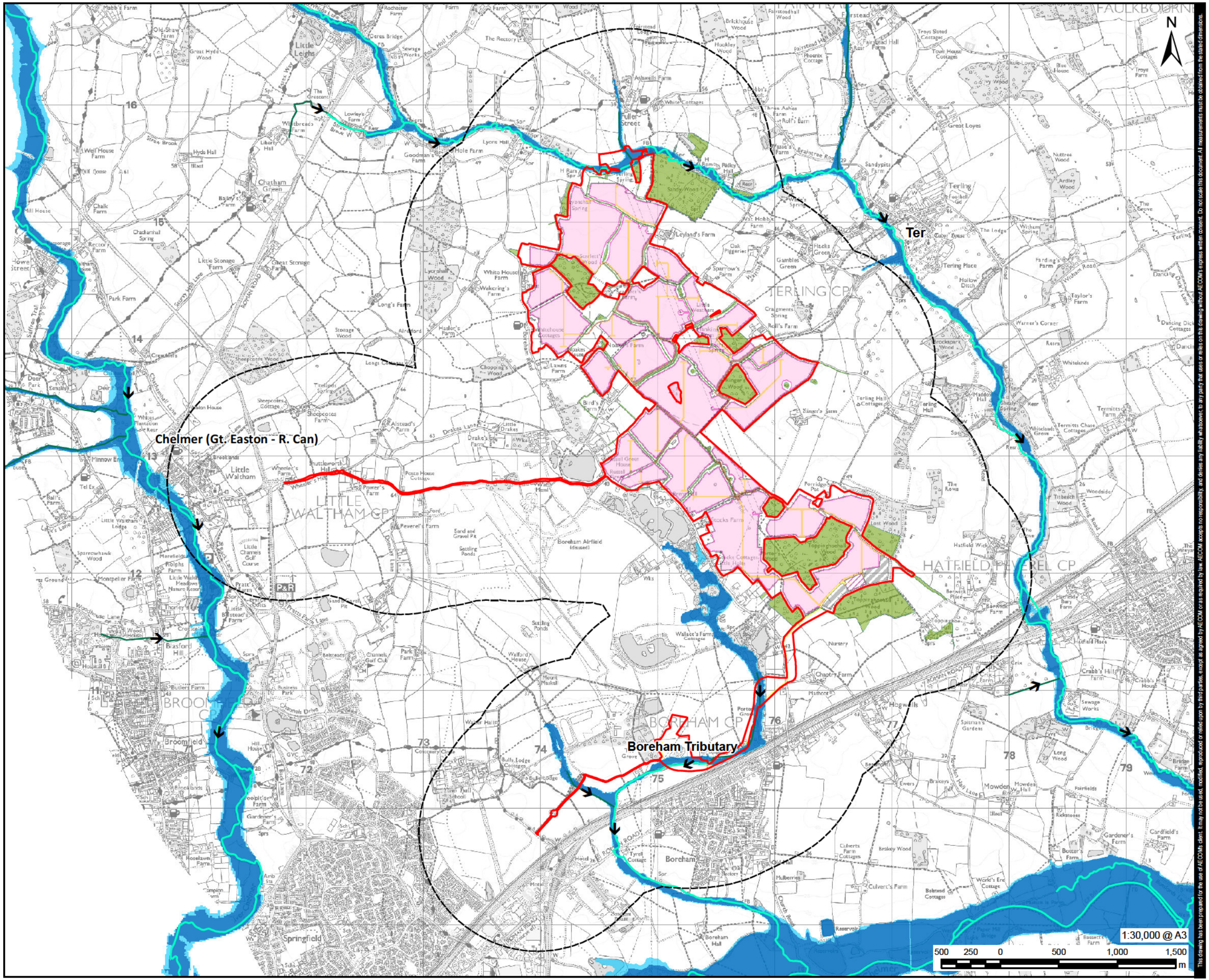
13. Annexes

Annex A - Development Parameter Plans



Revision: 0 Drawn: BM Checked: BB Approved: PD Date: 2022-02-01

Filename: \\na.aecomnet.com\lfs\EMEA\Bristol-UKBRI2\Legacy\UKBRI2FP001\VOL1\BE\Projects\Environmental\General\GIS\Projects\Chelmsford\02_Maps\ES\WTR_ES_9_2b_Flood_Zones.mxd

AECOM

PROJECT

60640215 - LONGFIELD SOLAR FARM

CLIENT

Longfield Solar Farm

CONSULTANT

AECOM Limited
3rd Floor Portwall Place,
Portwall Lane,
Bristol, BS1 6NA
[redacted]

LEGEND

- Order Limits
- 1km Site Buffer
- Flow Direction
- Main Rivers
- Ordinary Watercourse
- Flood Zone 3
- Flood Zone 2

Indicative Scheme Layout

- Grid Connection Route
- Hedgerow
- Proposed Fencing
- Primary Access
- Secondary Access
- PV Table
- BESS Compound
- Construction Compounds
- Longfield Substation
- Woodland

NOTES

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ISSUE PURPOSE

Environmental Statement
APFP Regulation: 5(2)(a)

PINS REFERENCE NUMBER

EN010118

FIGURE TITLE

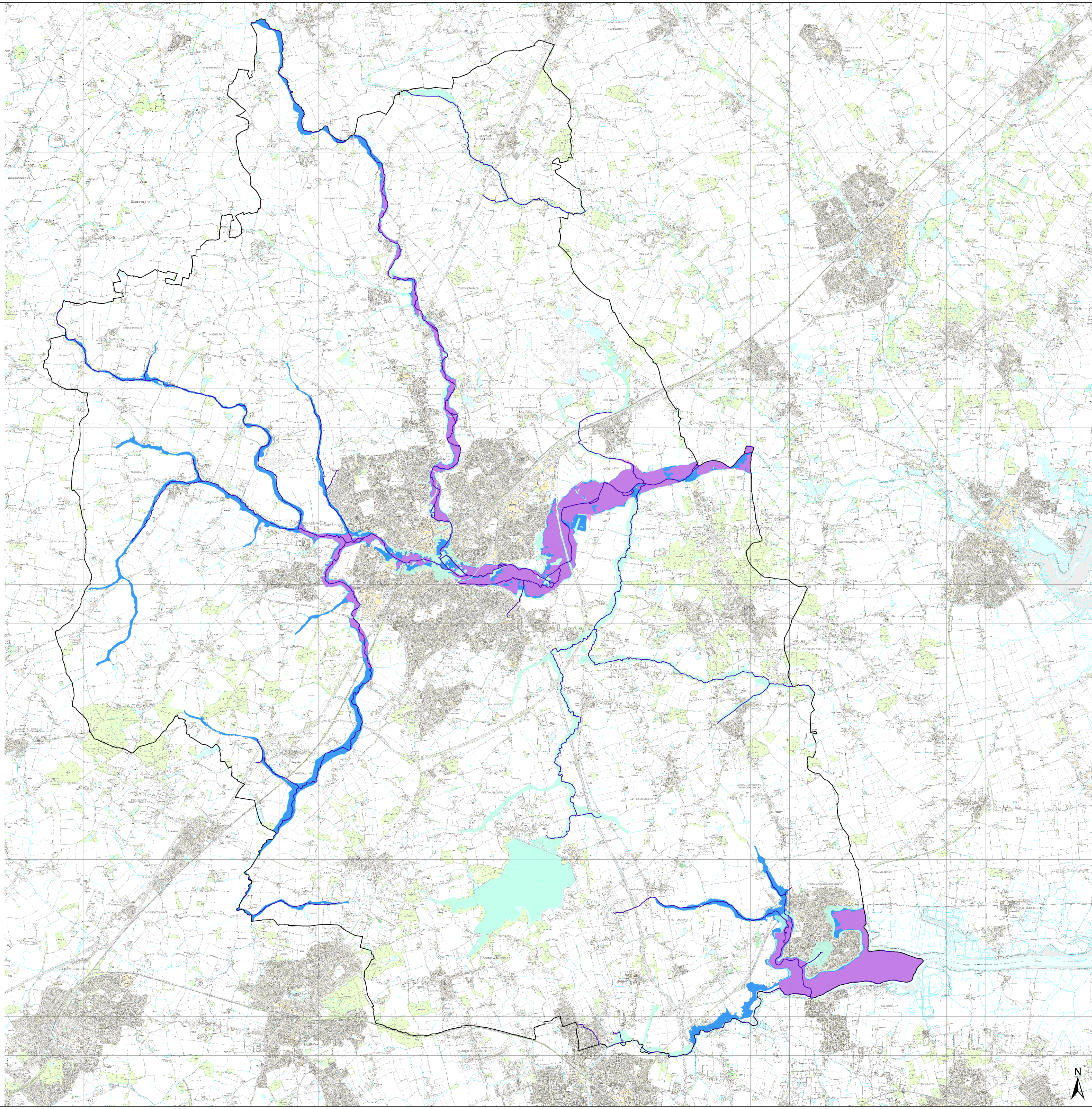
Fluvial Flood Zones including indicative concept design

FIGURE NUMBER

Figure 9-2b

Annex B – Flood Risk Mapping

Date: 12th March 2008
Filepath: L:\Water\Projects & Jobs\D115000 to D115999\D115326 Mid Essex FRA\GIS



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

LEGEND

River Centrelines

Chelmsford District Boundary

Present Day Flood Zones (2007)

Functional Floodplain

Flood Zone 3

Flood Zone 2

Revision Details	By / Check	Date	Suffix

Drawing Status

FINAL

Job Title

MID ESSEX SFRA
Chelmsford Borough Council

Drawing Title

Present Day Flood Zones

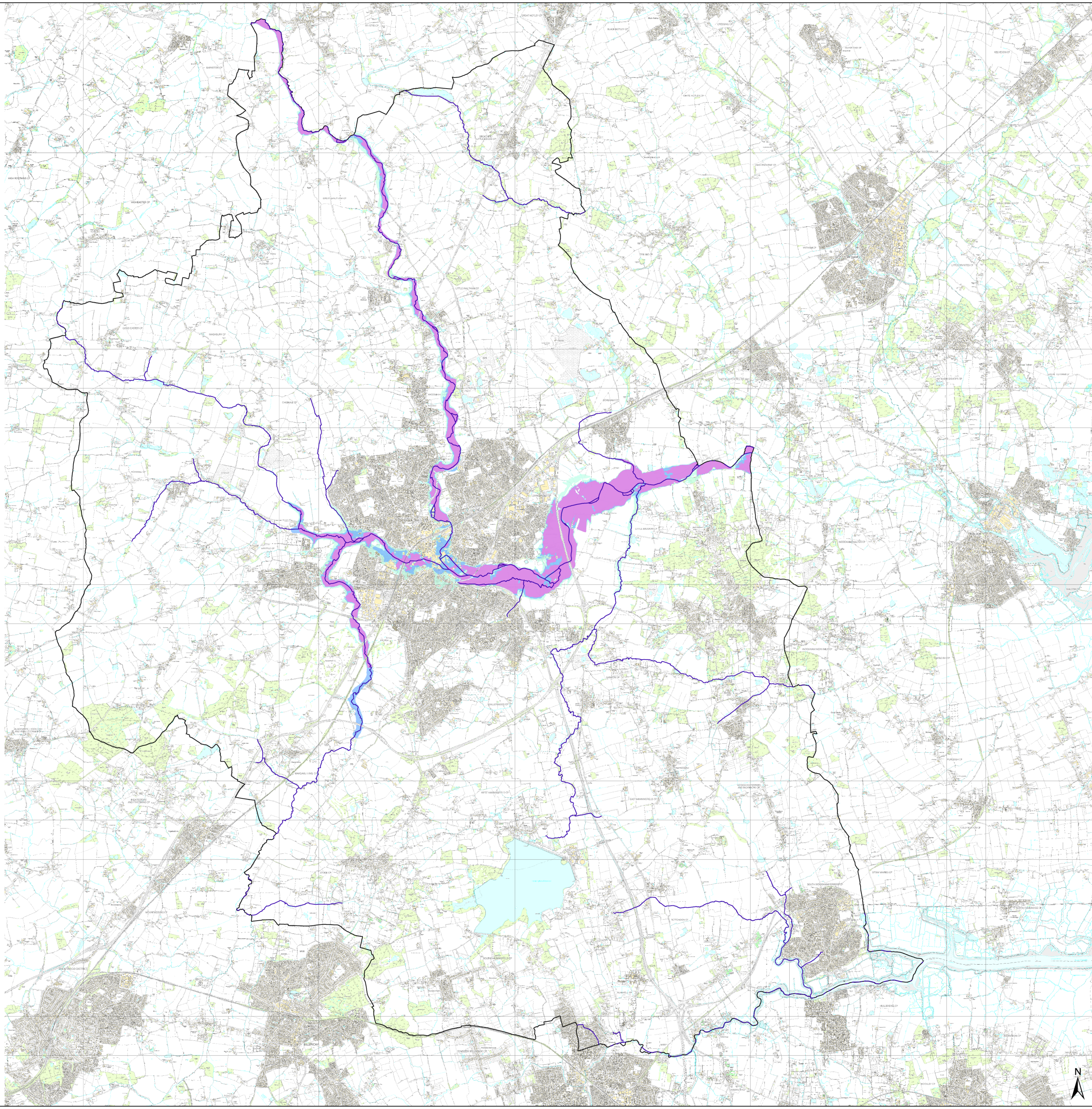
Scale at A1	1:50,000		
Drawn	AJG	Approved	
Stage 1 check	Stage 2 check	Originated	Date

Scott Wilson
Scott House
Alençon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
[redacted]

Drawing Number — Rev

FIGURE B39

Date: 12th March 2008
Filepath: L:\Water\Projects & Jobs\D115000 to D115999\D115326 Mid Essex FRA\GIS



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

LEGEND

River Centrelines

Chelmsford District Boundary

Climate Change Flood Zones

Functional Floodplain

Flood Zone 3

Flood Zone 2

Revision Details	By / Check	Date	Suffix

Drawing Status

FINAL

Job Title

MID ESSEX SFRA
Chelmsford Borough Council

Drawing Title

Climate Change Flood Zones

Scale at A1: 1:50,000

Drawn: AJG

Approved

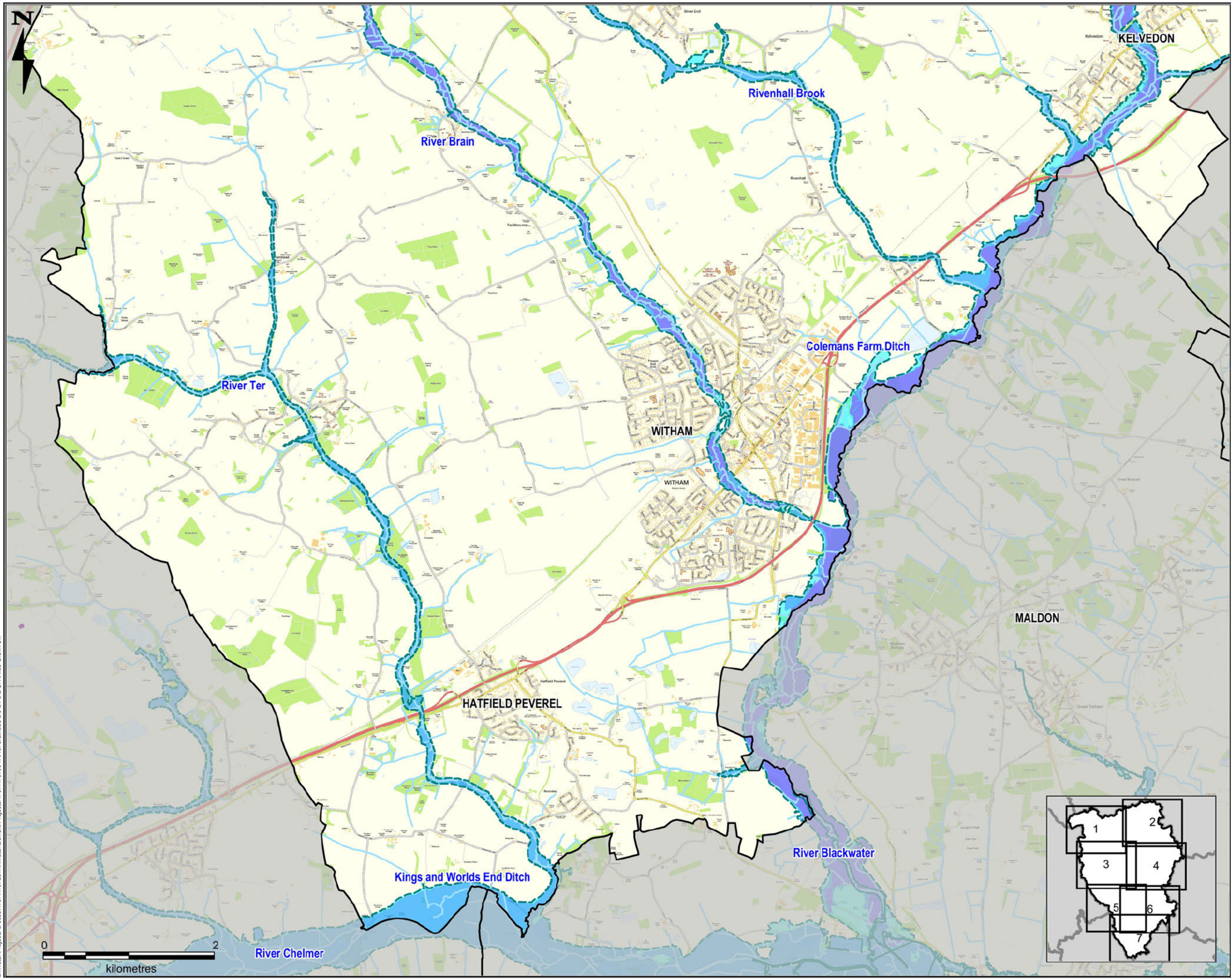
Stage 1 check | Stage 2 check | Originated | Date

Scott Wilson
Scott House
Alençon Link, Basingstoke
Hampshire, RG21 7PP
Telephone (01256) 310200
Fax (01256) 310201
[redacted]

Drawing Number

FIGURE B40

Rev



THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT

LEGEND

- Administrative Boundaries
- Main River
- Ordinary Watercourse
- Historic Records of Fluvial Flooding
- Flood Defences
- Flood Storage Areas
- Areas Benefiting from Flood Defences

Probability of Flooding from Rivers and the Sea

- Flood Zone 1 Low Probability
- Flood Zone 2 Medium Probability
- Flood Zone 3a High Probability
- Flood Zone 3b Functional Floodplain
- Flood Zone 3a plus climate change

Notes

Main Rivers are designated by Defra on a 'Main River Map'. The Environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only. However overall responsibility for maintenance lies with the riparian owner.
The Environment Agency Flood Map for Planning (Rivers and Sea) is available on the Environment Agency website (www.gov.uk/environment-agency) and displays the risk of flooding based on probability. Flood Zone 1: Land assessed, ignoring the presence of flood defences, as having a less than 0.1% annual probability of fluvial or tidal flooding in any year. Flood Zone 2: Land assessed, ignoring the presence of flood defences, as having between a 1% and 0.1% annual probability of fluvial flooding in any year. Flood Zone 3: Land assessed, ignoring the presence of flood defences, as having a 1% or greater annual probability of fluvial flooding in any year.
The Flood Map displays the location of linear raised flood defences such as embankments and walls. Flood storage areas, land designated and operated to store flood water are displayed in a separate polygon layer. Land that may benefit from the presence of flood defences during a 1% fluvial or 0.5% tidal flood event. These are areas that would flood if the defence were not present, but may not flood because the defence is present. Areas benefitting from flood storage areas may be remote from the flood defence structure.
This map is intended to provide a strategic overview of fluvial flood risk and should not be used to assess flood risk for individual properties.

In February 2016, the Environment Agency published revised guidance on climate change allowances. In the absence of model outputs for the updated climate change allowances, this Level 1 SFRA has adopted a conservative approach to assessing climate change for the purpose of the Sequential Test by using the existing Flood Zone 2 extent (1 in 1000 annual probability of river flooding) as a proxy for the Flood Zone 3a plus climate change. This represents the 'higher central' allowance. Developers should note that for all subsequent site specific FRAs, confirmation is required from the Environment Agency on the appropriate climate change assessment approach for each site.

Revision Details | Suffix

Purpose of Issue
FINAL

Client
Braintree District Council

Project Title
Braintree
Level 1 Strategic Flood
Risk Assessment

Drawing Title
Flood Zone Maps

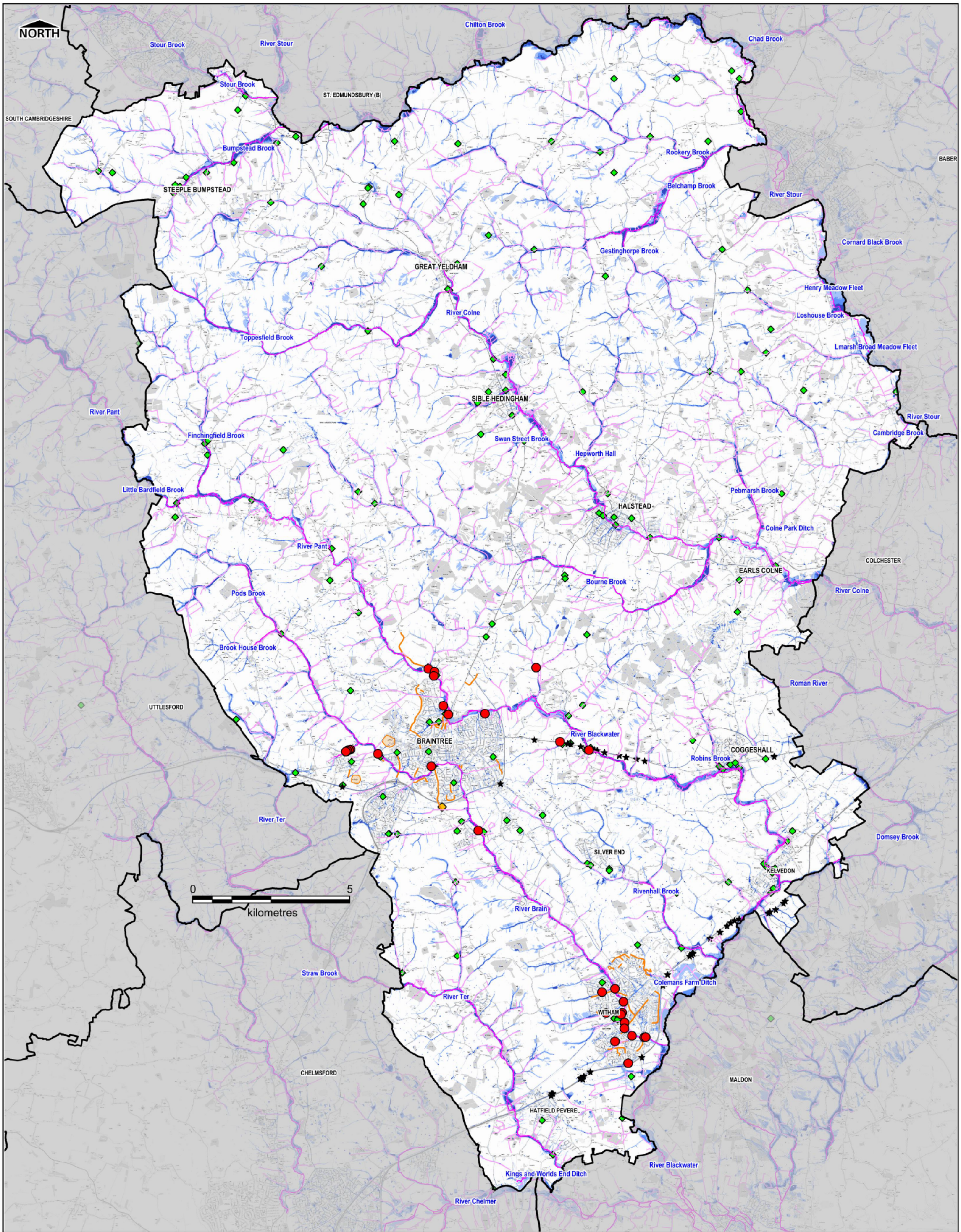
Drawn	Checked	Approved	Date
SB	JB	JR	Nov 2016

AECOM Internal Project No.	Scale at A3
60478467	1:40,000

AECOM Infrastructure & Environment UK Limited
Midpoint
Alençon Link, Basingstoke,
Hampshire, RG21 7PP
United Kingdom
T +44 (0)1256 310 200
[redacted]

AECOM

Drawing Number	Rev
FIGURE 2.7	03



N:\Water\Current Projects\47076478457 Braintree DC L1 & 2 SFRA\06 GIS

LEGEND

- Administrative Boundaries
- Main River
- Ordinary Watercourse
- BDC Flood Summaries
- ECC Flood Incident Records
- Highways England Flood Records
- Known Flood Hotspots (EA & ECC)

Probability of Flooding from Surface Water

- High (>3.3% AEP)
- Medium (1% - 3.3% AEP)
- Low (0.1% - 1% AEP)
- Very Low (<0.1% AEP)

NOTES

This map shows the predicted likelihood of surface water flooding based on the Environment Agency's Risk of Flooding from Surface Water (RoFSW) data, which may be subject to further analysis in the future. Further information is provided on the Environment Agency website (www.gov.uk/environment-agency).

The Risk from Surface Water Flooding is divided into categories: High: each year, the chance of flooding is greater than 1 in 30 (3.3%). Medium: each year, the chance of flooding is greater than 1 in 100 (1%) and 1 in 30 (3.3%). Low: each year, the chance of flooding is between 1 in 1000 (0.1%) and 1 in 100 (1%). Very Low: each year, the chance of flooding is less than 1 in 1000 (0.1%). The potential impact of surface water flooding can vary according to the depth of the water, and its velocity (speed and direction that it is flowing in).

Surface water flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead. This type of flooding can be diffucit to predice as it is hard to forecast exactly where or how much rain will fall in any storm. This map is intended to provide a strategic overview of surface water flood risk and should not be used to assess flood risk for individual properties.

Braintree District Council provided flood risk summaries for the towns and villages of Braintree as assessed by the local community, which is idenfited by the "BDC Flood Summaries".

Essex County Council have provided information on surface water flooding from the 18th June 2015 throughout Braintree and Witham.

Project Title

Braintree District Council
Strategic Flood Risk Assessment Update

Drawing Title

Risk of Flooding from Surface Water

Client

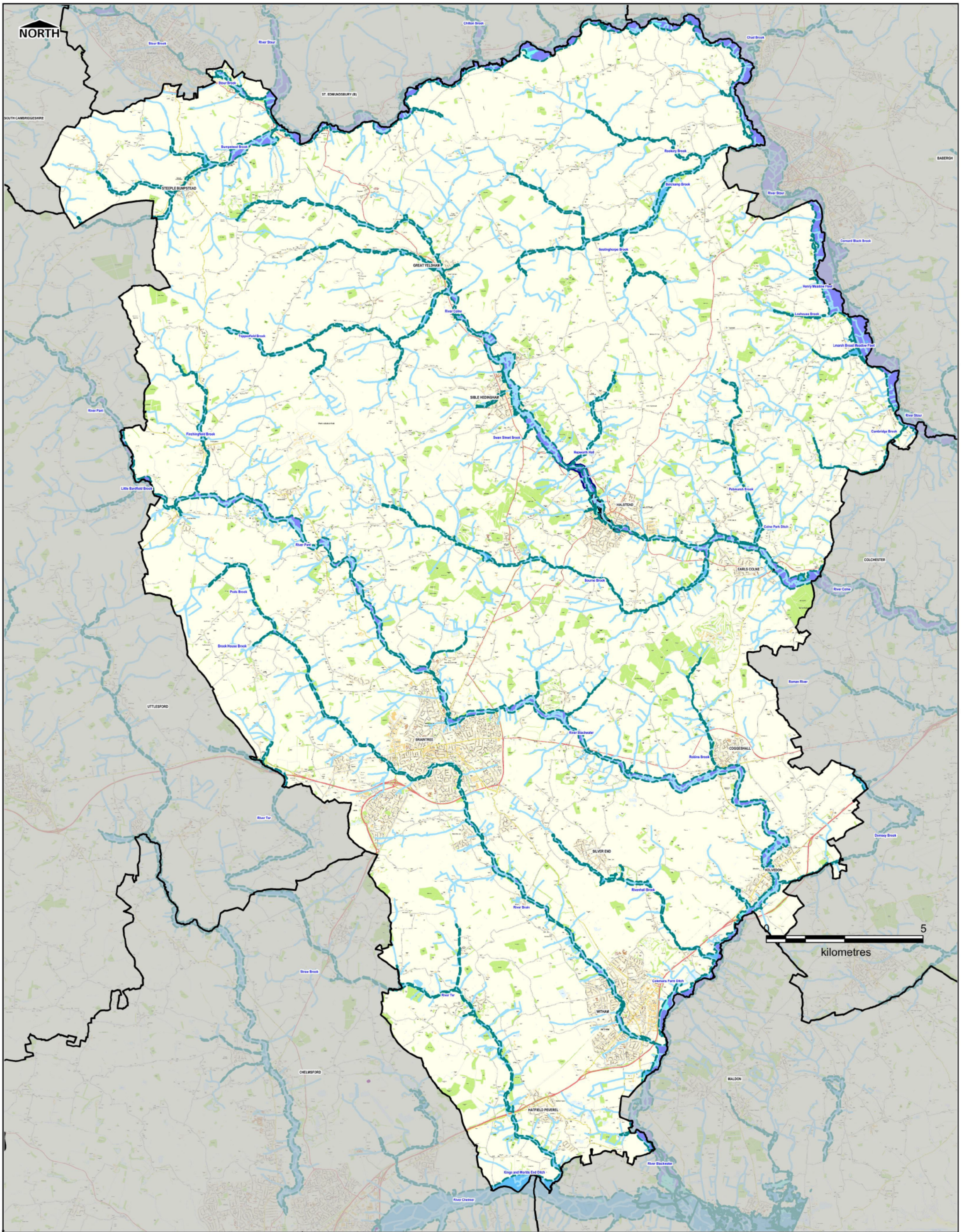
Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Mid Point
Alencon Link
Basingstoke, RG21 7PP
[redacted]
AECOM

Drawn	SB	Version	2
Checked	JB	Date	November 2016
Approved	JR	Scale at A3	1:110,000

Drawing Number: FIGURE 3

Rev: 02



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LEGEND

- Administrative Boundaries
- Main River
- Ordinary Watercourse
- Historic Records of Fluvial Flooding
- Flood Defences
- Flood Storage Areas
- Areas Benefiting from Flood Defences

Probability of Flooding from Rivers and the Sea

- Flood Zone 1 Low Probability
- Flood Zone 2 Medium Probability
- Flood Zone 3a High Probability
- Flood Zone 3b Functional Floodplain
- Flood Zone 3a plus climate change

NOTES

Main Rivers are designated by Defra on a 'Main River Map'. The Environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only. However overall responsibility for maintenance lies with the riparian owner. An Ordinary Watercourse is a watercourse that does not form part of a Main River. This includes all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows according to the Land Drainage Act 1991. The Environment Agency Flood Map for Planning (Rivers and Sea) is available on the Environment Agency website (www.gov.uk/environment-agency) and displays the risk of flooding based on probability. Flood Zone 1: Land assessed, ignoring the presence of flood defences, as having a less than 0.1% annual probability of fluvial or tidal flooding in any year. Flood Zone 2: Land assessed, ignoring the presence of flood defences, as having between a 1% nd 0.1% annual probability of fluvial flooding in any year. Flood Zone 3: Land assessed, ignoring the presence of flood defences, as having a 1% or greater annual probability of fluvial flooding in any year. Land that may benefit from the presence of flood defences during a 1% fluvial or 0.5% tidal flood event. These are areas that would flood if the defence were not present, but may not flood because the defence is present. This map is intended to provide a strategic overview of fluvial flood risk and should not be used to assess flood risk for individual properties.

In February 2016, the Environment Agency published revised guidance on climate change allowances. In the absence of model outputs for the updated climate change allowances, this Level 1 SFRA has adopted a conservative approach to assessing climate change for the purpose of the Sequential Test by using the existing Flood Zone 2 extent (1 in 1000 annual probability of river flooding) as a proxy for the Flood Zone 3a plus climate change. This represents the 'higher central' allowance. Developers should note that for all subsequent site specific FRAs, confirmation is required from the Environment Agency on the appropriate climate change assessment approach for each site.

Project Title

Braintree District Council
Strategic Flood Risk Assessment update

Drawing Title

Flood Zone Map

Client

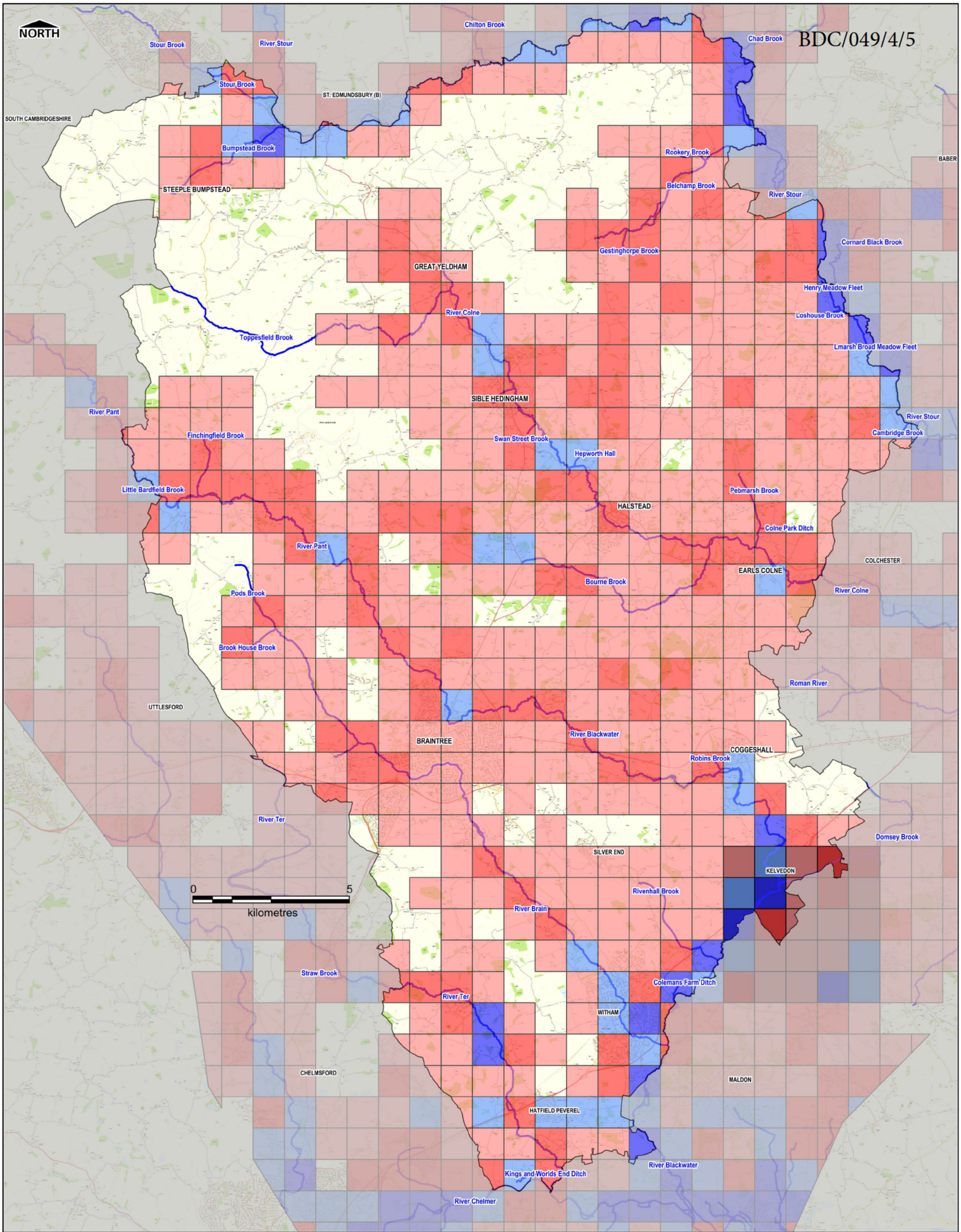
Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Midpoint
Alençon Link, Basingstoke,
Hampshire, RG21 7PP
[redacted]

Drawn	SB	Version	2
Checked	JB	Date	November 2016
Approved	JR	Scale at A3	1:110,000

Drawing Number: FIGURE 2

Rev: 03



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LEGEND

- Administrative Boundaries
- Main River
- Ordinary Watercourse

Probability of Flooding from Ground Water

- >= 75%
- >= 50% <75%
- >= 25% <50%
- <25%

NOTES

Areas Susceptible to Groundwater Flooding (AStGWF) is a strategic scale map showing groundwater flood areas on a 1km square grid. It was developed specifically by the Environmental Agency for use by Lead Local Flood Authorities (LLFAs) for use in Preliminary Flood Risk Assessment (PFRA) as required under the Flood Risk Regulartions. The was produced to annotate indicative Flood Risk Areas for PFRA with information to allow LLFAs to determine whether there may be a risk of flooding from groundwater.

The data has used the top two susceptibility bands of the British Geological Society (BGS) 1:50,000 Groundwater Flood Susceptibility Map and thus covers consolidated aquifers (chalk, sandstone etc., termed 'cleanwater' in the data attributes) and superficial deposits.It does not take account of the chance of flooding from groundwater rebound. It shows the proportion of each 1km grid square where geological and hydrogeological conditions show that ground water might emerge. The susceptible areas are represented by one of four area catergories (listed above) showing the proportion of each 1km square that is susceptible to groundwater emergence. It does not show the likelihood of groundwarer flooding occuring.

In common with the majority of datasets showing areas which may experience groundwater emergence, this dataset covers a large area of land, and only isolated locations within the overallsusceptible area are actually likley to suffer the consequences of groundwater flooding.

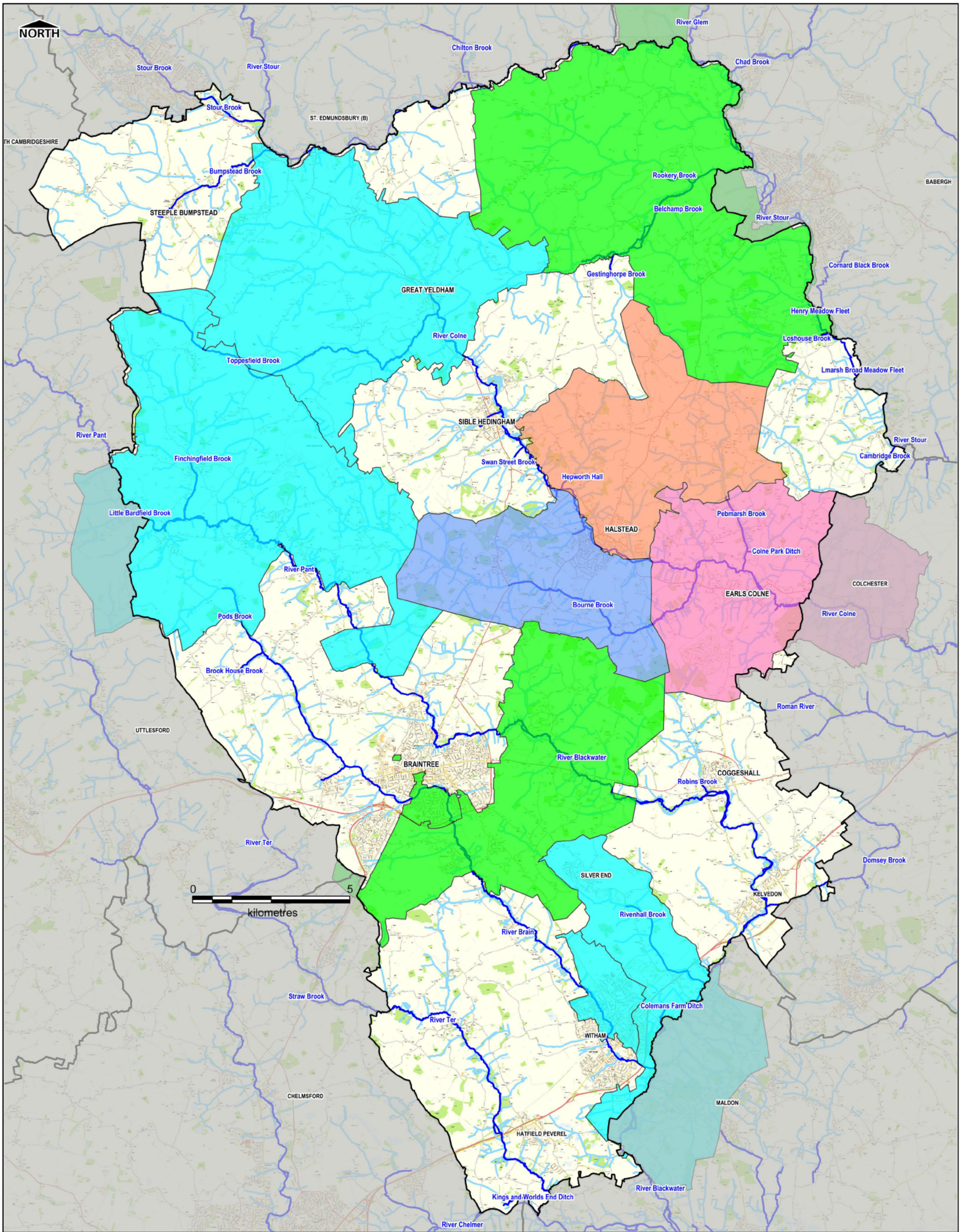
Project Title
Braintree District Council
Strategic Flood Risk Assessment Update

Drawing Title
AREAS SUSCEPTIBLE TO
GROUNDWATER FLOODING

Client
Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Mid Point
Alencon Link
[redacted]
AECOM

Drawn	SB	Version	2	Drawing Number	Rev
Checked	JB	Date	November 2016	FIGURE 4	02
Approved	JR	Scale at A3	1:110,000		



N:\Water\Current Projects\47076047845 Braintree DC L1 & 2 SFRA\06 GIS

LEGEND

- Administrative Boundaries
- Main River
- Ordinary Watercourse

External Sewer Flood Incidents

- 1
- 2
- 3
- 5
- 6

Purpose: FINAL

NOTES

Anglian Water Services has provided an extract from their DG5 Flood Register for the study area. Due to data protection requirements the data has not been provided at individual property level; rather the register comprises the number of properties within 4 digit postcode areas that have experienced flooding either internally or externally within the last 10 years.

It should be noted that records only appear on the DG5 register where they have been reported to AWS, and as such they may not include all instances of sewer flooding.

Furthermore given that AWS target these areas for maintenance and improvements, areas that experienced flooding in the past may not longer be at greatest risk of flooing in the future.

This map is intended to provide a strategic overview of sewer flood risk and should not be used to assess flood risk individal properties.

Project Title: Braintree District Council
Strategic Flood Risk Assessment Update

Drawing Title: External Sewer Flood Incidents

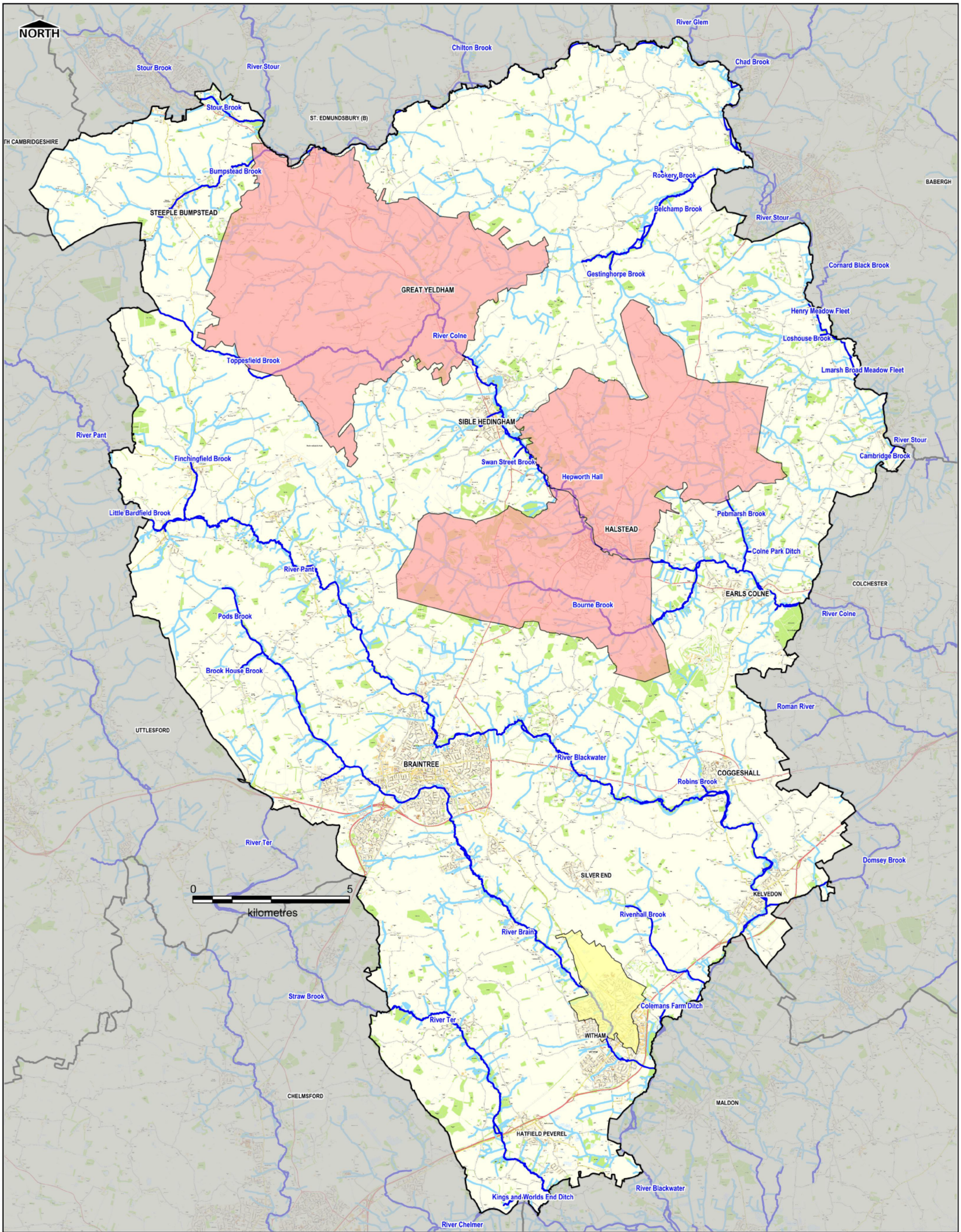
Client: Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Midpoint
Alençon Link
Basingstoke, Hampshire.
[redacted]

Drawn	SB	Version	2
Checked	JB	Date	November 2016
Approved	JR	Scale at A3	1:110,000

Drawing Number: FIGURE 5.1

Rev: 02



N:\Water\Current Projects\47076047845? Braintree DC L1 & 2 SFRA\06 GIS

LEGEND

Administrative Boundaries
Main River
Ordinary Watercourse

Internal Sewer Flood Incidents

(pink)	1	(3)
(yellow)	2	(1)

Purpose: FINAL

NOTES

Anglian Water Services has provided an extract from their DG5 Flood Register for the study area. Due to data protection requirements the data has not been provided at individual property level; rather the register comprises the number of properties within 4 digit postcode areas that have experienced flooding either internally or externally within the last 10 years.

It should be noted that records only appear on the DG5 register where they have been reported to AWS, and as such they may not include all instances of sewer flooding.

Furthermore given that AWS target these areas for maintenance and improvements, areas that experienced flooding in the past may not longer be at greatest risk of flooing in the future.

This map is intended to provide a strategic overview of sewer flood risk and should not be used to assess flood risk individal properties.

Project Title: Braintree District Council
Strategic Flood Risk Assessment Update

Drawing Title: Internal Sewer Flood Incidents

Drawn	SB	Version	2
Checked	JB	Date	November 2016
Approved	JR	Scale at A3	1:110,000

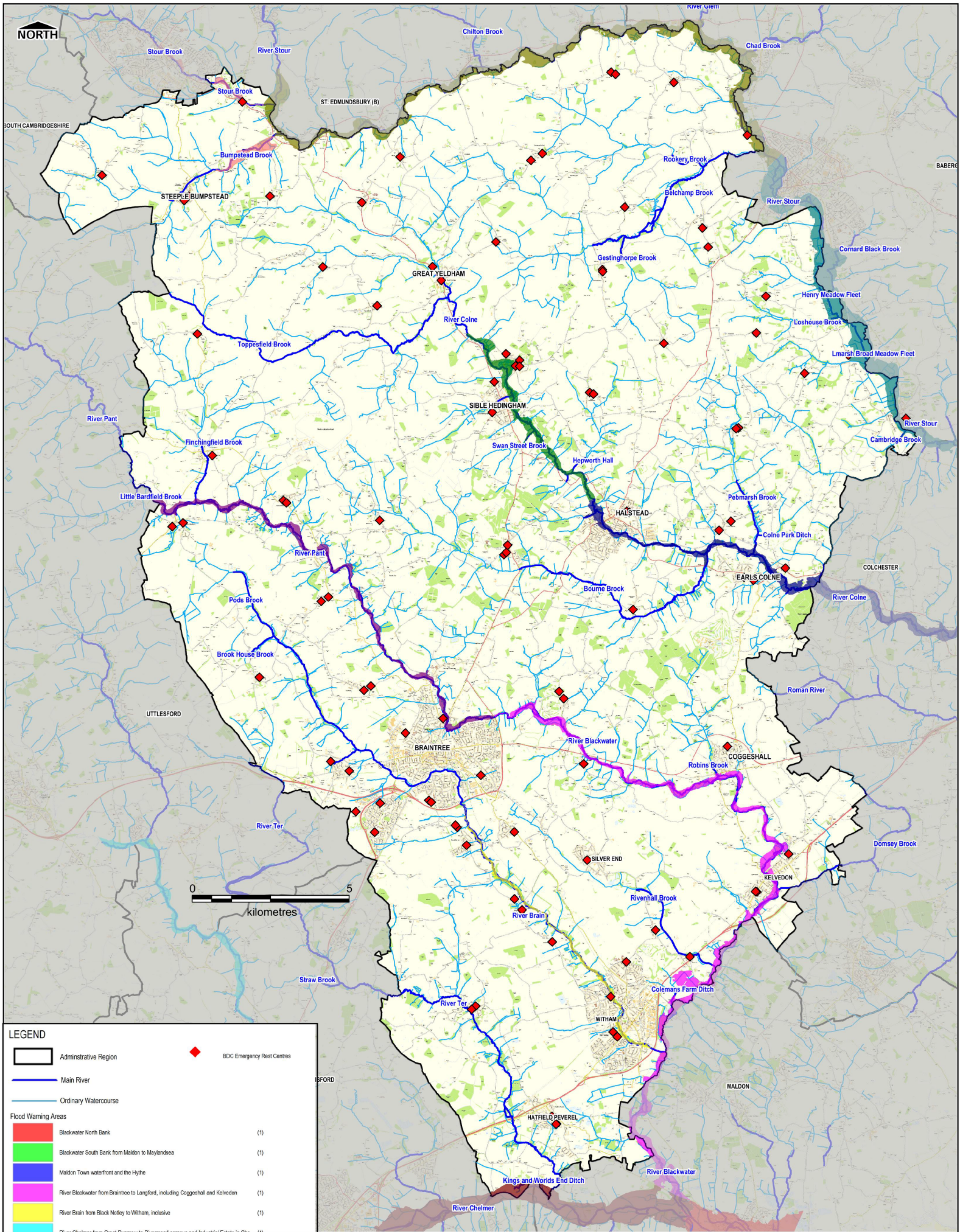
Client: Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Midpoint
Alencon Link
Basingstoke, Hampshire,
RG21 7PP, UK

[redacted]

FIGURE 5.2

Rev 02



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NOTES

The Environment Agency provide a free flood warning service for many areas at risk of flooding from rivers and the sea. In some parts of England the Environment Agency may be able to provide warnings when flood from groundwarer is possible. The Environment Agency free flood warning service can provide advance notice of flooding and can provide time to prepare.

The Environment Agency issue flood warnigs to homes and businesses when flooding is expected. Upon receipt of a flood warning, occupants should take immediate action.

The Envirorment Agency issue flood alerts when flooding is possible. Flood alerts cover larger areas than flood warnings and are issued more frequently. Upon receipt of a flood warning, occupants should be prepared for flooding and to take action.

If a flood alert for groundwater if available this does not mean that your property is definitely at risk. it is very difficult to predict the exact location of flooding from groundwater as it is oftem related to local geology. To help people, the Environment Agency provde flood alerts for large areas that could be affected if groundwater levels were high.

Project Title
Braintree District Council
Strategic Flood Risk Assessment Update

Drawing Title
Flood Warning Areas and
Emergency Rest Centres

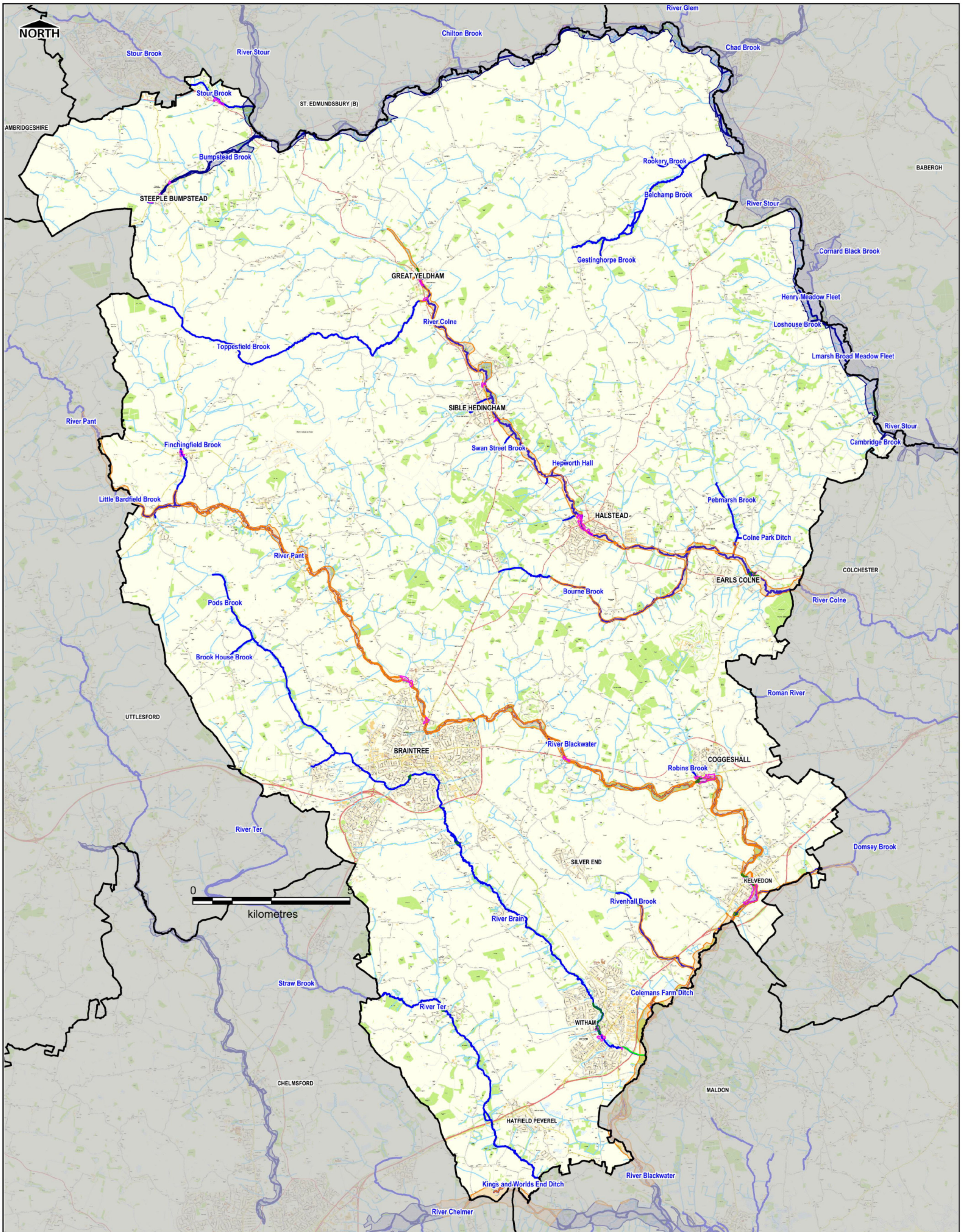
Client
Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Midpoint
Alençon Link
Basingstoke, Hampshire
[redacted]
AECOM

Drawn	SB	Version	2
Checked	JB	Date	November 2016
Approved	JR	Scale at A3	1:110,000

Drawing Number
FIGURE 6

Rev
02



N:\Water\Current Projects\4707\4707XXXX Braintree DC L1 & 2 SFRA\06 GIS

LEGEND

- Administrative Boundaries
- Main River
- Ordinary Watercourse

Historic Flood Outlines

- Historic Flood Record
- 1947 Flood Outline
- 1970 Flood Outline
- 2001 Flood Outline
- 2009 Flood Outline

NOTES

Main Rivers are designated by Defra on a 'Main River Map'. The Environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only. However overall responsibility for maintenance lies with the riparian owner.

An Ordinary Watercourse is a watercourse that does not form part of a Main River. This includes all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows according to the Land Drainage Act 1991.

Purpose: FINAL

Project Title: Braintree District Council
Strategic Flood Risk Assessment Update

Drawing Title: Environment Agency
Historic Flood Outlines

Drawn	SB	Version	2
Checked	JB	Date	November 2016
Approved	JR	Scale at A3	1:110,000

Client: Braintree District Council

AECOM Infrastructure & Environment UK Ltd
Midpoint
Alençon Link
Basingstoke, Hampshire,
[redacted]

Drawing Number: FIGURE 7

Rev: 02

Annex C – Additional Mapping

Flood map for planning

Your reference	Location (easting/northing)	Created
Longfield	**575399/213026**	**16 Mar 2021 9:19**

Your selected location is in flood zone 3, an area with a high probability of flooding.

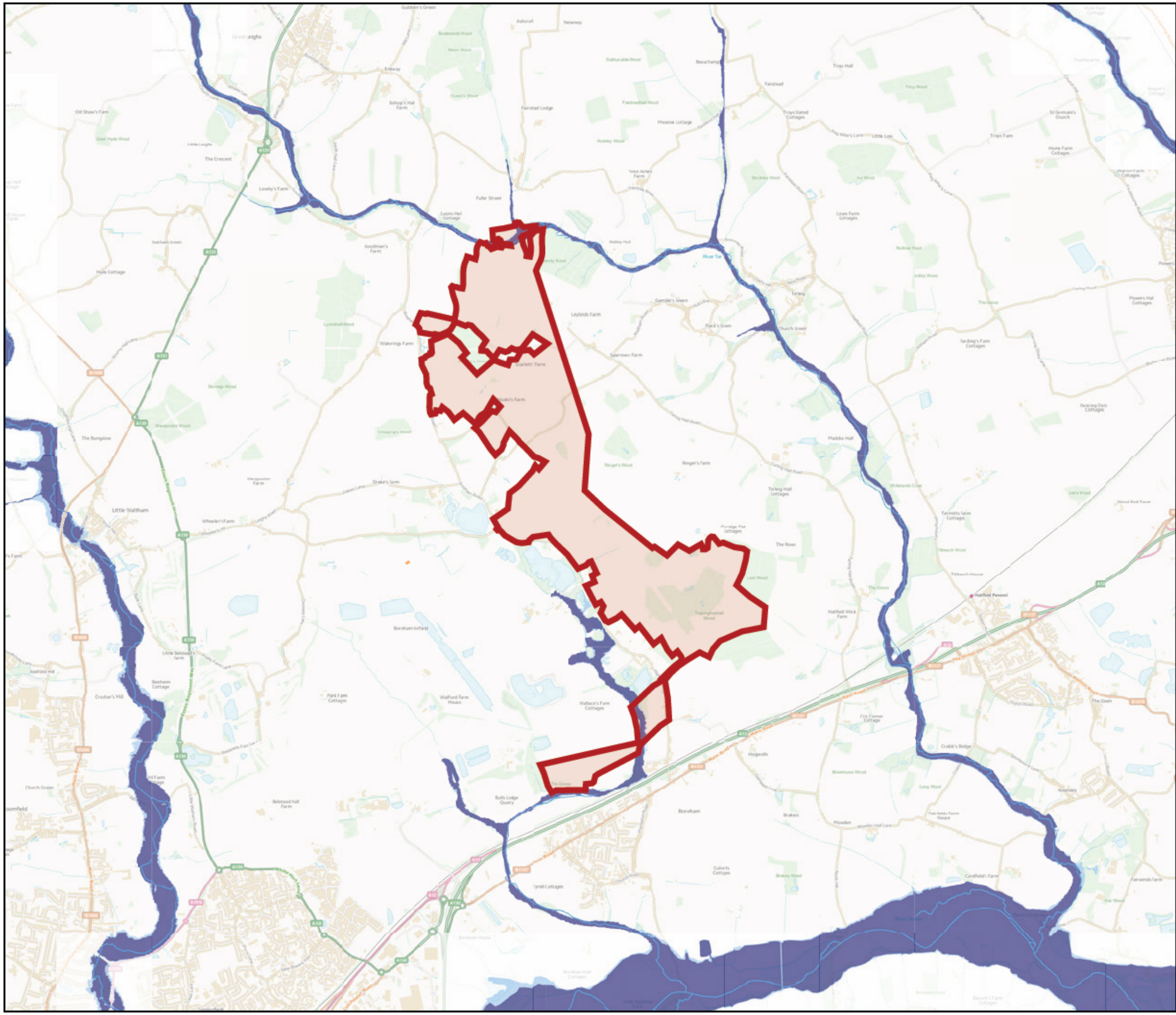
This means:

- you must complete a flood risk assessment for development in this area
- you should follow the Environment Agency's standing advice for carrying out a flood risk assessment (see www.gov.uk/guidance/flood-risk-assessment-standing-advice)

Notes

The flood map for planning shows river and sea flooding data only. It doesn't include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.



Environment Agency

Flood map for planning

Your reference
Longfield

Location (easting/northing)
575399/213026

Scale
1:50000

Created
16 Mar 2021 9:19

- Selected area
- Flood zone 3
- Flood zone 3: areas benefitting from flood defences
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Flood storage area

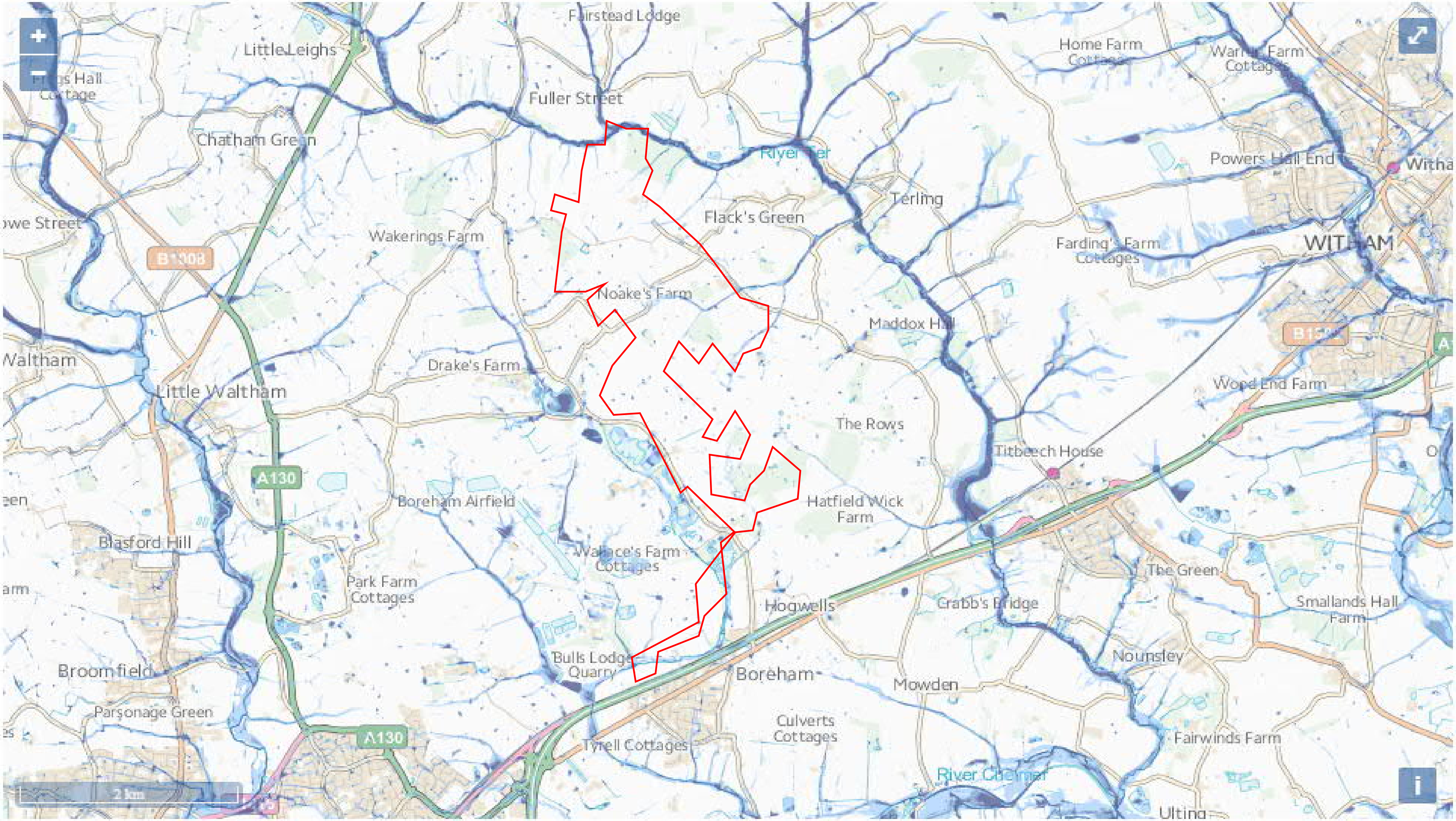
0 500 1000 1500m

Flood risk

Extent of flooding

Location

BOREHAM, ESSEX



Extent of flooding from surface water

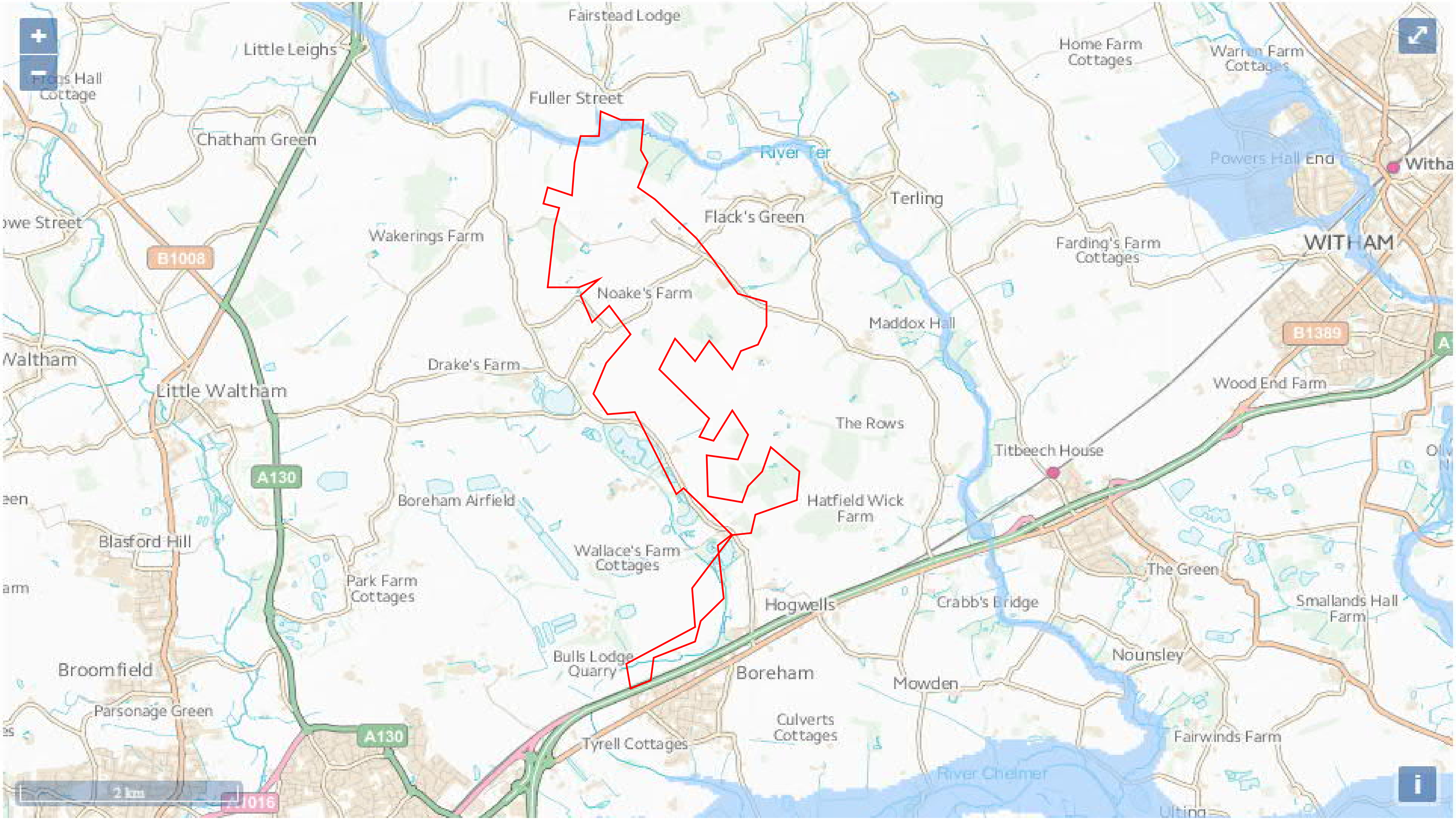
High Medium Low Very low Location you selected

Flood risk

Extent of flooding

Location

BOREHAM, ESSEX



Extent of flooding from reservoirs

Maximum extent of flooding   Location you selected

Annex D - Pluvial Modelling Report

ARCUS

SURFACE WATER MODELLING TECHNICAL NOTE

LONGFIELD SOLAR FARM

LONGFIELD SOLAR ENERGY FARM LTD

FEBRUARY 2022

Longfield Solar Farm

1 INTRODUCTION

1.1 Project Background

Arcus Consultancy Services Ltd (Arcus) has been instructed by Longfield Solar Energy Farm Ltd to produce a surface water model at the location of the proposed Longfield Solar Farm (the Development) located north of Boreham village, Chelmsford at National Grid Reference E 576665, N 212070 (the DCO Site).

The purpose of the surface water modelling is to confirm the existing surface water depths and flow routes at the Site and surrounding land in order to incorporate surface water betterment measures as part of the biodiversity measures proposed as part of the Development.

2 METHODOLOGY

2.1 Initial Design Parameters

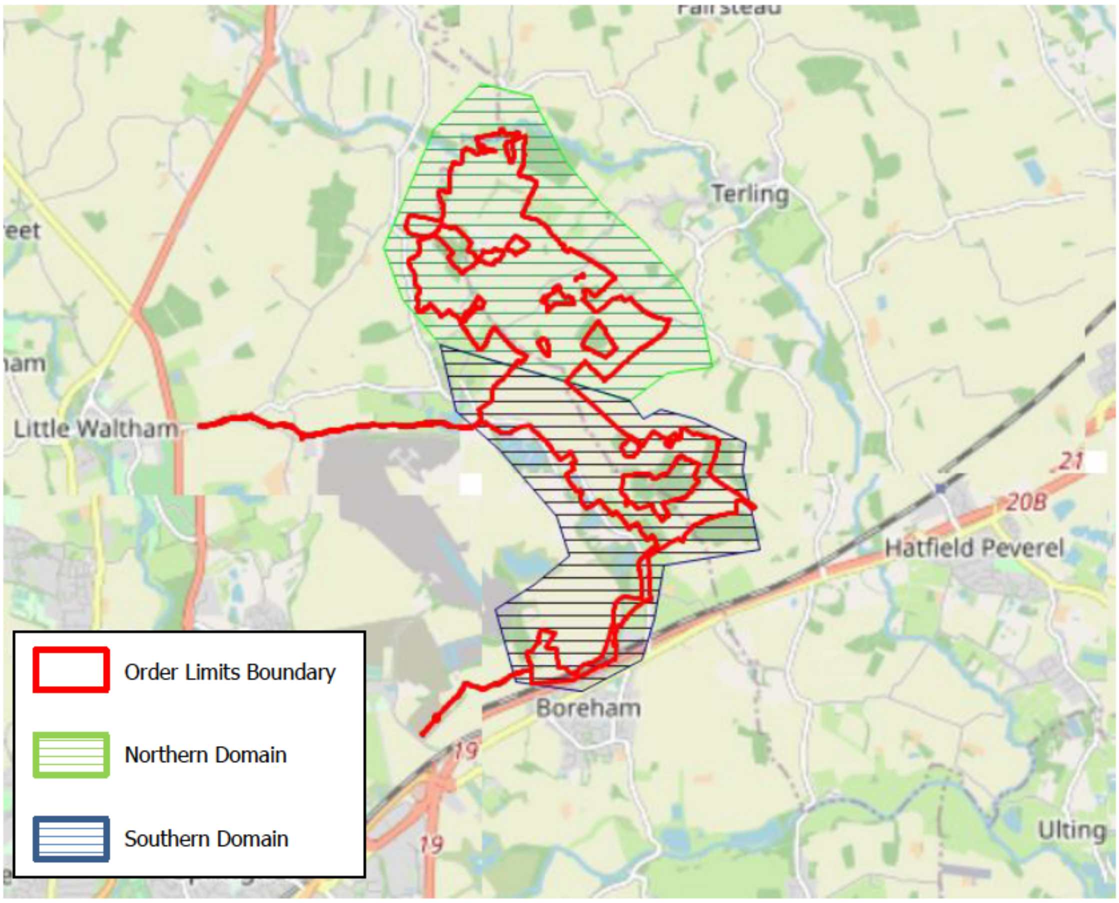
The surface water characteristics of the Site has been modelled in a 2D simulation utilising Flood Modeller 5.0 software and Alternating Direction Implicit (ADI) solver.

The topography at the Site and surrounding catchment is represented in the model by 2019 LiDAR data to 1 metre (m) resolution (TL71 and TL70).

All model runs are set to a timestep of 2 seconds and grid sizing of 4 m. To enable the model to run at such a grid size the Site was split into a northern and southern domain, as shown in Plate 1, to incorporate the Site and surrounding catchment.

The northern and southern domains are approximately 5.7 square kilometres (km^2) and 5.2 km^2 in area respectively.

Plate 1 – 2D Model Domain (Taken from Flood Modeller)

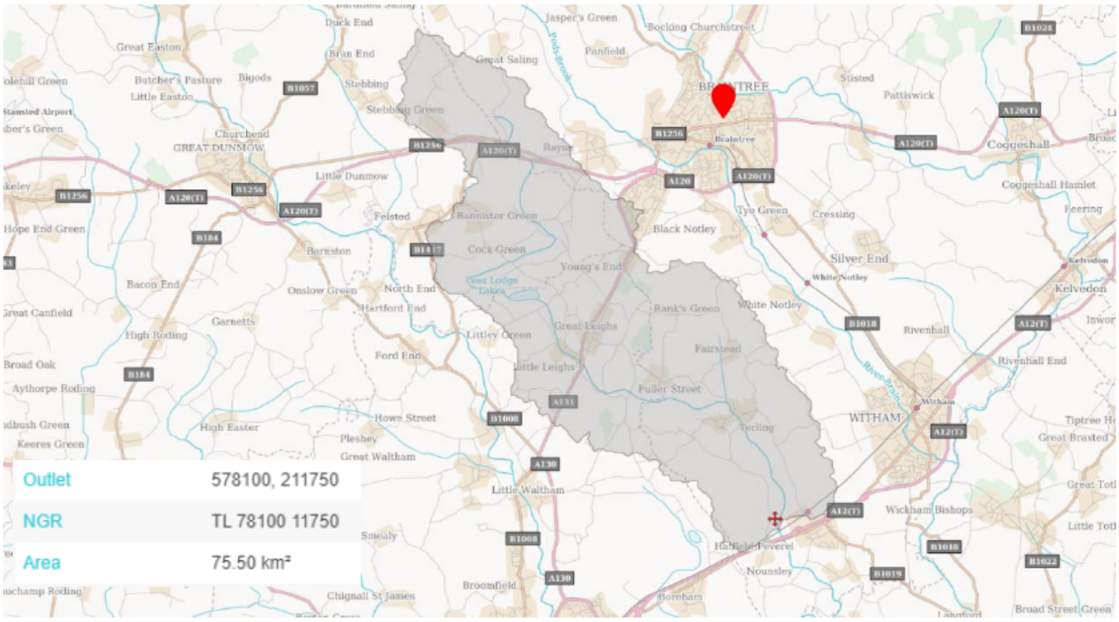


2.2 Hydrology Data

To develop hyetographs, catchment descriptors have been imported from the UK Centre for Ecology and Hydrology (CEH) Flood Estimation Handbook (FEH) web map[1] for a number of return periods as a 100 % rural model from a catchment of 75.5 km² as shown in Plate 2.

[1] UK Centre for Ecology and Hydrology, Flood Estimation Handbook. [Online]. Available at: [redacted]

Plate 2 – FEH Catchment



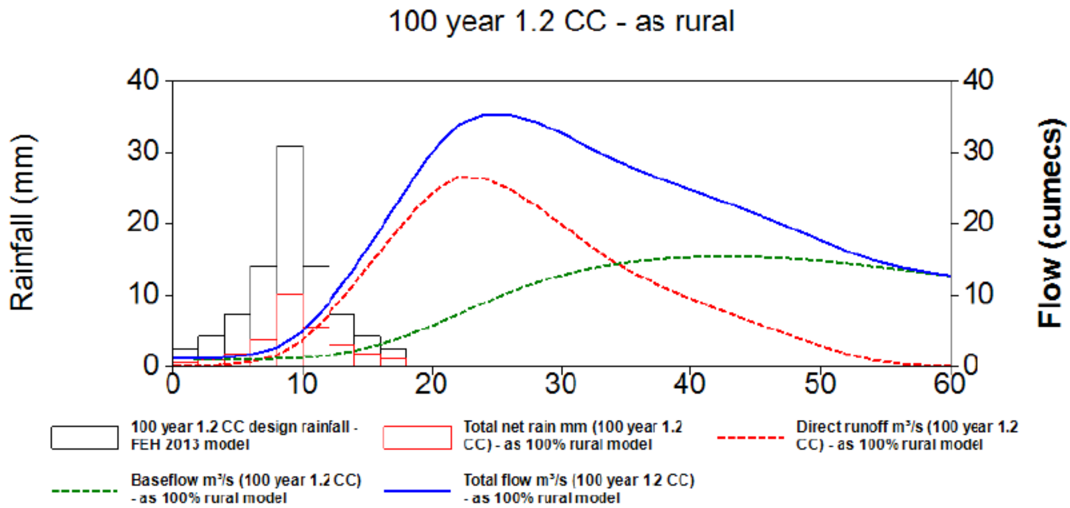
To account for the percolation capacity of the catchment the net loss rainfall data has been utilised within the Revitalised Flood Estimation Handbook 2 (ReFH2) software to generate a hyetograph which represents rainfall loses within the catchment. The summer profile shows the greatest rainfall intensities and has been utilised to demonstrate a 'worst-case scenario'.

The 1:100-year return period is the appropriate return period for the Development and has been utilised.

The Development has an operational lifetime of less than 50 years. In accordance with Environment Agency (EA) climate change allowances[2] a 20 % uplift has been applied to the 1:100-year hyetograph to account for increases in rainfall intensities associated with climate change up to 2069 with a hyetograph shown in Plate 3.

Outputs from the REFH2 hyetograph are shown in Appendix A.

Plate 3 – 1 in 100-Year (+20%) REFH2 Hyetograph



[2] Environment Agency, Flood Risk Assessment: Climate Change Allowances (2021). [Online]. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

2.3 Iterative Design

To measure the potential impact of the Development on surface water flood depths and flows the modelling process has been conducted through an iterative process. This process has been conducted in three key modelling phases; the baseline scenario, the refined baseline scenario and the operational phase scenario. The design details of each phase are detailed in the following sections.

2.3.1 Baseline Scenario

The baseline scenario model has been developed to identify the existing surface water flow characteristics at the Site and any areas of potential surface water flood risk at or emanating from the Site.

Ordnance Survey (OS) buildings data has been incorporated into the baseline scenario model with existing buildings within the model domains raised above topography.

OS roads data has been incorporated into the baseline scenario with existing roads within the model domains depressed 0.1 m below existing topography.

A universal Manning's N roughness value of 0.03 has been incorporated into the model to represent short grass pasture grounds in accordance with Chow 1959[3].

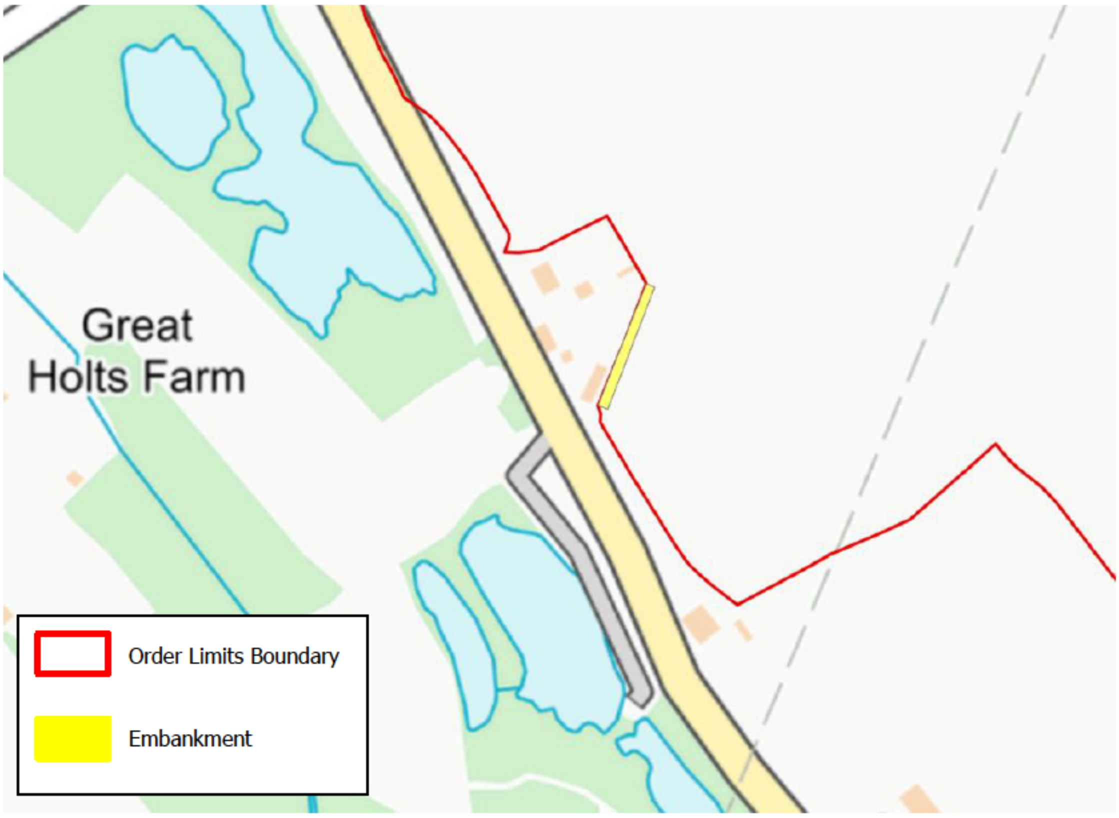
2.3.2 Refined Baseline Scenario

The refined baseline scenario has been developed to add further characteristics of the catchment into the baseline scenario to identify the surrounding surface water characteristics.

Consultations with surrounding landowners were conducted in September 2021 by Pershing Consultants where the baseline scenario methodology and outputs were reviewed. Consultations identified the presence of a 1 m high embankment located to the east of Stocks Farm which diverted surface water flow routes away from the property and within the Site. The embankments have therefore been incorporated into the model and raised 1 m above existing topography. The location of the embankment is show in Plate 3.

[3] Chow, Manning's N Values for Channels, closed Conduits Flow Partially Full and Corrugated Metal Pipes (1959). [Online]. Available at: [redacted]

Plate 3 – Embankments at Stocks Farm



Aerial imagery and photographs obtained from an Arcus hydrology site walkover in July 2021 have been assessed to identify existing ground conditions and land use at the Site and surrounding areas. The Manning's N roughness value has been amended from the universal value for any areas identified as woodland, roads and tracks as detailed in Plate 4 and Table 1 with values derived from Chow 1959.

Plate 4 – Manning's N Roughness Values (Taken from Flood Modeller)

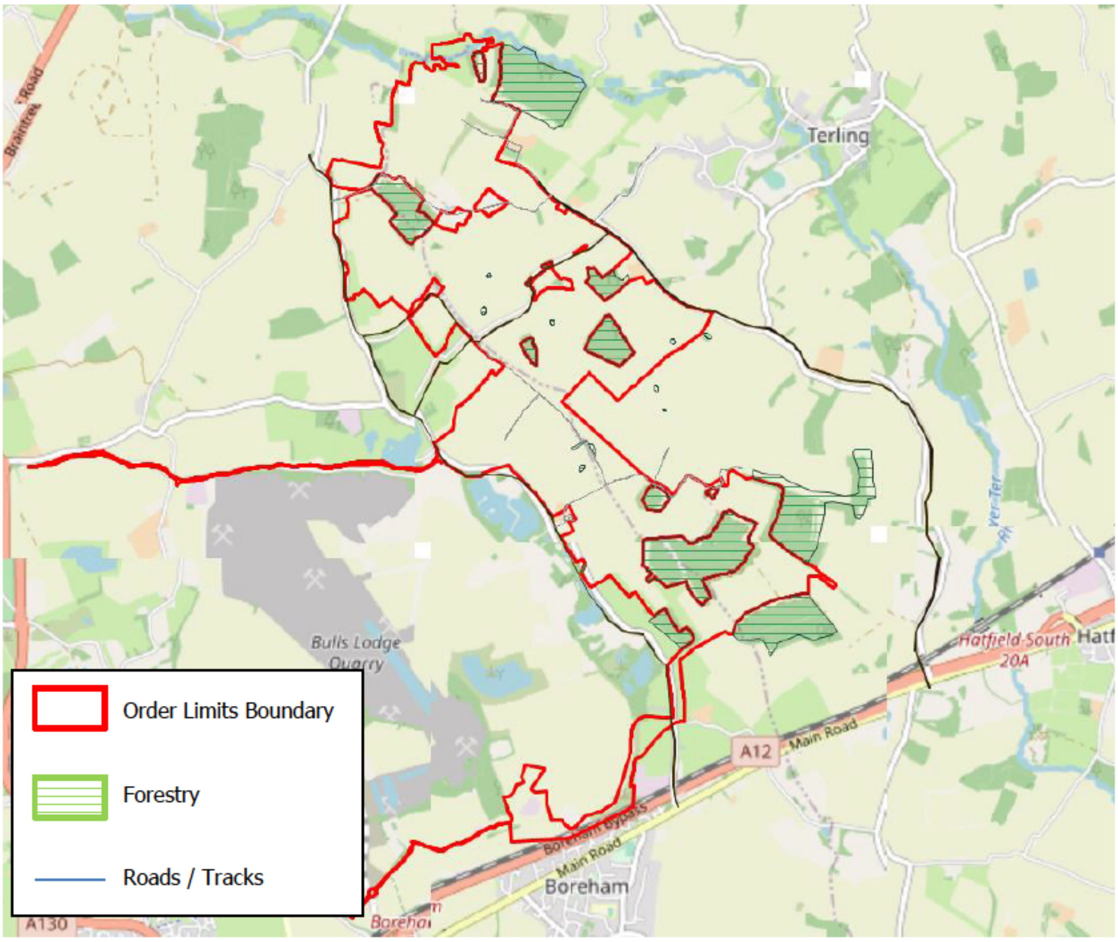


Table 1: Manning's N Roughness Values

Ground Condition Type	Manning's N Value Applied	Chow 1959 Definition
Woodland	0.15	Trees – dense willows, summer, straight
Tracks	0.025	Earth – no vegetation
Roads	0.02	Concrete – on good excavated rock

Aerial imagery and photographs have been assessed to identify existing roads and tracks not incorporated within the OS roads data. These have been depressed by 0.1 m below existing topography.

2.3.3 Operational Phase Scenario

The operational phase scenario has been developed to identify the potential surface water impact of infrastructure associated with the Development and to quantify the potential betterment of mitigation measures proposed.

The existing flow routes and surface water flood depths have been assessed form the refined baseline scenario to confirm proposed betterment measures alongside outcomes of local consultations. The proposed mitigation measures are detailed further in Section 2.4 and have been incorporated into the operational phase scenario.

The PV array tables will be driven into the ground via narrow legs and therefore will not contribute to impermeable areas. Impermeable areas associated with the Development are therefore limited to the Battery Energy Storage System (BESS), Bull's Lodge Substation, inverters, transformers and an onsite plant and welfare facility. If string inverters are utilised then inverter units will not result in an increase in impermeable areas. As the type of inverter is yet to be confirmed the inverts are assumed to be 'on field' inverters to represent a 'worst case scenario' related to surface water runoff. Sustainable Drainage Strategies (SuDS) for the BESS, onsite plant and welfare facility and Bull's Lodge Substation have been designed by Arcus[4] and Mott MacDonald[5] respectively, with such strategies designed to manage any potential increase in surface water runoff rates.

The impermeable areas of the Development are therefore further limited to invert units which have been incorporated into the model and raised above existing topography.

An attenuation pond has been incorporated into the model to the east of Stocks Farm to intercept existing surface water. The proposed pond will not be designed to drain a defined impermeable or infrastructure but to intercept surface water along existing flow routes and thus increase the potential for attenuation of surface water within the Order Limits Boundary.

This has been modelled by depressing a feature of the total area, length and depth of the pond into existing height data. The pond structure has been designed using the Source Control feature within Micro Drainage software to incorporate 1 in 4 slopes. The pond structure will not serve a defined extent of impermeable areas but instead intercept surface water across existing flow routes and has not been designed to a defined rainfall return period. The design details of the pond are as follows:

- Depth 1 m;
- Slope 1 in 4;
- Base area 50 m²; and
- Total area 200.5 m².

To intercept surface water flows leading to Waltham Road and Stocks Farm, a swale has been incorporated to the model to the east of Stocks Farm by depressing a feature of the area, length and depth of the swale into existing height data. The design details of the swale are as follows:

- Length 70 m;
- Depth 1 m;
- Slope 1 in 4;
- Base width 0.5 m²; and
- Total area 6.9 m².

The locations of the proposed pond and swale are shown in Plate 5.

[4] Arcus, Longfield Solar Farm, SuDS Strategy (2021).
[5] Motts MacDonald, Drainage Strategy (2021).

Plate 5 – Stocks Farm Pond and Swale Location (Taken from Flood Modeller)

To provide additional surface water attenuation capacity and limit the potential surface water runoff associated with the Development, shallow filter drains along existing flow routes identified within the refined baseline scenario are proposed. The locations of the proposed filter drains are shown in Appendix C.

The filter drains have been incorporated into the model by depressing a feature of the area, length and depth of the drains into existing topography. The lengths of the filter drains vary relative to their location with depths of 1 m and widths of 0.5 m.

3 MITIGATION AND BETTERMENT MEASURES

As mentioned in Section 2.3.3, shallow filter drains are proposed along existing surface water flow routes in accordance with topographic contours. The filter drain features will not incorporate an active outfall but intercept surface water and allow it to infiltrate (as per the baseline scenario) along existing flow routes and provide additional attenuation of surface water throughout the operation of the Development.

The filter drain units will be gravel filled and will be approximately 1 m in depth and 0.5 m in width, with an example filter drain unit shown in Plate 6.

Plate 9: Shallow Filter Drains[6]

Following consultation with surrounding landowners, a pond and swale feature will be implemented to the east of Stocks Farm to intercept and attenuate surface water. This will limit potential surface water flood depths at the surrounding properties and on Waltham Road.

The design parameters of the pond and swale are detailed in Section 2.3.3.

The swale structure will be located at a topographic low point along existing contours in order to intercept surface water without flows dispersing horizontally across the feature and thus leading to overtopping at a low point. An example of a swale structure is shown in Plate 10.

[6] Malmaynes Solar Farm – Arcus As-built drainage review

Plate 10: Example Perimeter Swale at a Solar Farm Site[7]

4 RESULTS

4.1 Model Stability

To assess model stability the Manning's N Roughness value has been universally increased and decreased by 20 %. Modelling outputs identify a negligible maximal differentiation in surface water depths, thus demonstrating low sensitivity to modelled assumptions. As such, there is confidence that the model is producing credible results.

The maximum total mass error is 8 % with mass error decreasing throughout the iterative modelling process as shown in Table 2.

Table 2: 2D Model Total Mass Error

Simulation	Northern Domain Total Mass Error	Southern Domain Total Mass Error
Baseline	-7 %	8 %
Refined Baseline	-4 %	-4 %
Operational Phase	-4.3 %	-3.7 %

4.2 Baseline Scenario

The 1:100-year (+20 %) modelled outputs for the baseline scenario show maximum surface water flood depths of approximately 0.9 m in isolated area within the Order Limits Boundary, with significant areas of the model extent limited to surface water flood depths of less than 0.1 m.

[7] Bent Spur Solar Farm - Arcus As-built drainage review

Maximum depths within the Order Limits Boundary are shown at NGR E 576712, N 212576.

Areas within the Order Limits Boundary associated with existing surface water features (i.e. ponds, open land drains) demonstrate depths significantly greater than those upon the surrounding surface due to the depression in topography associated with the features.

The maximum surface water flood depths at the residential properties to the west of the DCO Site are approximately 0.8 m to 1 m. Areas within the vicinity of the Site are shown to have depths exceeding 1 m but are associated with existing surface water bodies.

There are areas on the wider extents of the model active area which are unrepresentative of surface water depths due to water reaching the extent of the model domains and glass-walling (i.e. water cannot exit the model extent).

4.3 Refined Baseline Scenario

To demonstrate the difference in surface water depths during the iterative modelling process, the depths at the maximum point within the Order Limits Boundary and outwith of the Order Limits Boundary for the baseline scenario have been assessed alongside the refined baseline scenario.

There are no significant benefits at the location of the maximal depths during the refined baseline scenario due to the location being a topographic low point, with depths within this areas not impacted by model variances.

The addition of the existing banks adjacent to Stocks Farm into the model is shown to redirect surface water flow routes, which correlates with anecdotal evidence from local landowner consultations.

The baseline and refined baseline scenarios at Stocks Farm are shown in Plates 11 and 12. The insertion of the bank results in additional surface water attenuation within the DCO Site and a reduction in offsite surface water depths.

The 1:100-year (+20 %) surface water depths for the refined baseline scenario are shown in Appendix B.

Plate 11: Baseline Model Stocks Farm Output

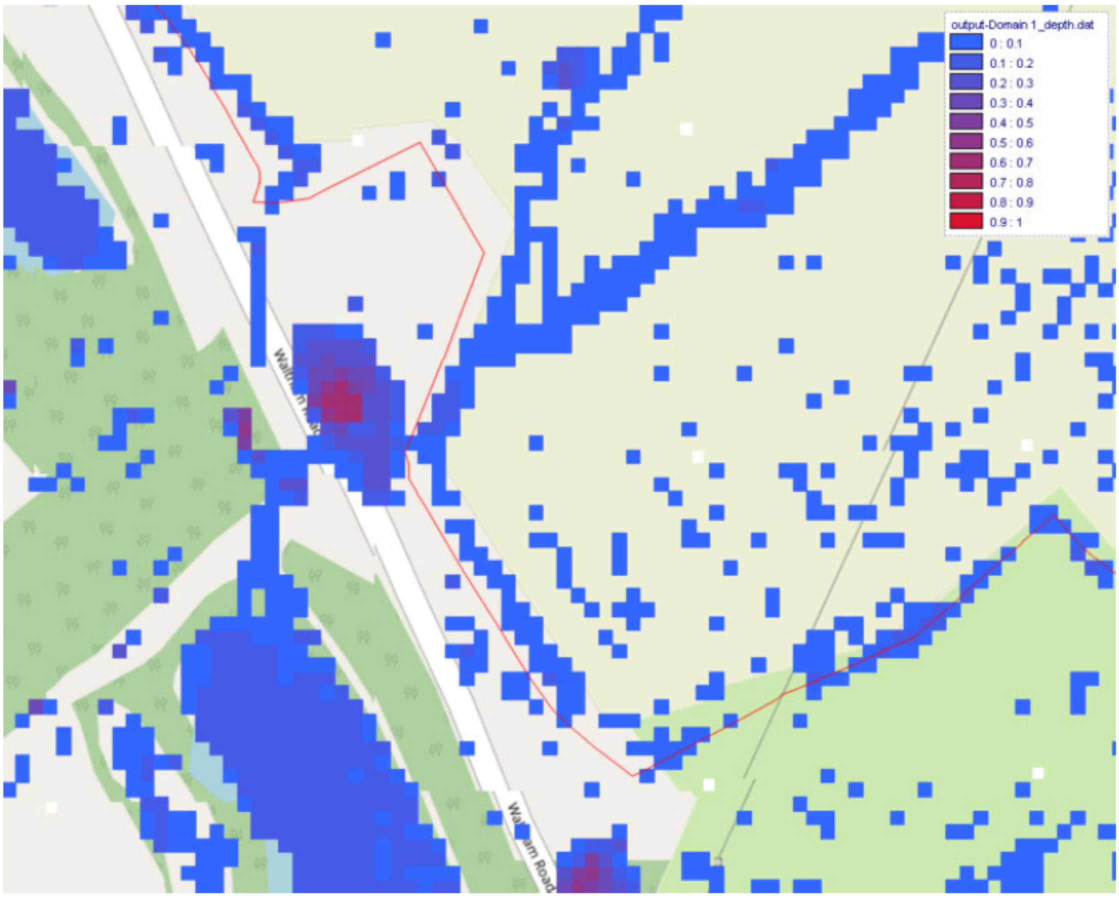
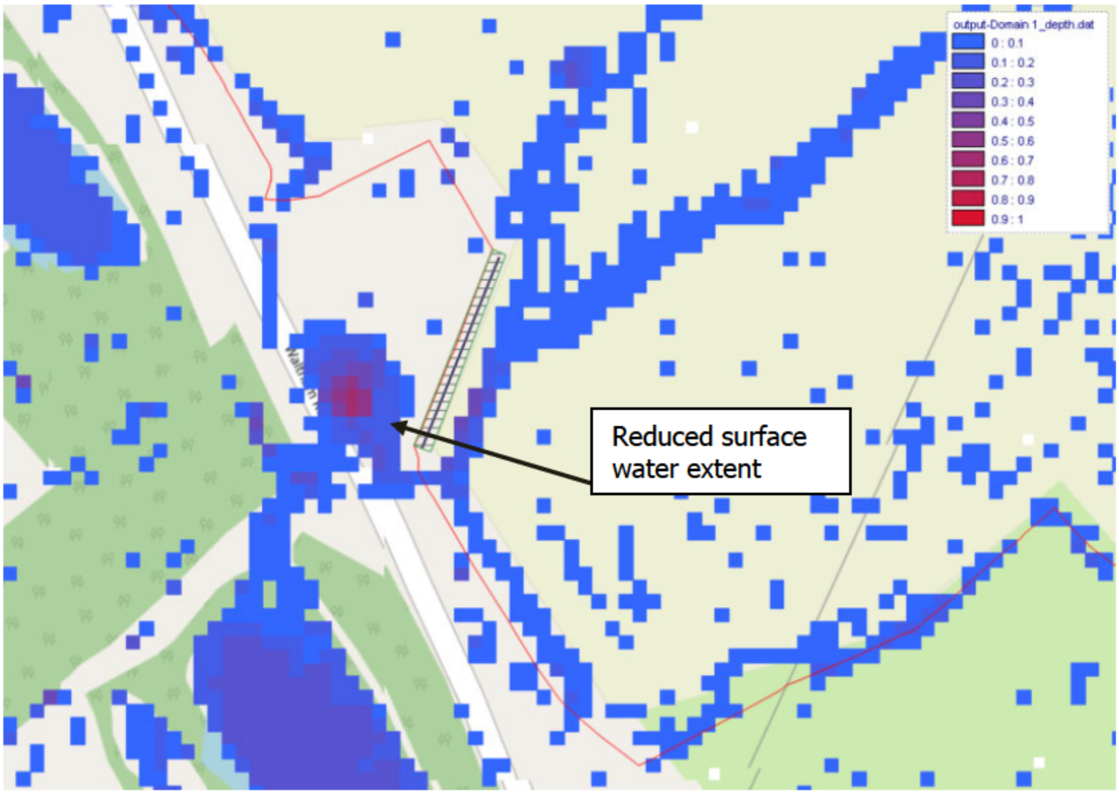


Plate 12: Refined Baseline Model Stocks Farm Output



4.4 Operational Phase Scenario

To demonstrate the difference in depths during the iterative modelling process the depths at the maximum point within the Order Limits Boundary and outwith of the Order Limits Boundary for the baseline scenario have been assessed alongside the refined baseline scenario.

The location of the maximum surface water depths within the Order Limits Boundary shows no significant reduction. The area with the maximal depths is a topographic low point and is therefore unlikely to have benefited from the benefit measures incorporated within the iterative modelling process.

The filter drains incorporated within the DCO Site are shown to vary in attenuation potential, with the attenuation capacity of the proposed features varying between 50 to 90 %.

Areas to the north west of the Site near Lawn Farm and Noakes House are shown to have benefitted from the insertion of filter drains along identified surface water flow routes as shown in Plate 13 and 14.

Plate 13: Refined Baseline Scenario Northern Flood Depths

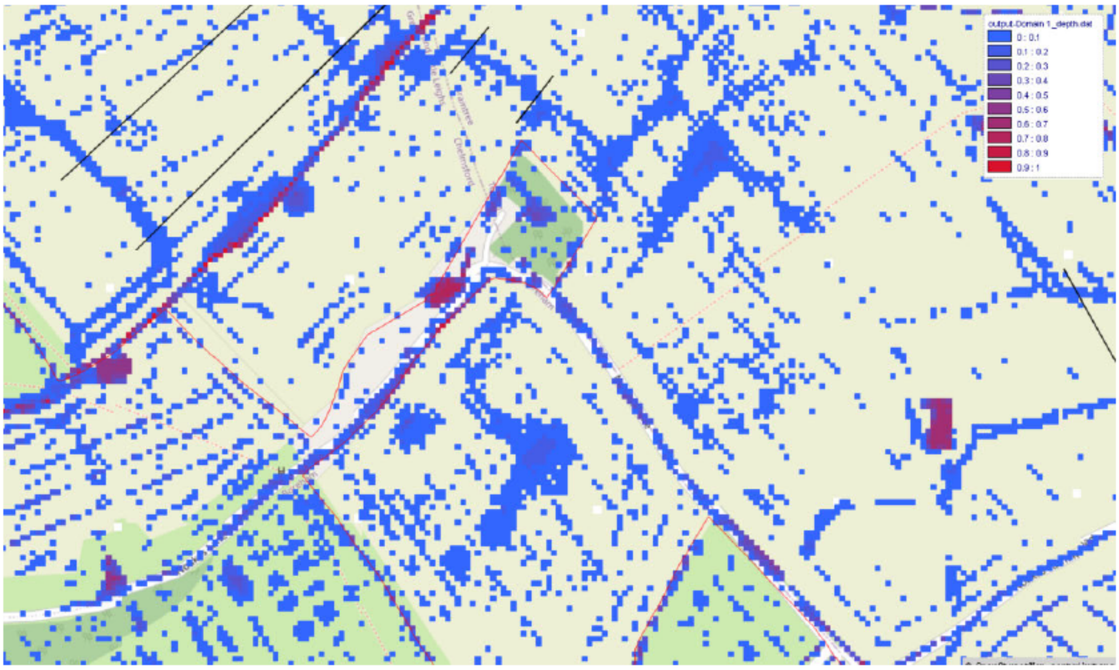
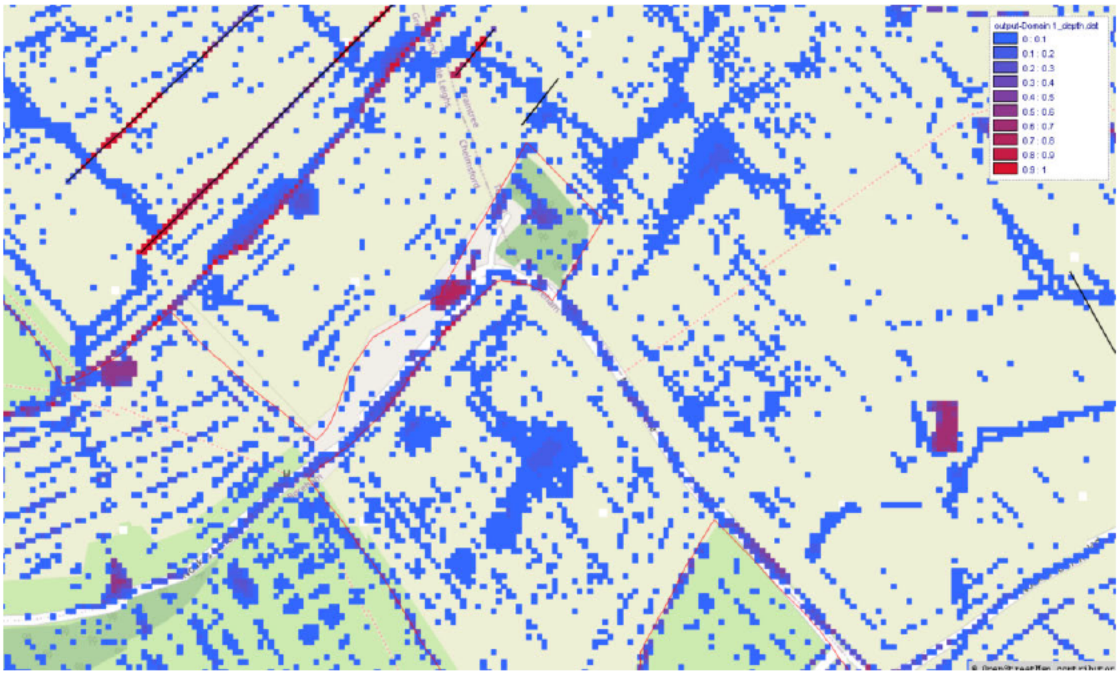


Plate 14: Operational Phase Scenario Northern Flood Depths



The pond and swale units implemented to the east of Stocks Farm are shown to attenuate and intercept surface water along existing flow routes. The maximum depths for the pond and swale during the 1:100-year (+20 %) 2D scenario are shown in Table 3.

Table 3: 2D Model Depth Reductions

Unit	Surface Water Depths
Pond	0.9 m
Swale	0.38 m

Surface water depths at the DCO Site and surrounding areas are shown to reduce at varying locations as detailed in Table 4, demonstrating the benefit of the proposed betterment measures in the interception and attenuation of surface water.

Table 4: 2D Model Depth Reductions

Location	NGR	Baseline Scenario 1:100 (+20%) Depths	Operational Phase Scenario 1:100 (+20%) Depths	Reduction in Depths
Noakes Lane	E 573970, N 213772	0.53 m	0.37 m	0.16 m
Waltham Road	E 573967, N 213 798	0.06 m	0.01 m	0.05 m
Stocks Farm	E 575492, N 212060	0.11 m	0.1 m	0.1 m
Wallace's Lane	E 575822, N 211580	0.82 m	0.7 m	0.12 m
Within OLB	E 576194, N 211921	0.26 m	0.03 m	0.23 m

The 1:100-year (+20%) surface water depths for the operational phase scenario are shown in Appendix C.

5 CONCLUSION

Arcus have produced a 2D hydraulic model utilising Flood Modeller software to demonstrate the surface water flows and depths of the DCO Site and surrounding areas during the 1:100-year+20 % scenario.

To demonstrate the current surface water characteristics of the DCO Site and surrounding areas an iterative process has been applied to enable comparisons of potential betterment measures.

The betterment measures incorporated into the 2D modelling include incremental filter drains, swales and an attenuation pond.

The 2D iterative modelling process demonstrates the benefit of incorporating surface water management measures within the Longfield Solar Farm Development i.e. a reduction in depth and extent of surface water.

The proposed surface water management measures are shown to provide betterment to the surrounding areas and the DCO Site.

APPENDIX A – REFH2 OUTPUT

UK Design Flood Estimation

Generated on 25 August 2021 09:02:37 by reagand
Printed from the ReFH2 Flood Modelling software package, version 3.2.7650.24314

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details Checksum: C1D5-8D6A

Site name: FEH_Catchment_Descriptors_578100_211750_REFH2.3

Easting: 578100

Northing: 211750

Country: England, Wales or Northern Ireland

Catchment Area (km²): 75.5

Using plot scale calculations: No

Model: 2.3

Site description: None

Model run: 100 year 1.2 CC

Summary of results

Rainfall - FEH 2013 model (mm):	93.12	Total runoff (ML):	2191.47
Total Rainfall (mm):	87.05	Total flow (ML):	6572.36
Peak Rainfall (mm):	30.85	Peak flow (m³/s):	35.52

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	18:00:00	No
Timestep (hh:mm:ss)	02:00:00	No
SCF (Seasonal correction factor)	0.99	No
ARF (Areal reduction factor)	0.94	No
Seasonality	Summer [Winter]	Yes
Climate change factor	1.20	Yes

Loss model parameters

Name	Value	User-defined?
Cini (mm)	75.57	No
Cmax (mm)	360.11	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	12.37	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	1.1	No
BL (hr)	56.33	No
BR	2.02	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	1.11	No
Urbext 2000	0.01	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No
Exporting drained area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	2.572	0.000	0.557	0.000	1.092	1.092
02:00:00	4.210	0.000	0.951	0.051	1.056	1.107
04:00:00	7.264	0.000	1.757	0.239	1.029	1.268
06:00:00	14.053	0.000	3.814	0.674	1.024	1.698
08:00:00	30.851	0.000	10.287	1.615	1.066	2.681
10:00:00	14.053	0.000	5.559	3.835	1.215	5.050
12:00:00	7.264	0.000	3.087	7.485	1.559	9.045
14:00:00	4.210	0.000	1.856	11.854	2.167	14.021
16:00:00	2.572	0.000	1.158	16.460	3.063	19.523
18:00:00	0.000	0.000	0.000	20.957	4.243	25.200
20:00:00	0.000	0.000	0.000	24.791	5.674	30.465
22:00:00	0.000	0.000	0.000	26.923	7.269	34.192
24:00:00	0.000	0.000	0.000	26.647	8.878	35.525
26:00:00	0.000	0.000	0.000	25.029	10.370	35.399
28:00:00	0.000	0.000	0.000	22.694	11.676	34.370
30:00:00	0.000	0.000	0.000	19.983	12.762	32.745
32:00:00	0.000	0.000	0.000	17.185	13.619	30.803
34:00:00	0.000	0.000	0.000	14.668	14.260	28.928
36:00:00	0.000	0.000	0.000	12.660	14.722	27.382
38:00:00	0.000	0.000	0.000	10.962	15.040	26.002
40:00:00	0.000	0.000	0.000	9.438	15.235	24.674
42:00:00	0.000	0.000	0.000	8.025	15.322	23.347
44:00:00	0.000	0.000	0.000	6.683	15.310	21.993
46:00:00	0.000	0.000	0.000	5.365	15.204	20.569
48:00:00	0.000	0.000	0.000	4.082	15.010	19.092
50:00:00	0.000	0.000	0.000	2.856	14.734	17.589
52:00:00	0.000	0.000	0.000	1.736	14.383	16.119
54:00:00	0.000	0.000	0.000	0.871	13.974	14.845
56:00:00	0.000	0.000	0.000	0.402	13.532	13.934
58:00:00	0.000	0.000	0.000	0.158	13.080	13.238
60:00:00	0.000	0.000	0.000	0.041	12.631	12.672
62:00:00	0.000	0.000	0.000	0.002	12.192	12.193
64:00:00	0.000	0.000	0.000	0.000	11.767	11.767
66:00:00	0.000	0.000	0.000	0.000	11.356	11.356
68:00:00	0.000	0.000	0.000	0.000	10.960	10.960

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
70:00:00	0.000	0.000	0.000	0.000	10.578	10.578
72:00:00	0.000	0.000	0.000	0.000	10.209	10.209
74:00:00	0.000	0.000	0.000	0.000	9.853	9.853
76:00:00	0.000	0.000	0.000	0.000	9.509	9.509
78:00:00	0.000	0.000	0.000	0.000	9.177	9.177
80:00:00	0.000	0.000	0.000	0.000	8.857	8.857
82:00:00	0.000	0.000	0.000	0.000	8.548	8.548
84:00:00	0.000	0.000	0.000	0.000	8.250	8.250
86:00:00	0.000	0.000	0.000	0.000	7.962	7.962
88:00:00	0.000	0.000	0.000	0.000	7.684	7.684
90:00:00	0.000	0.000	0.000	0.000	7.416	7.416
92:00:00	0.000	0.000	0.000	0.000	7.158	7.158
94:00:00	0.000	0.000	0.000	0.000	6.908	6.908
96:00:00	0.000	0.000	0.000	0.000	6.667	6.667
98:00:00	0.000	0.000	0.000	0.000	6.434	6.434
100:00:00	0.000	0.000	0.000	0.000	6.210	6.210
102:00:00	0.000	0.000	0.000	0.000	5.993	5.993
104:00:00	0.000	0.000	0.000	0.000	5.784	5.784
106:00:00	0.000	0.000	0.000	0.000	5.583	5.583
108:00:00	0.000	0.000	0.000	0.000	5.388	5.388
110:00:00	0.000	0.000	0.000	0.000	5.200	5.200
112:00:00	0.000	0.000	0.000	0.000	5.019	5.019
114:00:00	0.000	0.000	0.000	0.000	4.843	4.843
116:00:00	0.000	0.000	0.000	0.000	4.674	4.674
118:00:00	0.000	0.000	0.000	0.000	4.511	4.511
120:00:00	0.000	0.000	0.000	0.000	4.354	4.354
122:00:00	0.000	0.000	0.000	0.000	4.202	4.202
124:00:00	0.000	0.000	0.000	0.000	4.056	4.056
126:00:00	0.000	0.000	0.000	0.000	3.914	3.914
128:00:00	0.000	0.000	0.000	0.000	3.778	3.778
130:00:00	0.000	0.000	0.000	0.000	3.646	3.646
132:00:00	0.000	0.000	0.000	0.000	3.519	3.519
134:00:00	0.000	0.000	0.000	0.000	3.396	3.396
136:00:00	0.000	0.000	0.000	0.000	3.277	3.277
138:00:00	0.000	0.000	0.000	0.000	3.163	3.163
140:00:00	0.000	0.000	0.000	0.000	3.053	3.053

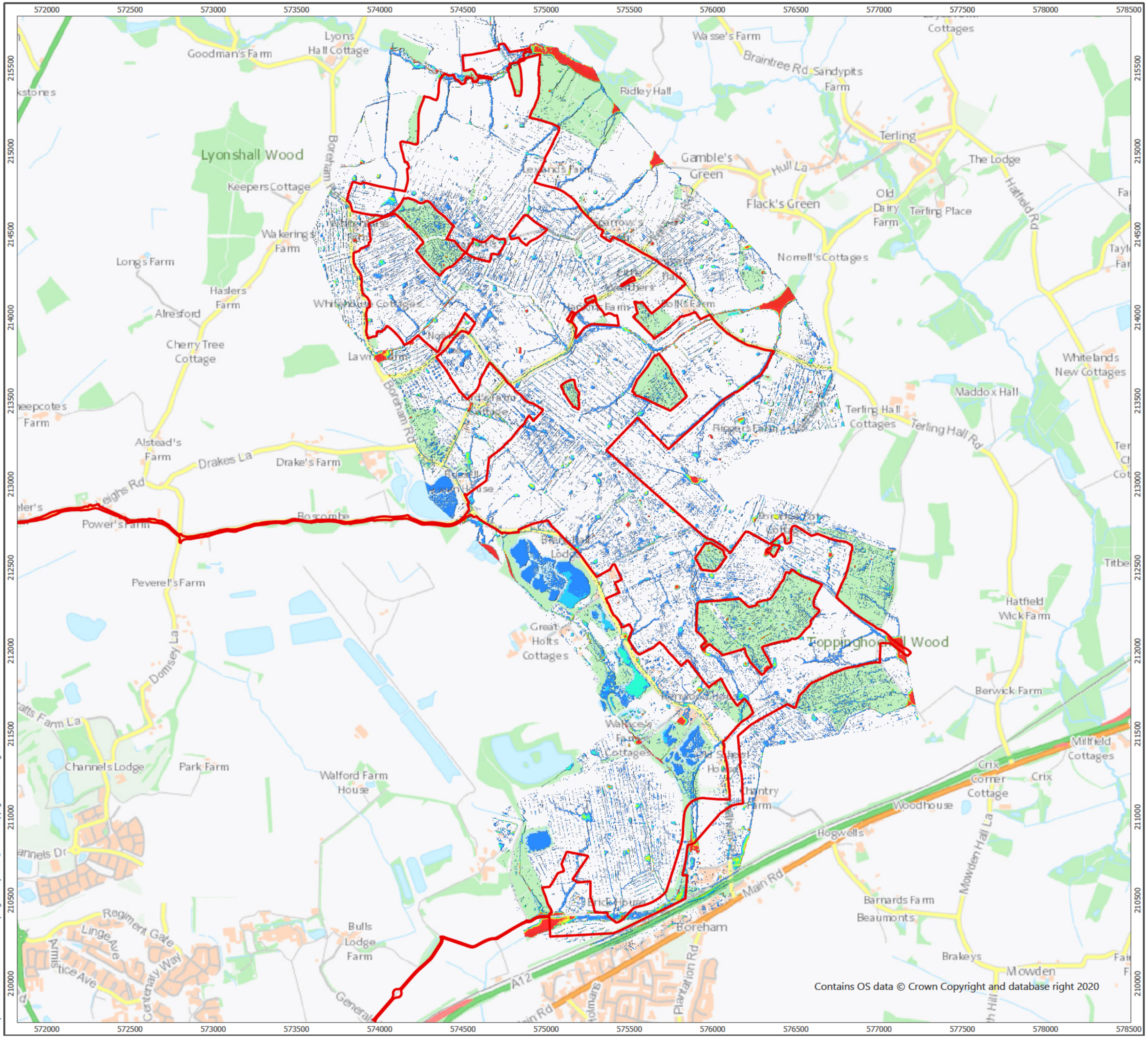
Time (hh:mm:ss)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
142:00:00	0.000	0.000	0.000	0.000	2.946	2.946
144:00:00	0.000	0.000	0.000	0.000	2.844	2.844
146:00:00	0.000	0.000	0.000	0.000	2.744	2.744
148:00:00	0.000	0.000	0.000	0.000	2.649	2.649
150:00:00	0.000	0.000	0.000	0.000	2.556	2.556
152:00:00	0.000	0.000	0.000	0.000	2.467	2.467
154:00:00	0.000	0.000	0.000	0.000	2.381	2.381
156:00:00	0.000	0.000	0.000	0.000	2.298	2.298
158:00:00	0.000	0.000	0.000	0.000	2.218	2.218
160:00:00	0.000	0.000	0.000	0.000	2.140	2.140
162:00:00	0.000	0.000	0.000	0.000	2.066	2.066
164:00:00	0.000	0.000	0.000	0.000	1.994	1.994
166:00:00	0.000	0.000	0.000	0.000	1.924	1.924
168:00:00	0.000	0.000	0.000	0.000	1.857	1.857
170:00:00	0.000	0.000	0.000	0.000	1.792	1.792
172:00:00	0.000	0.000	0.000	0.000	1.730	1.730
174:00:00	0.000	0.000	0.000	0.000	1.669	1.669
176:00:00	0.000	0.000	0.000	0.000	1.611	1.611
178:00:00	0.000	0.000	0.000	0.000	1.555	1.555
180:00:00	0.000	0.000	0.000	0.000	1.501	1.501
182:00:00	0.000	0.000	0.000	0.000	1.448	1.448
184:00:00	0.000	0.000	0.000	0.000	1.398	1.398
186:00:00	0.000	0.000	0.000	0.000	1.349	1.349
188:00:00	0.000	0.000	0.000	0.000	1.302	1.302
190:00:00	0.000	0.000	0.000	0.000	1.257	1.257
192:00:00	0.000	0.000	0.000	0.000	1.213	1.213
194:00:00	0.000	0.000	0.000	0.000	1.170	1.170
196:00:00	0.000	0.000	0.000	0.000	1.130	1.130

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	75.5	No
ALTBAR	60	No
ASPBAR	151	No
ASPVAR	0.22	No
BFIHOST	0.46	No
BFIHOST19	0.44	No
DPLBAR (km)	12.68	No
DPSBAR (mkm^{-1})	18.3	No
FARL	0.99	No
LDP	27.82	No
PROPWET (mm)	0.31	No
RMED1H	11.5	No
RMED1D	28.8	No
RMED2D	36.9	No
SAAR (mm)	570	No
SAAR4170 (mm)	592	No
SPRHOST	41.84	No
Urbext2000	0.01	No
Urbext1990	0.01	No
URBCONC	0.73	No
URBLOC	1.22	No
DDF parameter C	-0.02	No
DDF parameter D1	0.27	No
DDF parameter D2	0.27	No
DDF parameter D3	0.25	No
DDF parameter E	0.31	No
DDF parameter F	2.56	No
DDF parameter C (1km grid value)	-0.03	No
DDF parameter D1 (1km grid value)	0.26	No
DDF parameter D2 (1km grid value)	0.29	No
DDF parameter D3 (1km grid value)	0.26	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.53	No

APPENDIX B – REFINED BASELINE SCENARIO 1 IN 100-YEAR +20% SURFACE WATER DEPTHS



Longfield Solar Farm

ARCUS

Order Limits Boundary

1 in 100-Year (+20%) Surface Water Depths (m)

- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.35
- 0.40
- 0.45
- 0.50

1:22,000 Scale @ A3

0 400 800 Meters

NORTH

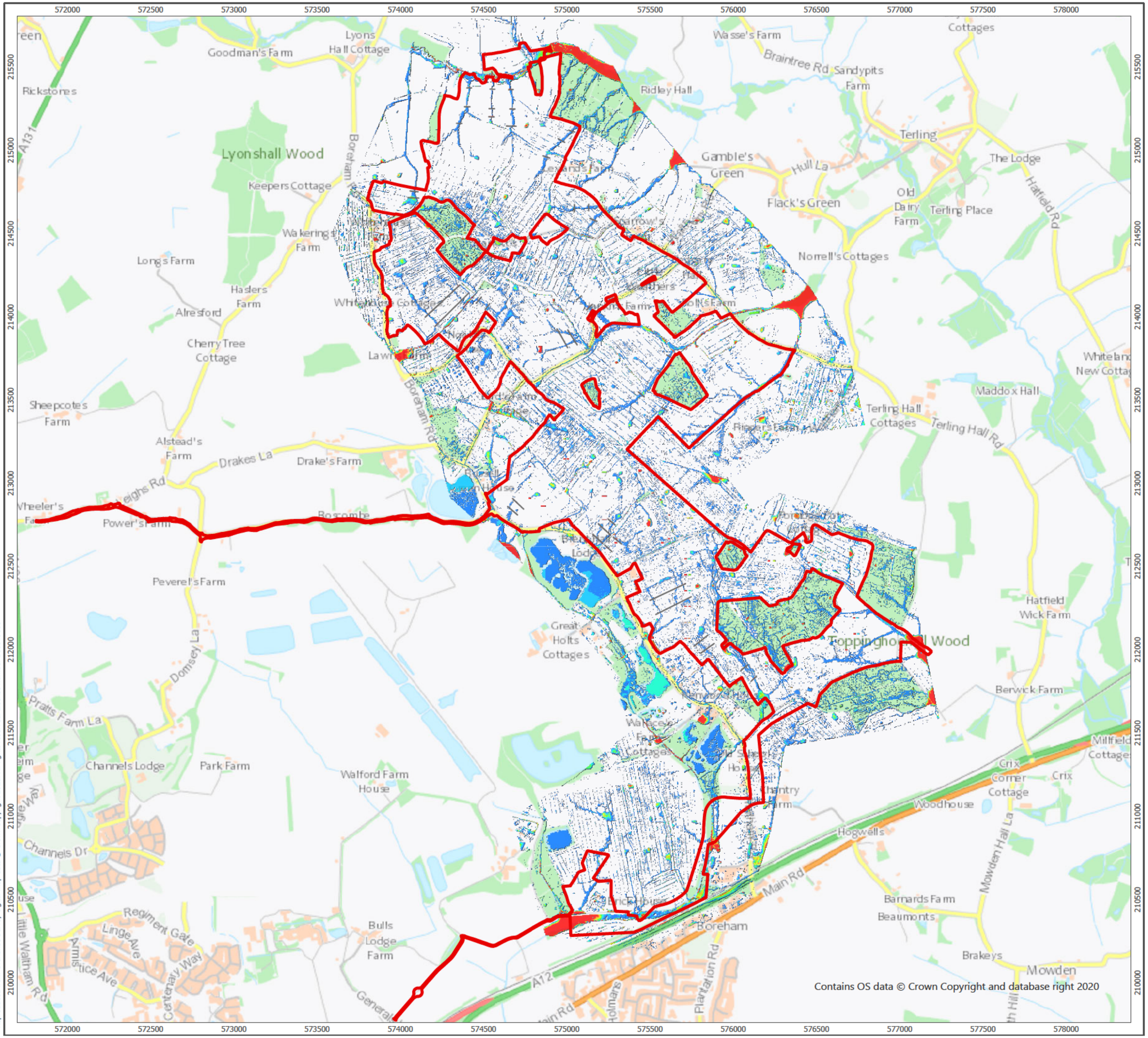
Produced By: CH	Ref: 4077-PUB-050
Checked By: RD	Date: 28/10/2021

Baseline Full Model
Figure No. 50

Longfield Solar Farm

N:\GIS\Hydrology\Projects\4077 Longfield\4077 Longfield.aprx\4077-PUB-050 Baseline Full Model

APPENDIX C – OPERATIONAL PHASE SCENARIO 1 IN 100-YEAR +20% SURFACE WATER DEPTHS



Longfield Solar Farm

ARCUS

- Order Limits Boundary
- Filter Drains

1 in 100-Year (+20%) Surface Water Depths (m)

- 0.10
- 0.15
- 0.20
- 0.25
- 0.3
- 0.35
- 0.4
- 0.45
- 0.5

1:22,000 Scale @ A3

0 400 800 Meters

NORTH

Produced By: CH	Ref: 4077-PUB-051
Checked By: RD	Date: 28/10/2021

Iteration 3 Full Model
Figure No. 51

Longfield Solar Farm

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