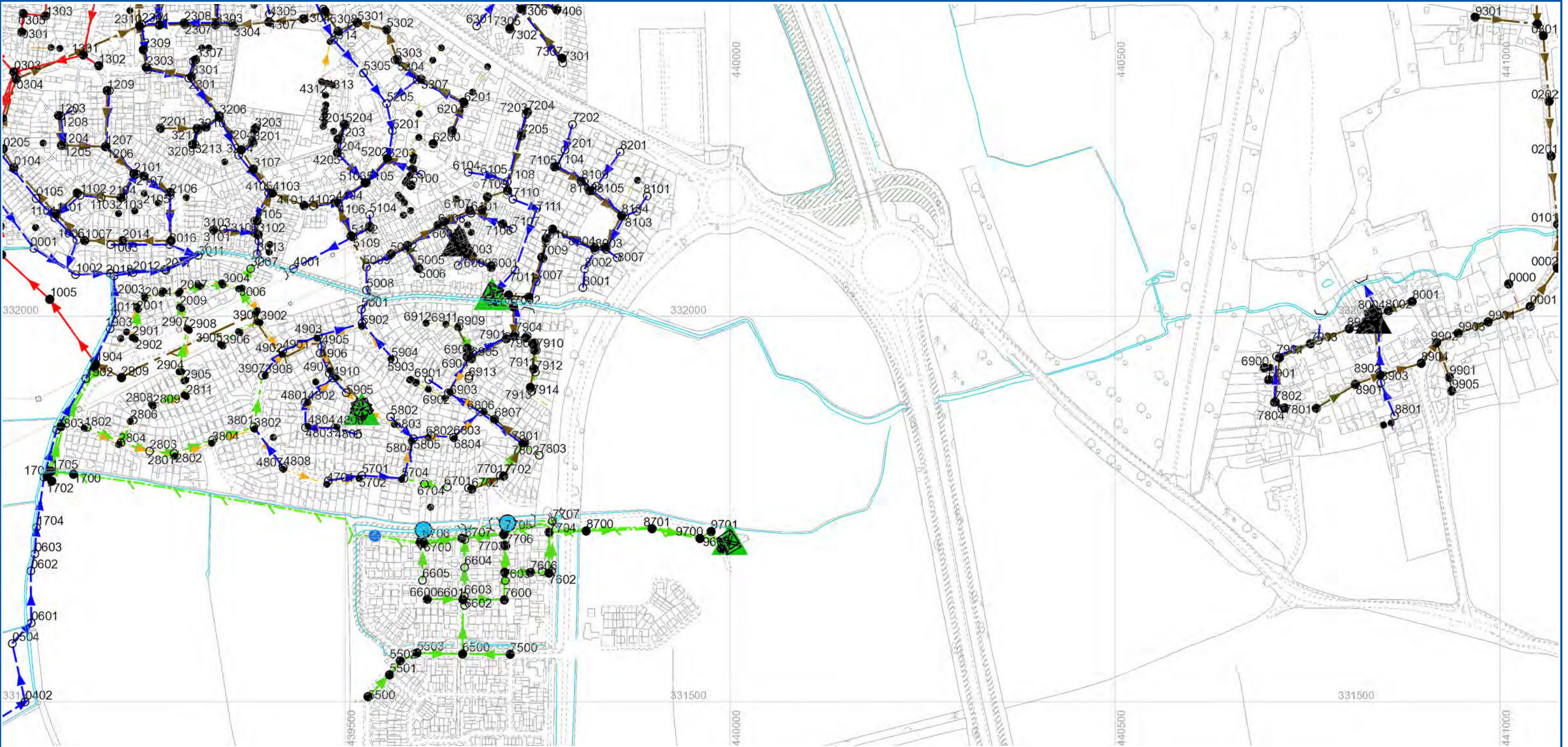
Topographical survey

Adopted sewer plans

Flood modelling report

Thulston Brook realignment drawing





LEGEND

LandlineLine

Polygon Closing Line

Property Closing Line

Bottom Of Slope

Top Of Slope

Step

Mean High Water

Traffic Calming

Standard Gauge Track

Bottom Of Cliff

Top Of Cliff

Mean Low Water

Path

Overhead Construction

Culvert

Pylon

Ridge Or Rock Line

Narrow Gauge Track

Railway Buffer

Tunnel Edge

Line Of Posts

Drain

Default Line

Building Outline

Edge Line

Road Or Track

Building Division

Inland water Line

General Surface Natural Line

Building Overhead Line

Landform Natural Line

Historic Interest Line

Landform Manmade Line

Unclassified

LandlineArea

Other

Mixed Woodland Fill

Nonconiferous Tree Fill

Coniferous Tree Fill

Orchard Fill

Coppice Or Osiers Fill

Scrub Fill

Boulders Fill

Rock Fill

Scree Fill

Rough Grassland Fill

Heath Fill

Salmarsh Fill

Marsh Fill

Reeds Fill

Slope Fill

Cliff Fill

Ancillary

Balancing Lagoon

Grease Trap

Interceptor

Screen

Chamber

Flushing Chamber

Soakaway

Overflow

Fitting

Blind Shaft

Facility Connector

Head Node

Lamphole

Sewerage Air Valve

Sewerage Chem cal Injection Point

Sewerage Hatch Box

Sewerage Pressure Washout

Vent Column

Waste Water Outfall

Control Valve

Hydrobrake

Penstock

Sewerage Isolation Valve

Sewerage Non Return Valve

Manhole

Foul Bifurcat on Manhole

Combined Bifurcation Manhole

Dual Manhole

Foul Single Manhole

Combined Single Manhole

Surface Water Single Manhole

Tw n Manhole

Foul Adopted Manhole

Combined Adopted Manhole

Surface Adopted Manhole

Transferred Manhole

Unsurveyed Manhole

Operational Site

Waste Water Pump

S104

Transferred Asset

S102

Null STW

Adopted Sewer

None

Highway Drain

Null Private

S24

Disposal Site

Off-Line Waste Water Storage

On-Line Waste Water Storage

Wet Well

Waste Water Process Structure

Disposal Site

Off-Line Waste Water Storage

On-Line Waste Water Storage

Wet Well

Waste Water Process Structure

Disposal Site

Off-Line Waste Water Storage

On-Line Waste Water Storage

Wet Well

Waste Water Process Structure

Sludge Treatment Point

Sludge Treatment Structure

Gravity Sewer Pipe

Foul Gravity Sewer

Combined Gravity Sewer

Surface Water Gravity Sewer

S104 Surface Water Gravity Sewer

S104 Combined Gravity Sewer

S104 Foul Gravity Sewer

Private Surface Water Gravity Sewer

Private Combined Gravity Sewer

Private Foul Gravity Sewer

Surface Water Unserved Pipe

Combined Unserved Pipe

Foul Unserved Pipe

Transferred Surface Water Sewer

Transferred Combined Sewer

Transferred Foul Sewer

Disposal Pipe

Overflow Pipe

Culverted Water Course

Waste Internal Site Pipe

Sewer Service Connection

Gravity Sewer Others

Pressure Sewer Pipe

Surface Water Pressure Sewer

Combined Pressure Sewer

Foul Pressure Sewer

S104 Surface Water Pressure Sewer

S104 Combined Pressure Sewer

S104 Foul Pressure Sewer

Private Surface Water Pressure Sewer

Private Combined Pressure Sewer

Private Foul Pressure Sewer

Surface Water Vacuum Sewer

Foul Vacuum Sewer

Combined Vacuum Sewer

S104 Surface Water Vacuum Sewer

S104 Combined Vacuum Sewer

S104 Foul Vacuum Sewer

Private Surface Water Vacuum Sewer

Private Combined Vacuum Sewer

Private Foul Vacuum Sewer

Surface Water Siphon

Combined Siphon

Foul Siphon

Private Surface

Private Combined

Private Foul Siphon

S104 Surface

S104 Combined

S104 Foul Siphon

Surface Water

Combined Unserved

Foul Unserved

Disposal Pipe

Service Pipe

Surface Water

Combined Lateral

Foul Lateral Drain

S104 Surface Water

S104 Combined Lateral

S104 Foul Lateral Drain

Private Surface Water

Private Combined Lateral

Private Foul Lateral

MATERIALS

- NONE

- ASBESTOS CEMENT

- BRICK

- CONCRETE BOX CULVERT

- CAST IRON

- CONCRETE

- CONCRETE SEGMENTS (BOLTED)

- CONCRETE SEGMENTS (UNBOLTED)

- DUCTILE IRON

- GLASS REINFORCED PLASTIC

- MASONRY IN REGULAR COURSES

- MASONRY RANDOMLY COURSED

- POLYETHYLENE

- PITCH

- POLYPROPYLENE

- PLASTIC STEEL COMPOSITE

- POLYVINYL CHLORIDE

- REINFORCED PLASTIC MATRIX

- SPUN (GREY) IRON

- STEEL

- UNKNOWN

- VITRIFIED CLAY

- OTHER

CATEGORIES

W - WEIR

C - CASCADE

DB - DAMBOARD

SE - SIDE ENTRY

FV - FLAP VALVE

BD - BACK DROP

S - SIPHON

D - HIGHWAY DRAIN

S104 - SECTION 104

SHAPE

C - CIRCULAR

E - EGG SHAPED

O - OTHER

R - RECTANGLE

S - SQUARE

T - TRAPEZOIDAL

U - UNKNOWN

PURPOSE

C - COMBINED

E - FINAL EFFLUENT

F - FOUL

L - SLUDGE

S - SURFACE WATER



Severn Trent Water Limited
Asset Data Management
PO Box 5344
Coventry
CV3 9FT
Telephone: 0345 601 6616

SEWER RECORD

O/S Map Scale: 1:5,000

Date of Issue: 29-03-21

This map is centred upon:

X: 440065.59 Y: 331923.77

Disclaimer Statement:

1 Do not scale off this Map

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3 On 1 October 2011 most private sewers and private lateral drains in Severn Trent Water's sewerage area, which were connected to a public sewer as at 1 July 2011, Transferred to the ownership of Severn Trent Water and became public sewers and public lateral drains. A further transfer takes place on 1 October 2012. Private pumping stations, which form part of these sewers or lateral drains, will transfer to ownership of Severn Trent Water on or before 1 October 2016. Severn Trent Water does not possess complete records of these assets. These assets may not be displayed on the map

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Thulston Brook Realignment

Concept Design

Final Report

August 2019

www.jbaconsulting.com

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Revision History

Revision Ref/Date	Amendments	Issued to
Draft v1.0/ August 2019	Draft Report	Cannon Consulting
Draft v2.0/ August 2019	Final Report (minor amendments)	Cannon Consulting

Contract

This report describes work commissioned by Cannon Consulting Engineers, on behalf of JSC Farming Ltd and Central Land Holdings Ltd, by an email dated 16.05.2019. JSC Farming Ltd and Central Land Holdings Ltd's representative for the contract was James Howard of Cannon Consulting. Rebecca Thrower and Catherine Porter of JBA Consulting carried out this work.

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Purpose

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Executive summary

Thulston Brook intersects land permitted for development at Boulton Moor, Derby. The proposed works require a small section of the brook to be straightened in order to facilitate development. A site walkover was conducted by members of the JBA ecology and geomorphology teams to determine any constraints to the proposed works or opportunities for enhancement. The site visit built on previous survey work dating between 2005 and 2018 undertaken by Penny Anderson Associates (PAA).

With respect to ecology, JBA did not find any additional constraints on site as flagged in the 2018 surveys by PAA, with the exception of the potential for the site to support reptiles in low numbers. Recommendations for the avoidance of harm to reptiles seeking refuge in the debris on site are provided in this report. Fresh evidence of Badger activity on site was identified in the walkover survey, indicating that Badger are foraging and commuting locally. Further bat surveys are also likely to be required should the works be delayed beyond September 2020 and dependent on the exact nature of the works/the extent of felling of trees on site. It is recommended that where possible, vegetation is retained and protected during the works. Where this is not possible, compensatory planting should be undertaken. All de-vegetation works should be undertaken outside of the nesting bird season (March to September) or preceded by a nesting bird check and subject to its findings.

A conceptual design has been produced for the realignment of the Thulston Brook. Whilst the proposed realignment involves straightening the river corridor to facilitate the permitted development, the conceptual design comprises a sinuous channel planform in which low flows would be conveyed through a narrower channel to improve morphological conditions in the Thulston Brook. The dimensions of the realigned section of channel have been based on identified analogue sites; however, the design is conceptual and will need to be developed further. A list of design risks and constraints have been identified and 'next steps' recommended in order to develop the conceptual design to outline and detailed design stages.

This report comprises the baseline geomorphology and ecology assessments and details of the conceptual design. Separate reports have been prepared to document the Preliminary WFD Assessment (Appendix A) and the hydraulic modelling results (Appendix B).

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Abbreviations

EA	Environment Agency
PAA	Penny Anderson Associates
CIEEM	The Chartered Institute of Ecology and Environmental Management
GCN	Great Crested Newt
JBA	Jeremy Benn Associates
WFD	Water Framework Directive

1 Introduction

1.1 Terms of Reference

JBA Consulting was commissioned by Cannon Consulting Engineers to investigate a proposed realignment of the Thulston Brook at a permitted development site at Boulton Moor, Derby. To deliver this study, JBA have been commissioned to undertake a hydromorphology assessment, concept design and hydraulic modelling. Also included in this commission is the preparation of a Preliminary WFD Assessment.

1.2 Project overview

The Thulston Brook flows in an easterly direction through a proposed development site at Boulton Moor, Derby, which is currently greenfield and used for agriculture (Figure 1-1). Outline planning permission for the site has been received. The developers would now like to explore options for the removal of the 'kink' in the watercourse, which appears in the centre of the site and is limiting the development plan.

This project involves the preparation of a conceptual design, with indicative cross-sections and route of the realignment. It involves carrying out baseline hydromorphology and ecology assessments, to understand current conditions at the site and inform the design and any potential constraints. These assessments also form the basis of the Preliminary WFD Assessment (Appendix A), which assesses whether the conceptual design has the potential to be compliant with the Water Framework Directive. Hydraulic modelling has been carried out to test whether the realignment conceptual design and post-development scenario are likely to increase flood risk (Appendix B).

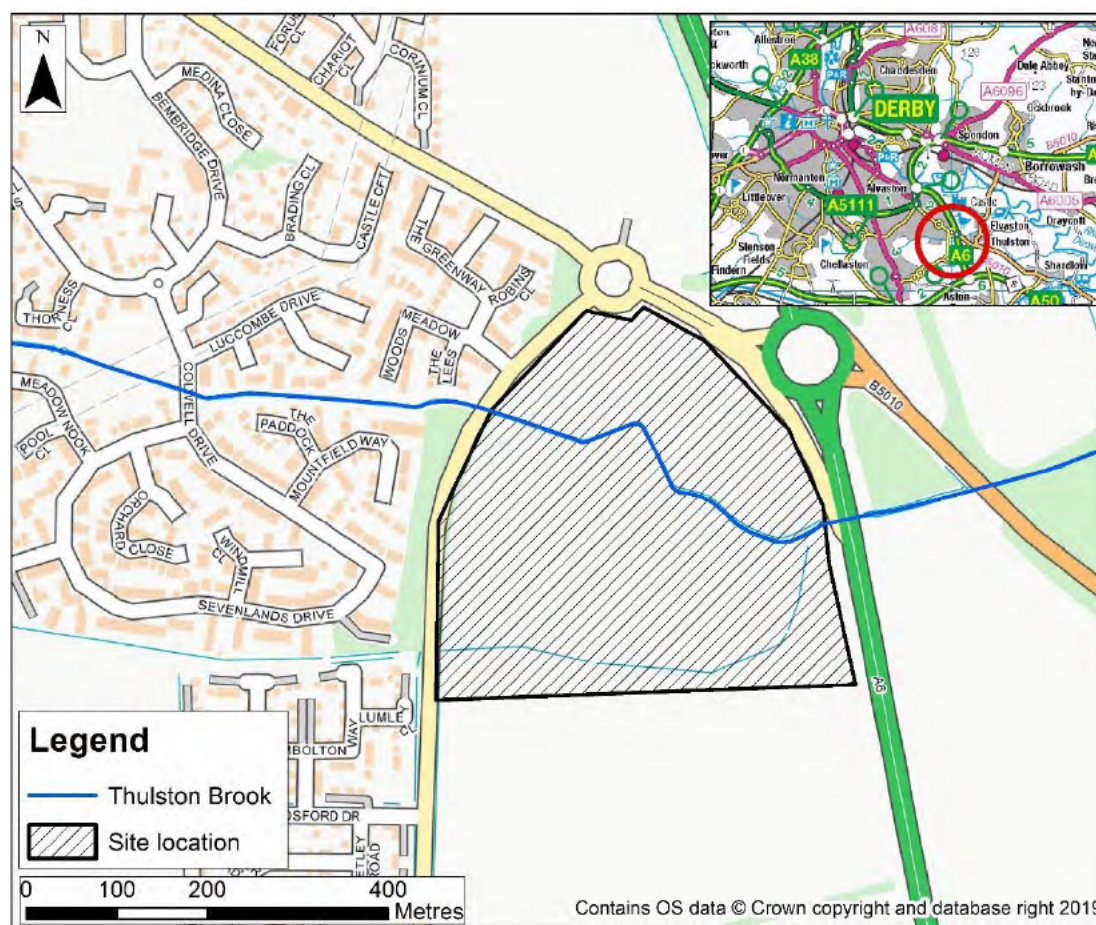


Figure 1-1: Site location

1.3 Methodology

The site was visited by JBA Ecologist Catherine Porter and JBA Geomorphologist Rebecca Thrower on 13th June 2019. A site walkover was conducted following Thulston Brook and the perimeter of the site. Observations were recorded using GISmapp, JBA's bespoke iOS-based mobile data capture tool. This allows full data capture on an iPad in the field of geolocated photographs and spatial data that is then synced in real time using the mobile phone network with our servers out in the field.

1.3.1 Hydromorphology

A hydromorphology survey was undertaken to record features of the channel, riparian zone and floodplain, such as the channel geometry, flow conditions, bed substrate and any depositional or erosional features. The watercourse was surveyed through the study area and the reach upstream.

The findings of the hydromorphology field survey have been supplemented by information gathered during the desk-based assessment. This includes research of the local geology, flow regime and land-uses as well as a historical map analysis to understand the local and wider controls on system functioning. The hydromorphology assessment is presented in Chapter 2 and provides the necessary baseline understanding to inform the concept design, and the WFD Assessment.

1.3.2 Ecology

The ecology survey sought to provide an update to previous ecology surveys completed on site. These were completed by Penny Anderson Associates Ltd (PAA). in 2005, 2007, 2008 and 2018. The most recent reports written in September and October 2018 respectively, comprised a bat survey report and an extended phase 1 habitat survey (PAA, 2018 and PAA, 2018a). These documents provided the framework for this report, with the survey conducted in June 2019 building on this existing data. This report does not attempt to replicate these reports, rather to highlight any notable changes that have occurred since October 2018.

1.4 Limitations

The dense field margin lining Thulston Brook may have obscured field signs of Otter *Lutra lutra* and Water Vole *Arvicola amphibius*. Dense Ivy *Hedera Helix* cladding obscured many of the potential roosting features present on mature tree species lining Thulston Brook.

The depth of the channel meant it was not possible to observe the bed substrate within the study area. However, inferences have been made based on the channel upstream.

Access was not possible downstream of the study area.

2 Hydromorphology

2.1 Catchment Overview

The Thulston Brook is a small tributary watercourse that flows into the River Derwent south of Draycott, Derbyshire. It rises on Boulton Moor and flows in a predominantly easterly direction towards the Derwent. The Lower Derwent catchment is a mixed rural and urban catchment that comprises the city of Derby and large villages, as well as agricultural land.

The Thulston Brook is ungauged and there is no suitably located gauge on the River Derwent through which the flow regime might be inferred. However, it can be assumed from the gentle topography that the Thulston Brook is relatively slow to respond to heavy rainfall events, although urbanisation of the upper catchment will have increased the flashiness of the flow regime.

2.2 Water Framework Directive

The Thulston Brook is not defined under the Water Framework Directive as a stand-alone water body. Instead, it falls within Derwent from Bottle Brook to Trent water body (GB104028053240) which is designated as Heavily Modified (EA, 2019). The current overall status of this water body is 'Moderate' (2016) and has been since 2013. Each quality element within the Ecological Status is classified as 'Moderate', with only the Chemical Status managing to achieve and sustain a 'Good' status.

2.3 Historical channel change

The present-day course of the Thulston Brook through the site is largely unchanged compared to historical maps. However, the land-use in the vicinity of the site has changed considerably, with the majority of the land-cover in the late 1800s occupied by agriculture. The course of the river at the site, and indeed at several other locations, seem to follow field boundaries and the unnatural 'kink' in the channel planform at the site, suggests the watercourse was historically realigned along the field boundary.

The headwaters of the Thulston Brook have been modified and the upper catchment heavily urbanised since the Industrial Revolution. Further modifications to the catchment and watercourse include the construction of the major road networks, which has seen parts of the river channel straightened (such as at the downstream extent of the site).

2.4 Contemporary conditions

The hydromorphology walkover assessment was undertaken on the 13th June 2019. Heavy rain had fallen in the catchment prior to the survey; however, conditions on the day were relatively dry. Access downstream of the site was not possible. The locations of the photos presented in this section are shown on Figure 2-1.

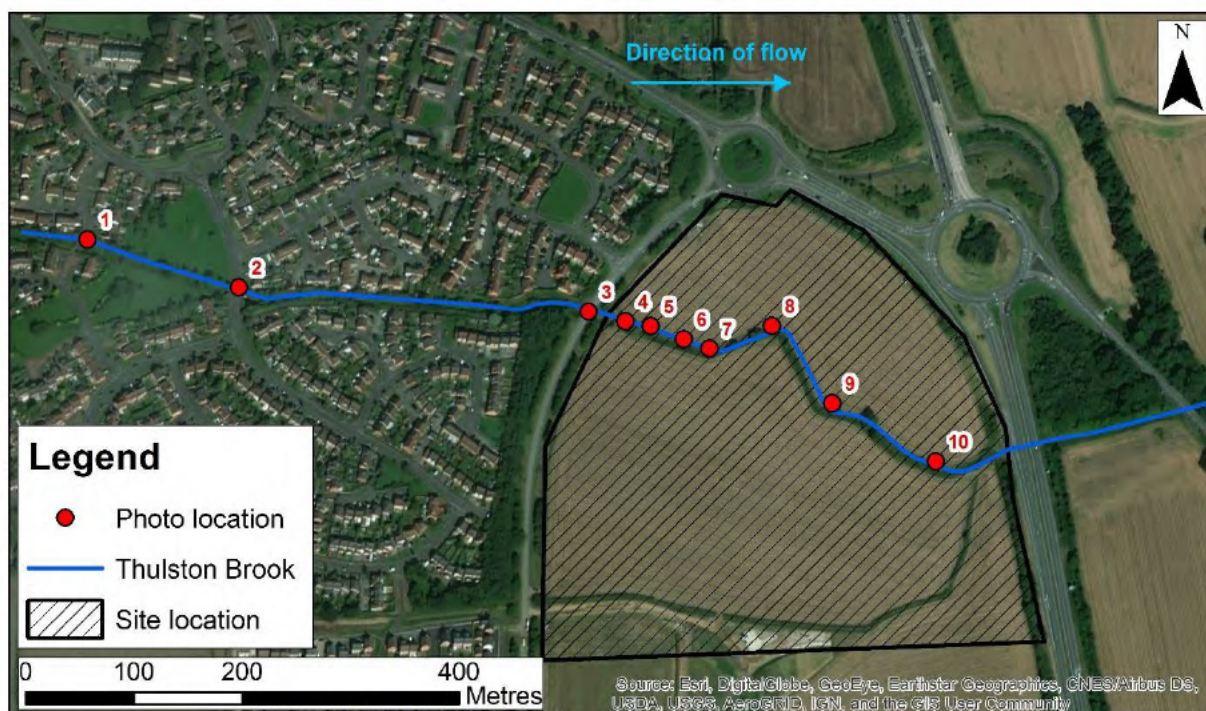


Figure 2-1: Locations of photos

2.4.1 Watercourse conditions upstream of the site

The Thulston Brook upstream of the site is straight and uniform. The channel shape is wide at the bed with banks that slope at approximately 45 degrees to the channel (Figure 2-2). Flow in the channel is slow moving and biotopes are characterised by extended pools, indicating a low energy system which is consistent with the wider area due to a relatively small catchment area and gentle topography. The uniformity of the water surface and flow biotopes suggest a uniform bed profile with minimal hydromorphic features.

The reach is depositional and fine sediment accumulation is visible in where the channel has been widened and, in response and by means of natural adjustment, deposition has created a shallower depth. The Thulston Brook has recently been dredged between Thorness Close and Snelsmoor Lane (nearly 700m of channel) to remove this accumulation of fine sediment (Derby City Council, 2017a). This is reportedly the first time the channel has been dredged in 30 years. The accumulation of silt during this time was significant; it was estimated approximately 1,000m³ of silt would be removed (Derby City Council, 2017b), and silt deposition in this reach will continue due to the low energy conditions exacerbated by physical modification (i.e. straightening). The low energy flow conditions and accumulation of silt allow significant vegetation growth in-channel (Figure 2-3). A veneer of silt deposits on vegetation above the water level indicate large quantities of silt are transported during higher flows.

The floodplain, whilst wide and unconfined, is densely urbanised as the watercourse flows through a residential area. There is a poor connectivity between the channel and the floodplain, with steep banks and a deeply set channel limiting out-of-bank flows.



Figure 2-2: Thulston Brook upstream of the site



Figure 2-3: Thulston Brook looking upstream from Chellaston Lane

2.4.2 Watercourse conditions at the site

The channel is over-wide throughout the study area but is particularly wide downstream of the road, owing to the culverts and physical modification at this location (Figure 2-4). Despite the width, view of the bed substrate is not possible due to the depth of the channel (estimated to be $>1\text{m}$). Based on the conditions upstream, it is likely the bed conditions in this reach are dominated by fine sediment.

The planform of the channel remains straight (Figure 2-5). There is a bend in the watercourse towards the centre; however, the planform appears artificially straight and not curved, which would be expected with a natural meander. As with upstream of the site the channel is choked with emergent vegetation.

Although difficult to assess because of the vegetation, it is possible the geometry of this reach through the site is more heterogenous than upstream, with variable bank slopes in places (Figure 2-6). Variable bank slopes create a range of habitats by allowing different parts of the bank slope to be wetted depending on the water level. However, despite some local water surface variability caused by the emergent vegetation, flows in the channel are generally uniform and slow moving. Gliding flows characterise the majority of the reach, indicating some visible flow movement but low energy conditions.

No evidence of erosion was found in the study reach. Other than deposition of fine sediment along the bed, no depositional features are present within the channel. Even at the channel bends, where some variation in bank slopes and channel morphology might be expected in a naturally functioning system, the channel geometry and flow conditions are uniform (Figure 2-7). It is suspected the channel is overwide and creating a partial impoundment on water levels, restricting diversity of flows.



Figure 2-4: Particularly over-wide channel within the vicinity of the culverts



Figure 2-5: Straight channel planform with significant vegetation growth



Figure 2-6: Potential for bank slope variation beneath the vegetation



Figure 2-7: Minimal morphological diversity even at channel bends

As with the upstream extent of the site area, the channel is particularly wide at the downstream end as it approaches a culvert under the A6. As a result, the channel is choked with emergent vegetation and barely visible. Flows, where visible, are characterised by extended pools.



Figure 2-8: Over-wide channel upstream of road bridge culvert

3 Ecology

3.1 Data Search

In line with the Chartered Institute of Ecology and Environmental Management's (CIEEM) guidelines on the lifespan of ecological reports and surveys (CIEEM, 2019), the existing data search results included within the latest extended phase 1 habitat report are considered to remain valid, being less than 12 months old (PAA, 2018a). For this reason, JBA have not acquired additional historic ecological records.

3.2 Phase 1 Habitat Survey

The phase 1 habitat survey did not reveal any significant changes in either vegetation structure or composition relative to the most recent extended habitat survey undertaken by PAA. A handful of additional species were recorded on site (most of which are considered to have been present at the time of the last survey but presumably overlooked). These include Gorse *Ulex europaeus*, Poppy *Papaver* sp., Ragwort *Jacobaea vulgaris*, Yellow Flag Iris *Iris pseudacorus*, Horsetail *Equisetum* sp., Sorrel *Oxalis* sp. and Birds-Foot Trefoil *Lotus corniculatus*. These species were primarily recorded along Thulston Brook. These additional species are relatively widespread and common and do not pose any constraints to the proposed works.

Thulston Brook itself was wet at the time of survey. The width and level of modification was unaltered, but the depth was more difficult to determine due to the level of siltation within the channel, which obscured the bed. It is estimated that the water level had dropped since the previous survey in 2018. It was slow flowing and culverted in sections, with gabion baskets reinforcing the banks at the perimeter. Debris was present adjacent to the road. The bank was steeper than 45°.



Figure 3-1: Thulston Brook at the eastern perimeter of the site. Here the channel is choked with emergent vegetation.

3.2.1 Protected Species

Water Vole and Otter

No signs of Otter or Water Vole were recorded during the 2019 field survey. No further recommendations for Water Vole and Otter apply.

Badgers

In line with the previous extended phase 1 report, no Badger *Meles meles* setts were recorded on or adjacent to the site. However, mammal paths were present lining the perimeter of the field and well-worn entrance paths were present under the perimeter fencing to the scrub beyond. These were likely to be formed by Badger, especially given the recent Badger activity recorded in the 2018 survey.



Figure 3-2: A well-worn mammal path on the site perimeter, with entrance to the scrub border under the fence.

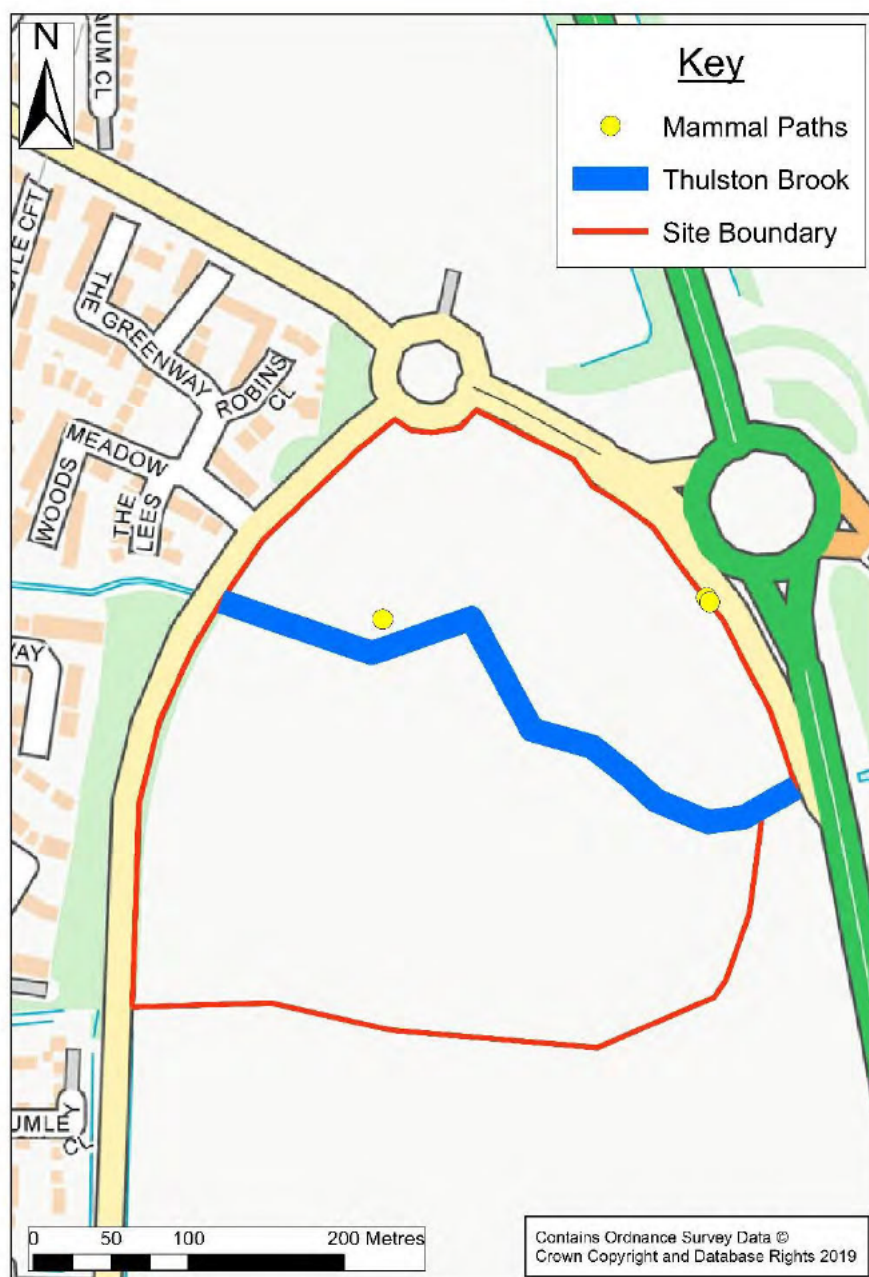


Figure 3-3: Mammal paths across the site, suggesting low levels of Badger activity.

Bats

No additional potential roosting features had developed since the last assessment in 2018 (as visible from the ground). Furthermore, there was no evidence of staining, droppings or scratching on any of the trees.



Figure 3-4: Several of the mature trees lining Thulston Brook were clad in Ivy, obscuring signs of bat activity and potential roosting features from the ground.

Birds

No additional species of bird (noted since the extended phase 1 report compiled by PAA in 2018), were recorded on site. Furthermore, no nests or nest building activity were recorded in the June 2019 survey.

Reptiles and Amphibians

The site is bound by major roads with no ponds within the site boundary. This coupled with the lack of recent Great Crested Newt (GCN) *Triturus cristatus* records within close proximity to the site suggests it is very unlikely to support GCN. No further recommendations for GCN apply. However, the site does offer some provision for reptiles, with long grass and debris which could provide refuge for species such as Grass Snake *Natrix natrix*. It is unlikely reptiles will be present on site in great numbers however, due to the limited connectivity to wider habitats and the sub-optimal habitat present on site (high disturbance due to agricultural operations).



Figure 3-5: Refugia was present on the site perimeter, providing suitable cover for reptiles.

4 Concept Design of Channel Realignment

4.1 Overview

A concept design has been prepared for a section of the Thulston Brook, where it crosses the permitted development site at Boulton Moor. Whilst the purpose of the realignment is to provide more space for the proposed development, it provides an opportunity to improve hydromorphological functioning within part of the Thulston Brook.

As discussed in Chapter 2, the channel is rich with biodiversity but to the point of being choked by macrophytes. The channel is also over-deep and thought to be heavily silted along the bed. The reach upstream of the site has been recently dredged due to a significant accumulation of fine sediment. Local controls, such as a shallow gradient, channel modification and disconnection from the floodplain, will have contributed to these depositional conditions; however, clean gravels are visible in the Thulston Brook.

Immediately upstream of the B5010 culvert the watercourse is constricted, and gravels have been deposited along the bed (Figure 4-1). The gravels are devoid of silt owing to the narrowed channel width, which creates faster velocities and higher shear stresses capable of flushing through fine sediment.



Figure 4-1: Clean gravels visible on the bed of the Thulston Brook where the channel narrows. Photos taken by Grantham Coates Surveys in June 2016.

This surveyed section (XS 1) has therefore been used to inform the dimensions of the realigned channel, but with the top of bank width fitted to the existing channel width within the study area (informed by XS 8). The bank heights have also been fitted to the existing ground levels through the study reach, which are considerably higher than at the analogue site (Figure 4-2). The narrow bed at the base of the channel has been retained to encourage transport of fine sediment. It is expected this channel would convey low flows (i.e. Q70 – Q95 flows) with the berm features being submerged during higher flows, such as the Q10 or flood flows.

The surveyed cross-sections show the channel narrows towards the downstream extent. This inference is supported by the LIDAR which shows a narrower channel between XS 1 and the B5010 (Figure 4-3). This reach is far more sinuous than upstream and downstream, suggesting a more 'natural' section of watercourse and further implying the study reach has been historically modified. Nonetheless, in order to design a reach consistent with the over-arching segment, and to prevent a constriction in the watercourse that might increase flood risk to the proposed development, the channel has been designed to fit in with the width of the existing channel at the site.

The planform of the new channel is sinuous. It has been based on the planform seen in the downstream reach (Figure 4-3) and on remnants of former channels visible on historical mapping, which indicate places where the channel has been straightened along a field boundary. Both analogue sites suggest the natural planform of the watercourse to be irregularly sinuous.

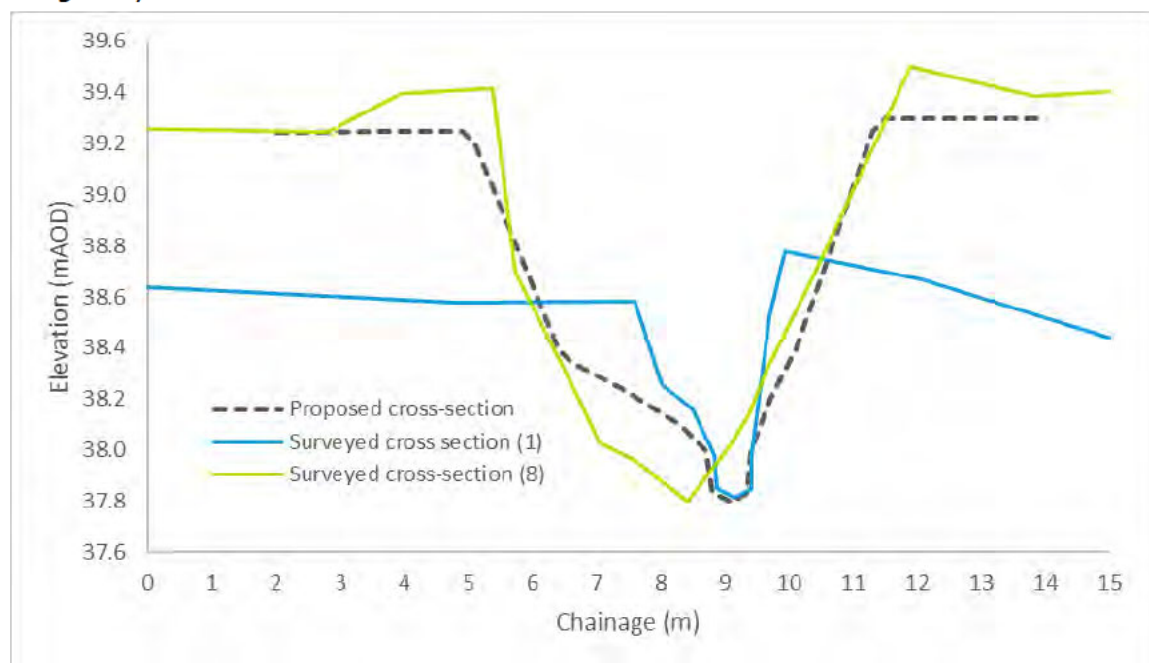


Figure 4-2: Surveyed cross-sections used to infer the new channel geometry

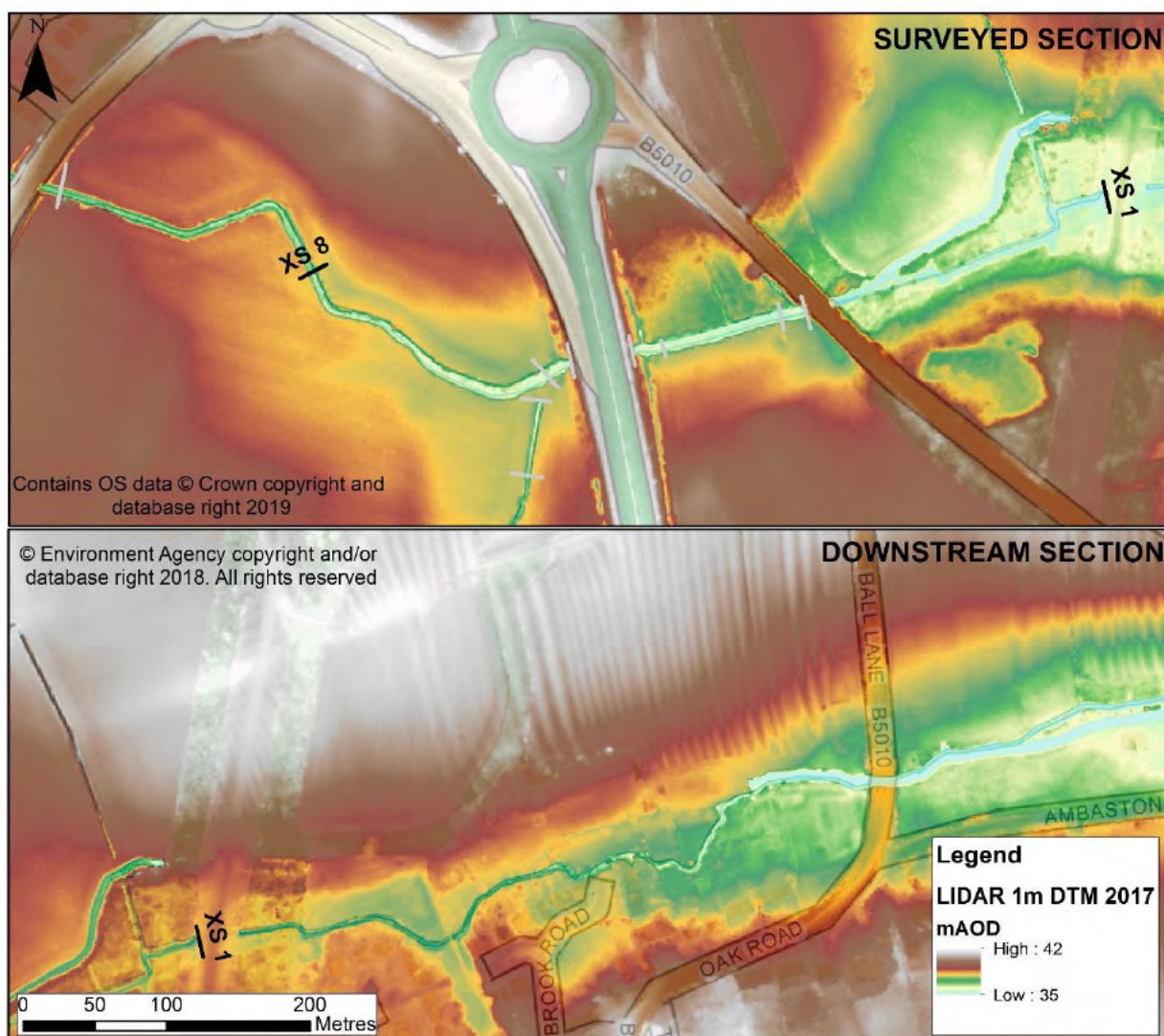


Figure 4-3: Location of surveyed cross-sections used to inform the new geometry

4.2 Risks and constraints

The design and plans produced for the Thulston Brook for this study are conceptual and cross-sections have been prepared as indicative only. Further work and investigations will need to be made during subsequent design phases. Key constraints and risks are outlined below:

- The depth of the channel and the gradient is constrained by bed elevations of the local, existing channel and by floodplain levels (to which the channel is largely disconnected from)
- The dimensions of the channel have been inferred from existing sections and from analogue sites; hydraulic modelling, other than to test the concept design for their impact on flood risk, has not been used to inform the design. Low flows modelling and interpretation of channel hydraulics will be required at a later design stage
- Channel bed and bank levels will need to be confirmed during the next design phase and results (particularly low flows and QMED flows) should be analysed in terms of sediment transport to ensure conditions are suitable to prevent siltation

- There may be sub-surface constraints that could affect the positioning of the channel, such as services or contaminated land; these will need to be investigated at the next design phase
- The realignment of the brook is likely to cause a reduction in channel length of approximately 20m (existing section is approximately 150m while the realigned length extends to 130m). This could influence hydraulics and trigger a hydromorphic response, in which localised velocities are marginally increased. The impact of this could be beneficial to the watercourse if fine sediment is flushed through by the higher energy; however, it will be imperative to create a sinuous course to avoid degraded morphological state observed upstream.
- The works are constrained by the presence/potential presence of the following protected groups: reptile, badger, bat and breeding bird. Recommendations to avoid disturbing or harming these species are given within Section 5.3.1 of this report.
- Where possible, habitat loss should be minimised, with mature trees and hedgerows retained. This may present a constraint to the works design to make allowances for habitat retention and enhancement on site.

4.3 Concept design

To improve hydromorphological functioning, the realigned channel has been designed to encourage healthy sediment transport and morphological diversity, which should provide a range of ecological habitats. The following criteria should be adhered to:

- The channel should be sufficiently sized to encourage sediment transport expected to operate during different flow conditions
- The channel width and shape should be heterogenous and not uniform, to encourage preferential wetting and diversity in flows
- The inside and outer bends should display a range of bank slopes, with the inside bends shallower and the outer banks steeper, to add variability to the channel
- The berm features (i.e. those forming the 'benches' of the channel above the low flows channel) should be sloped and curved rather than flat to vary the proportion of the berm that is submerged as the water level increases
- The planform should be more heterogenous and not straight to encourage hydromorphic processes of erosion and deposition

The conceptual plan for the route of the proposed realignment is shown in Figure 4-6, with indicative cross-sections shown in Figure 4-4 and Figure 4-5 below to illustrate the proposed channel shape and desired functioning.

Source: <http://www.ayrshirerivertrust.org/blog/2014/08/11/doon-fencing-proposals-agreed/>

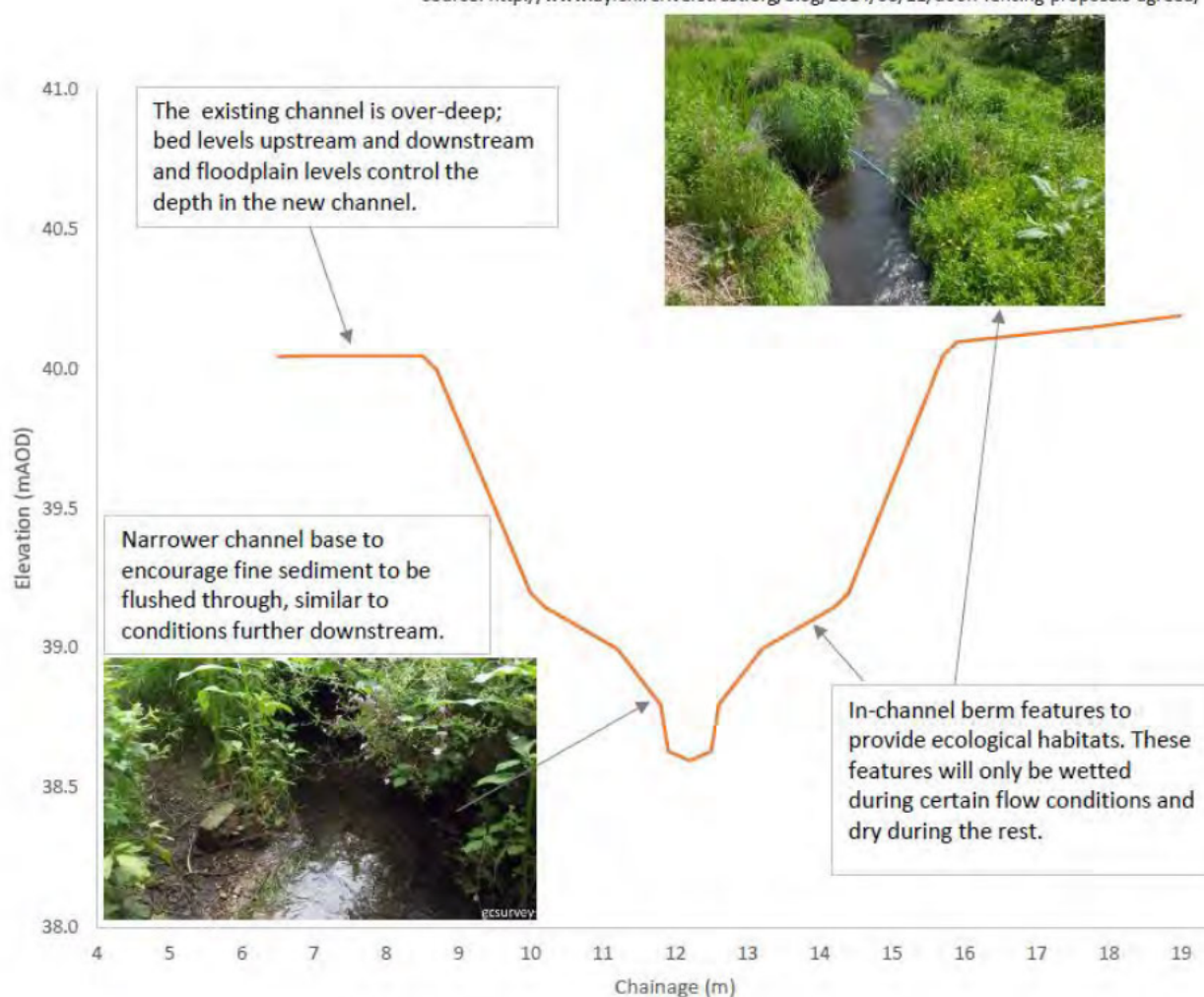


Figure 4-4: Indicative cross-section (A)

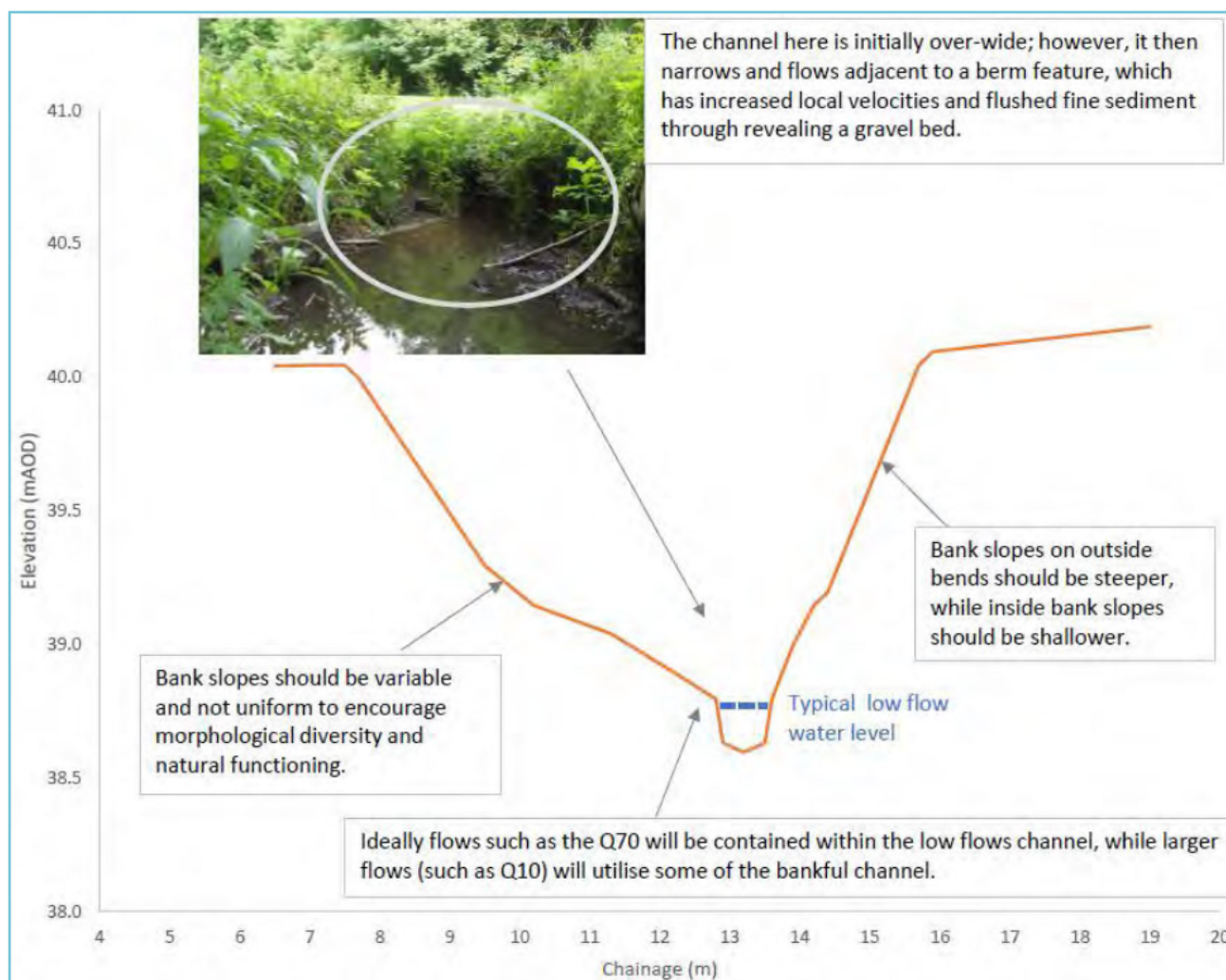


Figure 4-5: Indicative cross-section (B)

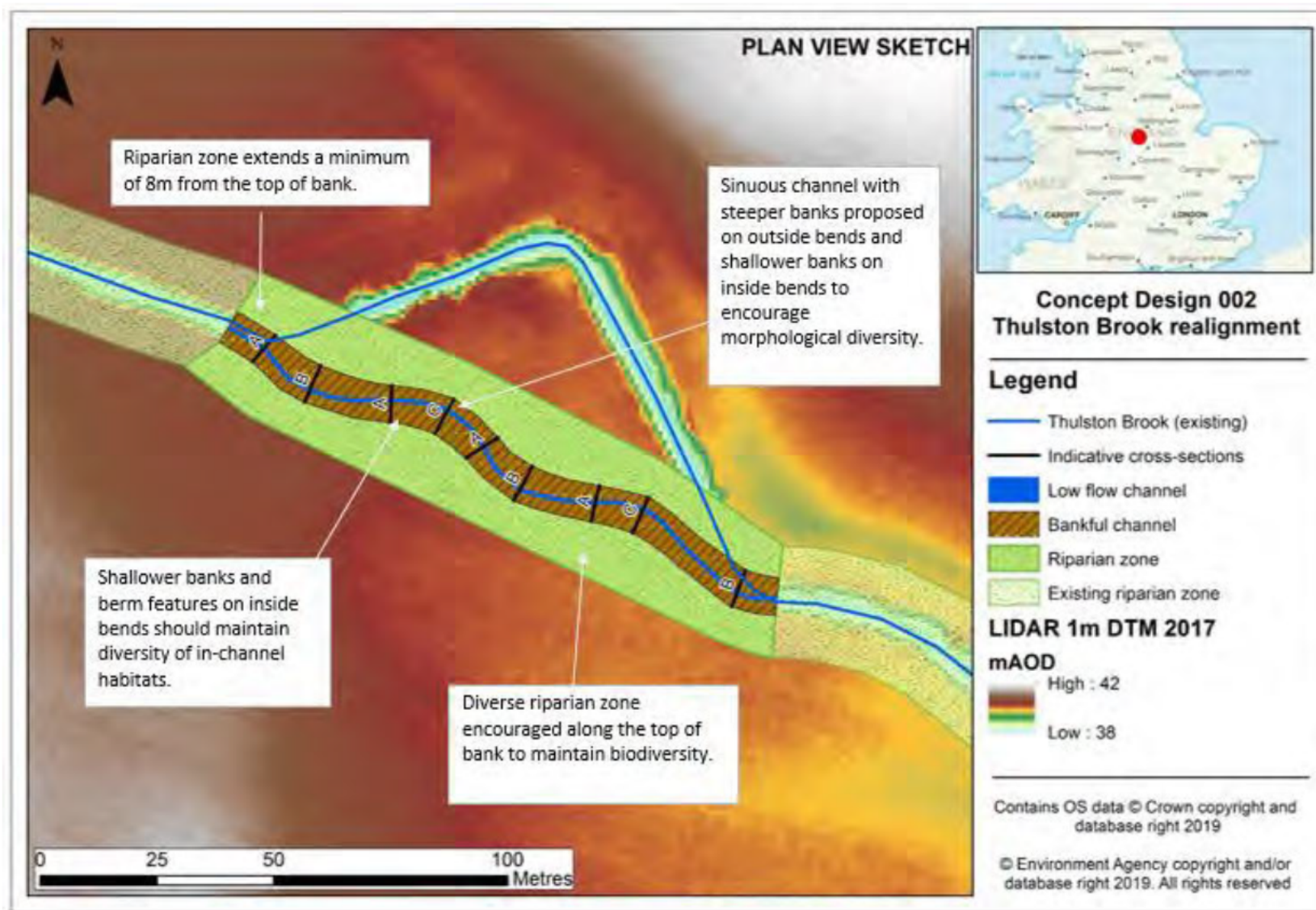


Figure 4-6: Concept design for the Thulston Brook realignment

5 Conclusions and Recommendations

5.1 Summary of baseline environmental conditions

5.1.1 Hydromorphology

The Thulston Brook through Boulton Moor is a low energy, lowland river system. The planform is straight (thought to be a result of historic physical modification rather than a natural feature) and channel geometry relatively uniform, which creates homogenous flow conditions and a lack of morphological diversity. Through the permitted development site, there does appear to be some variation to the channel shape, with some of the banks at shallower gradient than others; however, morphological diversity is still low.

The channel is disconnected from its floodplain through the study area. This has affected sediment transport mechanisms and crucial linkages between the river system and exacerbating fine sediment issues in-channel (flood flows are not able to deposit fine sediment on the floodplain during receding flows). Upstream the channel has been recently dredged (Derby City Council, 2017b), compounding the low energy nature of the watercourse through a uniform and overly-deep channel.

Biodiversity in the Thulston Brook appears high, with a diverse range of plants within the riparian zone. However, the low energy nature of the river, worsened by over-widening, has created conditions in which in-channel vegetation thrives. The channel is now mostly choked with emergent vegetation.

5.1.2 Ecology

The site offers low to moderate ecological value, with the Brook and riparian vegetation offering the highest value on site. This most recent survey (2019), did not identify any additional constraints (further to the 2018 survey), except for the potential of the site to support reptiles in low numbers. Recommendations regarding reptiles are given below in Section 5.3.1. As such, the recommendations and observations of the two most recent survey reports compiled by PAA remain valid.

5.2 Key conceptual design risks and constraints

The design and plans produced for the Thulston Brook for this study are conceptual and cross-sections have been prepared as indicative only. Further work and investigations will need to be made during subsequent design phases. Key constraints and risks are outlined below:

- The depth of the channel and the gradient is constrained by bed elevations of the local, existing channel and by floodplain levels
- The dimensions of the channel have been inferred from existing sections and from analogue sites; hydraulic modelling has not been used to inform the design, but will be required at a later design stage
- Channel bed and bank levels will need to be confirmed during the next design phase and results should be analysed in terms of sediment transport to ensure conditions are suitable to prevent siltation
- There may be sub-surface constraints that could affect the positioning of the channel, such as services or contaminated land; these will need to be investigated at the next design phase
- The works are constrained by the presence/potential presence of the following protected groups: reptile, badger, bat and breeding bird. Recommendations to avoid disturbing or harming these species are given within Section 5.3.1 of this report.

- Where possible, habitat loss should be minimised, with mature trees and hedgerows retained. This may present a constraint to the works design to make allowances for habitat retention and enhancement on site.

5.3 Recommendations

5.3.1 Ecology

Habitats

The vegetation in and adjacent to Thulston Brook was diverse and of moderate ecological value. It is recommended that where possible, the flora of the site is maintained or replaced like-for-like (where possible), using species of local provenance. Emphasis should be placed on retention as a priority, with protection throughout the works. The scheme should consider filling in the gaps within hedgerows and tree lines to improve connectivity on site (PAA, 2018).

Badgers

The works may cause disturbance to Badgers foraging locally. It is recommended that, to limit disturbance to Badger, night-time working should be avoided. All materials should be stacked securely, and all excavations should be covered overnight to prevent exploration by Badger. If this is not possible, excavations should be left with an escape ramp of no greater than 45 degrees. If night-time working is required all lighting should be downward facing, directional and fitted with a cowl to prevent light spill and directed away from areas of scrub.

Bats

The recommendations given in the recent bat survey report (compiled by PAA in 2018), remain valid following the updated survey. Whilst many of the trees on site could not be fully assessed from the ground, it is believed that the potential roosting features identified in the 2018 report have not altered and that there still remains a risk of roosting bats. Therefore, a licence would still be required from Natural England should works require arboricultural operations and should works affect Tree 6 (as defined in PAA, 2018), an emergence survey and more detailed inspection of potential roosting features would be required. The 2018 bat survey report also details recommendations for lighting and habitat retention/replacement. Should a bat be found on site during works, works must cease, and a licenced bat ecologist contacted immediately.

Birds

The nesting potential within the site area was considered to be moderate and removal of vegetation where necessary could have an adverse impact to nesting birds. The removal of vegetation should be conducted outside of the breeding season (March - September, inclusive), or preceded by a nesting bird survey by a suitably qualified ecologist. Any nests found should be safeguarded until the chicks have successfully fledged.

Reptiles

The site is unlikely to support great numbers of reptiles but as a precaution, piles of debris on site should be dismantled by hand under the supervision of an experienced Ecologist prior to removal. In addition, site materials should be securely stored on site so as to limit potential refugia for reptiles.

5.4 Next Steps

The following action plan recommends the next steps that should be undertaken to develop the concept design and progress towards detailed design, which will be required prior to construction. The following steps are recommended as a guide; however, other steps or tasks may be identified during the design process.

- Develop design concepts further to outline design stage
 - o Undertake detailed low flows modelling to determine suitable channel dimensions and hydromorphic features (i.e. height of in-channel berms, dimension and spacing of pool riffle sequences)
 - o Consider how protected species and habitats would be managed during and following the works to ensure minimal disturbance and impact
 - o Devise a plan for the riparian zone that benefits local ecology and considers any nearby analogue sites that are in good condition
 - o Consider any further site constraints not investigated during this commission; for example, whether any ground investigation works, or heritage assessments are needed prior to construction
 - o Undertake further survey work, such as sub-surface search to identify any utilities or services, that will be needed to inform the design
 - o Consider how banks and access will be managed following the works and if they will be maintained
- Prepare detailed designs
 - o Prepare necessary design documents (e.g. Designers Risk Assessment, General Arrangement drawing, Sections drawings)
 - o Prepare methodology for how the works will be undertaken
- Apply for relevant permits or licences
 - o For example, an Environmental Permit may be required; this will require design drawings and an updated WFD Assessment to assess whether the designed scheme is compliant with WFD objectives
 - o Any other licences or permits identified as necessary during the design phases

Appendices

A Preliminary Water Framework Directive Assessment

Thulston Brook realignment

Water Framework Directive PRELIMINARY Assessment

Final Report

August 2019

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Contract

This report describes work commissioned by Cannon Consulting Engineers, on behalf of JSC Farming Ltd and Central Land Holdings Ltd, by an email dated 16.05.2019. JSC Farming Ltd and Central Land Holdings Ltd's representative for the contract was James Howard of Cannon Consulting. Rebecca Thrower and Catherine Porter of JBA Consulting carried out this work.

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Purpose

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Abbreviations

JBA	Jeremy Benn Associates
HMWB	Heavily Modified Water Body
WFD	Water Framework Directive

1 Introduction

1.1 WFD Overview

The Water Framework Directive (WFD) came into force in 2000 and is the most substantial piece of EU water legislation to date. All new activities in the water environment will need to take the Directive into account. The Directive imposes legal requirements to protect and improve the water environment.

1.1.1 Scope of the WFD Assessment

The EU Water Framework Directive was transposed into law in England and Wales by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. The 2003 regulations were consolidated and replaced with the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. The Directive requires that Environmental Objectives be set for all surface and ground waters in England and Wales to enable them to achieve Good Status (or Good Ecological Potential for Heavily Modified and Artificial Water Bodies) by a defined date. These Environmental Objectives are listed below:

- Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters.
- Aim to achieve at least good status/potential for all water bodies by 2021. Where this is not possible and subject to the criteria set out in the Directive, aim to achieve good status/potential by 2027.
- Meet the requirements of Water Framework Directive Protected Areas.
- Promote sustainable use of water as a natural resource.
- Conserve habitats and species that depend directly on water.
- Progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment.
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants.
- Contribute to mitigating the effects of floods and droughts.

1.1.2 Preventing Deterioration in Status

Any activity which has the potential to have an impact on the ecology of a water body will need consideration in terms of whether it could cause deterioration in its Ecological Status or Potential¹.

For each water body, three different status objectives are identified within the RBMP. These are the overall status objective, the ecological status or potential objective and the chemical status objective. A default objective for all water bodies is to prevent the deterioration in the Ecological Status (or Ecological Potential for Heavily Modified and Artificial Water Bodies) of the water body. Note, the Ecological Status applies only to surface water bodies, and not ground water bodies. A separate assessment may be required to assess the impacts on the chemical and quantitative status of a ground water body, if the proposed activity is likely to cause impact.

The Ecological Status of a water body is determined through analysis of its constituent Biological Quality Elements. These elements are in turn supported by a series of Physico-Chemical and Hydromorphological Quality Elements. These Quality Elements are taken from Annex V of the Directive and are listed below. The overall Ecological Status is determined by the lowest element status.

The Biological Quality Elements assessed in the WFD include:

- Fish
- Invertebrates
- Macrophytes
- Phytobenthos

The WFD defines the flow, shape and physical characteristics of a watercourse as its 'hydromorphology'. Any in-channel works can impact upon the shape of a watercourse and the natural processes that occur within it, including:

- Flow patterns
- Width and depth of a channel
- Features such as pools, riffles, bars and bank slopes
- Sediment availability/ transport
- Interaction between a channel and its floodplain
- Ecology and biology (i.e. habitats which support plants and animals)

The WFD considers the chemistry of a watercourse through general water quality (physico-chemical measurements) and chemical pollutants. All three environmental components; morphology, hydrology and chemistry, support the Biology of a water body.

Any activity that has the potential to have an impact upon any of the Quality Elements will need consideration in terms of whether it could cause a deterioration in the status of a water body. The activity will also need to be considered in terms of whether it will compromise the ability of the water body to reach Good Ecological Status or Good Ecological Potential by the date specified in the Catchment Data Explorer.

Any adverse impacts can cause a water body's ecology to deteriorate and prevent environmental improvements from being undertaken. Nevertheless, in-channel works can also be beneficial if they can be designed to help achieve environmental improvements included in the RBMP, thus enhancing the water environment for plants and animals.

1.1.3 Artificial or Heavily Modified Water Bodies

Whilst good ecological status is defined as a slight variation from undisturbed natural conditions in natural water bodies, artificial and heavily modified water bodies are unable to achieve natural conditions. Instead, artificial and heavily modified water bodies have a target to achieve Good Ecological Potential, which recognises their important uses, whilst making sure ecology is protected as far as possible. Ecological potential is also measured on the scale high, good, moderate, poor and bad. The chemical status of these water bodies is measured in the same way as for natural water bodies.

Specific mitigation measures have been identified for each Artificial and Heavily Modified Water body and are listed in the RBMP. These mitigation measures are necessary to reduce the existing hydromorphological impacts on the water body and all measures need to be in place in order for the water body to achieve Good Ecological Status or Potential.

1.2 Purpose of this WFD Assessment

JBA Consulting was commissioned by JSC Farming Ltd and Central Land Holdings Ltd to undertake a WFD assessment for a proposed realignment of a section of the Thulston Brook in Derby.

This WFD assessment constitutes a Preliminary Assessment as it has been prepared during the first stage of the design process, in which only a conceptual design is available. This Assessment is intended to inform the design process and to demonstrate whether the works have the potential to be WFD-compliant; it will need to be updated during the detailed design stage to assess whether the works are compliant with WFD before construction can begin.

This Preliminary WFD Assessment aims to determine the effects of the proposed realignment on ecological, hydromorphological and chemical quality and identify any potential impacts that could cause deterioration in the current status of the water body or could hinder the water body from meeting its WFD objectives in the future.

The Thulston Brook is not defined under the Water Framework Directive as a standalone water body. Instead, it falls within Derwent from Bottle Brook to Trent water body (GB104028053240) which falls within the Humber River Basin District (RBD). The Environmental Objectives, together with the specific actions (mitigation measures) necessary to enable the water body to meet these objectives, are set out in the Humber River Basin District River Basin Management Plan (RBMP) (Environment Agency (EA), 2009) and Catchment Data Explorer (EA, 2019).

2 Assessment Methodology

2.1 Overview

The following flow chart summarises the WFD Assessment process.

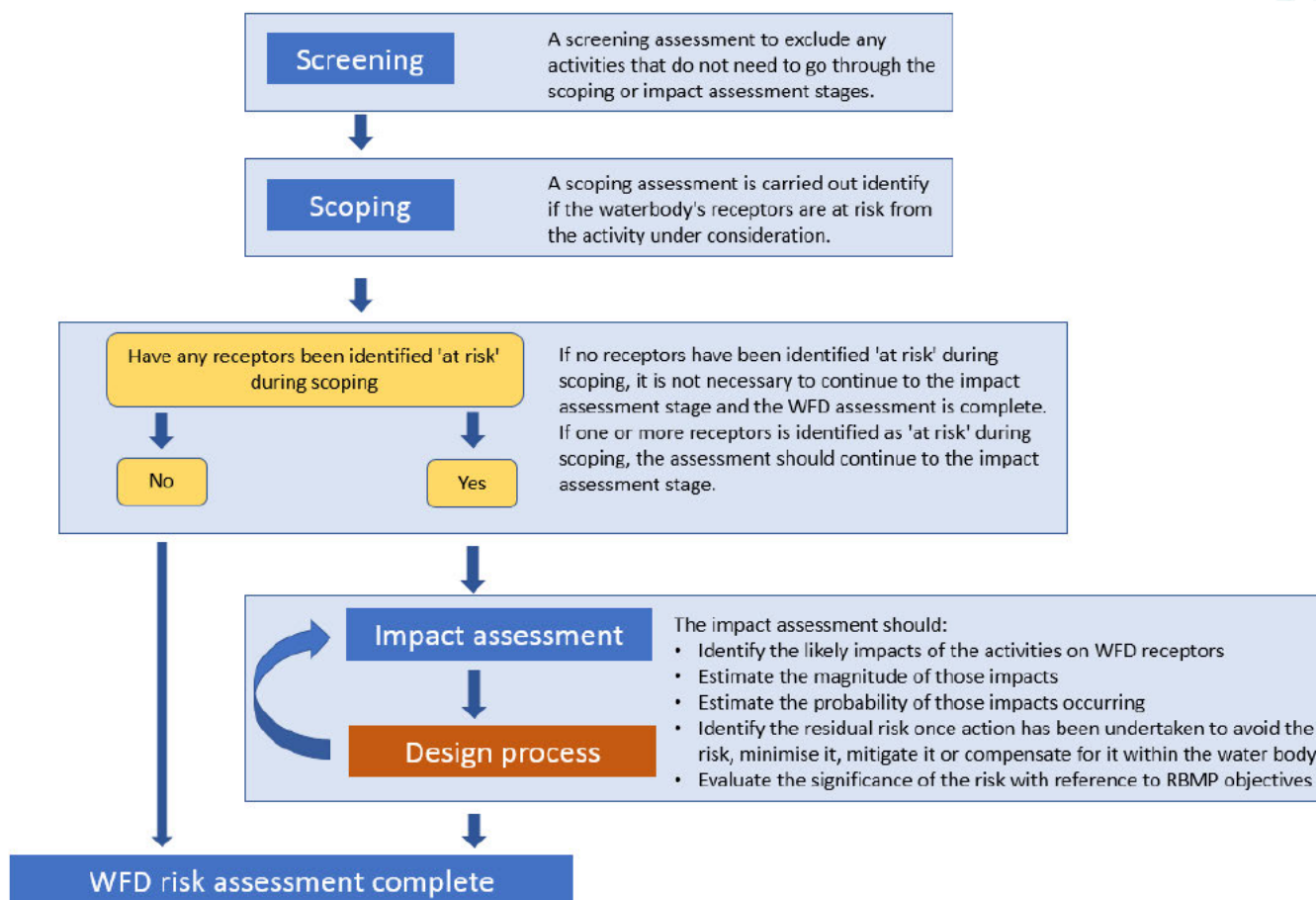


Figure 2-1: WFD assessment process flow chart

2.2 Screening Assessment

The Screening Assessment aims to exclude any activities that do not need to go through the scoping or impact assessment stages.

The Humber RBMP and the Environment Agency's web-based Catchment Data Explorer were used to determine which water bodies could be potentially affected by the proposed works. The names, ID numbers, designation, status classification and objectives for all relevant water bodies were obtained and downloaded from the EA's Catchment Data Explorer.

The initial stage of the assessment screens the proposed works against the Ecological and Chemical Status objectives for the water bodies potentially affected by the works, together with their Quality Elements. The aim of this process is to determine whether the works could have an impact upon any of these criteria. Those criteria for which no potential adverse effects are identified are not considered further in the assessment. Any potential adverse effects are screened into the assessment and are carried forward to a detailed assessment.

2.3 Scoping Assessment

A detailed assessment is then undertaken to determine the effects that the proposed works could have upon those Quality Elements screened into the assessment. Any impacts identified are then considered in relation to the Ecological Status of the water body, which

comprises biology, hydrology, hydromorphology and water chemistry, and the water body objectives.

The following assessment objectives are then used to determine whether the proposed works comply with the overarching objectives of the WFD. These objectives were derived from the Environmental Objectives of the Directive (as listed in section 1.2).

- Objective 1: The proposed scheme does not cause deterioration in the Status of the Ecological Elements of the water body.
- Objective 2: The proposed scheme does not compromise the ability of the water body to achieve its WFD status objectives.
- Objective 3: The proposed scheme does not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD.
- Objective 4: The proposed scheme contributes to the delivery of the WFD objectives.

In order to establish whether the strategy complies with the WFD it is necessary to ascertain whether the preferred options have the potential to result in:

- Failure of a water body to achieve Good Ecological Status or Potential; or
- Failure to prevent a deterioration in the Ecological Status or Potential of a water body

If the answer to these questions is 'no' the strategy can be considered WFD compliant. If either of these failures is identified and if any receptors are identified as 'at risk', further assessment may be required to identify if the strategy meets all of the conditions set out by the WFD Legislation.

2.4 Impact Assessment

The third stage of the WFD Assessment, if determined as necessary from the Screening and Scoping Assessments, is to undertake an Impact Assessment to consider the impacts of the proposed scheme in more detail and recommend necessary mitigation measures. An impact assessment must be carried out for each receptor identified during scoping as being at risk from your activity.

The Impact Assessment describes how any identified impacts from the proposed scheme will be mitigated, to either avoid or minimise the impacts. The assessment shows how any impact on WFD receptor caused by the proposed activity fits with the objectives of any affected WFD water bodies. After the works have been amended to try and avoid, minimise, mitigate or compensate for the risks to WFD receptors the following questions will need to be answered:

- Could the activity still cause a water body to deteriorate from one WFD status class to another or cause significant localised impacts that could contribute to this happening?
- Could the activity prevent or undermine action to get water bodies to good status?

When these questions are answered, the following should be borne in mind:

- A water body deteriorates in status when one WFD receptor (an "element") is affected such that it drops from one WFD status class to another.
- A significant localised impact on an element is one that is either long-lasting; causes severe harm; or affects a wide area within a water body. These are likely to contribute to a water body dropping from one status to another and highly likely to prevent action to get water bodies to good status.

- Elements at high status are very sensitive. The assessment will need to demonstrate that there will be a negligible impact on those aspects of the water environment
- Elements at bad status must not be made worse.

If it cannot be demonstrated with a high level of confidence that the activity supports RBMP objectives then, in order for the Environment Agency to permit the activity, it must be shown that the activity meets the criteria set out in Article 4(7) of the WFD. Article 4(7) sets out stringent environmental and socio-economic tests to assess if a scheme meets strict environmental and sustainability criteria.

3 Project Description

3.1 Project Overview

The Thulston Brook flows in an easterly direction through a permitted development site at Boulton Moor, Derby, which is currently greenfield and used for agriculture (Figure 3-1). Outline planning permission for the site has been received. The developers would now like to explore options for the removal of the 'kink' in the watercourse, which appears in the centre of the site and is limiting the development plan. This Preliminary WFD Assessment considers the impacts of the proposed realignment (and not the impact of the permitted urban development).

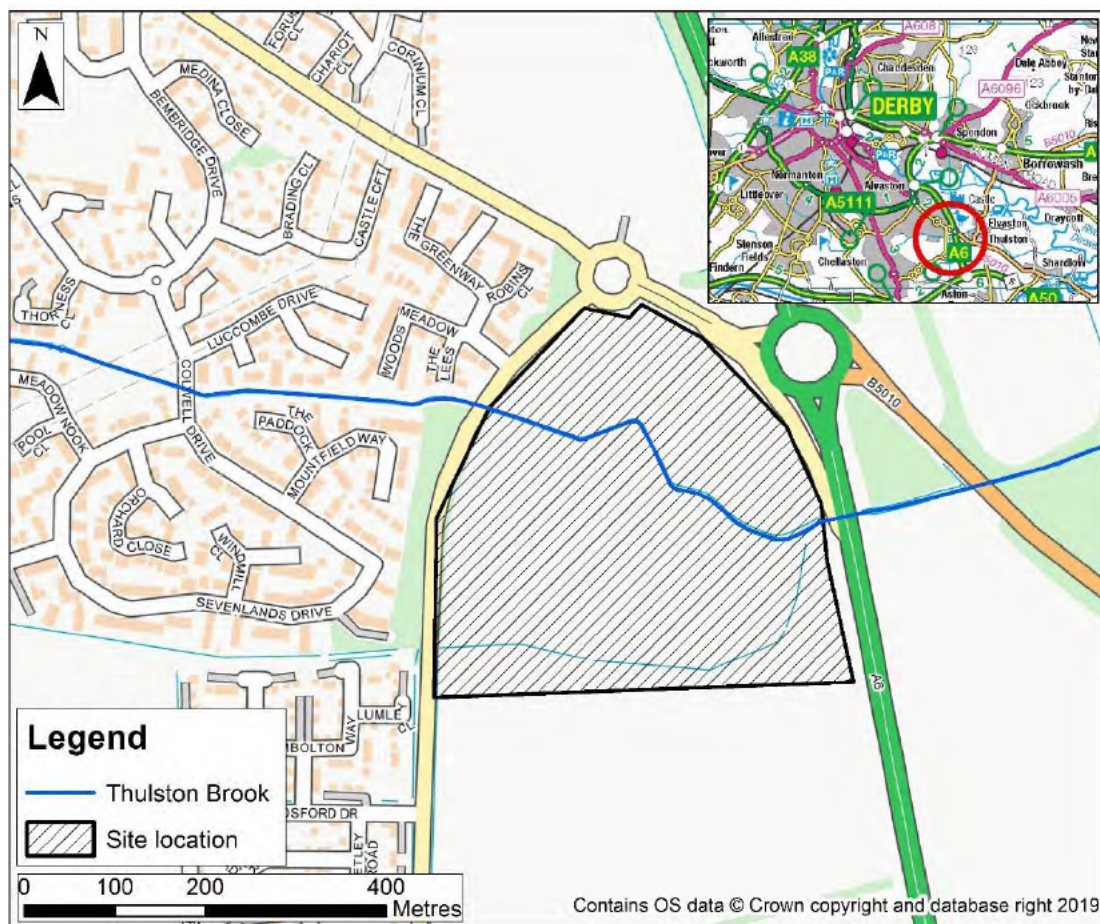


Figure 3-1: Site location

3.2 Proposed Works

JBA Consulting has been commissioned to prepare the concept design of the proposed realignment. The concept design comprises a plan view sketch of the proposed realignment (Figure 3-2) and indicative cross-sections. As part of the proposed works, a new section of channel would be created between NGR 439950 331970 and NGR 440060 331920. The old section of channel would be filled in as part of the urban development.

Key aspects of the design include the following:

- The channel should be sufficiently sized to encourage sediment transport expected to operate during different flow conditions
- The channel width and shape should be heterogenous and not uniform, to encourage preferential wetting and diversity in flows
- The inside and outer bends should display a range of bank slopes, with the inside bends shallower and the outer banks steeper, to add variability to the channel

- The berm features (i.e. those forming the 'benches' of the channel above the low flows channel) should be sloped and curved rather than flat to vary the proportion of the berm that is submerged as the water level increases
- The planform should be more heterogenous and not straight to encourage hydromorphic processes of erosion and deposition

There will be a slight reduction in channel length by 20m. Hydraulic modelling has been undertaken to determine the impact of this on flood risk.

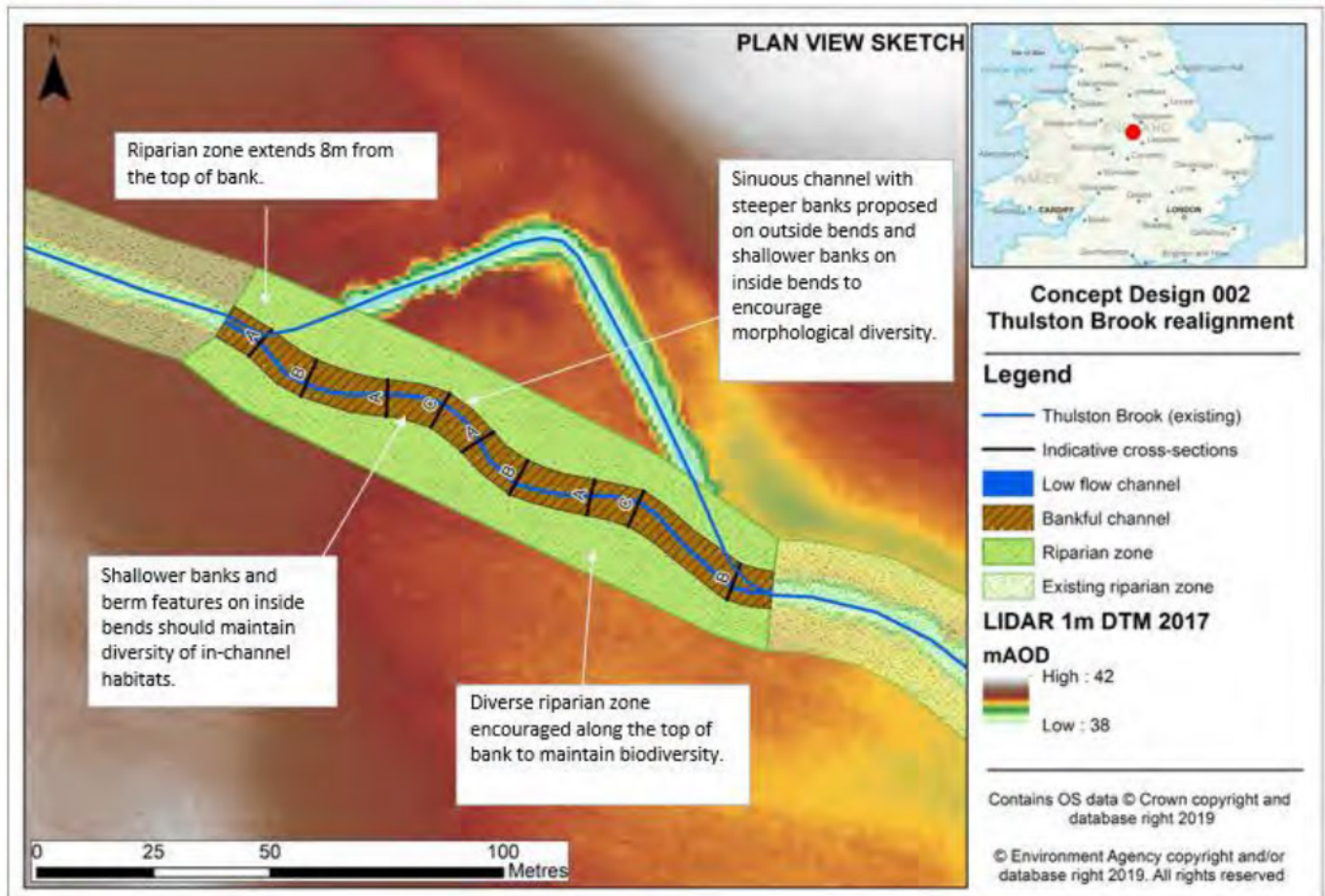


Figure 3-2: Proposed realignment

4 WFD Screening Assessment

4.1 Overview

This screening assessment aims to screen in any works that require WFD Assessment and to identify which WFD water bodies are within and near to the proposed works.

The results of the assessment are presented below. A full and detailed WFD assessment would be required should it be concluded that the scheme could cause deterioration in the status of the water body or prevent it from achieving its status objectives. The baseline status of elements within water bodies screened into the assessment are discussed in this chapter.

4.2 WFD water bodies

4.2.1 WFD water bodies

Although the Thulston Brook is classified as main river, it is not defined under the Water Framework Directive as a standalone water body. Instead, it falls within Derwent from Bottle Brook to Trent water body (GB104028053240) which falls within the Humber River Basin District (RBD). For the purposes of this assessment, the status and objectives of the Derwent from Bottle Brook to Trent water body have been applied to the Thulston Brook.

The proposed works are located above the Derwent – Secondary Combined groundwater body; however, as discussed in Chapters 1 and 2, this assessment considers the impacts to the Ecological Status, which is a classification of surface water bodies but not groundwater. Potential impacts to groundwater are considered within the Hydromorphology element; Connectivity to groundwater.

4.2.2 Current status

Details of the classification, status and objectives, as described by the EA Catchment Data Explorer, are summarised in Table 4-1 below.

Table 4-1: Current WFD status

Water body ID	Name of water body	Hydromorphological designation	Current Overall Status/ Potential	Overall Status Objective
GB104028053240	Derwent from Bottle Brook to Trent	Heavily Modified	Moderate	Moderate (2015) - Objective has been reached; main objective is now to prevent deterioration in status between 2015 and 2021.
GB40402G990400	Derwent – Secondary Combined	Not applicable – groundwater body	Poor	Good (2027)

4.3 Screening Outcome: water bodies

The following table indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

Water body/ies	Reason	Screening outcome
Derwent from Bottle Brook to Trent	The proposed realignment is within this water body catchment. In the absence of its own water body to assess the works by, this water body will be screened into the assessment.	Screened in

4.4 Baseline Status of screened-in water bodies

For each water body screened into the assessment, details on the status of each element, as described by the EA Catchment Data Explorer (2019), are given below.

4.4.1 Derwent from Bottle Brook to Trent water body

The three tables below describe the current status of the Ecological Elements according to the most recent WFD cycle.

Biological Quality Element	Current Status (2016)	Objective
Macrophytes and Phytobenthos Combined	Moderate	Moderate (2015)
Fish	Good	Good (2015)
Invertebrates	High	Good (2015)

Hydromorphological Quality Element	Current Status (2014)	Objective
Hydrological Regime	Supports good (no status in 2015 or 2016)	Not assessed
Morphology	Not assessed	Not assessed

Physico-Chemical Quality Element	Current Status (2016)	Objective
Ammonia (Phys-Chem)	High	Good (2015)
Biochemical Oxygen Demand (BOD)	High	Not Given
Dissolved Oxygen	High	Good (2015)
pH	High	Good (2015)
Phosphate	Moderate	Moderate (2015)
Temperature	Good	Good (2015)

4.5 Protected Areas

The WFD specifies that areas requiring special protection under other EC Directive and waters used for the abstraction of drinking water are identified as protected areas. These areas have their own objectives and standards. Article 4 of the WFD requires Member States to achieve compliance with the standards and objectives set for each protected area by 22nd December 2015, unless otherwise specified in the community legislation under which the protected area was established.

There are no statutory designated sites within 2km of the works area. In addition, there are no riverine protected sites within the vicinity of this 2km buffer.

4.5.1 Nitrate Vulnerable Zones (NVC)

The European Commission Nitrates Directive requires areas of land that drain into waters polluted by nitrates to be designated as Nitrate Vulnerable Zones (NVZs).

There are no nitrate vulnerable zones within 2km of the works area.

4.5.2 Drinking Water Groundwater Safeguard Zones (SgZ)

Drinking Water Protected Areas (DrWPA) are designated under the Water Framework Directive, with the aim of avoiding deterioration in their quality in order to reduce the level of purification treatment required in the production of drinking water. SgZs are areas where actions will be targeted to address the causes of DrWPA objective failure/risk of failure.

There are no Drinking Water Safeguard Zones (Groundwater) within 2km of the works area, however there is one Drinking Water Safeguard Zone (Surface Water) within the works area:

- Humber (SWSGZ2302) Church Wilne Res & Lower Derwent.

4.6 Summary

To conclude the Screening Assessment, the following quality elements need to be considered further within the Scoping Assessment:

- Derwent from Bottle Brook to Trent
 - o Biological Elements
 - o Hydromorphological Elements
 - o Physico-chemical Elements

5 WFD Scoping Assessment

5.1 Overview

This scoping assessment identifies whether the water body's receptors, identified during the screening assessment, are at risk from the proposed works discussed in Chapter 3. This assessment is supported by the evidence in the main report². The proposed development works are being appraised in terms of their impact on WFD status and objectives.

Some WFD Quality Elements have not been formally assessed as part of the classification for this water body. However, due to the scale and nature of the proposed works, all WFD Quality Elements have been included in the previous screening and any identified impacts have been considered in relation to the ecological status of the water body and the status objectives.

Article 4.7 of the Directive defends deterioration in status or failure to meet WFD objectives resulting from new modifications or sustainable human development activities (if all conditions set out under this Article are met). If the assessment procedure predicts that an activity will cause deterioration in water body status or prevent a water body from meeting its ecological objectives, then an assessment is also required against the conditions listed in Article 4.7 of the WFD. European Member States will not be in breach of the WFD if all the assessment conditions are met.

5.2 Derwent from Bottle Brook to Trent water body

5.2.1 Biological Quality Assessment

Table 5-1 represents an assessment of the proposed works against the biological quality elements of the Derwent from Bottle Brook to Trent (GB104028053240) water body.

Table 5-1: Assessment of works against the biological elements

WFD Quality Element	Current Status	Potential Impact	Consider in impact assessment?
Macrophytes and Phytobenthos Combined	Moderate	The proposed channel realignment will result in the direct loss of macrophytes and phytobenthos as sections of the existing channel are lost. The works have the potential to make the channel less suitable for macrophytes and phytobenthos to establish in the new channel, however, the proposed measures to increase the heterogeneity of the channel will lessen this effect. Any pollution associated with the temporary works may indirectly affect macrophytes and phytobenthos downstream by attenuating the light and reducing photosynthesis or by negatively affecting the chemical composition of the flow. Finally, should any aquatic invasive non-native species be present in the channel, the works have the potential to spread these without adequate control.	Yes
Fish	Good	Records held by the Environment Agency indicate the presence of Gudgeon <i>Gobio</i>	Yes

		<i>gobio</i>, Common Minnow <i>Phoxinus phoxinus</i>, Common Barbel <i>Barbus barbus</i>, Common Bream <i>Abramis brama</i>, Silver Bream <i>Abramis bjoerkna</i>, Grayling <i>Thymallus thymallus</i>, Rudd <i>Scardinius erythrophthalmus</i>, Common Bleak <i>Alburnus alburnus</i>, Perch <i>Perca fluviatilis</i>, Chub <i>Leuciscus cephalus</i>, Dace <i>Leuciscus leuciscus</i> and Roach <i>Rutilus rutilus</i> within the River Derwent approximately 4.2km downstream of the proposed works location. It is possible that many of these species are present in Thulston Brook and within the works footprint. These species need to be considered in the works methodology. During construction, there is the potential for fish populations to be negatively impacted through temporary habitat loss/disturbance, noise and vibration, temporary fish passage inhibition, sediment mobilisation and fuel spills. Should dewatering take place, this may also leave fish stranded without appropriate rescue. During operation, there is the potential for fish populations to be impacted through changes to the hydrodynamic regime.	
Invertebrates	High	The proposed channel realignment will result in the direct loss of invertebrates as sections of the existing channel are lost. The works have the potential to make the channel less suitable for invertebrates to establish in the new channel, however the proposed measures to increase the heterogeneity of the channel will lessen this effect. Finally, any pollution associated with the temporary works may indirectly affect invertebrates downstream by negatively affecting the chemical composition of the flow and by suffocating those affected by sedimentation.	Yes

5.2.2 Hydromorphological Quality Elements

Table 5-2 presents an assessment of the proposed works against the hydromorphological quality elements of the Derwent from Bottle Brook to Trent (GB104028053240) water body.

Table 5-2: Assessment of works against the hydromorphological quality elements

WFD Quality Element	Current Status	Potential Impact	Consider in Impact Assessment?
Hydrology: Quantity and Dynamics of flow	Supports good	The proposed realignment would not impact the quantity and dynamics of flow in the river channel.	No
Hydrology: Connection to ground water bodies	Supports good	The proposed works will involve realignment and movement of part of the river channel. The new channel will maintain a natural bed in which flows and sediment can be exchanged between the ground water body and the fluvial system. The depth of the 'new' channel will be consistent with the existing channel and deep excavations should not be necessary as part of the temporary works; therefore, the groundwater level is not expected to change or be affected by the channel realignment works.	No
River Continuity	Not assessed	The proposed works will involve physical modification of the river channel over a distance of approximately 100 to 150m. The realignment will reduce overall channel length by approximately 20m, which has the potential to increase velocities by shortening the flow path. No in-channel structures are proposed so longitudinal river continuity should be unaffected. However, the change to sediment dynamics with the change in channel planform has the potential to impact this element, both locally and at the reach scale.	Yes
Morphology: River width and depth	Not assessed	The proposed works will involve physical modification of the river channel over a distance of approximately 100 to 150m. This will change the river width and the depth of the river during certain flow conditions, which has the potential to influence sediment transport processes. The overall width and depth of the river channel compared to surrounding ground levels (former floodplain, but now severely disconnected as shown by the hydraulic modelling) will remain similar to existing, given that the upstream and downstream bed levels will control the gradient of the modified reach and the top of bank levels (which will need to correspond to ground levels within the riparian zone) will contribute to controlling the overall depth of the channel.	Yes
Morphology: Structure and substrate of the riverbed	Not assessed	The proposed works will involve physical modification of the river channel over a distance of approximately 100 to 150m. A new channel bed will be created during the works; it is expected that excavation of (former) floodplain	Yes

		material will create a bed substrate similar to existing, given that the channel is not being moved far from its existing position and there is no notable change in the geology maps between these locations. Given that a change to sediment transport conditions is expected, there is the potential for an indirect change to the local bed substrate over time. Hopefully a reduced channel width during low flow conditions would mean fine sediment is transported rather than deposited, which could initiate a shift towards a coarser bed substrate with less silt deposition. However, geotechnical surveys may be required during a later design stage to determine the exact nature of the ground material.	
Morphology: Structure of the riparian zone	Not assessed	The proposed works will involve physical modification of the river channel over a distance of approximately 100 to 150m. This will involve creation of a new riparian zone and will impact the existing structure.	Yes

5.2.3 Physico-Chemical Quality Assessment

Table 5-3 presents an assessment of the proposed works against the physico-chemical quality elements of the Derwent from Bottle Brook to Trent (GB104028053240) water body water body.

Table 5-3: Assessment of works against the physico-chemical quality elements

WFD Quality Element	Current Status	Potential Impact	Consider in Impact Assessment?
Acid Neutralising Capacity	High	The acid neutralising capacity of the waterbody is unlikely to be affected by the proposed scheme because channel inputs are likely to be kept to a minimum, with the focus on maintaining the natural chemistry of the river.	No
Biochemical Oxygen Demand (BOD)	High	Dissolved Oxygen levels and Biochemical Oxygen Demand (BOD) could be affected by short-term increased sedimentation if silt mobilisation occurs during the proposed works. The pH level of the water body could be impacted by in-channel works involving concrete.	Yes
Dissolved oxygen	High		
pH	High		
Ammonia (Phys-Chem)	High	The proposed works are considered to not have an effect on the other physico-chemical elements listed here, as in-channel works are highly unlikely to affect the Ammonia, Phosphate or Temperature of the water body.	No
Phosphate	Moderate		
Temperature	Good		
Chemical (GW)	Poor		

5.3 Impacts of works on protected sites

Table 5-4 presents an assessment of the proposed works against any protected sites identified in the Derwent from Bottle Brook to Trent (GB104028053240) water body.

Table 5-4: Assessment of works on protected sites

Name	Current status	Potential Impact	Consider in Impact Assessment?
Drinking Water Safeguard Zone (Surface Water): Humber (WSGZ2302) Church Wilne Res & Lower Derwent	At risk from: MCPA and Metaldehyde (herbicide and pesticide respectively).	As the surrounding land is arable, there is a slight risk that by realigning the river channel, herbicides and pesticides are introduced to the waterbody.	Yes

6 WFD Impact Assessment

6.1 Overview

The Scoping Assessment presented in Chapter 5 identified some receptors may potentially be at risk from the proposed works. An Impact Assessment is therefore required to describe how these identified impacts will be mitigated.

The Impact Assessment needs to consider if there is a pathway linking the pressure to the receptor. If there is no pathway there can be no impact on the receptor and there is no need for any further assessment of that receptor to be carried out. If there is a potential pathway the assessment should consider if the activity, and the pressure it creates, may cause deterioration of the receptor.

In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD Quality Elements, this section should be revised.

6.2 Impact Assessment

Table 6-1 discusses each of the receptors identified as being potentially at risk in the scoping assessment. Mitigation measures are recommended to mitigate the effects of the proposed works. It should be noted that these mitigation measures differ to the Mitigation Measures identified for any Heavily Modified water body.

Table 6-1: Impacts and mitigation measures

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Macrophytes and Phytobenthos Combined	Direct	Temporary impacts upon macrophytes and phytobenthos are likely as a result of small areas of vegetation clearance in the immediate footprint of the works. In addition, any in-channel works have a greater potential for permeant impacts on the existing macrophytes and phytobenthos communities. Provided an appropriate naturalised design is drawn up with suitable substrates, it is anticipated that macrophytes and phytobenthos will re-colonise the area once in-channel works are completed. As a precaution against any unidentified in channel invasive non-native species, the check-clean-dry approach to biosecurity will be required throughout the works. Pollution prevention measures should be followed throughout the works to reduce sediment mobilisation and the potential for pollution events (e.g. silt curtains, pollution booms).
Fish	Direct and Indirect	Dependent on the final design there are potential impacts on any fish species present. Due to the temporary nature of the works themselves and provided appropriate fish bypasses are in place during any de-watering and in-channel works (if intended), disturbance to fish fauna during the construction phase is not anticipated to be significant as fish are expected to avoid the immediate area during works.

		The detailed design of the realigned channel will dictate whether there are any longer-term impacts on the fish fauna present within the river. Provided the new channel incorporates appropriate bed substrates, flow conditions and allows for fish passage and refuge for juvenile fish, there are anticipated to be no permanent impacts on fish as a result of the proposed works. The channel substrate was very silty and, as such, less suitable for spawning; a suitable channel design may provide a positive impact if this consideration is incorporated. Any in-channel works could also affect water chemical and physio-chemical elements needed to support fish. There is also a risk of pollution incidents (e.g. from machinery) which could also cause localised mortalities to fish if not mitigated. Therefore, pollution prevention measures should also be followed to reduce sediment mobilisation (e.g. silt curtains), with the works' compound located 10m away from the riverbank, and fuel appropriately stored. Relevant Guidance should be adopted e.g. CIRIA Guidance: <i>Control of water pollution from construction sites. Guidance for consultants and contractors (C532D)</i> (Masters-Williams, 2001).
Invertebrates	Direct and Indirect	Any works involving de-watering the watercourse and excavating bed materials are likely to impact on the invertebrate community. Bed materials should be removed and stored on site during the construction phase. Upon completion of the works, all bed materials should be reinstated to help facilitate recolonisation by macroinvertebrate fauna retaining natural bed habitats as far as practically possible. Any in-channel works have the potential to mobilise sediments which could impact upon habitat for invertebrate fauna. Due to the ephemeral nature of invertebrates, this receptor is anticipated to quickly recolonise from upstream following the works, providing that appropriate pollution prevention and silt mobilisation measures are put in place during the temporary works.
River Continuity	Direct	The proposed works will involve physical modification of the river channel over a distance of approximately 100 to 150m. The realignment will reduce overall channel length by approximately 20m, which has the potential to increase velocities by shortening the flow path. However, given that the channel appears to be in a low energy state with glide and extended pool biotopes characterising the flows, this reduction in channel length is not expected to cause significant change to existing flow and sediment transport dynamics. However, it is recommended that the overall length is not reduced any further.
Morphology: River width and depth	Direct	
Morphology: Structure and substrate of the riverbed	Direct and indirect	

		Over the length of the works the river width and the depth during certain flow conditions will be changed (unknown at this stage), which has the potential to influence sediment transport processes by narrowing the channel width during lower flows. The overall depth of the river channel compared to existing ground levels (former floodplain) will remain similar to existing, given that the upstream and downstream bed levels will control the gradient of the modified reach and the ground levels within the riparian zone will contribute to controlling the overall depth of the channel. This should mean increased velocities during lower flows, which would generate increased transportation of finer sized sediment such as silt. This could initiate a shift towards a coarser bed substrate with less silt deposition, which would be favourable to the watercourse. The change in planform from a straight channel to a more sinuous course has the potential to diversify in-channel morphology; albeit on a small scale. Geotechnical surveys may be required during a later design stage to determine the exact nature of the ground material within the proposed channel area. During the works there is the potential for fine sediment pollution which could impact downstream reaches; a sediment management plan should be created and adhered to, to outline the planned control of fine sediment.
Morphology: Structure of the riparian zone	Direct	The proposed works will involve creation of a new channel and therefore a new riparian zone will need to be established. Temporary disruption to the riparian zone could expose bare earth banks which may be vulnerable to erosion. To mitigate the potential for bank instability and exposure of fine sediment which could pollute the channel, re-planting of species found upstream and downstream should be undertaken as soon as possible. The works should be undertaken in suitable seasons to allow vegetation to establish (i.e. spring or summer). An adequate buffer zone should be maintained between the proposed urbanisation of the floodplain and the river channel, to prevent encroachment on the riparian zone and to limit transfer of on-site pollutants to the river.
Biochemical Oxygen Demand (BOD) and Dissolved Oxygen	Direct	Any in-channel works could cause suspension of silt which could reduce the dissolved oxygen levels within the waterbody, also indirectly impacting upon the fish fauna in the river. The likelihood of silt mobilisation would be greatly reduced if the channel is de-watered. Pollution prevention and silt management measures (e.g. silt curtains) should be followed throughout the works.

		Regular monitoring of Dissolved Oxygen (DO) levels should be undertaken during in-channel works immediately downstream of the works area. If DO levels fall below 5mg/l, works should be paused, and a fisheries expert should be consulted.
pH	Direct	The proposed works have the potential to impact upon the pH quality element of the waterbody, especially if any concrete is to be used in the final design. In addition, the soil to be used to re-grade and re-instate the riverbanks has the potential to be washed into the waterbody and alter its pH status. The use of concrete within the channel should be minimised where possible. All soils and substrates used in the proposed works should be of an appropriate origin and as close to the original, local composition as possible.
Drinking Water Safeguard Zone (Surface Water): Humber (WSGZ2302) Church Wilne Res & Lower Derwent	Indirect	Due to the historic use of the site for agriculture, it is considered likely that sediments within the works extent are contaminated and are potentially storing nitrates, pesticides and herbicides from agricultural run-off. It is recommended that further investigations are carried out to test for soil contamination. Any in-channel works, and excavation of the new riverbed have the potential to release any contaminated sediments into suspension. The likelihood of silt mobilisation would be greatly reduced if the channel is de-watered. Pollution prevention and silt management measures (e.g. silt curtains) should be followed throughout the works.

6.3 Water body Mitigation Measures

According to the Humber RBMP (Annex B, 2009), the Derwent waterbody is designated as Heavily Modified for the following reasons/uses:

- Drinking Water
- Flood Protection
- Urbanisation
- Water Regulation (impoundment release)
- Water Regulation (strategic transfer)

To reduce the hydromorphological impact of these uses, several mitigation measures were defined. Table 6-2 appraises whether the proposed works are likely to help deliver these mitigation measures, or whether they have the potential to prevent their implementation.

The RBMP has been updated since these measures were defined (2015); however, an updated list is not currently available on the EA Catchment Data Explorer website. For the full WFD Assessment it should be checked whether the Mitigation Measures have been changed and this section should be updated if they have been.

Table 6-2: Assessment of proposed works against the water body's mitigation measures

Mitigation Measure	Current Status (2009 RBMP)	Assessment of proposed works/ Recommended action
Retain marginal aquatic and riparian habitats (channel alteration)	In Place	The proposed channel realignment works will incorporate a riparian zone which will extend a minimum of 8m from the top of the bank. In addition, the channel design has the potential to create a greater diversity of habitats which will benefit the riparian flora of the new channel.
Appropriate techniques (invasive species)	In Place	Biosecurity measures should be put in place to ensure that no unidentified aquatic (or terrestrial) invasive non-native species are inadvertently spread on site or between sites.
Educate landowners on sensitive management practices (urbanisation)	Not in place	The recommendations and mitigation measures presented in this report provide information on how to avoid hydromorphological or ecological harm which should be directly fed back to the landowners.
Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)	Not in place	N/A – control of drainage from the permitted development is beyond the scope of this assessment.
Ensure there is an appropriate baseline flow regime downstream of the impoundment	Not in place	N/A – the proposed works will not be introducing a structure to the channel that could cause impoundment.
Appropriate water level management strategies, including timing and volume of water moved.	Not in place	N/A – the proposed works will not change the flow regime of the Thulston Brook.
Preserve and where possible enhance the ecological value of marginal aquatic habitat, banks and riparian zone	Not in place	The channel design has the potential to create a greater diversity of habitats (relative to the old channel) which will benefit the riparian flora and fauna of the new channel and increase biodiversity.
Management of the risk of fish entrainment in intakes for hydropower turbines or water resource purpose (or pumping stations) where there is downstream fish migration	Not in place	N/A – no in-channel structures are proposed as part of the proposed works.
Set-back embankments	Not in place	N/A – there are no formal embankments along the Thulston Brook within the study area.
Preserve and, where possible, restore historic aquatic habitats	Not in place	The channel design has the potential to create a greater diversity of habitats (relative to the old channel) which will benefit the riparian flora and fauna of the new channel and increase biodiversity.

6.4 WFD Assessment Objectives

Following consideration of the potential impacts and recommended mitigation measures, as well as the appraised Mitigation Measures for the water body, Table 6-3 assesses whether the proposed works comply with the overarching objectives of the WFD.

Table 6-3: Assessment of proposed works against WFD objectives

WFD Assessment Objectives	Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Ecological Elements of the water body	If all mitigation measures and recommendations detailed in this report are fully implemented into the design and construction process it is anticipated that there will be no deterioration in the status of the biological WFD quality elements of the Derwent from Bottle Brook to Trent (GB104028053240).
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The EA catchment data explorer gives the current Ecological Status of the waterbody as Moderate and the objective to maintain its Moderate Ecological Potential status between 2015 and 2021. Provided all the mitigation measures and recommendations detailed in this report are fully implemented during both the design and construction phases, the proposed works should not prevent the waterbody from achieving its objective.
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	The impact of the scheme will be direct and local to the site. If suitable mitigation measures are put in place, the project should not impact on areas elsewhere in the catchment. This can be achieved by sensitive design during the detailed design phase.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The aim of the current works is to modify the channel in a way to maximise the potential of the land for a permitted development. However, the works also present an opportunity to improve hydromorphological conditions within the waterbody local to the site by creating enhanced heterogeneity within this section of channel. This has the potential to maintain and improve the local habitat for biodiversity. This can only be achieved if all the mitigation measures and recommendations detailed in this report are fully implemented into the channel design prior to construction.

7 Discussion and Conclusions

7.1 Assessment Summary

Although the Thulston Brook is classified as main river, it is not defined under the Water Framework Directive as a standalone water body. Instead, it falls within Derwent from Bottle Brook to Trent water body (GB104028053240) which falls within the Humber River Basin District (RBD). For the purposes of this assessment, the status and objectives of the Derwent from Bottle Brook to Trent water body have been applied to the Thulston Brook. The status of this water body is Moderate. The objectives according to the EA Catchment Data Explorer is for this water body to maintain this status and not let it deteriorate.

The assessments detailed in this report are based on the information presented in the accompanying Thulston Brook Realignment report, which documents the findings of the baseline assessments. These comprise existing knowledge of the site and waterbody gained from desk study information, previous surveys and the most recent ecological and geomorphological walkover assessments.

A concept design of the realignment is presented within the accompanying Thulston Brook Realignment report. Although the final designs for the scheme have not been completed, provided the recommendations and mitigation measures given in this report are fully implemented, it is anticipated that there will be no deterioration to WFD status, and the scheme is likely to be WFD compliant. The final design of the scheme, in particular, the design of the channel realignment, associated planting scheme and detailed works methodologies will be required to conclude the WFD assessment process with regards to each of the quality elements identified in the Impact Assessment.

This report constitutes a Preliminary WFD Assessment, given that only a conceptual design of the proposed works is available at this stage. This assessment should be used to inform the design process and demonstrates that the works have potential to be WFD-complaint, provided the recommendations and mitigation measures outlined in this report are incorporated into the permanent and temporary works designs. Once a detailed design has been prepared, this report should be updated to assess whether the scheme is WFD-compliant before submission to any permit application.

7.2 Scheme Recommendations/Key Considerations

The impact assessment determines whether the proposed works have the potential to significantly impact any of the quality elements screened into the assessment. Any mitigation measures that need to be considered to make the works compliant with the WFD are presented in Table 6-1; however, the critical ones are listed below.

7.2.1 Channel realignment design

The design appraised in this assessment is conceptual and will need to be refined in more detail going forward. The design of the new channel should follow the design principles outlined in the accompanying report³. It should ensure hydromorphological functioning is improved rather than degraded, by narrowing the channel during low flow conditions and reducing the potential for siltation. Low flows modelling should be undertaken to design in-channel features such as the berms, or riffle and pool features, and to understand how sediment transport will be impacted by the works.

7.2.2 Pollution Prevention

Appropriate mitigation measures should be implemented to ensure that habitats within proximity of the works are not degraded as a result of pollution events during the construction phase. This mitigation should include:

- Following relevant guidance e.g. CIRIA Guidance: *Control of water pollution from construction sites. Guidance for consultants and contractors (C532D)* (Masters-Williams, 2001), including the implementation of toolbox talks.
- Any chemical, fuel and oil stores should be located on impervious bases within a secured bund with a storage capacity 110% of the stored volume.
- Biodegradable oils and fuels should be used where possible.
- Drip trays should be placed underneath any standing machinery to prevent pollution by oil/fuel leaks. Where practicable, refuelling of vehicles and machinery should be carried out on an impermeable surface in one designated area well away from any watercourse or drainage (at least 10m).
- Best practice sediment management techniques should be followed, and silt curtains should be used during any construction works within a watercourse. Additionally, monitoring of Dissolved Oxygen levels throughout the works should be put in place.
- Emergency spill kits should be available on site and staff trained in their use.
- Operators should check their vehicles on a daily basis before starting work to confirm the absence of leakages. Any leakages should be reported immediately.
- Daily checks should be carried out and records kept on a weekly basis and any items that have been repaired/replaced/rejected noted and recorded. Any items of plant machinery found to be defective should be removed from site immediately or positioned in a place of safety until such time that it can be removed.

7.2.3 Invasive Non-Native Species and Biosecurity

Appropriate biosecurity measures should be implemented throughout the works, including:

- Ensure all Personal Protective Equipment (PPE) and equipment is clean prior to entering and leaving site.
- Ensure vehicles are kept clean and do not let mud and debris accumulate on wheels or under wheel arches. Keep vehicular access to a minimum.
- Follow Check-Clean-Dry approach (<http://www.nonnativespecies.org/checkcleandry/index.cfm>).

7.2.4 Fish

The following measures should be implemented to protect fish on site:

- The Local Fisheries Officer from the Environment Agency should be contacted for area-specific advice for suitable works timings.
- If possible, the works should be phased to ensure only partial channel blockage to enable fish passage to continue during works.
- Any de-watering works should be supervised by a suitably experienced person to undertake a fish rescue.
- DO is lower in high temperatures, therefore de-watering activities should not be undertaken in very hot weather.
- During any de-watering period, fish friendly pumps should be adopted.

7.2.5 Temporary Works

The temporary works should adhere to the following best practice:

- Any bed materials to be excavated should be removed and stored on site during the construction phase. Upon completion of the works, all bed materials should be reinstated to help facilitate natural bed morphology and re-colonisation by macroinvertebrate fauna.
- The site compound should be located away from the riverbank.
- Any de-watering should be localised and not span the entire channel.

7.3 Conclusions

The proposed works have the potential to be compliant with the WFD objectives (as described in Table 6-3) if the appropriate mitigation measures are incorporated into the design. When designing the scheme and the new channel, the proposed works should aim to embrace the opportunity to reintroduce a more natural channel through the site, which includes the riparian zone, if deemed within the scope of the proposed works. This could result in a positive impact on the biological, chemical and hydromorphological elements of the Thulston Brook.

It is recommended that an experienced geomorphologist and ecologist are involved in the detailed design phase and in site supervision during construction of the channel and riparian works. This will help to ensure that the proposed works are as environmentally sensitive as possible, and that geomorphological and ecological impacts are minimised during construction on any downstream receptor habitats.

If a sympathetic design is not produced and a high level of mitigation is not implemented as part of the proposed scheme, it is possible that WFD objectives will not be satisfied and a further assessment against the conditions listed in Article 4.7 may be required. The potential to reduce the WFD status of this waterbody, should be continually re-assessed throughout all the design and implementation stages of this project.

If the recommendations outlined in the initial WFD assessment are used to fully inform the detailed design stage of the works, then it is anticipated that the proposed development and works to the channel, will not cause deterioration in the status (Moderate Overall Potential) of this waterbody.

References

Humber River Basin Management Plan; Annex B (2009) [Online] Available at:
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B Hydraulic Modelling

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2019s0649
Thulston Brook Realignment at Boulton
Moor, Derby
Canon Consulting
23 August 2019
Jingchun Wang
Alice Blanchard
Hydraulic modelling of proposed scenario

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1 Introduction

JBA Consulting were commissioned by Cannon Consulting Engineers to investigate a proposed channel realignment of the Thulston Brook at a permitted development site at Boulton Moor, Derby. As part of this study, hydraulic modelling was carried out to understand the impact of the proposed realignment on flood risk.

This study utilises the 2016 JBA Consulting hydraulic model developed to understand flood risk at the site. This technical note provides a summary of changes made to the 2016 Thulston Brook model used to assess the impact of the proposed realignment and the results of the analysis.

2 Hydraulic modelling - realignment proposal

2.1 1D model

The 2016 model formed the baseline model to the assessment, with no changes made to the model other than to re-run the model with the latest version of Flood Modeller and Tuflow (2018-03-AC-iDP-W64). A copy of the model was made to represent the proposed realignment concept design (shown in Figure 4-4 to Figure 4-6 of main report). The changes are illustrated in Table 1.

Table 1: Sections for the proposed scenario

Name	Type	Description
THUB_0742, THUB_0677	Interpolation	Removed
THUB_0620	River section	Retained and new geometry applied
THUB_0742, THUB_0727 THUB_0710, THUB_0698 THUB_0688, THUB_0676 THUB_0660, THUB_0649	River section	New sections added

Figure 1 shows how the proposed cross sections are represented by the indicative cross sections (Type A, B and C).

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Figure 1: Proposed plan

Figure 1 shows that Cross section A geometry was used for sections THUB_0742, THUB_0710, THUB_0688, THUB_0660. Cross section geometry B was used for sections THUB_0727, THUB_0676 and THUB_0620. Cross section geometry C used for THUB_0698 and THUB_0649.

2.2 2D model

The 2D model files were amended to represent the change in alignment of the watercourse. The files updated are detailed in Table 2 and shown in Figure 2.

Table 2: Mapinfo layers for the proposed scenario

Name	Description
1d_x1d_isis_nodes_Thulston_002	New node layer corresponding to the new 1D model

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2d_bc_hxi_THU_002	New 1D-2D link to represent change in channel alignment
2d_bc_hxe_THU_002	New code layer to represent change in channel alignment
2d_zsh_oldchannel_fill_002	Used to fill the depression on LiDAR data which represents the existing channel
2d_zln_Banks_003	New bank top levels

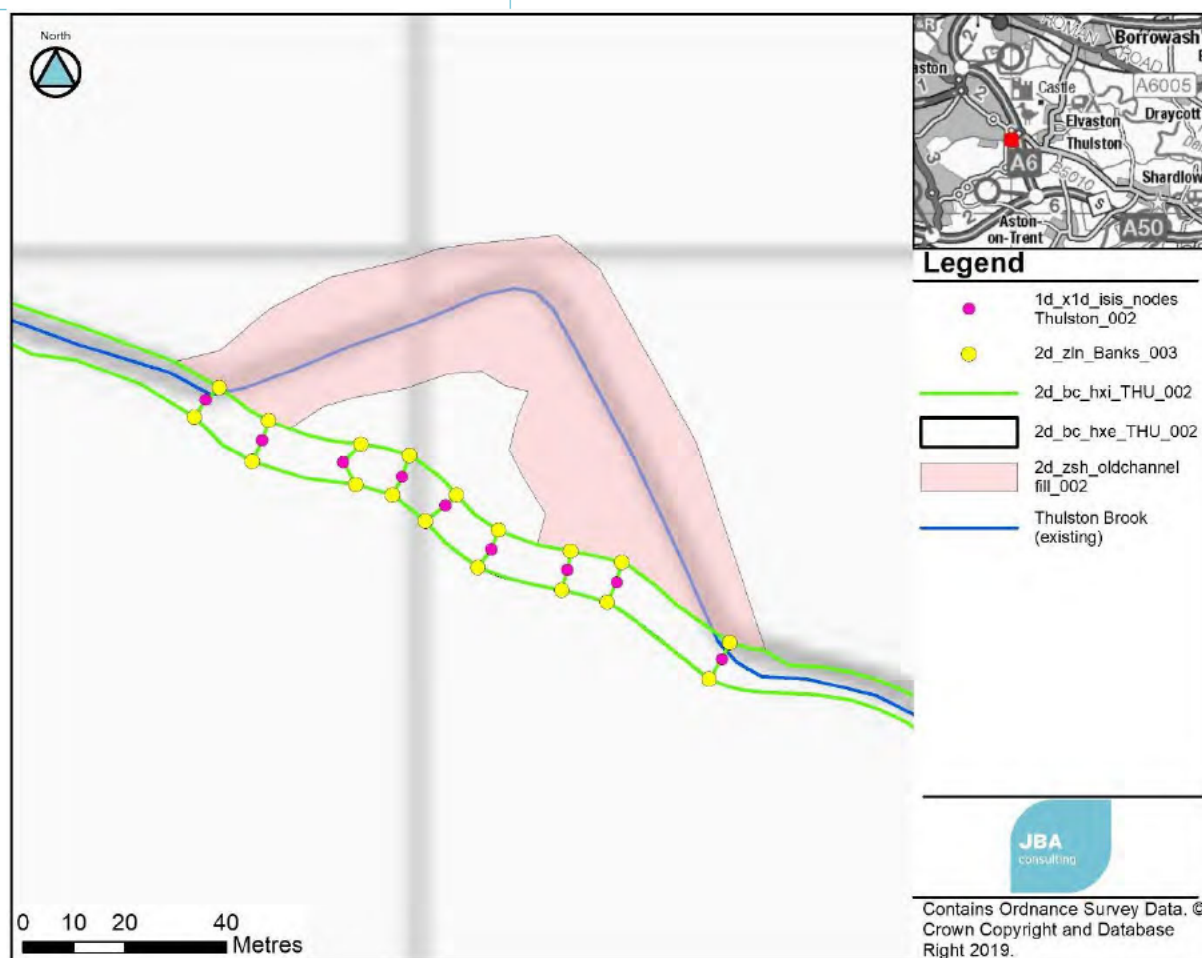


Figure 2: 2D model files

2.3 Modelled scenarios

The events were simulated with the hydraulic model:

- Baseline: 2-year, 20-year, 100-year, 100year plus 20% climate change, 100-year plus 30% climate change and 1,000-year.
- Proposed: 2-year, 20-year, 100-year, 100year plus 20% climate change, 100-year plus 30% climate change and 1,000-year.

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3 Model results

3.1 Baseline flood extents

No flooding is observed within modelled watercourse extent during the 2-year and 20-year baseline flood events. Flood extents for 100-year, 100-year plus 20% climate change, 100-year plus 30% climate change and 1,000-year flood events are shown in Figure 3.

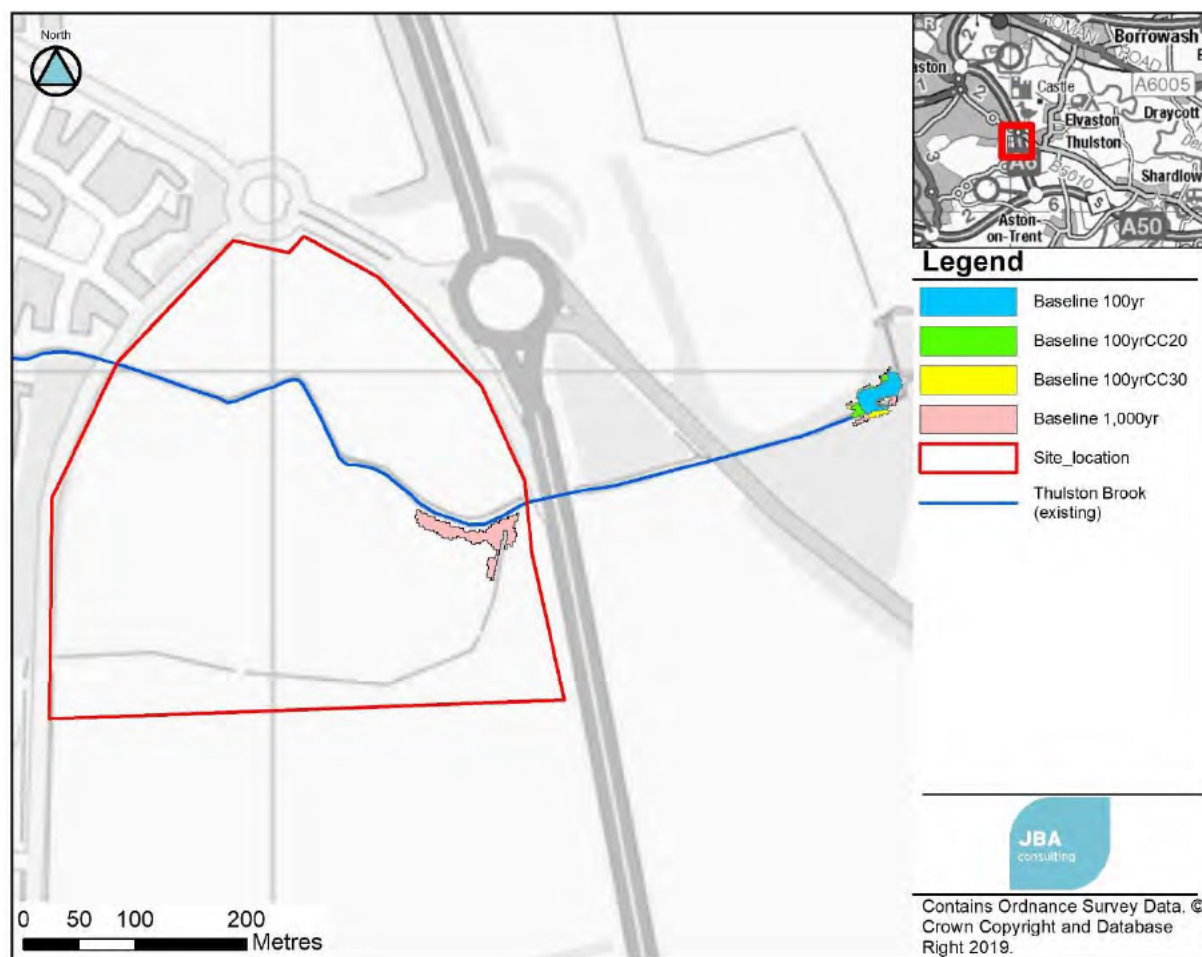


Figure 3: Baseline flood extents

Figure 3 shows that the site is only at risk of flooding during the modelled 1,000-year event.

3.2 Proposed flood extents

Figure 4 shows the flood extents for the 100-year, 100-year plus 20% climate change, 100-year plus 30% climate change and 1,000-year scenarios following the proposed

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channel realignment.

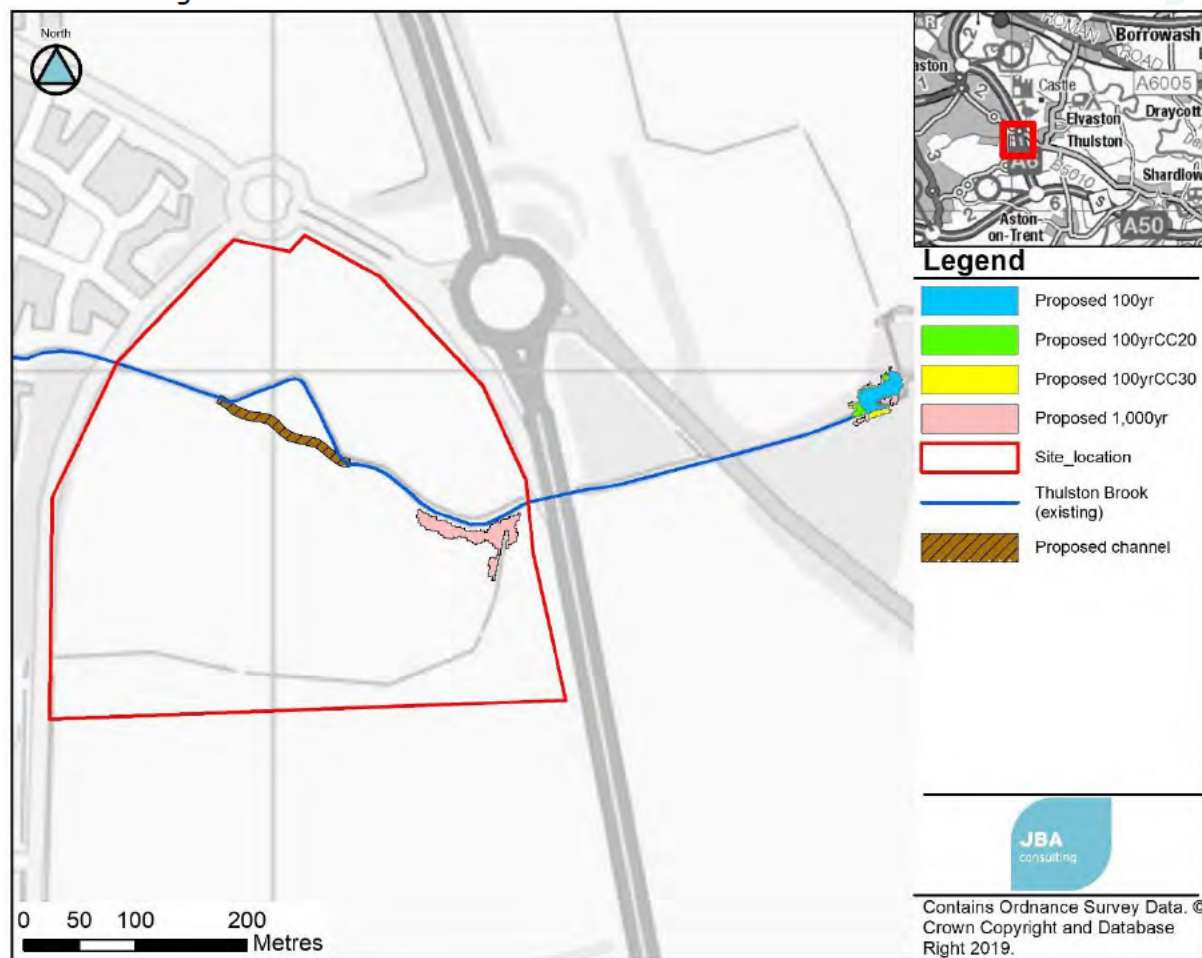


Figure 4: Proposed flood extents

Figure 4 shows that the realignment proposal will have no impact on flood extents.

3.3 Impact analysis of 100-year plus 30% climate change

The impact to flood depths during the 100-year plus 30% climate change event is shown in Figure 5.

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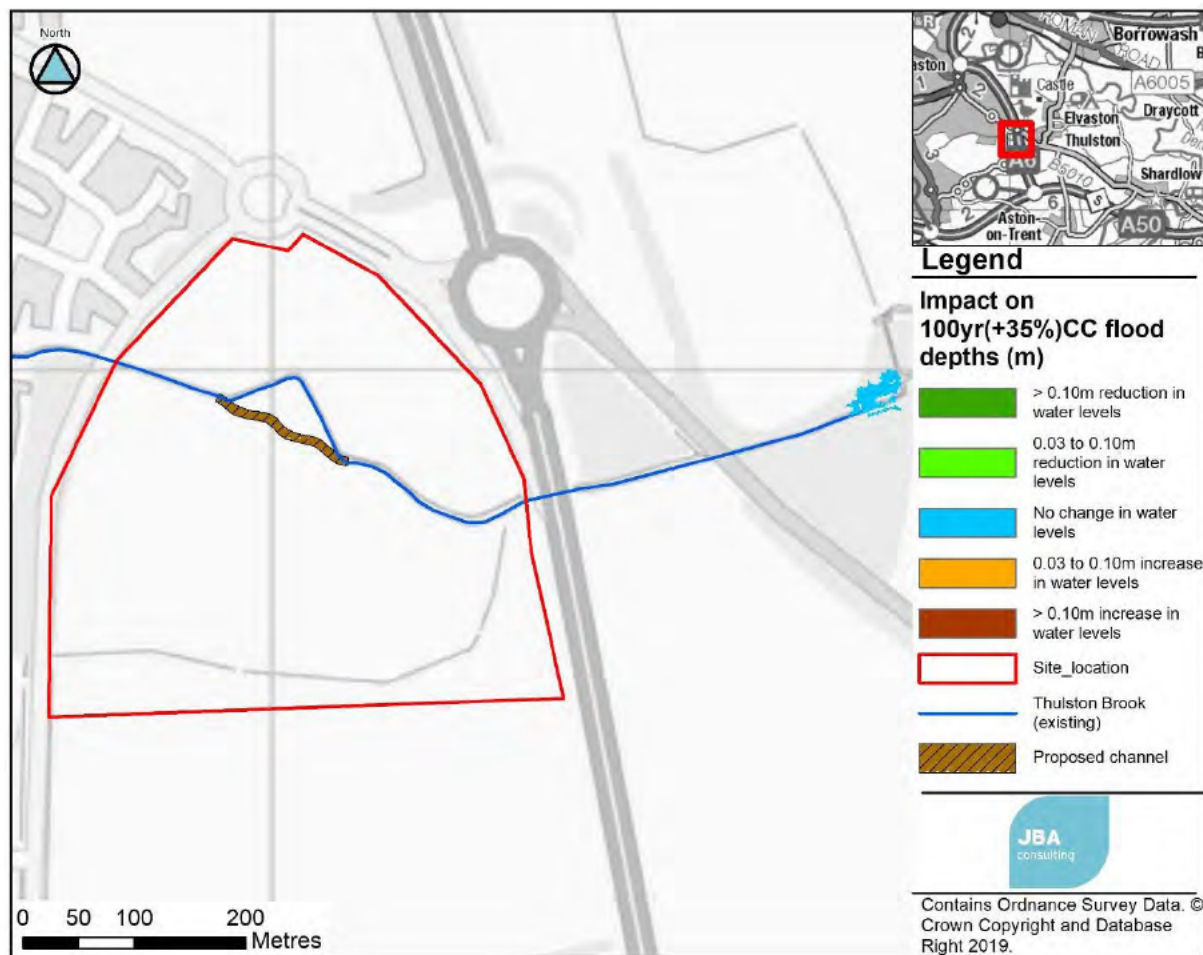


Figure 5: Proposed flood extents

Figure 5 shows that there is no change to flood depth during the 100-year plus climate change event following the proposed realignment.

3.4 Modelled maximum water level

There is a slight increase in maximum in-channel water levels upstream of the realigned channel in the proposed scenarios. The maximum increase in water levels are detailed in Table 3.

Table 3: Maximum increase in maximum water level during each return period

Flood event	Maximum increase (m)
2-year	0.12
20-year	0.095
100-year	0.068
100-year plus 20 climate change	0.055

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100-year plus 30 climate change	0.052
1,000-year	0.034

Table 3 shows that the largest increase in maximum water level is 0.12m (2-year) and the smallest increase is 0.034m (1,000-year).

Given that the change in water level is contained within the channel, the change in water level is deemed minimal. Therefore, it can be concluded that there is negligible change in flood risk in all modelled scenarios.

3.5 Discharge during 100-year plus 30% climate change scenario

The modelled flow at section THUB_0405 (most downstream cross section within the site) during the 100-year plus 30% climate change scenario is shown in Figure 6.

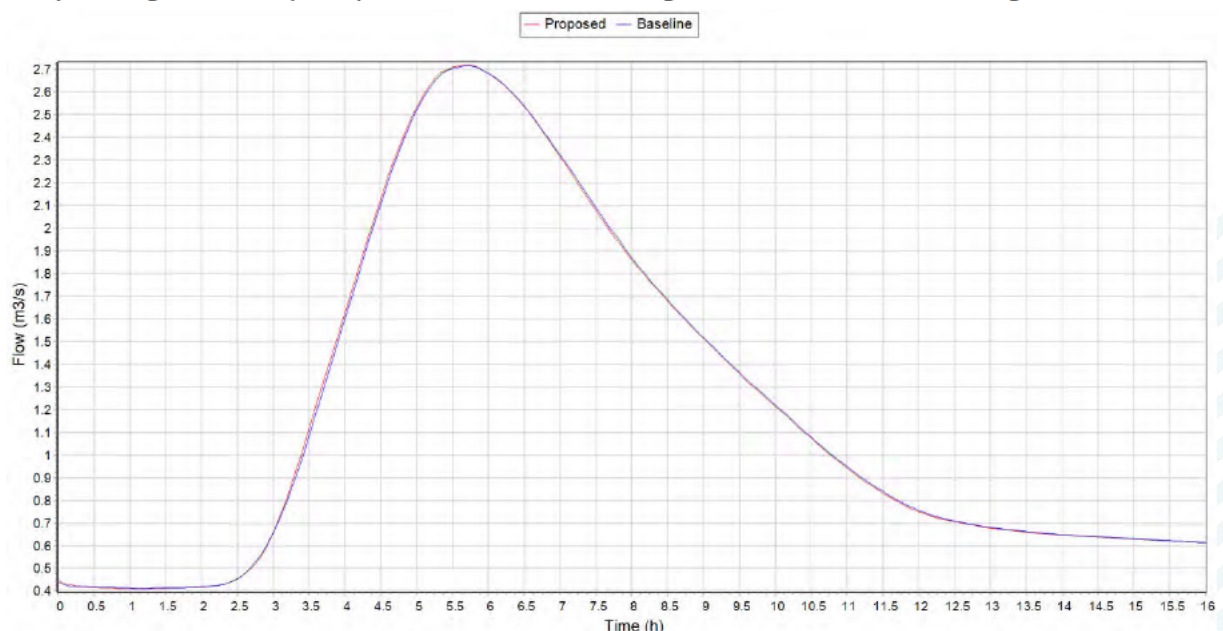


Figure 6: Modelled flow at section THUB_0405

Figure 6 shows that there is negligible difference between the baseline and proposed flow leaving the site during the 100-year plus 30% climate change scenario, which indicates that the proposed realignment will have no impact on the downstream flow.

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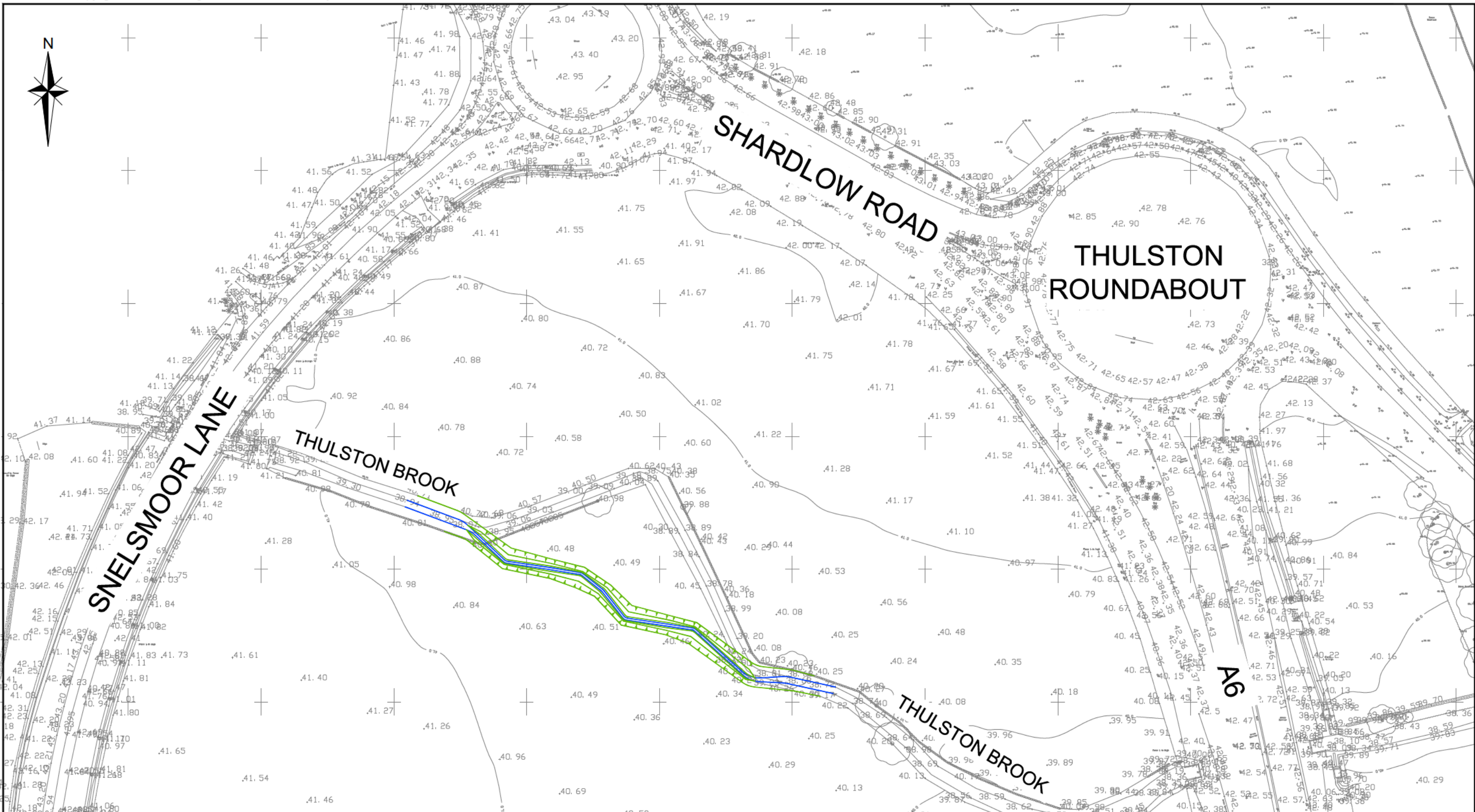
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DESIGNED BY	DRAWN BY	CHECKED BY			
-	DP	-			
SCALE @ A3 SIZE D.N.S.		DATE 14/03/2019			

PROJECT TITLE BOULTON MOOR
DRAWING TITLE WATERCOURSE RE-ALIGNMENT LOCATION PLAN

CLIENT JSC FARMS

CANNON
CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning

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DRAWING NUMBER E702 - PL - SK - 301	REV. P01

Appendix B – Proposed Site

Illustrative layout
Surface water management strategy
Development catchment plan
Surface water calculations
Maintenance plan
Typical sections



	INDICATIVE ATTENUATION BASIN
	INDICATIVE CELLULAR STORAGE
	INDICATIVE SW SPINE NETWORK
	ROADSIDE SWALE/GRASSED FILTER DRAIN
	ORIFICE CONTROL CHAMBER
	DEBRIS FILTER AT BASIN OUTLETS AND INLETS AS NECESSARY
CL = 41.20 IL = 40.00	INDICATIVE LEVELS

P02	NEW MASTERPLAN ADDED		-	DP	-	10/2021			
P01	NEW MASTERPLAN ADDED		-	DP	-	09/2021			
REV	DESCRIPTION		DE	DR	CH	DATE			
DESIGNED BY		DRAWN BY			CHECKED BY				
		DP			-				
SCALE @ A1 SIZE				DATE					
D.N.S.				08/09/2021					
PROJECT TITLE									
BM1									

CLIENT

JSC FARMING LTD &
CENTRAL LAND HOLDINGS LTD

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DRAWING NUMBER	REV.
E702 - PL - SK - 304	P02



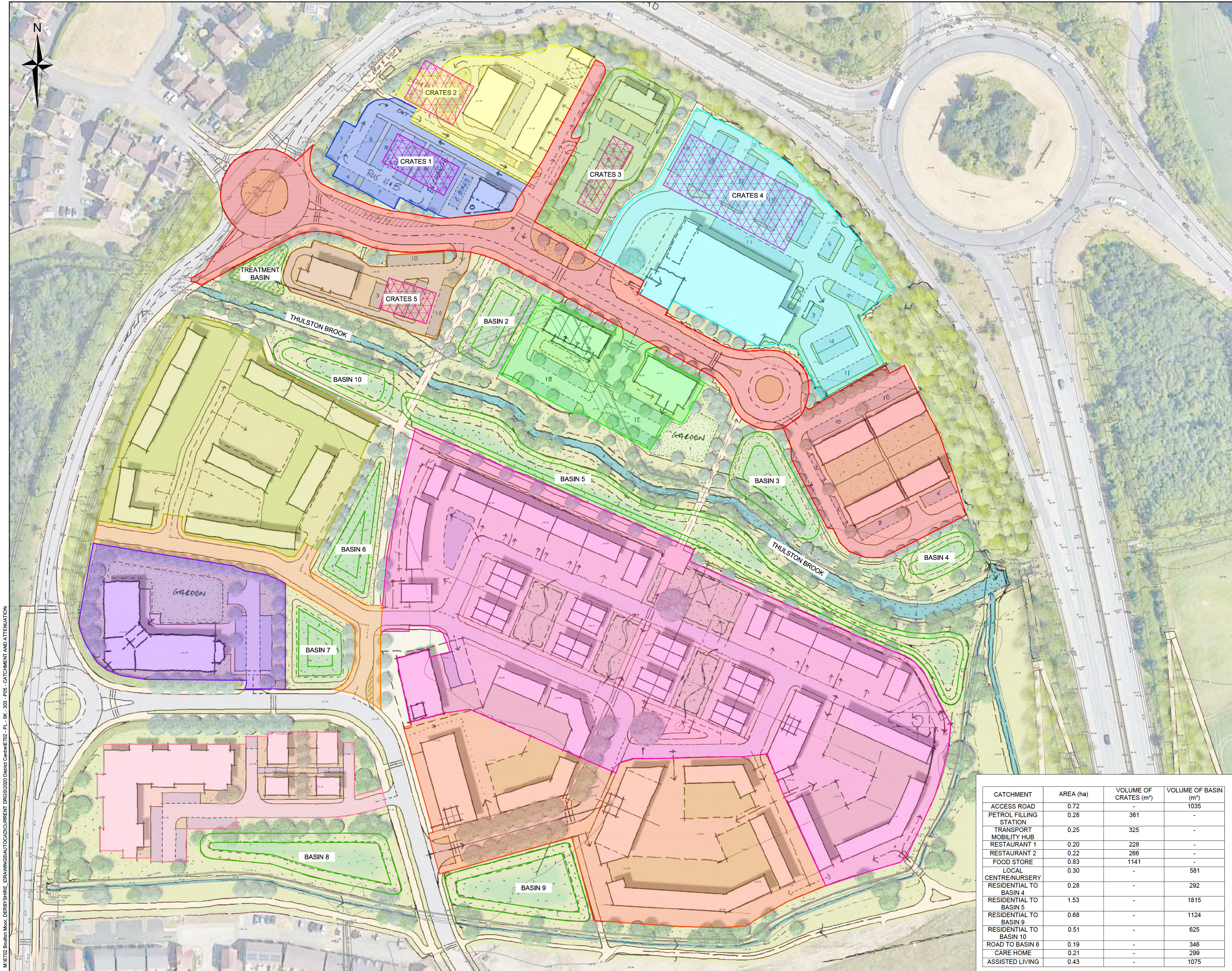
Legend
Site Boundary

Project
BOULTON MOOR,
DERBY
Drawing Title
DISTRICT CENTRE
ILLUSTRATIVE LAYOUT - OPTION
Date 06.07.21 Scale 1:1,000@A1 Drawn by ALC Check by DS
Project No 6748 Drawing No RG-M-2030 Revision H

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KEY

CATCHMENT AREA FOR CRATES 1

CATCHMENT AREA FOR CRATES 2

CATCHMENT AREA FOR CRATES 3

CATCHMENT AREA FOR CRATES 4

CATCHMENT AREA FOR CRATES 5

CATCHMENT AREA FOR BASIN 2

CATCHMENT AREA FOR BASINS 3 AND 4

CATCHMENT AREA FOR BASIN 5

CATCHMENT AREA FOR BASINS 6

CATCHMENT AREA FOR BASINS 7

CATCHMENT AREA FOR BASIN 8

CATCHMENT AREA FOR BASIN 9

CATCHMENT AREA FOR BASIN 10

INDICATIVE ATTENUATION BASIN

INDICATIVE CELLULAR STORAGE

NOTES

P05	NEW MASTERPLAN ADDED	-	DP	-	10/2021
P04	TREATMENT BASIN ADDED	-	DP	-	09/2021
P03	NEW MASTERPLAN ADDED	-	DP	-	09/2021
P02	REVISED TO SUIT NEW LAYOUT	-	DP	-	09/2021
P01	ATTENUATION AREAS REVISED	-	DP	-	08/2021
REV	DESCRIPTION	DE	DR	CH	DATE
DESIGNED BY		DRAWN BY	DP	CHECKED BY	
SCALE @ A1 SIZE		DATE			
D.N.S.		16/07/2021			
PROJECT TITLE	BM1				

DRAWING TITLE					
DRAINAGE CATCHMENTS AND ATTENUATION					
CLIENT					
JSC FARMING LTD & CENTRAL LAND HOLDINGS LTD					

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DRAWING NUMBER

E702 - PL - SK - 303

REV.

P05

CATCHMENT	AREA (ha)	VOLUME OF CRATES (m³)	VOLUME OF BASIN (m³)
ACCESS ROAD	0.72	-	1035
PETROL FILLING STATION	0.28	361	-
TRANSPORT MOBILITY HUB	0.25	325	-
RESTAURANT 1	0.20	228	-
RESTAURANT 2	0.22	266	-
FOOD STORE	0.83	1141	-
LOCAL CENTRE/NURSERY	0.30	-	581
RESIDENTIAL TO BASIN 4	0.28	-	292
RESIDENTIAL TO BASIN 5	1.53	-	1815
RESIDENTIAL TO BASIN 9	0.68	-	1124
RESIDENTIAL TO BASIN 10	0.51	-	625
ROAD TO BASIN 6	0.19	-	346
CARE HOME	0.21	-	299
ASSISTED LIVING	0.43	-	1075

Cannon Consulting		Page 1
Cambridge House Lanwades Business Park Kentford		
Date 15/01/2021 11:55 File	Designed by JH Checked by	
Micro Drainage		Source Control 2018.1
<u>ICP SUDS Mean Annual Flood</u> Input Return Period (years) 100 Soil 0.450 Area (ha) 1.000 Urban 0.000 SAAR (mm) 642 Region Number Region 5 Results 1/s QBAR Rural 4.0 QBAR Urban 4.0 Q100 years 14.1 Q1 year 3.5 Q30 years 9.5 Q100 years 14.1		
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Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.300	100.000	1.200

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	0.900	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	1.1		
Invert Level (m)	98.800	Diameter (m)	0.023		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.800
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	160.0	0.0	1.200	679.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
960 minute winter	BASIN	945	99.651	0.851	14.7	296.9380	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m ³)
960 minute winter	BASIN	Orifice	1.0	53.9

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.690	100.000	1.500

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.200	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	2.4		
Invert Level (m)	98.500	Diameter (m)	0.032		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.500
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	310.0	0.0	1.500	976.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
960 minute winter	BASIN	945	99.679	1.179	33.8	685.0769	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m ³)
960 minute winter	BASIN	Orifice	2.3	121.6

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.280	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	1.0		
Invert Level (m)	99.000	Diameter (m)	0.021		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	160.0	0.0	1.000	449.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
960 minute winter	BASIN	945	99.931	0.931	13.7	279.5323	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m ³)
960 minute winter	BASIN	Orifice	0.9	46.6

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	1.530	100.000	0.700

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	0.700	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	5.4		
Invert Level (m)	99.300	Diameter (m)	0.056		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.300
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	1984.0	0.0	0.700	3208.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	BASIN	945	99.902	0.602	75.0	1538.3280	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	BASIN	Orifice	5.0	247.7

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.190	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	0.7		
Invert Level (m)	99.000	Diameter (m)	0.018		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	146.0	0.0	1.000	546.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
960 minute winter	BASIN	945	99.674	0.674	9.3	191.7658	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m ³)
960 minute winter	BASIN	Orifice	0.6	29.2

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.190	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	0.7		
Invert Level (m)	99.000	Diameter (m)	0.018		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	146.0	0.0	1.000	546.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	BASIN	945	99.674	0.674	9.3	191.7658	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	BASIN	Orifice	0.6	29.2

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.210	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	0.7		
Invert Level (m)	99.000	Diameter (m)	0.018		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	159.0	0.0	1.000	438.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	BASIN	945	99.781	0.781	10.3	212.3730	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	BASIN	Orifice	0.6	31.2

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.380	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	1.3		
Invert Level (m)	99.000	Diameter (m)	0.025		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	697.0	0.0	1.000	1453.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
1440 minute winter	BASIN	1410	99.452	0.452	12.9	395.9080	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
1440 minute winter	BASIN	Orifice	0.9	59.3

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.680	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	2.4		
Invert Level (m)	99.000	Diameter (m)	0.034		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	825.0	0.0	1.000	1422.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
960 minute winter	BASIN	945	99.667	0.667	33.3	691.5959	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m ³)
960 minute winter	BASIN	Orifice	1.9	98.3

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
BASIN	0.510	100.000	1.000

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node BASIN Online Orifice Control

Flap Valve	x	Design Depth (m)	1.000	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	1.8		
Invert Level (m)	99.000	Diameter (m)	0.029		

Node BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	99.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	400.0	0.0	1.000	876.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
960 minute winter	BASIN	945	99.840	0.840	25.0	512.2220	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m ³)
960 minute winter	BASIN	Orifice	1.6	82.6

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
CRATES	0.250	100.000	1.510

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node CRATES Online Orifice Control

Flap Valve	x	Design Depth (m)	0.800	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	0.9		
Invert Level (m)	98.490	Diameter (m)	0.022		

Node CRATES Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.490
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	427.0	0.0	0.800	427.0	0.0	0.801	0.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	CRATES	945	99.106	0.616	12.2	252.0548	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	CRATES	Orifice	0.8	39.1

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	Cover Level (m)	Depth (m)
CRATES	0.300	100.000	1.510

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node CRATES Online Orifice Control

Flap Valve	x	Design Depth (m)	0.800	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	1.1		
Invert Level (m)	98.490	Diameter (m)	0.024		

Node CRATES Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.490
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	456.0	0.0	0.800	456.0	0.0	0.801	0.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	CRATES	945	99.179	0.689	14.7	301.1693	0.0000	OK
Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)				
960 minute winter	CRATES	Orifice	1.0	49.3				

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Depth (m)
CRATES	0.230	5.00	100.000	1200	1.510

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node CRATES Online Orifice Control

Flap Valve	x	Design Depth (m)	0.800	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	0.8		
Invert Level (m)	98.490	Diameter (m)	0.020		

Node CRATES Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.490
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	350.0	0.0	0.800	350.0	0.0	0.801	0.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	CRATES	945	99.182	0.692	11.3	233.0730	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	CRATES	Orifice	0.7	34.4

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Depth (m)
CRATES	0.830	5.00	100.000	1200	1.510

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node CRATES Online Orifice Control

Flap Valve	x	Design Depth (m)	0.800	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	2.9		
Invert Level (m)	98.490	Diameter (m)	0.039		

Node CRATES Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.490
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	1500.0	0.0	0.800	1500.0	0.0	0.801	0.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.99%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	CRATES	945	99.080	0.590	40.7	847.2076	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	CRATES	Orifice	2.4	117.6

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.950	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Depth (m)
CRATES	0.200	5.00	100.000	1200	1.510

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	0.950	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.950	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	40	0	0

Node CRATES Online Orifice Control

Flap Valve	x	Design Depth (m)	0.800	Discharge Coefficient	0.600
Replaces Downstream Link	✓	Design Flow (l/s)	0.7		
Invert Level (m)	98.490	Diameter (m)	0.019		

Node CRATES Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	98.490
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	300.0	0.0	0.800	300.0	0.0	0.801	0.0	0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	CRATES	945	99.189	0.699	9.8	201.7836	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	Outflow (l/s)	Discharge Vol (m³)
960 minute winter	CRATES	Orifice	0.6	31.2



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4

Crate Maintenance		
Maintenance schedule	Required action	Frequency
Regular Maintenance	Inspect to identify any area of under performance and correct (repair, improve etc)	Monthly for 3 months then annually
	Remove debris from drained area to prevent entry to the system	Monthly
	Check infiltration surfaces which allow water percolate into the tanks for blockages, correct as necessary	Annually
	Remove sediment from traps	Annually/as required
Remedial actions	Repair/ replace inlets, outlets, overflows, and vents	As required
Monitoring	Check that outlets, inlets, vents and overflows are in good condition and working as intended	Annually
	Inspect tank internally, remove any sediment if present and if required	Every 5 years (or more frequently if necessary)
(Based on advice in CIRIA C753)		

5

Pervious Pavement Maintenance		
Maintenance schedule	Required action	Frequency
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations - pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structure performance or a hazard to users, and replace lost jointing material	As required.
Remedial actions	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required
	Initial inspection	Annually
Monitoring	Inspect tank internally, remove any sediment if present and if required	Every 5 years (or more frequently if necessary)
	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action	Three-monthly, 48 hours after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually
(Based on advice in CIRIA C753)		

1

Basin Maintenance		
Maintenance schedule	Required action	Frequency
Regular Maintenance	Removal of litter and debris	Monthly
	Cut grass	Half yearly
	inspect and clear inlets, outlets, overflows etc.	Monthly
	inspect and repair banks, pipes, headwalls etc.	Monthly until able to establish the required silt removal frequency, then in accordance with established frequency
	Manage vegetation in wetter areas (micro-pools etc)	Annually or as established by ecologist/landscape architect
	Tidy dead growth	Annually (as per growing season)
	Removal sediment from traps, forebays etc.	Annually
Occasional maintenance	Reseed	As required.
	Prune adjacent trees	Every 2 years, or as otherwise advised
	Silt removal	Every 5 years (depending on the requirement for regular maintenance)
Remedial actions	Repair erosion or other damage	As required
	Repair inlets, outlets and overflows	As required
(Based on advice in CIRIA C753)		

2

Swale/Grassed Filter Drain Maintenance		
Maintenance schedule	Required action	Frequency
Regular maintenance	Litter and debris removal	Monthly, as required
	Grass cutting	Monthly, as required by season
	Upkeep of any other planting	Monthly, then decreasing in frequency, as required by season
	Inspect the swale bed for any ponding (a possible indication of reduced infiltration)	Monthly, as required
	Inspect inlets, outlets, overflows for debris and condition	Monthly
	Inspect system for silt (traps, chambers and surfaces)	Half yearly
Occasional maintenance	Reseed and replant bare areas, consider reasons for poor growth and failure of plants to establish and amend planting, improving soil etc.	As required.
Remedial actions	Repair erosion or other damage (reseed or re-turf)	As required.
	Relevel uneven surfaces	As required.
	Scarify topsoil, remediate soil to improve any reduction in infiltration	As required.
	Remove notable accumulations of sediment	As required.
	Remove and safely dispose of any oils or petrol residues	As required.
(Based on advice in CIRIA C753)		

3

Office Maintenance		
Maintenance schedule	Required action	Frequency
Remedial actions	Repair/ replace inlets, outlets, overflows.	As required
Monitoring	Check that controls, protection, outlets, inlets, and overflows are in good condition and working as intended	Half Yearly
(Based on advice in CIRIA C753)		

KEY

1

ATTENUATION BASIN

2

ROADSIDE SWALE/GRASSED FILTER DRAIN

3

ORIFICE CONTROL CHAMBER

4

ATTENUATION CRATES

5

PERMEABLE PAVING

NOTES

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SCALE @ A1 SIZE

D.N.S.

DATE

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PROJECT TITLE

BM1

DRAWING TITLE

MAINTENANCE PLAN

CLIENT

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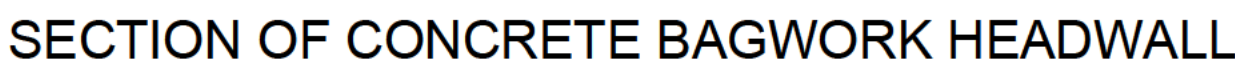
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P02



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