OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

DCO Submission

Environmental Statement

Chapter 9: Water Environment
Appendix 9.2: Flood Risk Assessment

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Rev P04

On behalf of
Oxfordshire Railfreight Limited

Prepared by BWB Consulting Ltd
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Flood Risk Assessment – Main Site

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EXECUTIVE SUMMARY

This Flood Risk Assessment (FRA) has been prepared in accordance with the requirements set out in the National Policy Statement for National Networks (NPSNN). It has been produced on behalf of Oxfordshire Railfreight Limited in respect of a Development Consent Order (DCO) for the proposed Oxfordshire Strategic Railfreight Interchange (SRFI). The DCO comprises a number of elements and due to their geographical location, they are covered by two assessments. This FRA focuses on the 'SRFI Main Site' – referred to as the 'study site' within this report.

This report demonstrates that the proposed development is not at significant flood risk, subject to the recommended flood mitigation strategies being implemented. Moreover, in compliance with the requirements of the NPSNN, the development will not increase flood risk to the wider catchment area subject to suitable management of surface water runoff.

The Environment Agency (EA) Flood Map for Planning, identifies the majority of the study site lies within Flood Zone 1. There are areas of Flood Zone 2 and 3 associated with the Ashgrove Brook and its tributary. There are no mapped Flood Zones associated with the Padbury Brook Tributary.

Bespoke hydraulic modelling exercises for the local watercourses within the study site have been undertaken. There is modelled floodplain within the study site associated with the Ashgrove Brook its tributary and the Padbury Brook tributary. Flood mechanisms largely comprises low bank levels and existing restrictive hydraulic structures.

To facilitate the proposals, alterations are required to the existing Ashgrove Brook and its tributary within the study site and surrounding area. Post-development hydraulic modelling has been undertaken and comparisons undertaken against the equivalent baseline events. Within the study site there is shown to be predominantly a decrease in modelled peak flood levels and extents, where new structures provide improved conveyance with the required freeboard in all modelled events. Flood levels are also shown to decrease along the Gagle Brook.

To facilitate the proposed rail works, an additional culvert, with an inverted syphon, is required along the Padbury Brook Tributary. It is also proposed to include measures to reduce the extent of flooding on the existing railway during the design event, namely through the creation of a two-stage channel and inclusion of bund (or similar). Within the study site, modelled flood extents are increased within the proposed two-stage channel, although these are a product of the design and remain within the extended channel.

Both the existing and proposed railways are shown to be removed from the flood extents during all modelled events up to and including the 1 in 100-year +58% event, inclusive of the design event.

The proposed warehouses are to be set upon raised plateaus which are significantly raised above the modelled design event peak flood levels of all watercourses within the site. Proposed finished floor levels are to be raised further above the surrounding ground levels of the development plateaus. Proposed ground levels are to be profiled to encourage pluvial runoff and overland flows to flow away from the built development towards the nearest drainage feature.

Should groundwater be encountered during construction a specialist should be consulted and appropriate dewatering undertaken as necessary. It is considered that the raised development plateaus, finished floor levels and profiling of ground levels will provide mitigation against any potential groundwater flooding post-development.

In the unlikely event of a breach from the Ardley Reservoir and Water Pumping Station, a flood wall has been proposed to formalise flows towards the Ashgrove Brook in the event of the breach. The wall height is to be set at minimum of 111.69mAOD providing 300mm freeboard above the modelled peak flood level.

The proposed development will introduce new impermeable surfaces to the site that will increase the surface water runoff generated. To manage this within the site, surface water drainage infrastructure will be included that will intercept, store and slowly release storm water falling on the built development. This will not only manage the surface water flood risk to the proposed development, but it will also prevent the development from adversely affecting downstream flood risk. It is proposed to drain foul water from the development separately to surface water. Two foul outfalls are proposed for the study site, within Ardley and Bicester respectively.

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1. INTRODUCTION

1.1 This Flood Risk Assessment (FRA) has been prepared in accordance with the requirements set out in the National Policy Statement for National Networks (NPSNN). It has been produced on behalf of Oxfordshire Railfreight Limited in respect of a Development Consent Order (DCO) for the proposed Oxfordshire Strategic Rail Freight Interchange (SRFI).

1.2 The DCO comprises a number of elements and due to their geographical location, they are covered by two assessments. This FRA focuses on the 'SRFI Main Site'. Summary information is included as **Table 1.1**.

Table 1.1: Site Summary

Site Name	Oxfordshire SRFI Main Site (DCO Works No. 1 to 10, 29 and 30)
Location	Oxfordshire
NGR (approx.)	SP533261
Development Type	Rail Freight Interchange
Flood Zone Classification	Flood Zones 1, 2 and 3
NPPF Vulnerability	Less Vulnerable
Anticipated Development Lifetime	75-years*
Environment Agency Office	Thames
Lead Local Flood Authority	Oxfordshire County Council
Local Planning Authority	Cherwell District Council

*In accordance with Paragraph 006 of the Flood Risk and Coastal Change Planning Practice Guidance

Sources of Data

- Topographical Survey by Greenhatch Group undertaken between September 2020 and August 2025, reference 36646_T
- Environment (EA) Agency consultation
- EA 1m Light Detection and Ranging (LiDAR) data, flown in 2019
- Oxfordshire County Council Consultation
- Cherwell District Council Consultation
- EA Flood Map for Planning and Risk of Flooding from Surface Water Data
- Cherwell District Council Strategic Flood Risk Assessment (SFRA)
- Oxfordshire County Council Preliminary Flood Risk Assessment and Addendum

- Thames River Basin Flood Risk Management Plan
- Oxfordshire County Council Local Flood Risk Management Strategy
- Cherwell Local Plan
- Site visit undertaken by BWB Consulting Ltd in March 2025
- Hydraulic modelling of the Gagle Brook, Ashbury Brook and Ashbury Brook Tributary undertaken by BWB Consulting Ltd in August 2025, reference OXSRFI-BWB-ZZ-XX-RP-YE-1001_HMR (GB)
- Hydraulic Modelling of the Padbury Brook Tributary undertaken by BWB Consulting Ltd in August 2025, reference OXSRFI-BWB-ZZ-XX-RP-YE-1005_HMR (PBT)
- Ground Investigations undertaken by BWB Consulting Ltd in September 2024, reference OFRI-BWB-ZZ-XX-RP-YE-0001-Ph2
- Thames Water Sewer Records
- British Geological Survey (BGS) Drift & Geology Maps

Situational Context

1.3 The proposed development comprises a number of interrelated component parts as follows, and collectively they are the Oxfordshire SRFI:

- **SRFI Main Site**
  - Works No. 1 to 10.
  - Works No. 29 and 30 Biodiversity and landscaping enhancement areas.
- **Offsite/Highways Works**
  - Works No. 11 OxSRFI Principal Access.
  - Works No. 12 Heyford Park Link Road (HPLR).
  - Works No. 13 Camp Road/Chilgrove Drive Junction and Bridleway.
  - Works No. 14 to 18 Junction 10 Highways Improvements.
  - Works No. 19, 20 & 21 Ardley Bypass.
  - Works No. 22 Junction 9 Highways Improvements.
  - Works No. 23 Middleton Stoney Relief Road (MSRR) pedestrian and cyclist connectivity.
  - Works No. 24 MSRR pedestrian and cyclist connectivity.
  - Works No. 25 B430 minor works.
  - Works No. 26 Quarry Cottages.
  - Works No. 27 Middleton Stoney Crossroads.
  - Works No. 28 Aves Ditch (North).
  - Works No. 31 to 33 Biodiversity and landscaping enhancement areas (Including Woodland Planting).
  - Works No. 34 Landfill work.
  - Works No. 35 Foul drainage outfall to Bicester.

- Works No. 36 Foul drainage outfall to Ardley.
- Works No. 37. Biodiversity and landscaping enhancement.
- Works No. 38 Ardley Tunnel works.

1.4 A site location plan is provided as **Figure 1.1**, for ease of reference and for the purpose of the FRAs, the individual components have been grouped together based upon the geographical location.

1.5 This FRA has been prepared in relation to the 'OxSRFI Main Site', referred to as 'the study site' throughout. The Offsite/Highway Improvement Works have been reviewed under separate cover (reference: OXSRFI-BWB-ZZ-XX-T-W-1007) and is included as **Appendix 1**.

Existing Site

1.6 The study site is generally split into two parcels split by the proposed Heyford Park Link Road (Works No. 12) and is bound to the north by the Chiltern Main Line railway. A small section of the M40 and Ardley Road lie to the east. Agricultural fields bind the site to the south. The western boundary is bound by a mix of agricultural fields and the disused Upper Heyford Airfield. The study site is predominantly greenfield in nature comprising a mix of agricultural fields with other notable features including Ashgrove Farm, Ardley Reservoir and Camp Road.

1.7 The Ashgrove Brook, an ordinary watercourse, initially flows from Upper Heyford Airfield through the study site in a south easterly direction. The watercourse then flows in a south-westerly and southerly direction where it is culverted beneath Camp Road and the B430 where it continues east to its confluence with the Gagle Brook, approximately 1.4km downstream of the study site.

1.8 A tributary of the Ashgrove Brook also flows from Upper Heyford Airfield, through the study site, in a south-easterly direction. The tributary is culverted beneath Camp Road where it then outfalls to the Ashgrove Brook.

1.9 The Gagle Brook flows in a south westerly and southerly direction to the east of Middleton Stoney. The watercourse is culverted beneath the B4030 where it then flows in an easterly direction towards and beneath the M40.

1.10 A tributary of the Padbury Brook rises to the north of Upper Heyford Airfield and flows in a north-easterly direction to its confluence with the Padbury Brook approximately 390m downstream of the study site.

1.11 The Padbury Brook rises to the north of the study site within agricultural fields, east of Somerton. The watercourse generally flows in an easterly direction where it is culverted beneath the Chiltern Main Line Railway, M40 and A43. The watercourse then continues to flow in an easterly to north-easterly direction to its ultimate confluence with the Great River Ouse, approximately 30km downstream of the study site.

1.12 The location of the study site and key watercourses are illustrated in **Figure 1.2**.

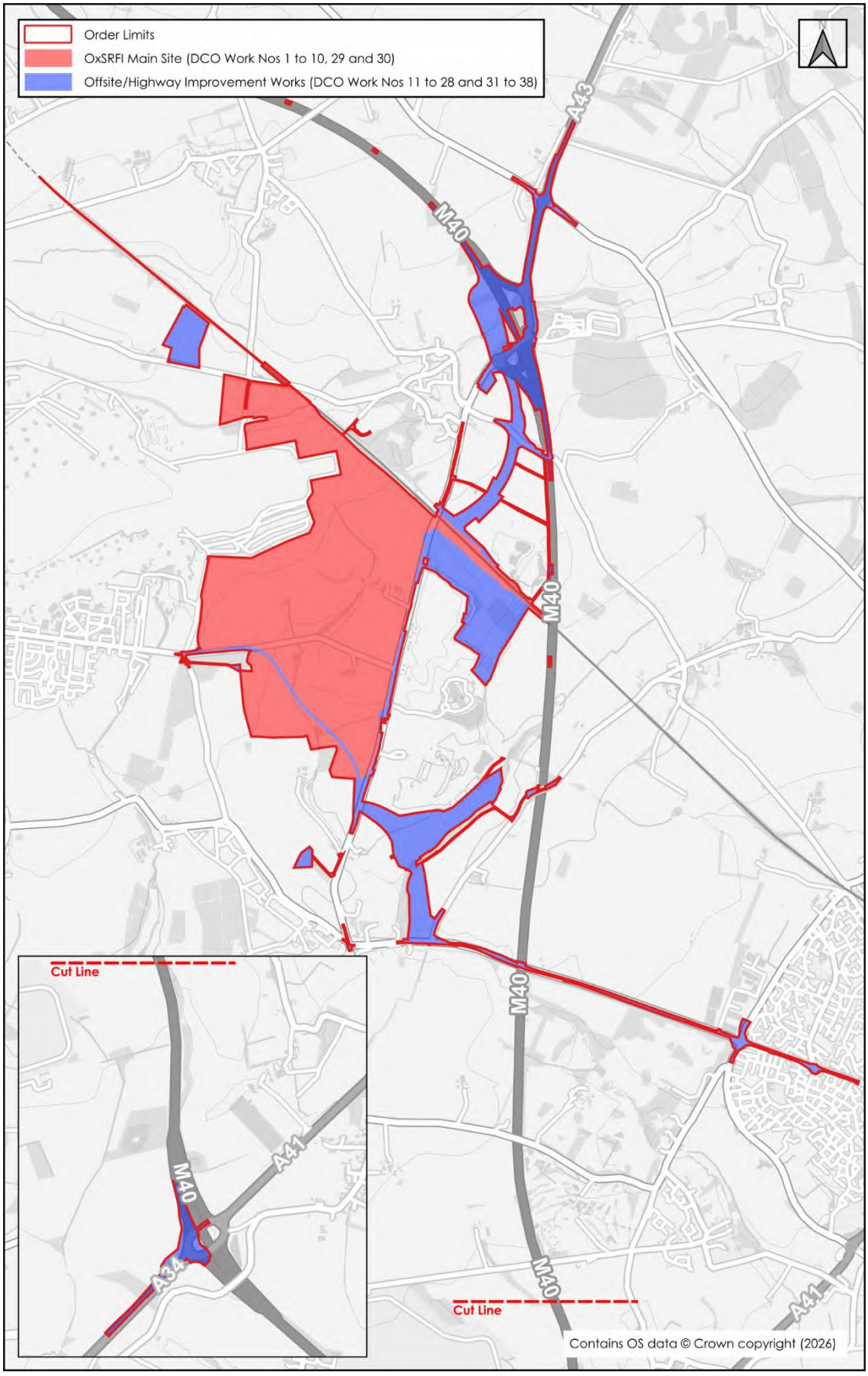

Figure 1.1: Site Location

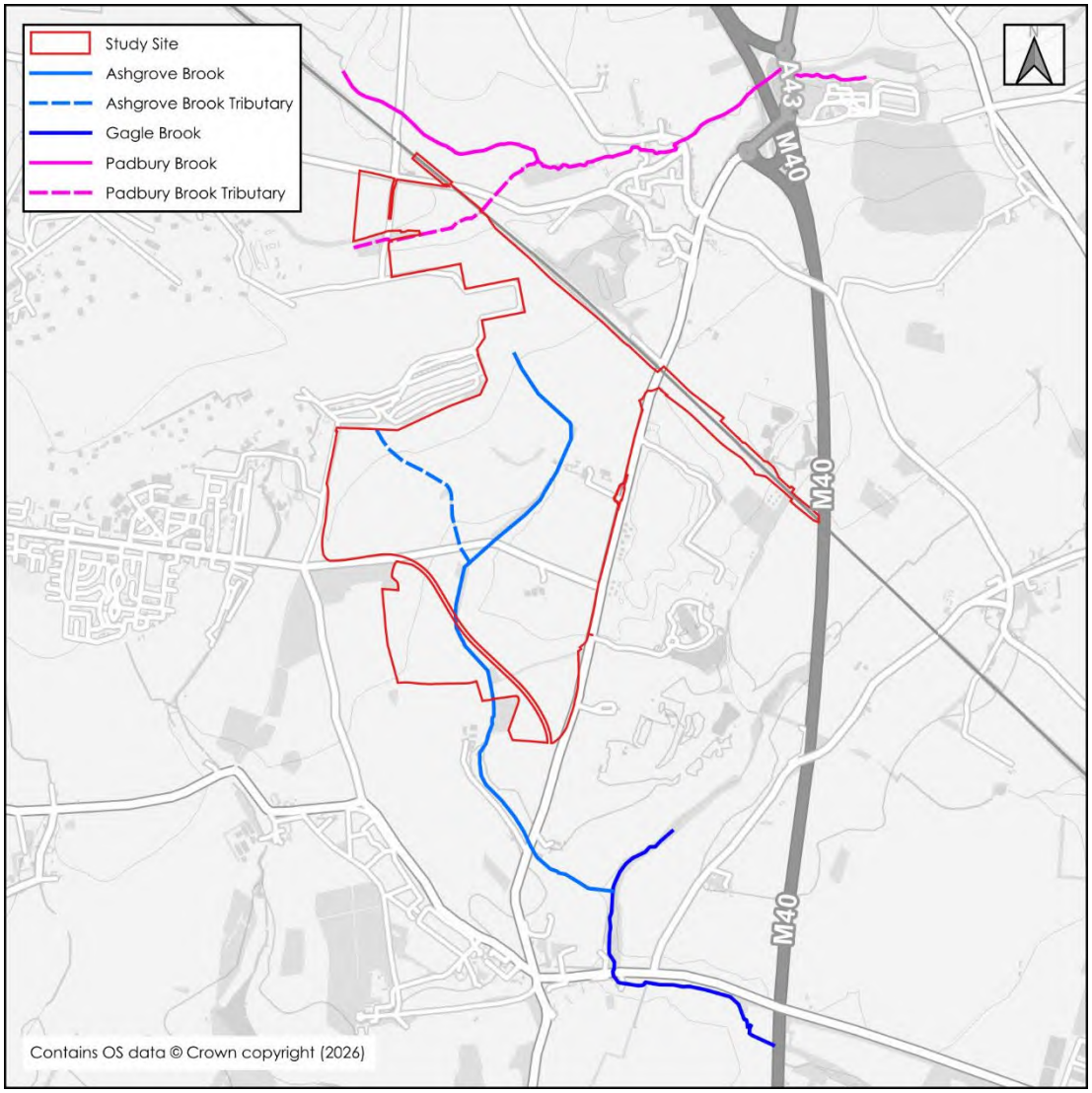

Figure 1.2: Study Site Location and Watercourse Network

1.13 The generalised topography of the study site is shown in **Figure 1.3**, with a full topographical survey (reference: 36646_T) included as **Appendix 2**. The study site demonstrates valley like topography where existing ground levels generally fall to the respective watercourses. In the very north of the study site ground levels fall from the north and south towards the Padbury Brook ranging from approximately 124.6 metres Above Ordnance Datum (mAOD) to approximately 114.9mAOD. Elsewhere within the study site ground levels fall from the west and east towards the Ashgrove Brook and Tributary ranging from approximately 124.7mAOD to approximately 102.0mAOD.

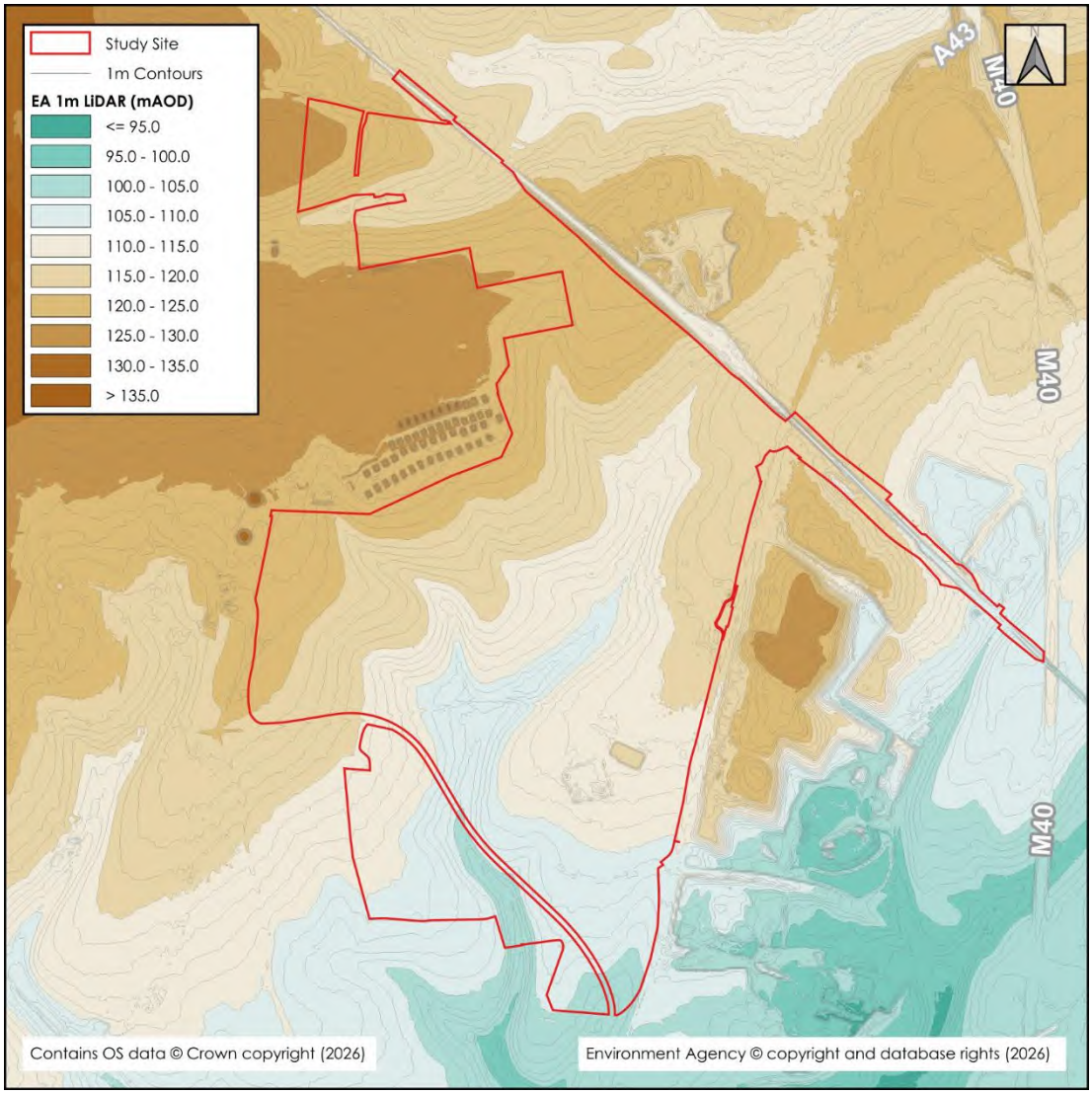

Figure 1.3: Existing Study Site Topography based on EA 1m LiDAR

Proposed Development

1.14 The proposals within the study site comprise a multi-unit SRFI with associated drainage infrastructure. Proposed access/egress is to be achieved via new connections to Camp Road, Bicester Road, M40 and A43.

2. FLOOD RISK PLANNING POLICY & GUIDANCE

National Policy Statement for National Networks

2.1 The NPSNN[1] provides planning policy guidance for the promoters of nationally significant infrastructure projects. The NPSNN includes guidance about the generic, and other, impacts which should specifically be considered in assessing and designing projects. It also sets the context for the examination of proposals by the Planning Inspectorate (PINS).

2.2 Paragraph 5.128 highlights the requirement for an FRA to accompany the application and must demonstrate that the project will be safe for its lifetime, without increasing flood risk elsewhere and, where possible, will reduce flood risk overall.

2.3 The NPSNN specifically refers to the NPPF for further, more detailed guidance on flood risk.

National Planning Policy Framework

2.4 The National Planning Policy Framework (NPPF)[2] sets out the Government's national policies on different aspects of land use planning in England in relation to flood risk.

2.5 Flood risk is identified as a combination of the probability and the potential consequences of flooding:

Flood Risk = Probability x Consequences

2.6 The probability is the chance of a flood occurring expressed as a return period or annual exceedance probability (AEP), and the consequences are the potential impacts of the flood (for example, damage to buildings or risk to people's safety).

2.7 Potential sources of flood risk are rivers and the sea, direct rainfall on the ground surface resulting in surface water runoff, rising groundwater, overwhelmed sewers and drainage systems, reservoirs, canals and lakes, and other artificial sources.

2.8 The NPPF states that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk. Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere. When considering flood risk, the NPPF requires development to account for future climate change.

National Planning Practice Guidance – Flood Risk and Coastal Change

2.9 The NPPF is accompanied by the Planning Practise Guidance (PPG) category entitled "Flood Risk and Coastal Change"[3]. This sets out the vulnerability to flooding of different land uses. It encourages development to be located in areas of lower flood risk where

[1] National Policy Statement for National Networks, Department for Transport, March 2024
[2] Revised National Planning Policy Framework, Ministry of Housing, Communities & Local Government, amended February 2025
[3] Planning Practice Guidance: https://www.gov.uk/guidance/flood-risk-and-coastal-change, amended February 2024

possible and stresses the importance of preventing increases in flood risk off site to the wider catchment area.

2.10 The PPG requires development to be designed to include flood risk management and resilience against the "design flood" for its lifetime. The PPG also states that all potential sources of flooding should be considered when preparing an FRA.

2.11 The "design flood" is an event of a given probability generally defined as:

- • river flooding likely to occur with a 1% AEP (a 1 in 100 chance each year); or
- • tidal flooding likely to occur with a 0.5% AEP (1 in 200 chance each year); or
- • surface water flooding likely to occur with a 1% AEP (a 1 in 100 chance each year),

plus, an appropriate allowance for climate change.

2.12 The PPG sets out the vulnerability to flooding of different land uses. It encourages development to be located in areas of lower flood risk where possible and stresses the importance of preventing increases in flood risk off site to the wider catchment area.

2.13 The NPPF and PPG include Table 1 which defines Flood Zones as shown on the Flood Map for Planning, and Table 2 which uses flood risk vulnerability to determine compatibility within the defined Flood Zones, both of which should be considered in conjunction with Annex 3 of the NPPF which defines flood risk vulnerability based on development uses. Annex 3 and Table 2 are recreated within **Appendix 3** of this report for reference.

2.14 This FRA is written in accordance with the NPPF and the PPG.

Flood Map for Planning

2.15 With particular reference to planning and development, the Flood Map for Planning identifies Flood Zones in accordance with Table 1 of the PPG. Further details on the Flood Zone classifications are outlined in **Table 2.1**.

Table 2.1: Flood Zone Classifications

Flood Zone	Description
Flood Zone 1 (Low Probability)	Land having less than a 1 in 1000 annual probability of river or sea flooding (<0.1% Annual Exceedance Probability (AEP)). All land outside of Flood Zone 2 and 3.
Flood Zone 2 (Medium Probability)	Land having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1% AEP); or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1% AEP).
Flood Zone 3a (High Probability)	Land having a 1 in 100 or greater annual probability of river flooding (>1% AEP); or land having a 1 in 200 or greater annual probability of flooding from the sea

Flood Zone	Description
	(>0.5% AEP). This is represented by "Flood Zone 3" on the Flood Map for Planning.
Flood Zone 3b (The Functional Floodplain)	Flood Zone 3b (The Functional Floodplain) is defined as land where water must flow or be stored in times of flood. This is not identified or separately distinguished from Zone 3a on the Flood Map for Planning.

2.16 The EA Flood Map for Planning, shown in **Figure 2.1**, identifies that the majority of the study site lies within Flood Zone 1. There are areas of Flood Zone 2 and 3 associated with the Ashgrove Brook downstream of the point in which the tributary joins the Brook, these watercourses do not have Flood Zones mapped upstream of this point. There are no mapped Flood Zones associated with the Padbury Brook Tributary within the study site.

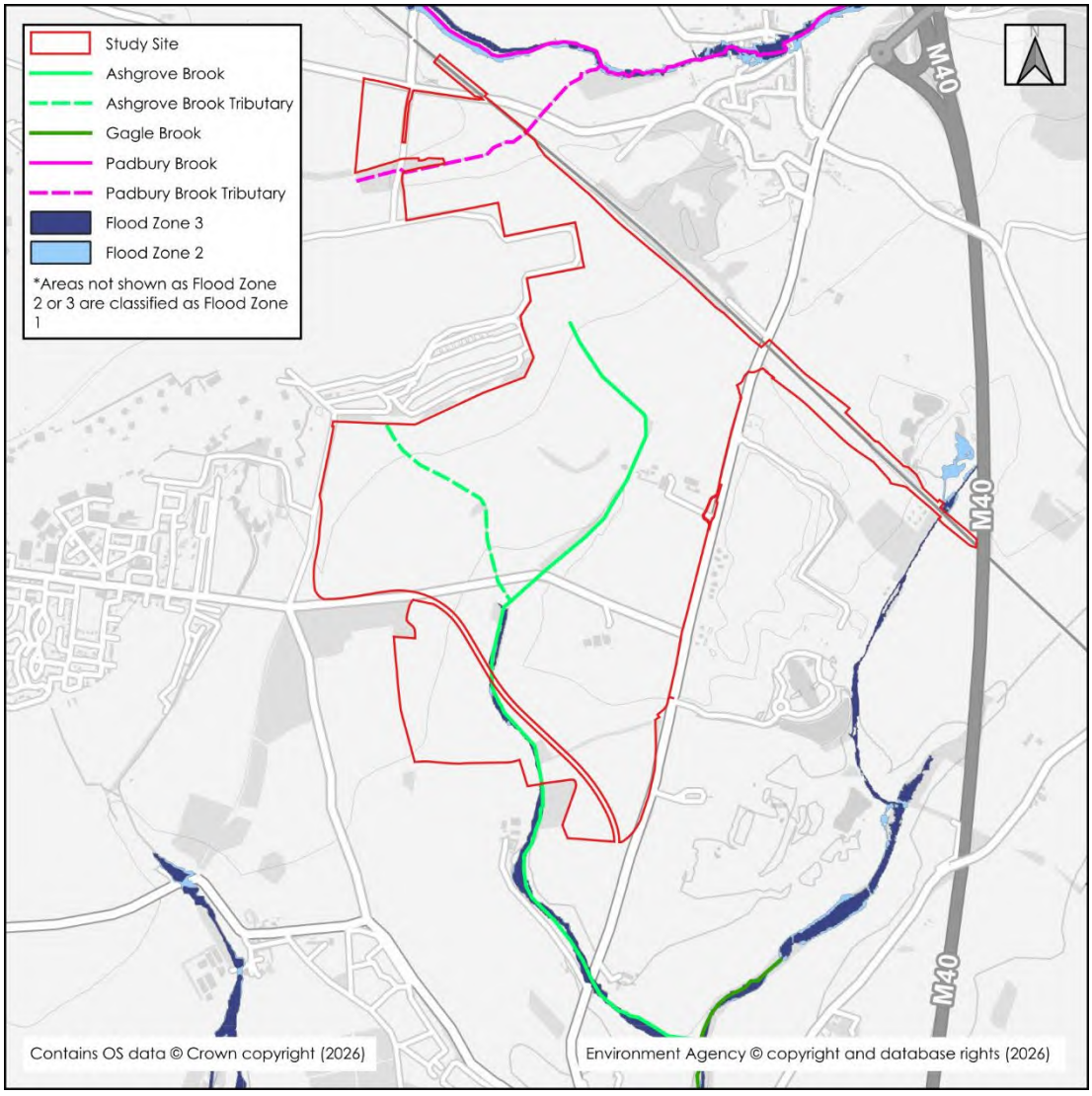

Figure 2.1: EA Flood Map for Planning

Climate Change

2.17 Predicted future changes in peak river flows caused by climate change are provided by the EA[4], with a range of projections applied to regionalised 'River Basin Districts', which are further subdivided into Management Catchments.

2.18 The site falls across two Management Catchments of the Thames River Basin District, the Cherwell and Ray and the Upper and Bedford Ouse Management Catchments. **Table 2.2** identifies the relevant peak river flow climate change allowances from these Management Catchments.

Table 2.2: Peak River Flow Climate Change Allowances for the Cherwell and Ray and Upper and Beford Ouse Management Catchments of the Thames River Basin District

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Cherwell and Ray Management Catchment			
Upper End	24%	27%	49%
Higher Central	11%	10%	25%
Central	6%	4%	15%
Upper and Bedford Ouse Management Catchment			
Upper End	24%	30%	58%
Higher Central	10%	11%	30%
Central	5%	4%	19%

2.19 When determining the appropriate allowance for use in a FRA the Flood Zone classification, flood risk vulnerability and the anticipated lifespan of the development should be considered. **Table 2.3** provides a matrix summarising the EA's guidance on determining the appropriate allowance(s).

Table 2.3: Application of Appropriate Peak River Flow Climate Change Allowances

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
1	Use the central allowance where a location may fall within Flood Zone 2 or 3 in the future.				
2	Use the higher central allowance	Use the central allowance			

[4] Environment Agency, Flood risk assessments: climate change allowances: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Last Accessed August 2025.

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
3a	Use the higher central allowance	Development should not be permitted	Use the central allowance		
3b	Use the higher central allowance	Development should not be permitted			Use the central allowance
If development is considered appropriate by the local authority when not in accordance with Flood Zone vulnerability categories, then it would be appropriate to use the higher central allowance.					

2.20 The site is located partially within Flood Zones 2 and 3. The proposals are considered 'Less Vulnerable' with an anticipated lifespan of 75 years in accordance with the PPG. Therefore, the Central allowance for the '2080s' epoch has been applied to the hydraulic modelling based on the appropriate Management Catchment for each watercourse (15% and 19%).

2.21 However, in accordance with EA climate change guidelines and the NPSNN, the Upper End allowance will also be assessed as a credible maximum storm event for each Management Catchment (49% and 58%)

Strategic Flood Risk Assessment

2.22 A Strategic Flood Risk Assessment (SFRA) is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.

2.23 Whilst superseded, the Cherwell District Council Level 1 SFRA (2017 Update)[5] provides information specific to the site location in the form of fluvial, surface water and groundwater flood risk mapping, as well as records of historical flooding. Information from the Level 1 SFRA (2017 Update) will be referenced within **Section 3**, where applicable.

2.24 A further update to the SFRA [6] was produced in 2022 to inform the Local Plan review for Cherwell. Information from the Level 1 SFRA (2022 Update) will be referenced within **Section 3**, where applicable.

Preliminary Flood Risk Assessment

2.25 A Preliminary Flood Risk Assessment (PFRA) is an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authorities (LLFAs).

[5] Level 1 Strategic Flood Risk Assessment (AECOM, May 2017)
[6] Level 1 Strategic Flood Risk Assessment (WHS, November 2022)

2.26 The Oxfordshire County Council PFRA[7] and its Addendum[8] consider flooding from surface water runoff, groundwater, ordinary watercourses and canals.

2.27 The PFRA references historical flooding across the county in 2001, 2006 and 2007; however, upon review the study site is not located within close proximity to the locations identified as have suffered adverse consequences from past flooding.

2.28 The PFRA Addendum includes limited additional information; Section 19 Flood Investigation are highlighted as ongoing for any further flood events occur.

2.29 Upon review no further information relevant to the study site is included within the PFRA or its Addendum.

Local Flood Risk Management Strategy

2.30 A Local Flood Risk Management Strategy (LFRMS) is prepared by an LLFA to help understand and manage flood risk at a local level.

2.31 The LFRMS aims to ensure that the knowledge of local flood risk issues is communicated effectively so that they can be better managed. The LFRMS also aims to promote sustainable development and environmental protection.

2.32 The Oxfordshire County Council LFRMS[9] has been reviewed and will be referenced within this report, where applicable.

River Basin Flood Risk Management Plan

2.33 Flood Risk Management Plans (FRMPs) explain the risk of flooding from rivers, the sea, surface water, groundwater and reservoirs. FRMPs set out how risk management authorities will work with communities to manage flood and coastal risk. Risk management authorities include the EA, Natural Resources Wales, local councils, Internal Drainage Boards, National Highways and LLFAs.

2.34 The site is located within the Thames River Basin District, and the Thames River Basin District FRMP[10] has been reviewed; however, no relevant site scale objectives were found.

Surface Water Management Plan

2.35 Surface Water Management Plan SWMPs are non-statutory plans which preceded the introduction of the Flood and Water Management Act 2010. They can provide an important evidence base of local flood risk issues which can include surface water drains, groundwater and small watercourses.

2.36 Cherwell District Council do not have a published SWMP for review.

[7] Preliminary Flood Risk Assessment (JBA Consulting, June 2011)
[8] Preliminary Flood Risk Assessment Addendum (Oxfordshire County Council, December 2017)
[9] Local Flood Risk Management Strategy (WHS, January 2025)
[10] Thames River Basin District Flood Risk Management Plan (Environment Agency, December 2022)

Section 19 Flood Investigation Reports

2.37 Under their duties of the Flood and Water Management Act 2010, LLFAs have a responsibility to publish reports of investigations of flood incidents. A Section 19 Flood Investigation Report is a public statement of the circumstances of a historical flood event and what parties have a role in managing the risks. The investigation does not always give an in-depth analysis of the flood risk or mechanisms, but it can provide a valuable record of past events.

2.38 Oxfordshire County Council have published 40 Section 19 reports on their website, which document the flooding that occurred between 2018 and 2024. The reports have been reviewed in relation to the location of the study site, but no evidence of flooding at the site was identified.

Local Plan

2.39 The adopted 2015 Cherwell Local Plan 2011-2031[11] has been reviewed during the preparation of this report.

2.40 Policy ESD 6: Sustainable Flood Risk Management has been summarised below:

- Culverting of watercourses should be avoided and removal of existing hydraulic structures is encouraged.
- A site specific FRA will be needed where proposals are; within Flood Zones 2 or 3, of 1 hectare or greater in Flood Zone 1, sites with known flood problems or sites within 9m of any watercourses.
- FRAs should assess all sources of flood risk.
- "Development should be safe and remain operational (where necessary) and proposals should demonstrate that surface water will be managed effectively on site and that the development will not increase flood risk elsewhere."

[11] Cherwell Local Plan 2011-2031. Cherwell District Council (2015)

3. POTENTIAL SOURCES OF FLOOD RISK

3.1 Flooding can occur from a variety of sources, or combination of sources, which may be natural or artificial. **Table 3.1** below identifies the potential sources of flood risk to the site in its current condition, and the impacts which the development could have in the wider catchment, prior to mitigation. These are discussed in greater detail in the forthcoming section. The mitigation measures proposed to address flood risk issues and ensure the development is appropriate for its location are discussed within **Section 4.0**.

Table 3.1: Pre-Mitigation Sources of Flood Risk

Flood Source	Potential Risk				Description
	High	Medium	Low	None	
Fluvial (Main Rivers)				X	The study site is located approximately 2.7km east of Flood Zones attributed to the nearest EA Main River.
Fluvial (Ordinary Watercourses)		X			Hydraulic modelling shows the watercourses within the study site are predominantly confined in channel; however, there is modelled floodplain in areas from the 1 in 30-year event.
Coastal				X	The study site is not at risk of coastal/tidal inundation.
Canals				X	The nearest canal is located approximately 2.8km west of the site and therefore not considered to pose a risk.
Groundwater			X		Site-specific ground investigations encountered shallow groundwater within the study site. In the event of groundwater emergence flows would follow existing topography to the local watercourse network.
Reservoirs and waterbodies			X		The site is shown to fall outside of areas at risk of inundation from reservoir failure, as mapped by the EA. The Ardley Reservoir and Water Pumping Station within the site is considered to pose a low risk to development due to the safety legislation and maintenance responsibilities of Thames Water.

Flood Source	Potential Risk				Description
	High	Medium	Low	None	
Pluvial runoff			X		The study site is shown to predominantly at a very low probability of flooding from surface water. Areas of probable flooding are either confined to isolated low spots or the local watercourse network.
Sewers			X		The majority of the study site is unaffected by public sewers. Flows from existing sewers are either largely captured by the local watercourses or directed away from the site.
Effect of Development on Wider Catchment		X			Development has the potential to result in the loss of fluvial floodplain unless appropriately mitigated.
		X			The development will result in an increase to the area of impermeable surfaces leading to an increase in the rate and volume of surface water runoff unless appropriately mitigated.

Fluvial Flood Risk

3.2 Flooding from watercourses occurs when flows exceed the capacity of the channel, or where a restrictive structure is encountered, which leads to water overtopping the banks into the floodplain. This process can be exacerbated when debris is mobilised by high flows and accumulates at structures.

Historical Flooding

3.3 The EA Historical Flood map shows no recorded flood outlines within the study site. The nearest outline is located approximately 2.7km west of the site attributed to the River Cherwell exceeding capacity in 1992.

3.4 'Oxfordshire Record Flood Incidents' mapping included within the LFRMS shows no recorded incidents within the study site. One instance of historical flooding is recorded to the north within Fewcott; however, no relevant information to this flood event is provided.

3.5 The Cherwell District Council Level 1 SFRA (2017 Update) indicates historical flooding in Lower Heyford and Fewcott between October and December 2012; however, the source of flooding is unconfirmed and no information is provided to confirm if this event impacted the study site. No additional recorded flood events are included within the 2022 update to the Level 1 SFRA.

Main Rivers

3.6 The nearest Main River Flood Zones are located approximately 2.7km west of the study site attributed to the River Cherwell. A review of EA 1m LiDAR data shows the study site lies approximately 38m above these Flood Zones. Therefore, flooding from Main Rivers now and in the future is not considered to pose a risk to the site.

Ordinary Watercourses

3.7 The EA Flood Map for Planning shows the study site to be predominantly within Flood Zone 1 (**Figure 2.1**); however, there is shown to be either partial or no representation of the Ashgrove Brook, its tributary and the Padbury Brook tributary. Therefore bespoke hydraulic modelling exercises have been undertaken, full details on the hydraulic modelling exercises are included in **Appendix 4** with the outputs discussed below.

Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook

3.8 The model was simulated for the 1 in 30-year, 1 in 100-year, 1 in 100-year +15%, 1 in 100-year +25%, 1 in 100-year +49%, and 1 in 1000-year flood events. The modelled floodplain extents are illustrated in **Figure 3.1**, with peak flood levels for the corresponding flood nodes provided in **Table 3.2**.

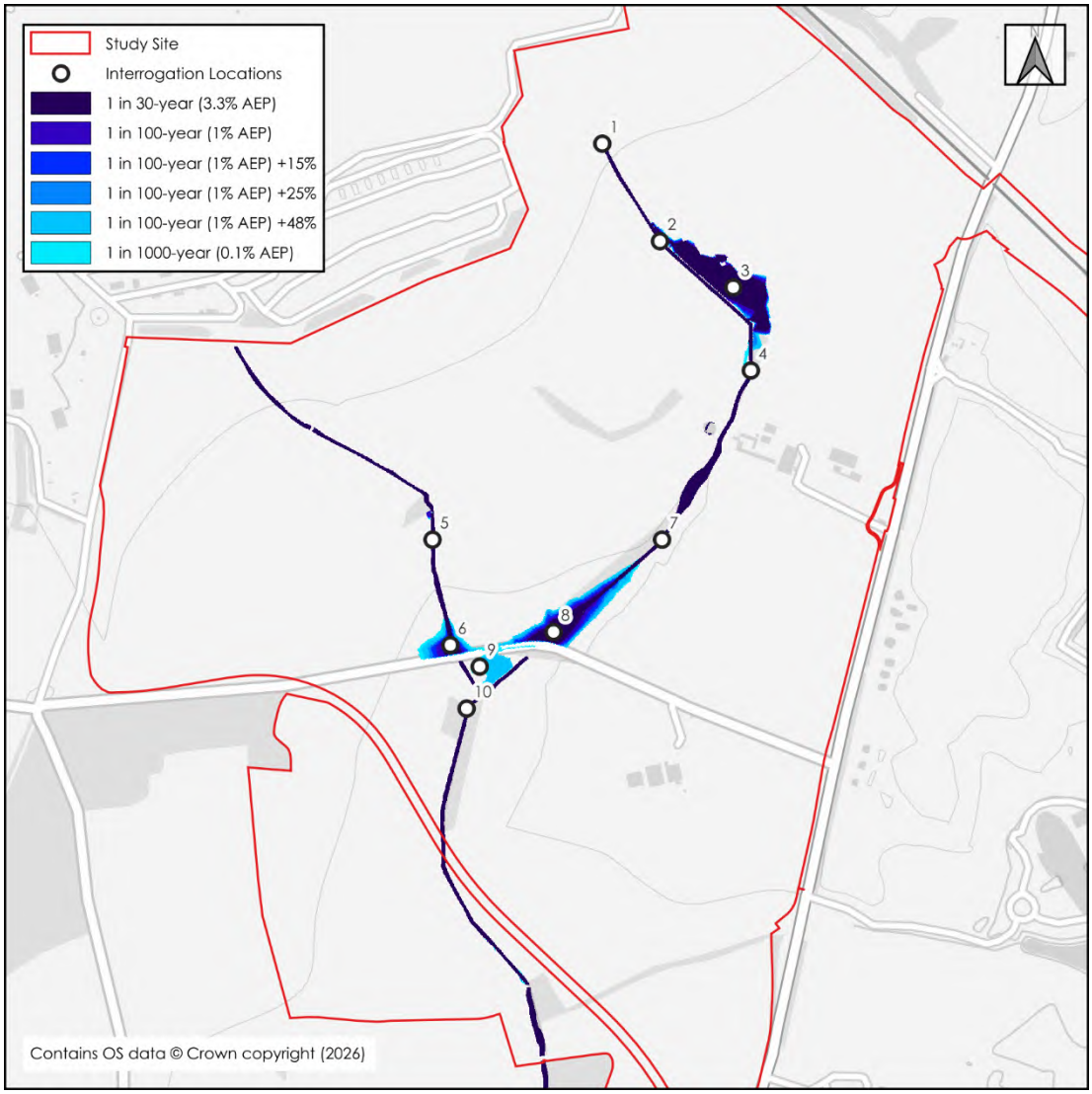

Figure 3.1: Baseline Modelled Peak Flood Extents – Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook

Table 3.2: Baseline Modelled Peak Flood Levels – Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 15%	1 in 100-Year + 25%	1 in 100-Year + 49%	1 in 1000-Year
1	118.11	118.14	118.16	118.17	118.20	118.23
2	115.17	115.18	115.19	115.19	115.20	115.21
3	112.83	112.83	112.83	112.83	112.83	112.84
4	110.58	110.60	110.62	110.63	110.66	110.68
5	109.82	109.84	109.85	109.86	109.87	109.88
6	107.78	107.94	108.07	108.14	108.29	108.39

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 15%	1 in 100-Year + 25%	1 in 100-Year + 49%	1 in 1000-Year
7	108.42	108.44	108.46	108.47	108.53	108.56
8	107.90	108.09	108.23	108.32	108.49	108.54
9	-	-	-	-	-	107.21
10	105.41	105.41	105.42	105.42	105.43	105.47

3.9 The Gagle Brook is shown to largely remain in channel during all modelled events and does not impact upon the study site.

3.10 In the upper reaches of the Ashgrove Brook, flows overtop the left bank during all modelled flood events and travel along the left floodplain. During the 1 in 1000-year event, flows also overtop the right bank for a short distance before re-joining the channel.

3.11 Flows back up behind restrictive structures beneath Camp Road on both the Ashgrove Brook and the tributary during all modelled flood events. During the 1 in 100-year +49% and 1 in 1000-year events flows overtop Camp Road and pool at the confluence between the two watercourses.

3.12 During the 1 in 100-year +15% event peak flood depths within the study site reach up to 0.92m and 1.14m in the 1 in 100-year +49% event.

3.13 Overall, there is considered to be a medium risk of flooding from the Ashgrove Brook and its Tributary. Appropriate mitigation measures are discussed in **Section 4**.

Padbury Brook Tributary

3.14 The model was simulated for the 1 in 30-year, 1 in 100-year, 1 in 100-year +19%, 1 in 100-year +30%, 1 in 100-year +58%, and 1 in 1000-year flood events. The modelled floodplain extents are illustrated in **Figure 3.2**, with peak flood levels for the corresponding flood nodes provided in **Table 3.3**.

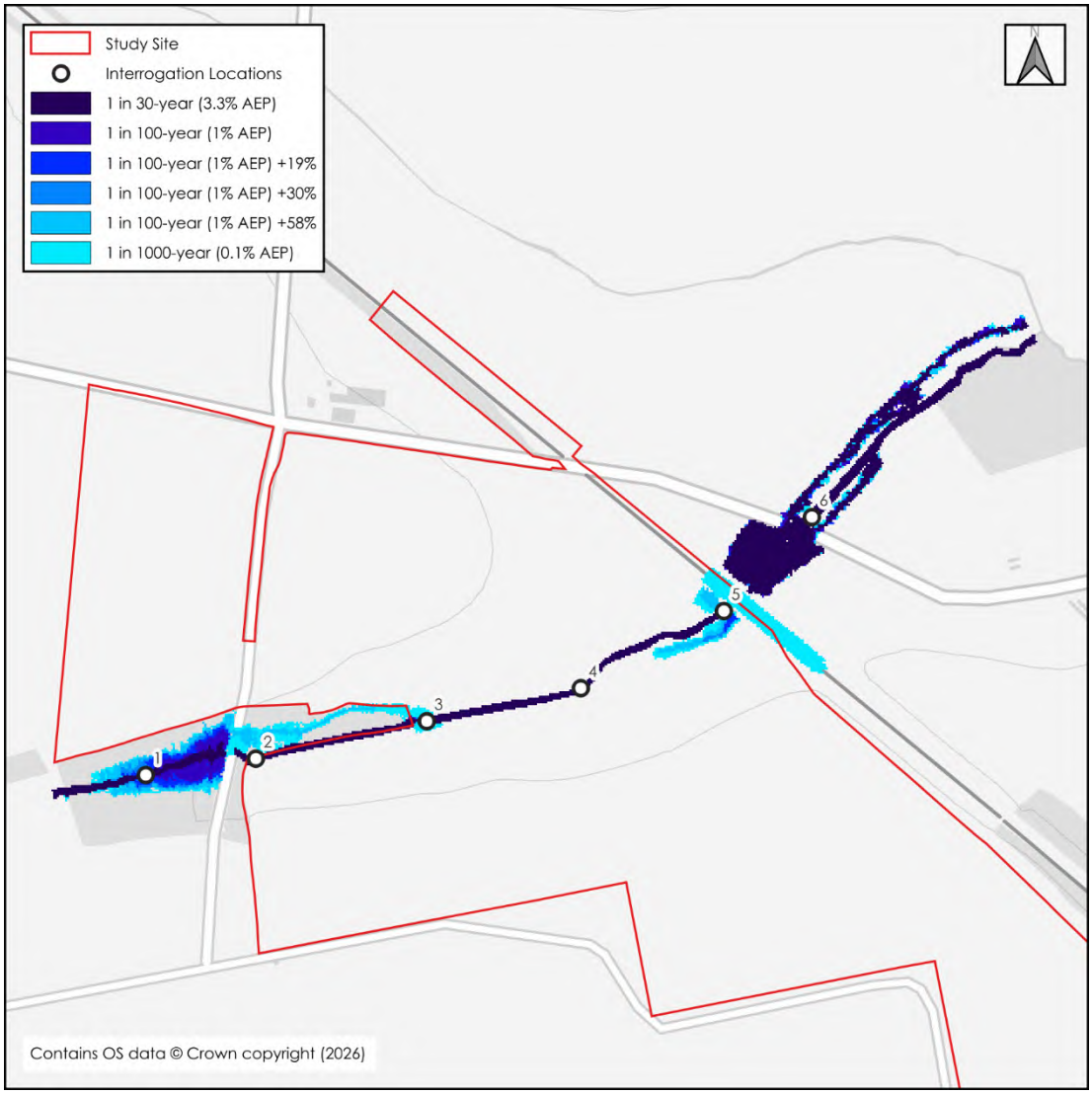

Figure 3.2: Baseline Modelled Peak Flood Extents – Padbury Brook Tributary

Table 3.3: Baseline Modelled Peak Flood Levels – Padbury Brook Tributary

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%	1 in 100-Year + 30%	1 in 100-Year + 58%	1 in 1000-Year
1	119.05	119.21	119.33	119.40	119.58	119.65
2	118.04	118.09	118.11	118.12	118.14	118.16
3	116.98	117.03	117.05	117.06	117.08	117.17
4	116.26	116.30	116.32	116.33	116.34	116.41
5	115.53	115.58	115.61	115.62	115.65	115.73
6	114.11	114.15	114.16	114.17	114.18	114.20

3.15 Upstream of the study site flows back up behind the culvert under Raghouse Lane and from the 1 in 100-year +58% event flows spill over the road forming a narrow flow route parallel to the channel. From the 1 in 1000-year event this flow route briefly enters the study site where the flows return to the channel.

3.16 Within the study site flows generally remain in channel, a small area of floodplain is present in the north-east from the 1 in 100-year +19% event where flows back up at the existing siphon under the Chiltern Main Line.

3.17 During the 1 in 100-year +19% event peak flood depths within the study site reach up to 0.05m and 0.09m in the 1 in 100-year +58% event.

3.18 Overall, given the limited flood plain and generally shallow depths there is considered to be a low risk of flooding from the Padbury Brook Tributary. Works and associated mitigation to deliver components of the proposed development are discussed in **Section 4**.

Pluvial Flood Risk

3.19 Pluvial flooding can occur during prolonged or intense storm events when the infiltration potential of soils, or the capacity of drainage infrastructure is overwhelmed leading to the accumulation of surface water and the generation of overland flow routes.

3.20 The RoFSW mapping has been collated and published by the EA, this shows the potential flooding which could occur 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. The mapping, shown in **Figure 3.3**, shows the probability of surface water flooding based on the Central climate change allowances for the '2050s' epoch and is the most precautionary surface water data projection currently published by the EA.

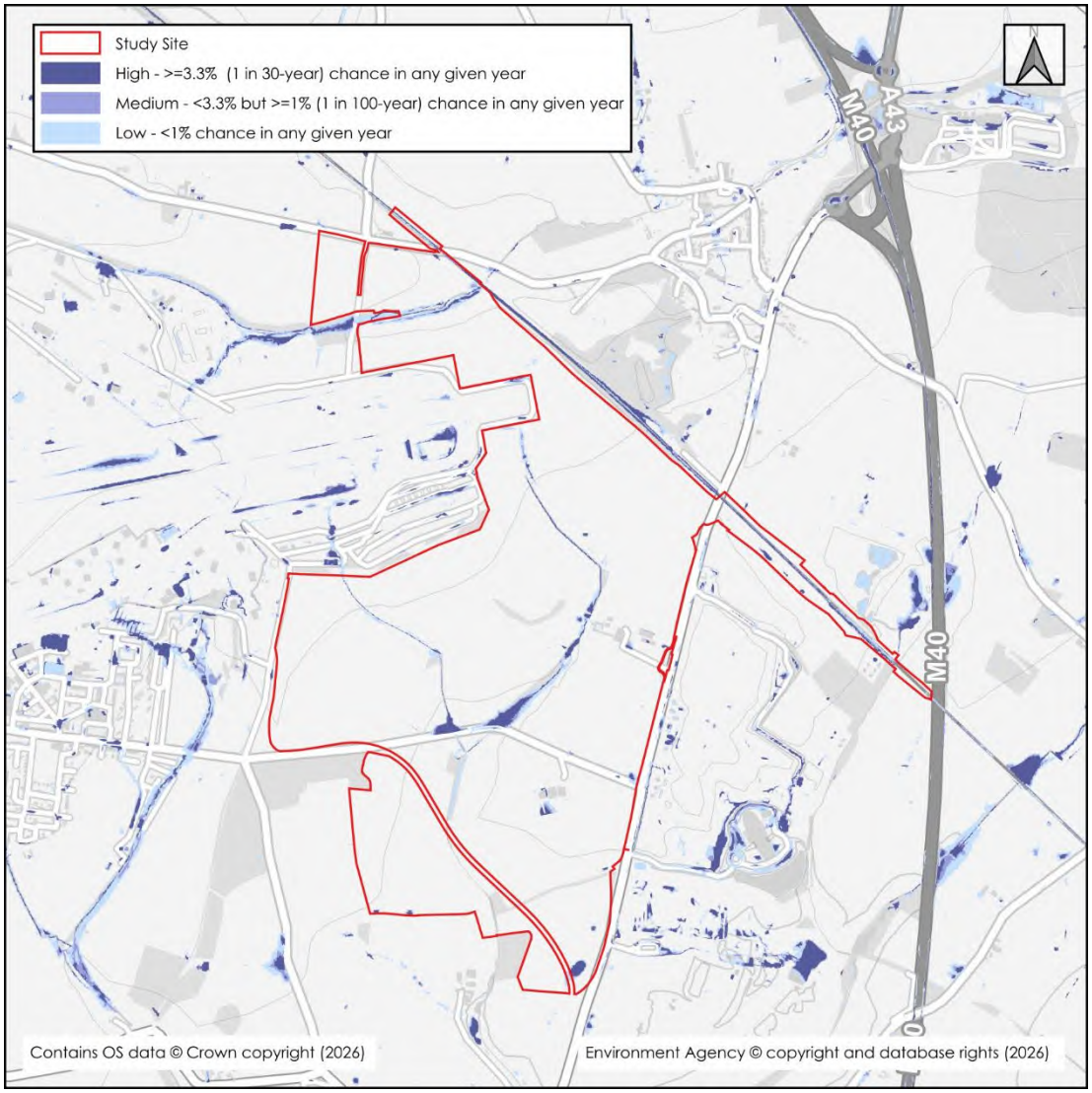

Figure 3.3: EA Risk of Flooding from Surface Water (yearly Chance of Flooding between 2040 and 2060)

3.21 The study site is shown to be predominantly at a very low probability of flooding from surface water. Areas with a low to high probability of flooding are shown in alignment to the Ashgrove Brook and its tributary; however, the risk from these sources is fluvial in nature and discussed in the **Fluvial Flood Risk** section above.

3.22 Elsewhere within the study site there are shown to be small, isolated areas with a low to high probability of flooding associated with existing topographic low spots. These areas are shown to have a low probability of reaches depths greater than 0.3m.

3.23 Access and egress routes via Camp Road, Bicester Road, the M40 and the A43 are shown to be at a low probability of flooding from surface water.

3.24 There are no records of historical surface water flooding at the study site reported in the Level 1 SFRA (2017 and 2022 Updates) or LFRMS.

3.25 Overall, the risk of surface water flooding at the study site is considered to be low. Mitigation measures to address any residual risk are outlined in **Section 4**.

Groundwater Flood Risk

3.26 Groundwater flooding occurs when the water table rises above ground elevations, or it rises to depths containing basement level development. It is most likely to happen in low lying areas underlain by permeable geology. This is most common on regional scale chalk aquifers, but there may also be a risk on sandstone and limestone aquifers or on thick deposits of sands and gravels underlain by less permeable strata such as that in a river valley.

3.27 BGS Mapping shows the study site to be underlain predominantly by White Limestone Formation (Principal Aquifer). A small area in the north is underlain by a mix of Rutland Formation Mudstone (Secondary B Aquifer), Forest Marble Formation – Limestone (Principal Aquifer) And Bladon Member - Mudstone and Limestone, Interbedded (Principal Aquifer).

3.28 Superficial deposits of Alluvium - Clay, Silt, Sand and Gravel (Secondary A Aquifer) and Head - Clay, Silt, Sand and Gravel (Secondary Undifferentiated Aquifer) are mapped within the study site along the alignment of the local watercourse network.

3.29 Aquifer definitions are summarised in **Table 3.4**.

Table 3.4: Aquifer Definitions

Aquifer	Definition
Principal	Layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
Secondary A	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
Secondary B	Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.
Secondary Undifferentiated	Assigned in cases where it has not been possible to attribute either category A or B to a rock type.

3.30 Areas Susceptible to Groundwater Flooding mapping appended to the Level 1 SFRA (2017 Update) shows the study site to lie in a cell at no risk of groundwater flooding or where >=25% to <50% of the cell is susceptible to groundwater flooding. It should be

noted that resolution of the mapping is such that a single point deemed to have a high susceptibility leads to the entire 1km^2 cell being designated at that risk.

3.31 The BWB Phase 2 Ground Investigation notes that during the 2021 limited ground investigation, shallow groundwater strikes during excavation and drilling were encountered at depths between 1.3m and 2.0m bgl. Water strikes were generally noted to be confined, with stratum of cohesive material identified above and below the water strike. The groundwater strikes and associated stratum are summarised in **Table 3.5**, the exploratory hole locations are shown in **Figure 3.4**.

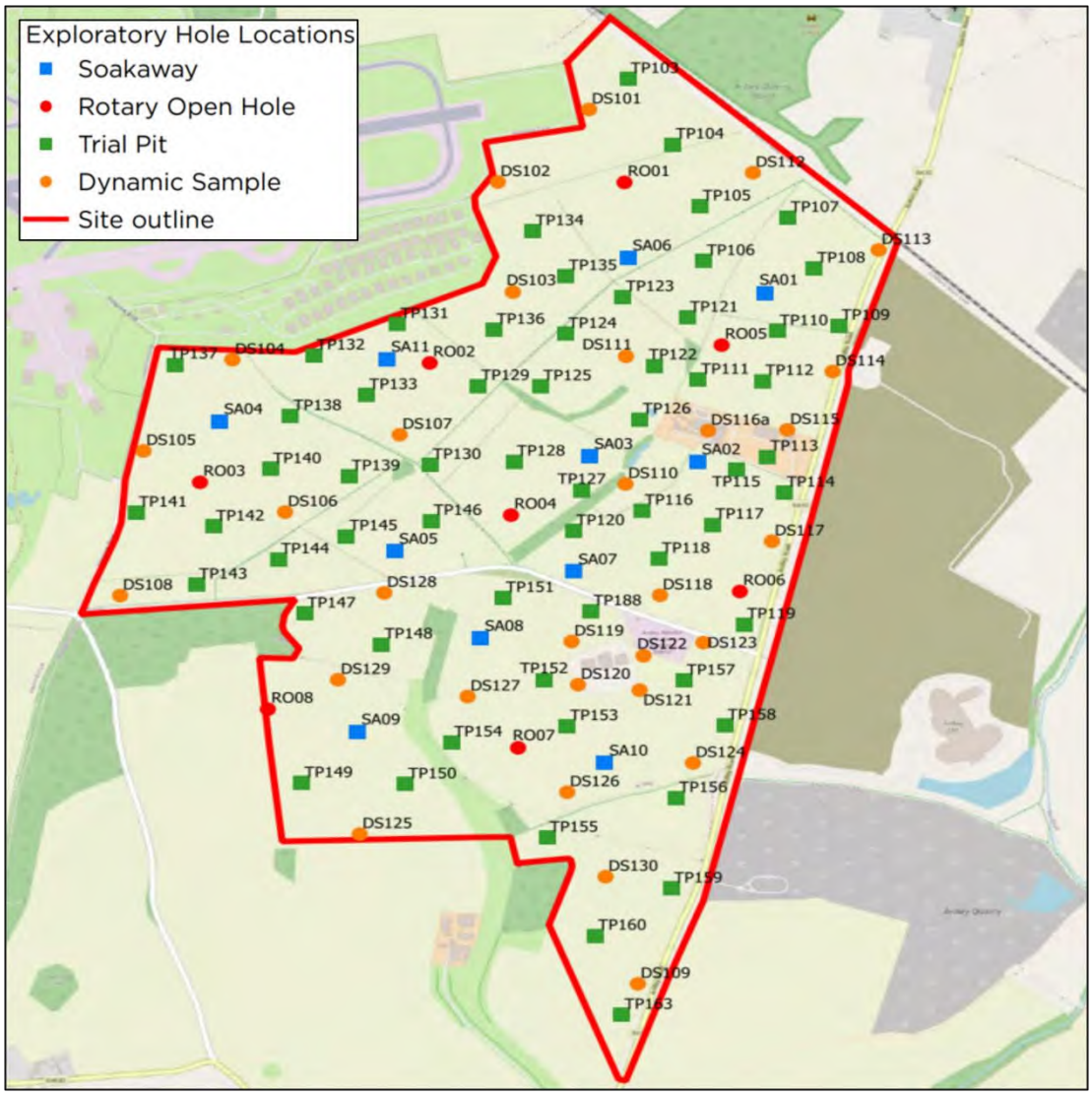

Figure 3.4: Phase 2 Ground Investigation – Exploratory Hole Locations - BWB Consulting Ltd (September 2024)

Table 3.5: Groundwater Strikes – Ground Investigation 2021

Location	Depth (m bgl)	Stratum
DS110	2.0	Alluvium (Sand)
SA03	1.3	White Limestone Formation (Limestone)
TP106	1.68	White Limestone Formation (Limestone)
TP120	1.6	White Limestone Formation (Sand)
TP121	1.45	Alluvium (Sand and Gravel)
TP146	1.6	White Limestone Formation (Gravel)
RO01	9.8	White Limestone Formation (Limestone)
RO02	9.8	White Limestone Formation (Limestone)
RO03	6.3	White Limestone Formation (Limestone)
RO04	7.1	White Limestone Formation (Limestone with Clay)
RO05	3.5	White Limestone Formation (Limestone)
RO06	8.1	White Limestone Formation (Clay with Limestone)
RO07	7.2	White Limestone Formation (Clay with Limestone)
RO08	7.2	White Limestone Formation (Clay with Limestone)

3.32 Any groundwater emergence would be expected to either occur within the low lying areas around the watercourses or be directed to these points via the local topography. Therefore, the consequence of groundwater flooding in the site is considered to be low. Appropriate mitigation measures are outlined in **Section 4**.

Flood Risk from Reservoirs & Large Waterbodies

3.33 Flooding can occur from large waterbodies or reservoirs if they are impounded above the surrounding ground levels or are used to retain water in times of flood. Although unlikely, reservoirs and large waterbodies could overtop or breach leading to rapid inundation of the downstream floodplain.

3.34 To help identify this risk, reservoir failure flood risk mapping has been prepared and published by the EA, this shows the largest area that might be flooded if a reservoir were to fail and release the water it holds. The map displays a worst-case scenario and is only intended as a guide. An extract of the mapping is included as **Figure 3.5**.

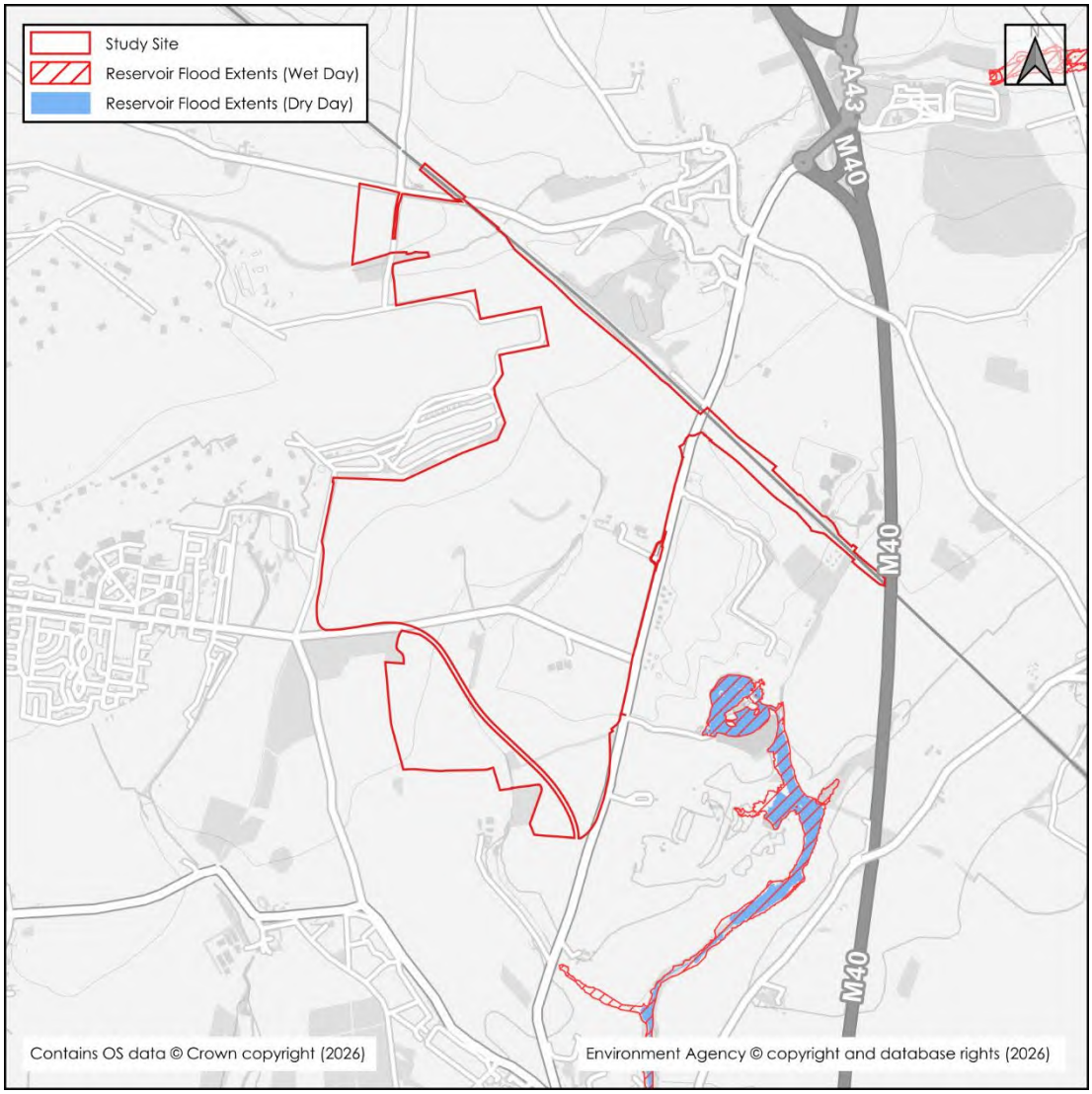

Figure 3.5: EA Reservoir Failure Extents

3.35 There are two flooding scenarios shown on the reservoir flood maps: a 'dry-day' and a 'wet-day'. The 'dry-day' scenario predicts the flooding that would occur if the dam or reservoir failed when rivers are at normal levels. The 'wet-day' scenario predicts how much worse the flooding might be if a river is already experiencing an extreme flood.

3.36 The study site is shown to be removed from the areas at risk of inundation in the event of reservoir failure as mapped by the EA. The nearest mapped extents are located 400m east associated with the Ardley Energy from Waste Facility Flood Storage Area.

3.37 The Ardley Reservoir and Water Pumping Station is a covered reservoir owned and maintained by Thames Water. The reservoir is not represented on the EA's mapping as it is a covered reservoir; however, in the event of a breach any flows would follow the existing topography and be directed towards the Ashgrove Brook to the west.

3.38 Based on the safety legislation in place and the maintenance and repair responsibilities of Thames Water, the actual probability of a significant failure on the Ardley Reservoir is considered to be low. Therefore, the risk of flooding at the site from this source is also

considered to be low. However, to ensure resilience of the proposed development against this residual risk mitigation has been developed to formalise any potential breach flows; this is discussed further within **Section 4**.

Flood Risk from Sewers

3.39 Sewer flooding can occur when the capacity of the infrastructure is exceeded by excessive flows, or as a result of a reduction in capacity due to collapse or blockage, or if the downstream system becomes surcharged. This can lead to the sewers flooding onto the surrounding ground via manholes and gullies, which can generate overland flows.

3.40 The local sewerage undertaker is Thames Water; a copy of their records is included in **Appendix 5**. There are two existing surface water sewers of unrecorded diameters within the study site.

3.41 The first sewer flows from the north-west within Upper Heyford Airfield and feeds the tributary of the Ashgrove Brook. The network is shown to predominantly serve a section of runway on the disused airfield. It is noted that whilst this network is not explicitly modelled within the hydraulic model a conservative approach has been taken applying flows for the contributing catchment downstream of the sewer outfall. Therefore, this risk will be dealt with in the same manner as the fluvial floodplain. Mitigation measures for the residual risk are outlined in **Section 4**.

3.42 The second surface water sewer emanates from the Ardley Field Waste and Recycling Centre and runs through the study site to the east parallel to the Chiltern Main Line. This sewer is expected to serve a limited catchment area and therefore convey low flows. In the event of exceedance flows would be directed to the south away from the study site. Therefore, there is considered to be a low risk of flooding from this sewer.

3.43 The Level 1 SFRA (2022 Update) reports the OX27 7 postcode area, in which the study site lies, has experienced 16 instances of sewer flooding; however, the locations of these are not provided.

Effect of Development on Wider Catchment

Displacement of Floodplain/Impedance of Flood Flows

3.44 The proposed development has the potential to displace floodplain/impede flood flows associated with the local watercourses unless appropriately mitigated. Appropriate mitigation is discussed in **Section 4**.

Development Land Use/Drainage Considerations

3.45 The proposed development will result in an increase to the area of impermeable surfaces leading to an increase in the rate and volume of surface water runoff unless appropriately mitigated.

4. FLOOD RISK MITIGATION

4.1 **Section 3** has identified the sources of flooding which could potentially pose a risk to the site and the proposed development. This section of the FRA sets out the mitigation measures which are to be incorporated within the proposed development to address and reduce the risk of flooding to within acceptable levels.

Post-Development Hydraulic Modelling

4.2 The proposed development comprises a SRFI which includes the construction of several warehouses, rail works and new access/egress locations. To facilitate the proposals, alterations are required to the existing watercourses within the study site and surrounding area. Further details on the post-development hydraulic modelling are included in **Appendix 4** with the outputs discussed below.

Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook

4.3 To facilitate the proposed development and accesses, several new culverts are required along the Ashgrove Brook, its tributary, and the Gagle Brook. The locations of the proposed structures are shown in **Figure 4.1**.

4.4 Detailed mapping of the proposed development conditions is included within **Appendix 4** and summarised below. The floodplain extents are shown in **Figure 4.2** and **Figure 4.3**, with modelled flood levels outlined within **Table 4.1**.

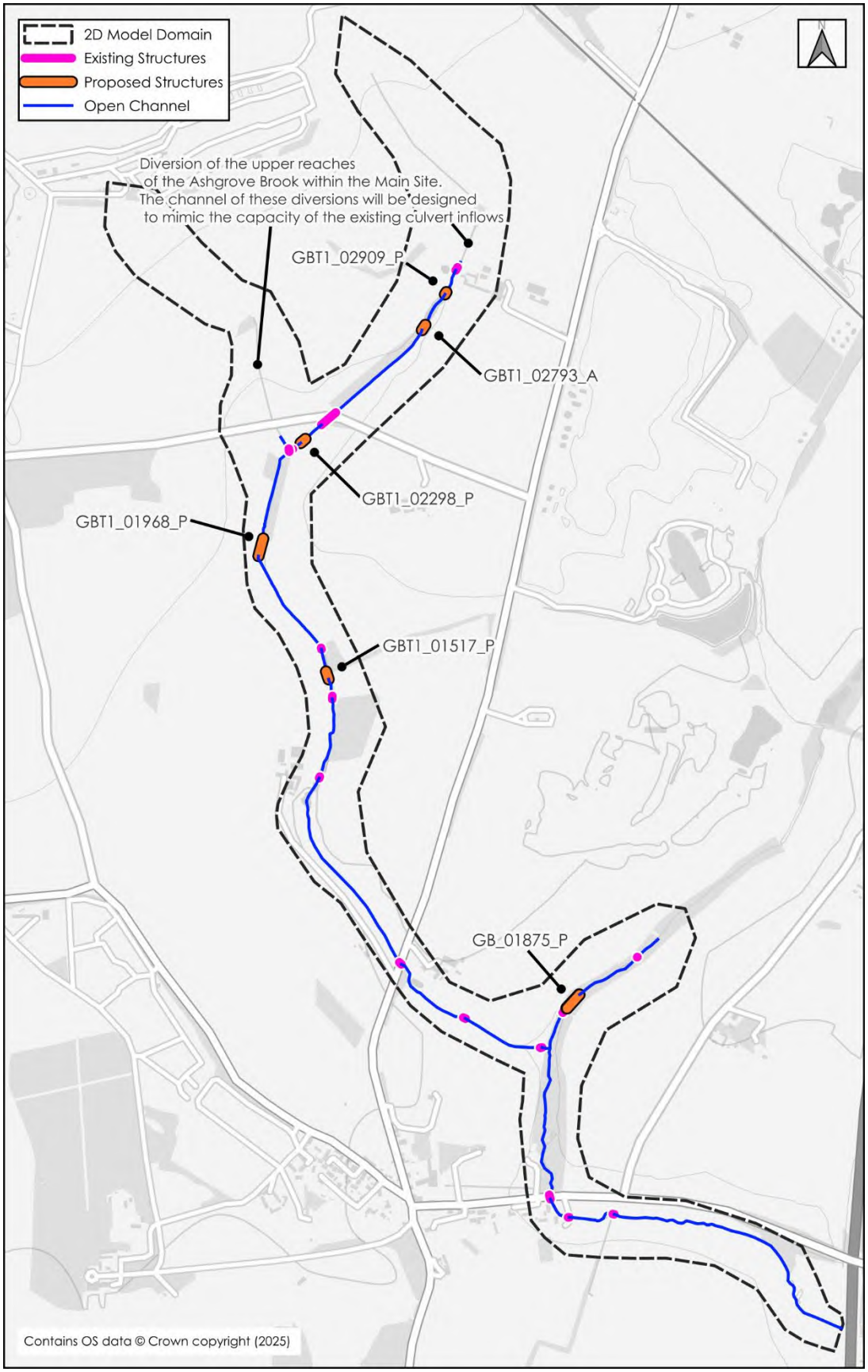

Figure 4.1: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Structures

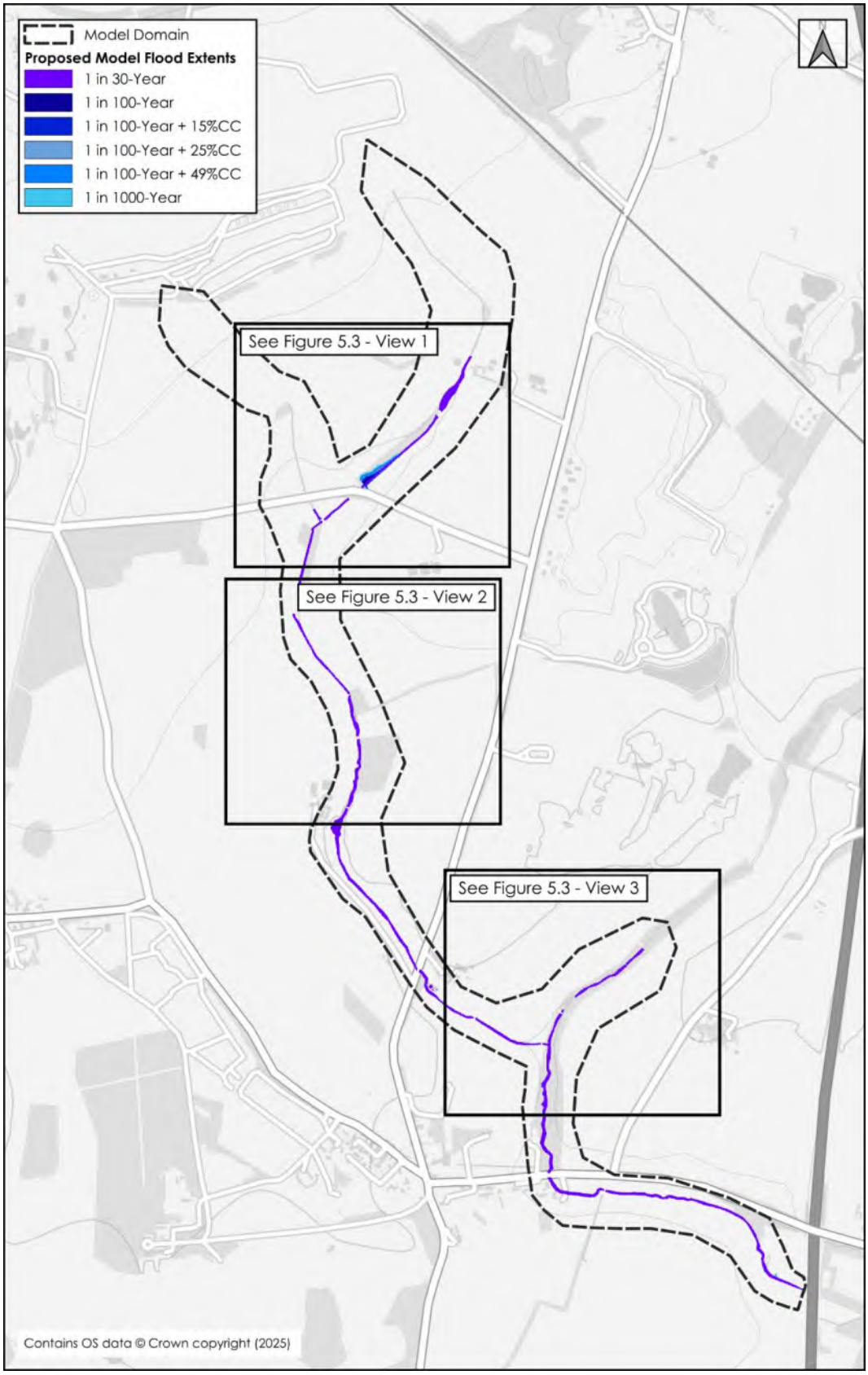

Figure 4.2: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Modelled Flood Extents

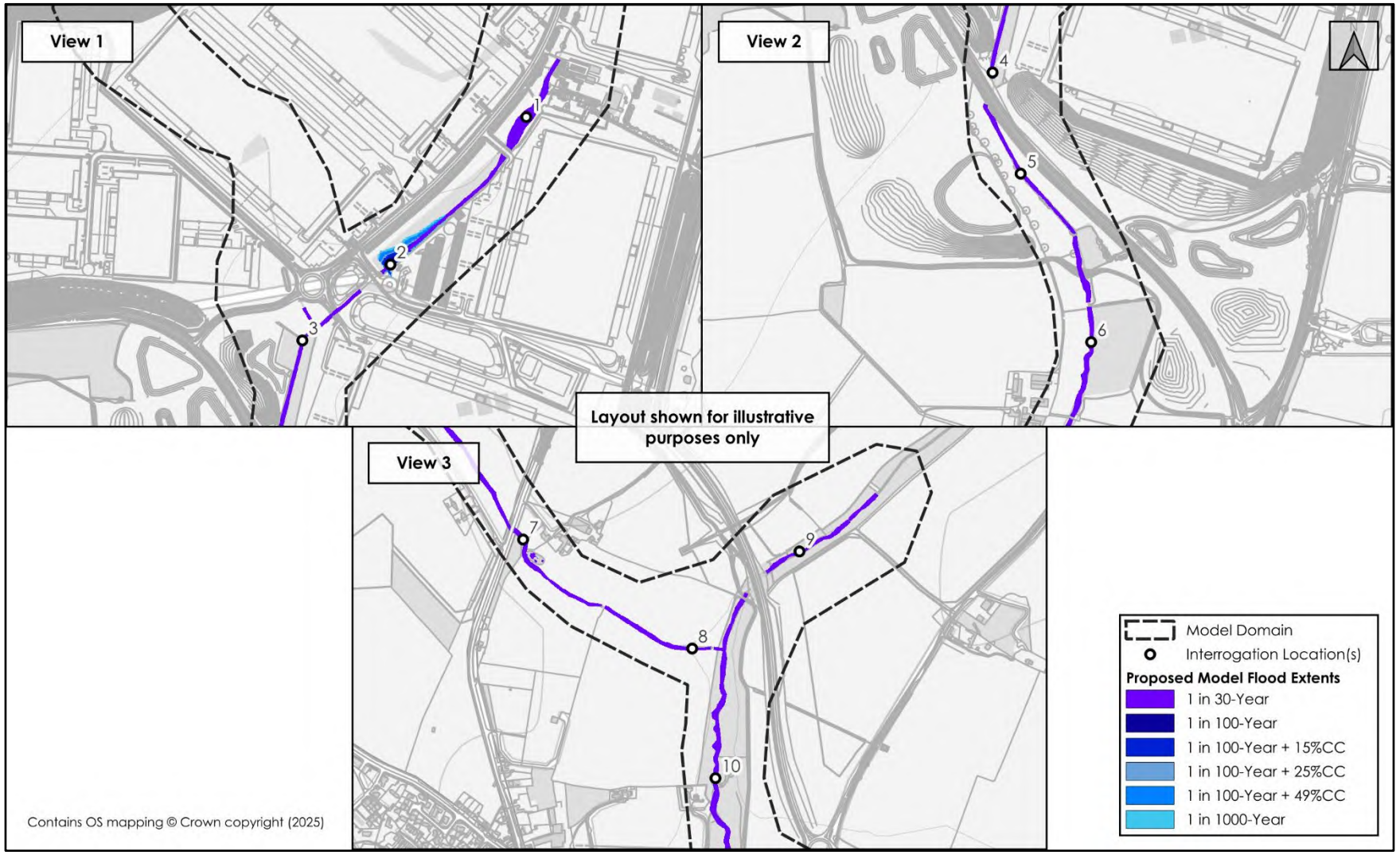

Figure 4.3: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Modelled Flood Extents – Locations 1, 2 and 3

Table 4.1: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 15%	1 in 100-Year + 25%	1 in 100-Year + 49%	1 in 1000-Year
1	108.95	108.96	108.96	108.97	108.97	108.97
2	106.84	107.54	107.73	107.84	108.07	108.21
3	105.38	105.39	105.40	105.40	105.42	105.42
4	104.69	104.70	104.71	104.72	104.74	104.75
5	102.92	102.94	102.94	102.95	102.96	102.97
6	100.39	100.41	100.42	100.43	100.45	100.46
7	94.94	94.96	94.97	94.98	95	95.02
8	88.93	88.94	88.96	88.97	89.03	89.05
9	89.47	89.51	89.53	89.54	89.57	89.60
10	86.32	86.36	86.38	86.40	86.43	86.46

4.5 The results under the proposed development conditions are similar to the baseline flood extents. Out of bank flows upstream of Camp Road are shown to decrease in the proposed scenario.

4.6 The proposed culverts demonstrate the required freeboard in all events up to and including the 1 in 1000-year event.

4.7 The proposed development modelled peak flood levels have been compared to the equivalent baseline peak flood levels to establish off site impacts. Mapping for all events is included in **Appendix 4**; the comparison mapping for the design event (1 in 100-year + 15%) is illustrated in **Figure 4.4** and discussed below.

4.8 The mapping shows that the along the upstream reaches of the Ashgrove Brook and tributary flood levels and extents are shown to decrease. Flood levels are also shown to decrease along the Gagle Brook. Upstream of structure GBT1_01968_P and GBT1_01517_P, flood levels are shown to increase as a result of the proposed culverts. However, flows are shown to be remain in channel, with no additional floodplain extents.

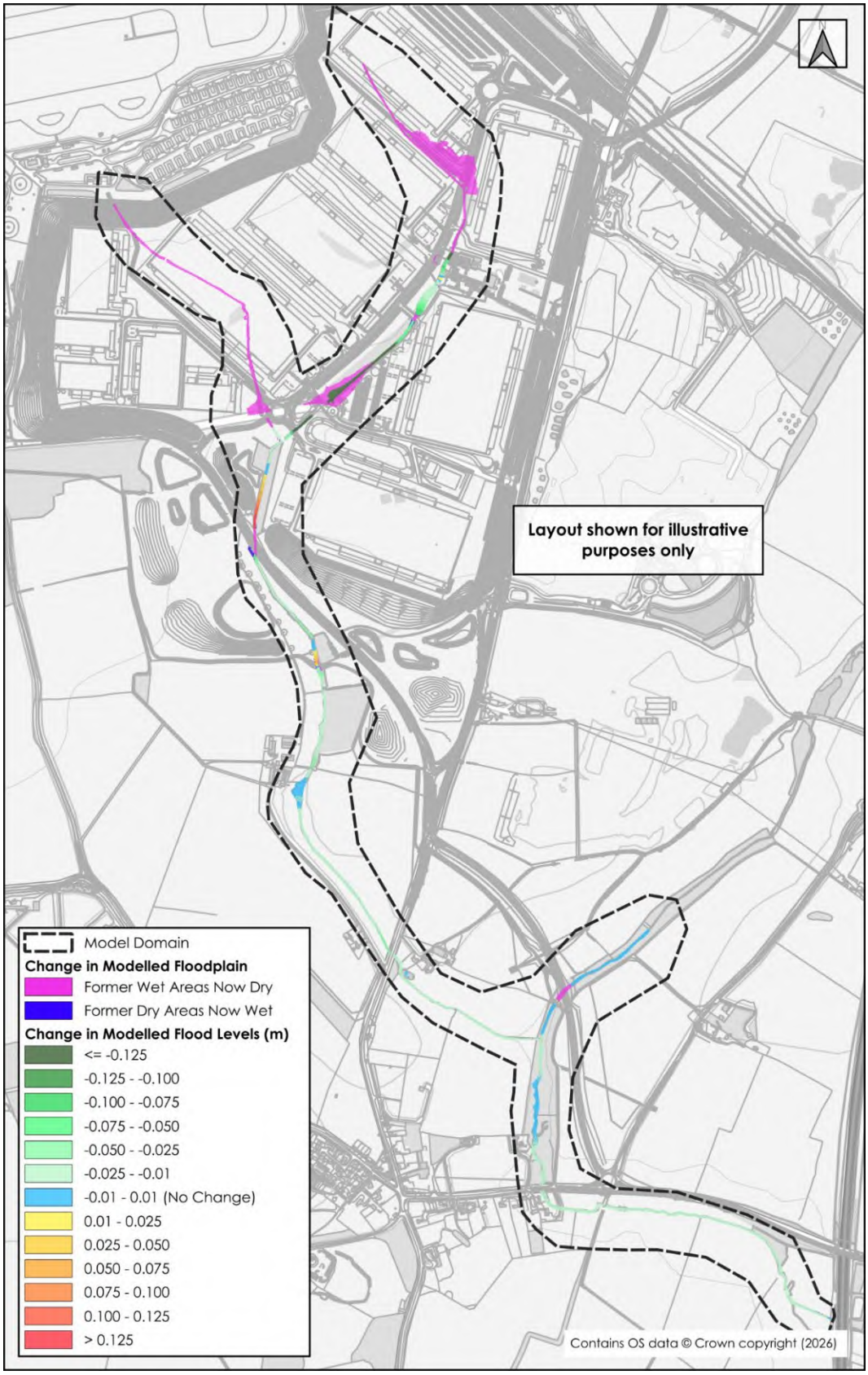

Figure 4.4: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 15% Climate Change

Padbury Brook Tributary

4.9 To facilitate the proposed rail works, an additional culvert with an inverted syphon is required along the Padbury Brook Tributary. It is also proposed to include measures to reduce the extent of flooding on the existing railway during the design event, namely through the creation of a two-stage channel and inclusion of bund (or similar). The proposed works are illustrated in **Figure 4.5**.

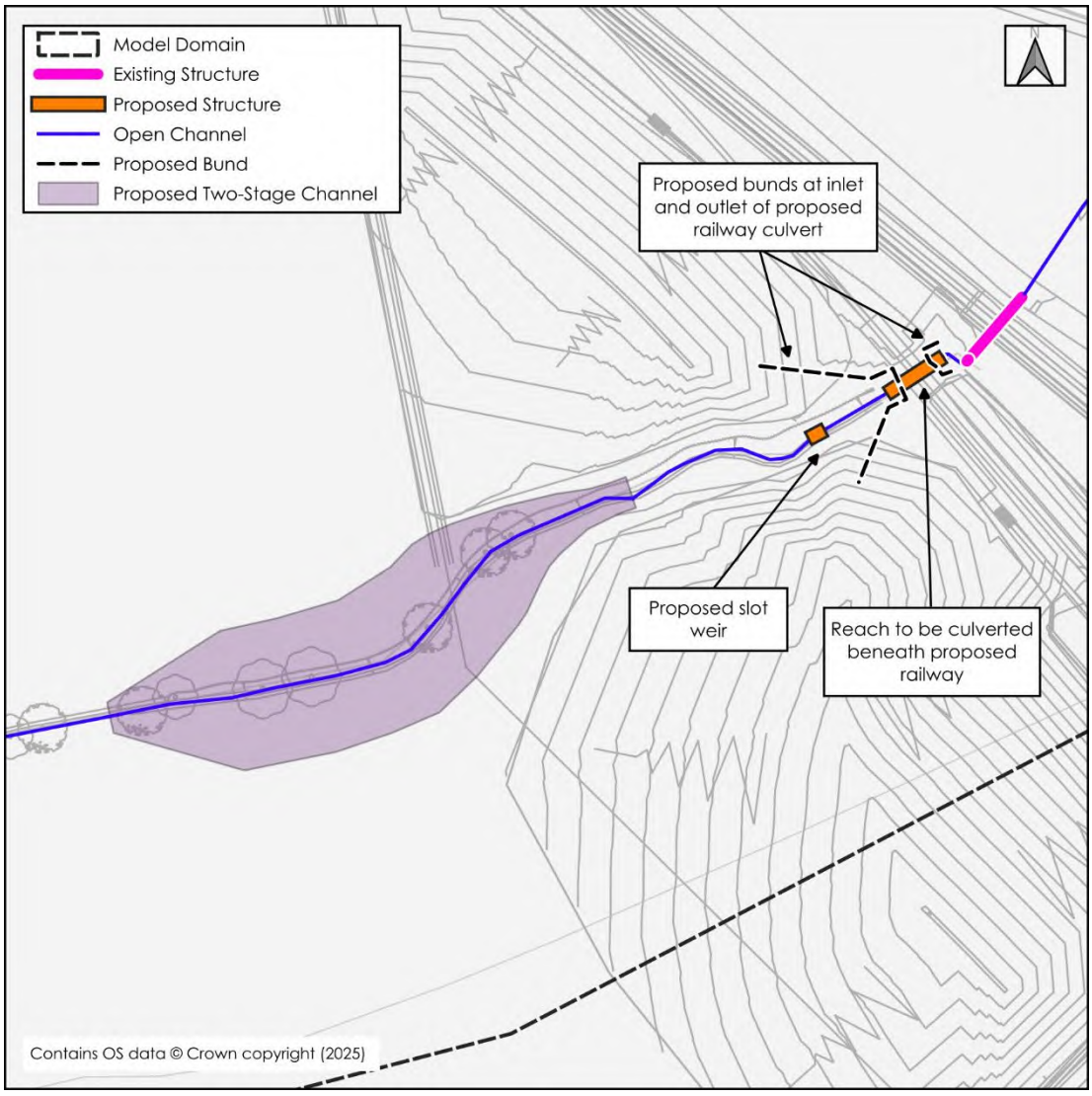

Figure 4.5: Padbury Brook Tributary – Proposed Works

4.10 Detailed mapping of the proposed development conditions is included within **Appendix 4** and summarised below. The floodplain extents are shown in **Figure 4.6**, with modelled flood levels outlined within **Table 4.2**.

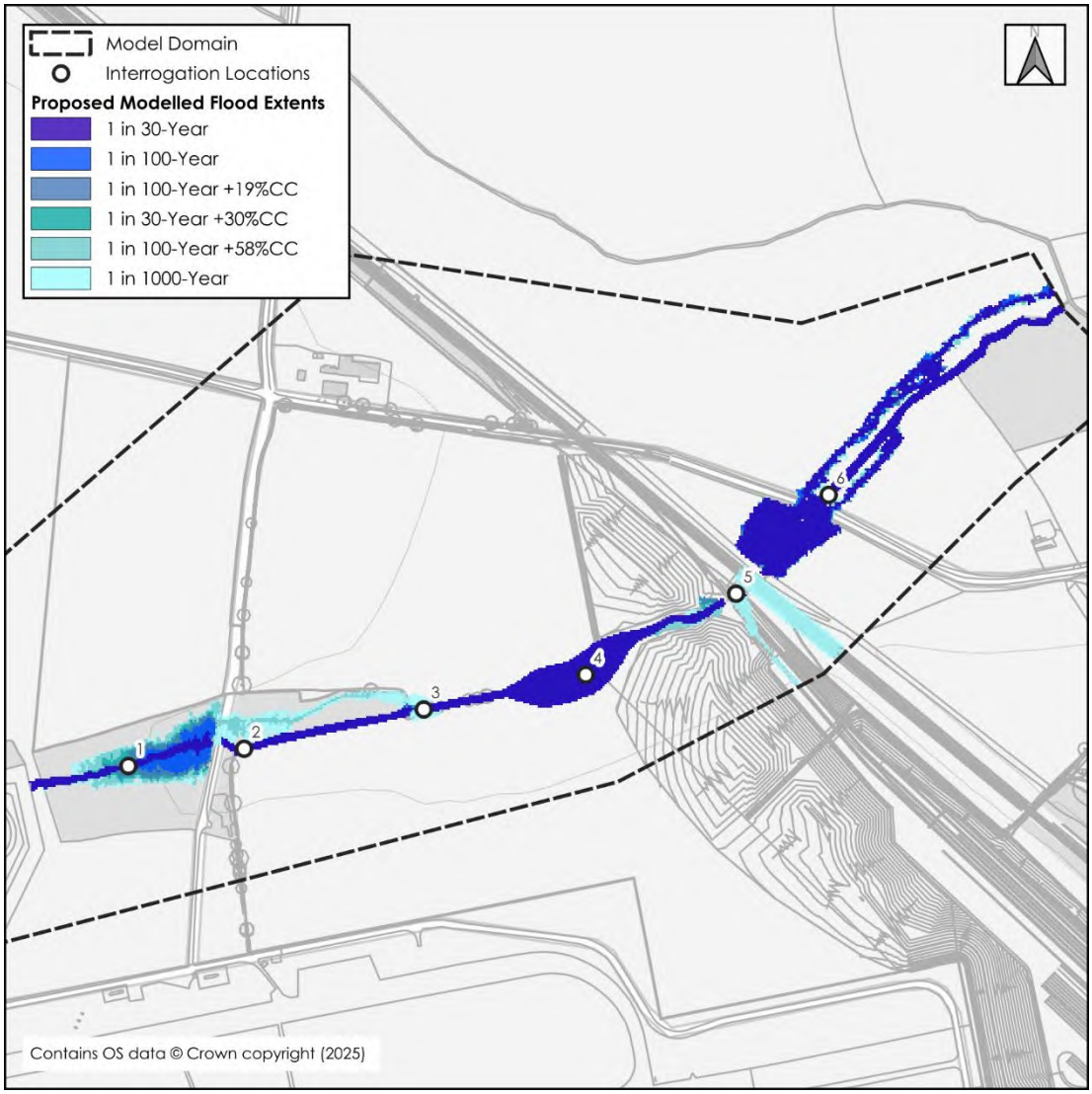

Figure 4.6: Padbury Brook Tributary – Proposed Modelled Flood Extents

Table 4.2: Padbury Brook Tributary – Proposed Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%	1 in 100-Year + 28%	1 in 100-Year + 58%	1 in 1000-Year
1	119.05	119.21	119.33	119.40	119.58	119.65
2	118.04	118.09	118.11	118.12	118.14	118.16
3	116.98	117.03	117.05	117.06	117.08	117.17
4	116.26	116.30	116.32	116.32	116.34	116.40
5	115.53	115.58	115.60	115.62	115.65	115.74
6	114.11	114.15	114.16	114.17	114.18	114.21

4.11 The proposed development modelled peak flood levels have been compared to the equivalent baseline peak flood levels to establish off site impacts. Mapping for all events is included in **Appendix 4**; the comparison mapping for the design event (1 in 100-year + 19%) is illustrated in **Figure 4.7** and discussed below.

4.12 The results under the proposed development conditions are broadly similar to those under the baseline conditions. Both upstream and downstream of the study site, there is shown to be no appreciable change to modelled flood levels (within model tolerances). The proposed bund is to be set to a crest of 116.3mAOD which provides a minimum 300mm freeboard above the 1 in 100-year +19% design event.

4.13 Within the study site, modelled flood extents are increased within the proposed two-stage channel, although these are a product of the design and remain within the extended channel. Flows are shown to back up behind the proposed railway culvert, in a similar manner to the backing up behind the existing railway culvert, with an increase in modelled flood levels. Flows are also shown to back up behind the proposed bund, which is shown to prevent flows overtopping onto the proposed railway from upstream during all modelled events.

4.14 During the 1 in 1000-year event, flows are shown to overtop from the open channel prior to entering the existing railway culvert, to flow onto both the existing and proposed railways. However, both railways are shown to be removed from the flood extents during all modelled events up to and including the 1 in 100-year +58% event, inclusive of the design event.

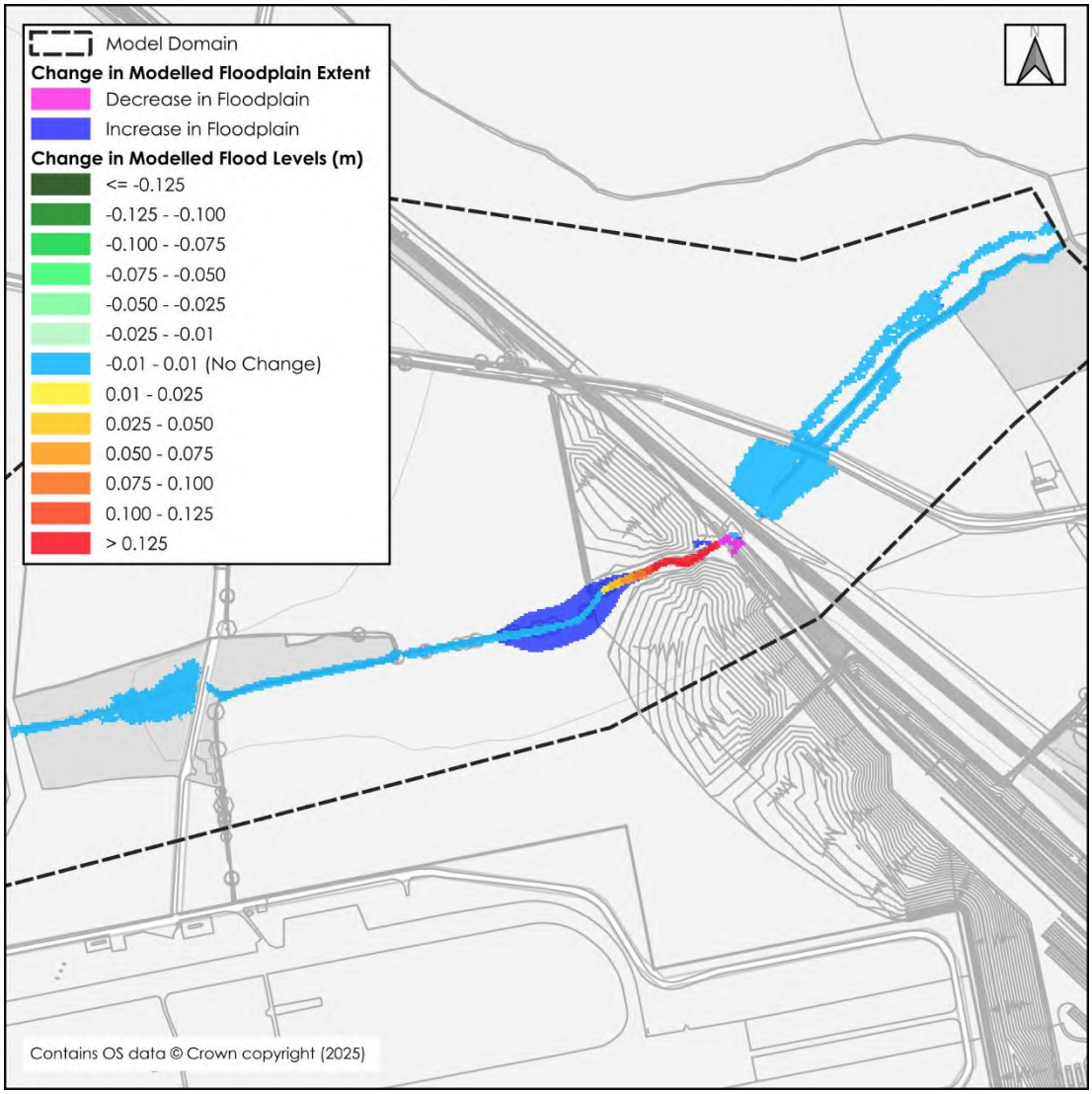

Figure 4.7: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 15% Climate Change

Development Levels

4.15 The Cherwell District Council Level 1 SFRA (2017 Update) states that for non-residential development finished floor levels may not need to be raised. However, due to other site parameters the proposed warehouses are to be set upon raised plateaus which are significantly raised above the modelled peak flood levels of all watercourses within the site.

4.16 To help manage surface water runoff within the development site, ground levels should be profiled to encourage pluvial runoff and overland flows to flow away from the built development towards the nearest drainage feature.

Safe Access and Egress

4.17 The proposed culverts designed to facilitates the access and egress routes provide the required freeboard in all events up to and including the 1 in 1000-year event. Therefore, safe access and egress is considered to be achievable.

Ardley Reservoir Modelling

4.18 The Ardley Reservoir and Water Pumping Station is considered to pose a low risk of flooding to the study site due to the safety legislation in place and the maintenance and repair responsibilities of Thames Water. However, to ensure resilience of the proposed development against this residual risk mitigation has been developed to formalise any potential breach flows.

4.19 It is proposed to incorporate a flood wall surrounding the reservoir to formalise breach flows. Hydraulic modelling has been undertaken by Binnies to understand the impact of the flood wall in the event of a reservoir breach. The post-development breach extents are illustrated in **Figure 4.8**.

4.20 The proposed wall has been modelled at an arbitrary height set 5m above the proposed ground levels, the modelled peak flood levels, summarised in **Table 4.3**, correspond to the flood nodes in **Figure 4.8** and have been used to determine the minimum wall height using a 300mm freeboard with a minimum crest of 111.69mAOD and ranges between 0.37m and 2.5m above the proposed ground levels.

4.21 The flood wall is shown to direct breach flows to the west of the reservoir where flows are largely contained within the valley topography of the Ashgrove Brook. The proposed development plateaus are raised above the modelled peak flood levels associated with the breach.

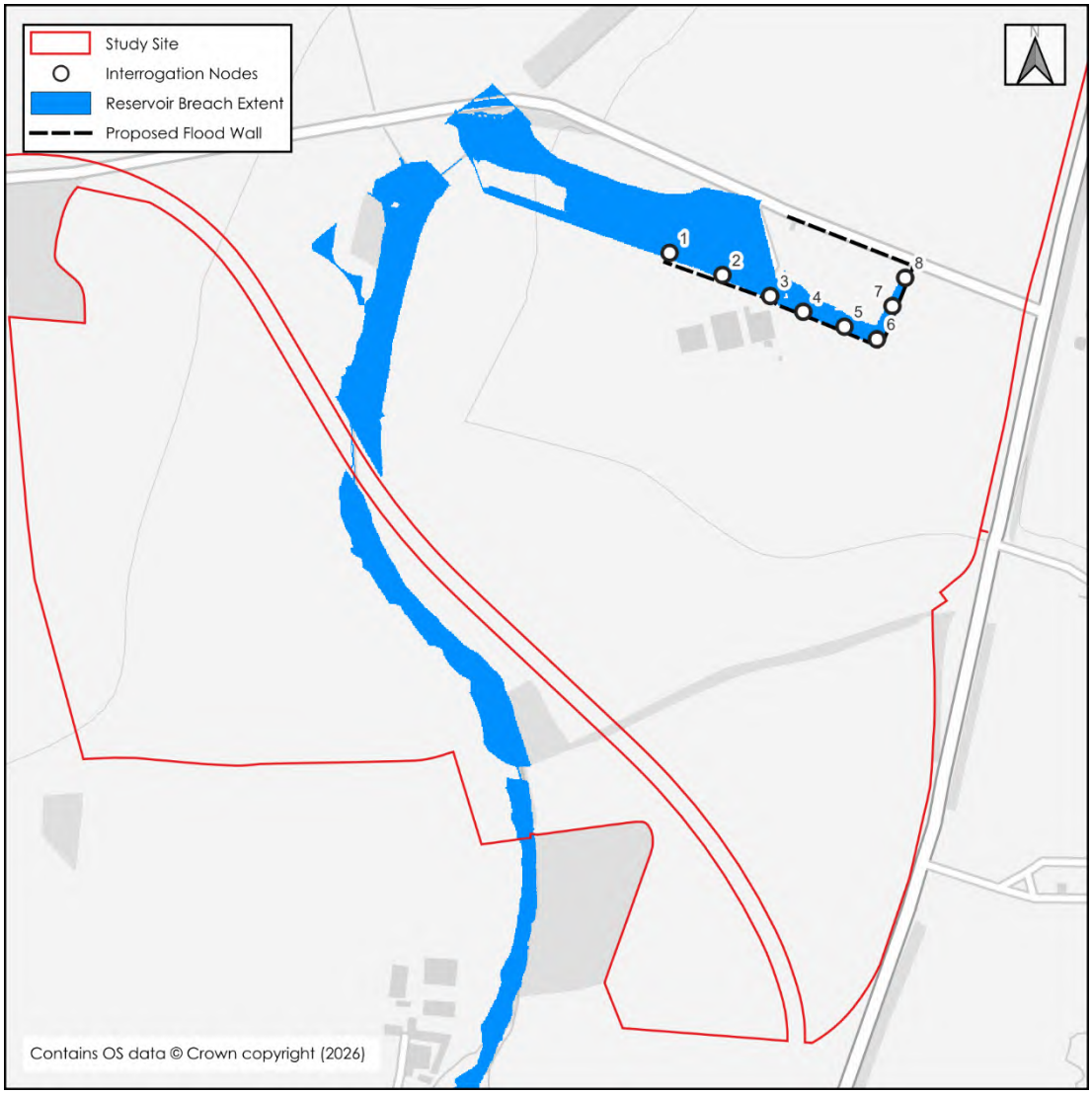

Figure 4.8: Ardley Reservoir and Water Pumping Station Modelled Breach Extents Post Mitigation

Table 4.3: Ardley Reservoir and Water Pumping Station Flood Wall Minimum Height Requirements

Node	Modelled Peak Flood Level (mAOD)	Freeboard (mm)	Minimum Wall Height (mAOD)
1	111.39	300	111.69
2	111.56		111.86
3	112.05		112.35
4	113.20		113.50
5	113.60		113.90
6	113.61		113.91

Node	Modelled Peak Flood Level (mAOD)	Freeboard (mm)	Minimum Wall Height (mAOD)
7	113.60	300	113.90
8	113.59		113.89

Groundwater Considerations

4.22 There is potential for shallow groundwater to be present within the site. Should groundwater be encountered during construction a specialist should be consulted and appropriate dewatering undertaken as necessary. It is considered that the raised development plateaus, finished floor levels and profiling of ground levels will provide mitigation for any potential groundwater flooding post-development.

Surface and Foul Water Drainage

4.23 The proposed development will introduce new impermeable surfaces to the site that will increase the surface water runoff generated. To manage this within the site, surface water drainage infrastructure will be included that will intercept, store and slowly release storm water falling on the built development. This will not only manage the surface water flood risk to the proposed development, but it will also prevent the development from adversely affecting downstream flood risk.

4.24 The discharge rate for each plot has been calculated and pro-rated based on its area. The attenuation requirement for each plot has been calculated on its discharge rate and contributing area for the 1 in 100-year + 40% climate change event.

4.25 Proposed attenuation has been provided within basins, swales and filter drains. Surface water drainage design commentary and the accompanying surface water drainage strategy is provided the accompanying SRFI Main Site Sustainable Drainage Statement (SDS) reference OXSRFI-BWB-ZZ-XX-T-W-1050_SDS.

4.26 The existing sewers feeding the Ashgrove Brook and its tributary are to be diverted in order to facilitate the diversions of the watercourses.

4.27 The proposed development should be designed with exceedance in mind, and the road network and landscaped areas should be used to convey overland flows above the capacity of the drainage networks towards the SuDS features.

4.28 It is recommended that proposed external ground levels are graded, where possible, such that finished floor levels are raised above the general surrounding ground levels, to help direct any overland flows and surface water runoff away from the buildings and towards the nearest drainage point.

4.29 In line with riparian responsibilities, it is recommended that the local watercourses within the ownership of the site, as well as the associated culvert and hydraulic structures, are regularly inspected, desilted and maintained where necessary to ensure these remain

in good operational condition and capable of conveying flows. This should be done in accordance with the latest LLFA and EA riparian guidance and best practice.

4.30 It is proposed to drain foul water from the development separately to surface water. It is proposed to discharge foul water from the main site to the Thames Water foul water sewer to the south-east in Bicester.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 This FRA has been prepared in accordance with the requirements set out in the NPSNN. It has been produced on behalf of Oxfordshire Railfreight Limited in respect of a DCO for the proposed Oxfordshire SRFI.

5.2 The DCO comprises a number of elements and due to their geographical location, they are covered by two assessments. This FRA focuses on the 'SRFI Main Site' referred to as the study site throughout this report.

5.3 This report demonstrates that the proposed development is not at significant flood risk subject to the recommended flood mitigation strategies being implemented. Moreover, the development will not increase flood risk to the wider catchment area subject to suitable management of surface water runoff.

5.4 The identified risks and mitigation measures are summarised within **Table 5.1**:

Table 5.1: Summary of Flood Risk Assessment

Flood Source	Risk & Proposed Mitigation Measures
Fluvial	Hydraulic modelling shows the watercourses within the study site are predominantly confined in channel; however, there is modelled floodplain in areas from the 1 in 30-year event. To facilitate the proposed development and accesses, several new culverts are required along the Ashgrove Brook, Ashgrove Brook Tributary, Gagle Brook and Padbury Brook Tributary. The proposed culvert crossings demonstrate the required freeboard in all events up to and including the 1 in 1000-year event. Comparison mapping shows the proposals do not result in an increase in modelled peak flood extents to third parties. To facilitate the proposed rail works, an additional culvert is required along the Padbury Brook Tributary. It is also proposed to include measures to reduce the extent of flooding on the existing railway during the design event, namely through the creation of a two-stage channel and inclusion of bund (or similar). Both the existing and proposed railways are shown to be removed from the flood extents during all modelled events up to and including the 1 in 100-year +58% event, inclusive of the design event. The proposed warehouses are to be set upon raised plateaus which are significantly raised above the modelled design event peak flood levels of all watercourses within the site. The proposed culverts designed to facilitates the access and egress routes demonstrate the required freeboard in all events up to and including the 1 in 1000-year event. Therefore, safe access and egress is considered to be achievable.
Pluvial	The study site is predominantly at a very low probability of surface water flooding small, isolated areas with a low to high probability of flooding exist associated with existing topographic low spots.

	Ground levels should be profiled to encourage pluvial runoff and overland flows to flow away from the built development towards the nearest drainage feature.
Groundwater	Should groundwater be encountered during construction a specialist should be consulted and appropriate dewatering undertaken as necessary. It is considered that the mitigation designed to address fluvial and pluvial risk will provide mitigation against any potential groundwater flooding post-development.
Reservoirs and waterbodies	The Ardley Reservoir and Water Pumping Station is considered to pose a low risk of flooding to the study site due to the safety legislation in place and the maintenance and repair responsibilities of Thames Water. A flood wall has been proposed to formalise flows towards the Ashgrove Brook in the event of the breach. The wall height is to be set providing 300mm freeboard above the modelled peak flood level with a minimum crest level of 111.69mAOD.
Other Sources of Flood Risk	The study site is considered to be at a low risk of flooding from Main Rivers, surface water and sewers.
Impact of the Development	The proposed development will introduce new impermeable surfaces to the site that will increase the surface water runoff generated. To manage this within the site, surface water drainage infrastructure will be included that will intercept, store and slowly release storm water falling on the built development. This will not only manage the surface water flood risk to the proposed development, but it will also prevent the development from adversely affecting downstream flood risk. It is proposed to drain foul water from the development separately to surface water. Two foul outfalls are proposed for the study site, within Ardley and Bicester respectively.
This summary should be read in conjunction with BWB's full report. It reflects an assessment of the Site based on information received by BWB at the time of production.	

APPENDICES

Appendix 1: Offsite and Highway Works Flood Risk Screening

A CAF GROUP COMPANY

ADVISORY

Oxfordshire Railfreight Limited
Oxfordshire Strategic Rail Freight Interchange
Oxfordshire
Flood Risk Screening – Offsite and Highways Works

www.bwbconsulting.com

DOCUMENT ISSUE RECORD

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APPENDICES

Appendix 1: Padbury Brook Hydraulic Modelling Report

1. INTRODUCTION

1.1 This Flood Risk Screening Report has been prepared in accordance with the requirements set out in the National Policy Statement for National Networks (NPSNN). It has been produced on behalf of Oxfordshire Railfreight Limited in respect of a Development Consent Order (DCO) for the proposed Oxfordshire Strategic Rail Freight Interchange (SRFI).

1.2 The proposed development comprises a number of interrelated component parts as follows, and collectively they are the Oxfordshire SRFI:

- **SRFI Main Site**
  - Works No. 1 to 10. SRFI Main Site
  - Works No. 29 and 30 Biodiversity and landscaping enhancement areas.
- **Offsite/Highways Works**
  - Works No. 11 OxSRFI Principal Access.
  - Works No. 12 Heyford Park Link Road (HPLR).
  - Works No. 13 Camp Road/Chilgrove Drive Junction and Bridleway.
  - Works No. 14 to 18 Junction 10 Highways Improvements.
  - Works No. 19, 20 & 21 Ardley Bypass.
  - Works No. 22 Junction 9 Highways Improvements.
  - Works No. 23 & 24 Middleton Stoney Relief Road (MSRR) pedestrian and cyclist connectivity.
  - Works No. 25 B430 minor works.
  - Works No. 26 Quarry Cottages.
  - Works No. 27 Middleton Stoney Crossroads.
  - Works No. 28 Aves Ditch (North).
  - Works No. 31 to 33 Biodiversity and landscaping enhancement areas (Including Woodland Planting).
  - Works No. 34 Landfill work.
  - Works No. 35 Foul drainage outfall to Bicester.
  - Works No. 36 Foul drainage outfall to Ardley.
  - Works No. 37. Biodiversity and landscaping enhancement.
  - Works No. 38 Ardley Tunnel works.

1.3 An illustrative site location plan is provided as **Figure 1.1**, which also identities the approximate extent of the development component parts. For ease of reference and for the purpose of the Flood Risk Assessments.

1.4 The SRFI Main Site works has been reviewed within a standalone Flood Risk Assessment (reference: OXSRFI-BWB-ZZ-XX-T-W-0006). This assessment has been prepared to review the flood risk associated with the works required outside of the Main SFRI Site.

1.5 A desktop assessment of the potential flood risk sources at each location is reviewed within the forthcoming sections. As the proposals are generally associated with improvements to existing infrastructure, the principle of a road, footway or new signage in each location has not been discussed. Instead, the assessment has focused on the presence of a potential flood risk source and the potential impact of the proposals on that flood risk source.

1.6 Where available, illustrative outlines of the proposed works are provided for context, although it should be noted that these are subject to change through design and development.

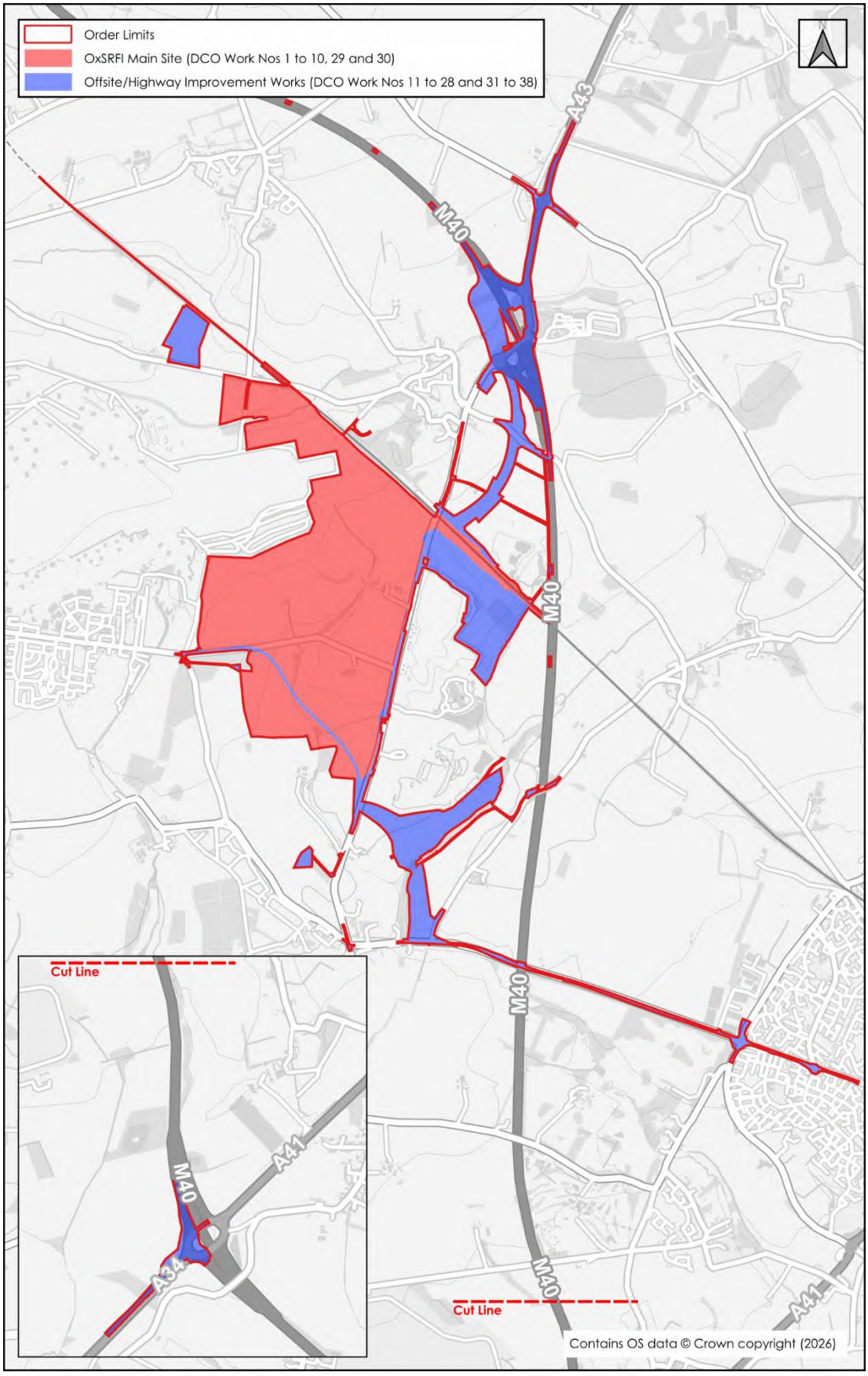

Figure 1.1: Site Location

Table 1.1: Summary of Highway Works

Works No.	Name/Location	Description of Proposed Works	Flood Zone Classification	Screened In/Out
11	B430/SRFI Main Site access	Roundabout on the B430 to form the principal access to the SRFI Main Site.	Flood Zone 1	Screened In
12	Heyford Park Link Road	Heyford Park Link Road connecting at the west end to the Camp Road and Chilgrove Drive junction.	Predominantly Flood Zone 1. Flood Zones 2 and 3 where works cross watercourse; however, this is superseded by detailed hydraulic modelling discussed in the forthcoming sections.	Screened In
13	Camp Road	Camp Road/Chilgrove Drive Junction and Bridleway works.	Flood Zone 1	Screened Out – The proposals include realignment of the existing junction, the area of impermeable surfacing is to remain unchanged such that existing highway drainage is sufficient and therefore not considered to result in a material impact on flood risk.
14 to 18	M40 Junction 10	M40 Junction 10 to A43 and B430 highway improvement works.	Predominantly Flood Zone 1. Flood Zones 2 and 3 where works cross watercourse; however, this is superseded by detailed hydraulic modelling discussed in the forthcoming sections.	Screened In
19, 20 and 21	Ardley Bypass	Proposed Ardley Bypass works.	Predominantly Flood Zone 1. Minor encroachment of Flood Zone 2 and 3.	Screened In

Works No.	Name/Location	Description of Proposed Works	Flood Zone Classification	Screened In/Out
22	M40 Junction 9	Junction 9 Highway Improvement Works.	Predominantly Flood Zone 1. Minor encroachment of Flood Zone 2 and 3.	Screened In
23 and 24	Middleton Stoney Relief Road (MSRR)	MSRR works connecting B430 and B4030 with shared use cycle track.	Predominantly Flood Zone 1. Flood Zones 2 and 3 where works cross watercourse; however, this is superseded by detailed hydraulic modelling discussed in the forthcoming sections.	Screened In
25	B430	Shared use cycle track on the western side of the B4030 connecting to that provided at the principal site access.	Flood Zone 1	Screened Out - No material changes to existing ground levels and no change to the area of impermeable surfaces are proposed.
26	Quarry Cottages	Quarry cottages turning head and public rights of way.	Flood Zone 1	Screened Out – No material changes to existing ground levels and no change to the area of impermeable surfaces are proposed.
27	Middleton Stoney	Middleton Stoney Crossroad Works.	Flood Zone 1	Screened In
28	Aves Ditch (North)	Improvements to field access through connection of the existing bridleway to provide access into the biodiversity and landscaping enhancement area.	Flood Zone 1	Screened Out - No material changes to existing ground levels and no change to the area of impermeable surfaces are proposed.

Works No.	Name/Location	Description of Proposed Works	Flood Zone Classification	Screened In/Out
31, 32 and 33	Middleton Stoney/B430	Biodiversity and landscaping enhancement areas (Including Woodland Planting).	Flood Zone 1	Screened Out – Biodiversity enhancements comprise provision of new grassland types this is not considered to result in a material impact on flood risk.
34	Landfill Works	Works to the waste management site to remove material for the construction of the railway works to the Chiltern Main Line private railway and the principal main site access.	Flood Zone 1	Screened In
35	Bicester	Foul water drainage outfall to Bicester.	Flood Zone 1	Screened Out – underground works to provide foul water connection points, no fundamental changes to surface. Therefore, there is not considered to be any impact on flood risk.
36	Ardley	Foul water drainage outfall to Ardley.	Flood Zone 1	Screened Out – underground works to provide foul water connection points, no fundamental changes to surface. Therefore, there is not considered to be any impact on flood risk.
37	Ardley Road	Biodiversity and landscaping enhancement.	Flood Zone 1	Screened Out – Biodiversity enhancements comprise provision of new grassland types this is not considered to result in a material impact on flood risk.

Works No.	Name/Location	Description of Proposed Works	Flood Zone Classification	Screened In/Out
38	Ardley Tunnel	Works to Ardley Tunnel to provide W8 loading gauge clearance through the tunnel.	Flood Zone 1	Screened Out – Underground tunnel works are not considered to have a material impact on flood risk.

Sources of Data

- Environment Agency (EA) Risk of Flooding from Surface Water (RoFSW) Data
- EA Flood Map for Planning
- Ordnance Survey mapping
- Cherwell District Council 2017 Strategic Flood Risk Assessment[1] (SFRA)
- Cherwell District Council 2022 SFRA[2]
- Oxfordshire County Council Preliminary Flood Risk Assessment[3] (PFRA) and Addendum[4]
- Hydraulic modelling of the Gagle Brook, Ashbury Brook and Ashbury Brook Tributary undertaken by BWB Consulting Ltd in August 2025, reference OXSRFI-BWB-ZZ-XX-T-W-1001_HMR (GB)
- Hydraulic Modelling of the Padbury Brook undertaken by BWB Consulting Ltd in August 2025, reference OXSRFI-BWB-ZZ-XX-T-W-1003_HMR (PB)
- Hydraulic Modelling of the Padbury Brook Tributary undertaken by BWB Consulting Ltd in August 2025, reference OXSRFI-BWB-ZZ-XX-T-W-1005_HMR (PBT)
- British Geological Survey Drift & Geology Maps

[1] Level 1 Strategic Flood Risk Assessment (AECOM, May 2017)
[2] Level 1 Strategic Flood Risk Assessment (WHS, November 2022)
[3] Preliminary Flood Risk Assessment (JBA Consulting, June 2011)
[4] Preliminary Flood Risk Assessment Addendum (Oxfordshire County Council, December 2017)

2. WORKS NO. 11: SRFI MAIN SITE ACCESS

Illustrative Proposals

2.1 The proposals include for amendments of the B430 to provide the principal access to the SRFI Main Site – the location of the works is illustrated in **Figure 2.1**.

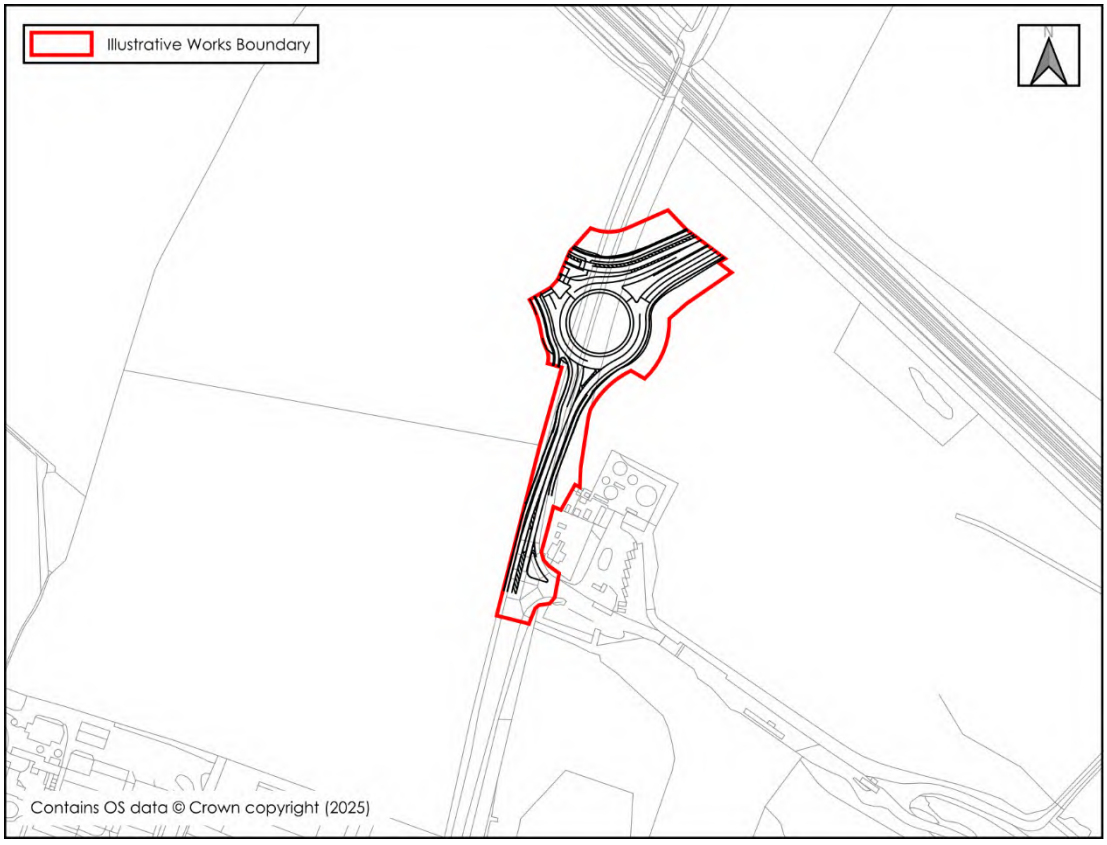

Figure 2.1: Illustrative Works - Works No. 11

Historical Flooding Incidents

2.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRA also did not identify any which had affected the area.

Fluvial Flood Risk

2.3 The proposed works are located entirely within Flood Zone 1 under present day which is land defined as having a low probability of flooding from rivers and sea. Additionally, the works are well removed from the combined Flood Zones with climate change.

Surface Water Flood Risk

2.4 The proposed works are shown to fall predominantly in an area at a very low probability of surface water flooding, although an area east of the existing B430 highway is an area identified to have a low to medium probability of flooding, as shown in **Figure 2.2**.

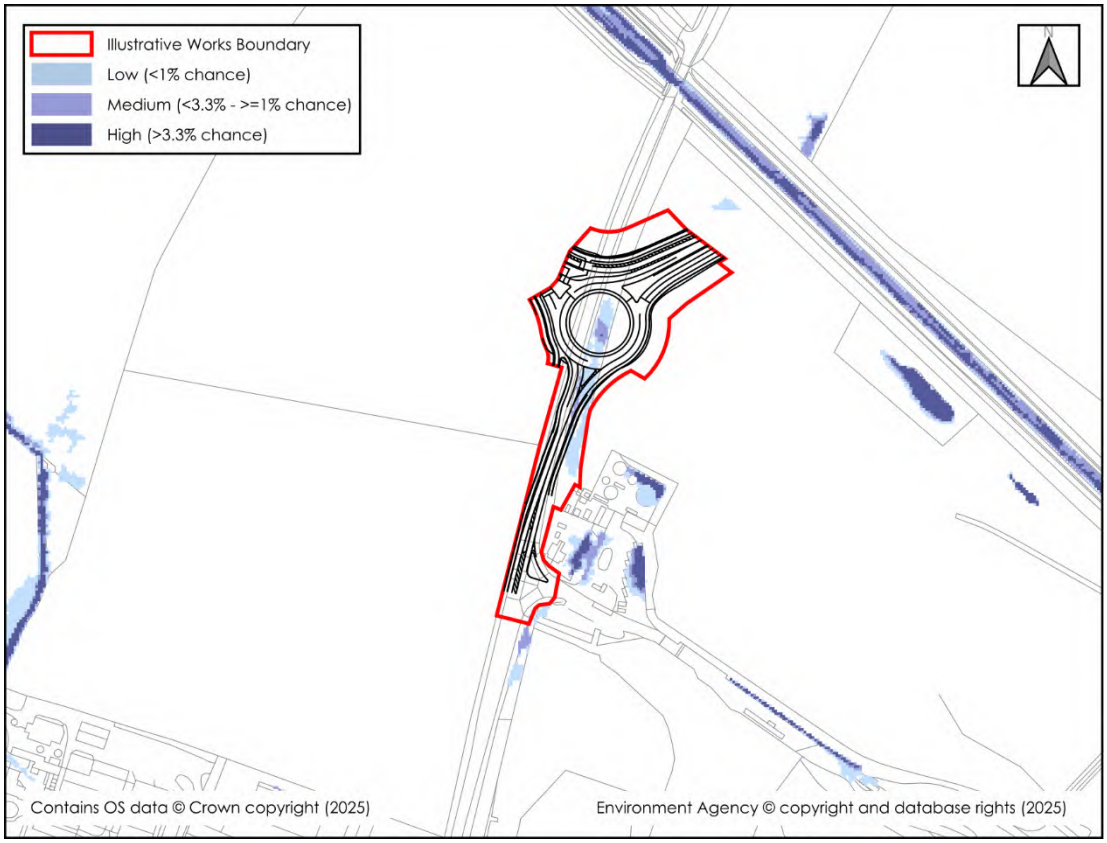

Figure 2.2: EA RoFSW data - Works No. 11

2.5 Upon review, it would appear that the flooding illustrated with the RoFSW is representative of localised ponding in an area of low lying ground adjacent to the carriageway; the mapping suggests there to be a very low probability of flooding in this area reaching depths greater than 0.2m

2.6 The works will introduce new impermeable surfaces. The proposals will include new surface drainage that will provide the necessary attenuated storage for runoff from the new impermeable surfaces, preventing an adverse impact on downstream flood risk. The drainage will include an appropriately restricted discharge rate and attenuated storage for the 1 in 100-year plus climate change event. The drainage proposals for these works are included in the SRFI Main Site surface water drainage strategy with further details included within the accompanying Sustainable Drainage Statement (SDS) (reference: OXSRFI-BWB-ZZ-XX-T-W-1050_SDS)

Groundwater Flood Risk

2.7 British Geological Survey (BGS) mapping identifies the proposed works are underlain by White Limestone Formation. Areas Susceptible to Groundwater Flooding mapping appended to the Cherwell District Council Level 1 SFRA (2017) shows the study site to lie in a cell at no risk of groundwater flooding. The proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

2.8 Other sources of flood risk have been reviewed including the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

2.9 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the works are not expected to negatively affect flood risk in the surrounding area, subject to improvements being made to the local highway drainage infrastructure to accommodate the additional impermeable surfaces.

3. WORKS NO. 12: HEYFORD PARK LINK ROAD

Illustrative Proposals

3.1 The proposals include construction of the Heyford Park Link Road connecting at the west end to the Camp Road and Chilgrove Drive junction. The proposed works are illustrated in **Figure 3.1**.

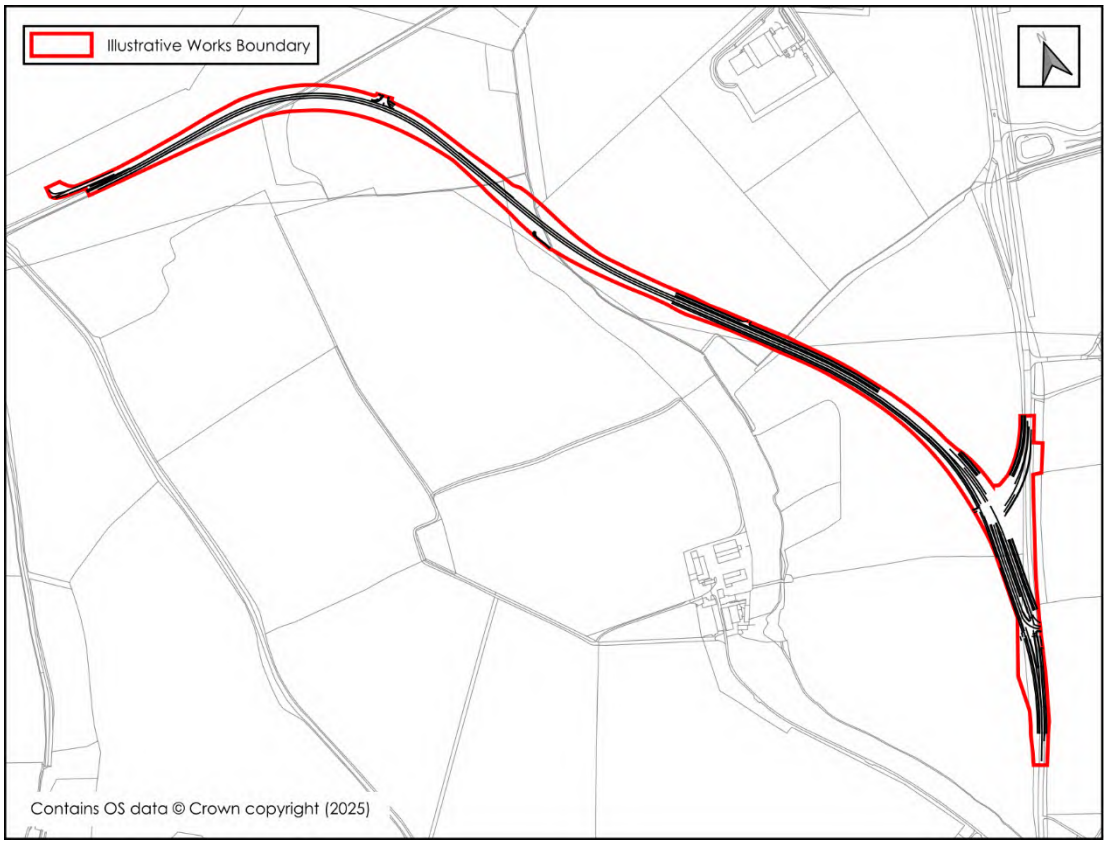

Figure 3.1: Illustrative Works Boundary - Works No. 12

Historical Flooding Incidents

3.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

3.3 The proposed works are located primarily within Flood Zone 1 including with climate change, which is land defined as being at a low probability of flooding from rivers and sea. An area of Flood Zones 2, 3 and combined climate change are present where the proposed works are set to cross the Ashgrove Brook. The Flood Map for Planning is shown in **Figure 3.2**.

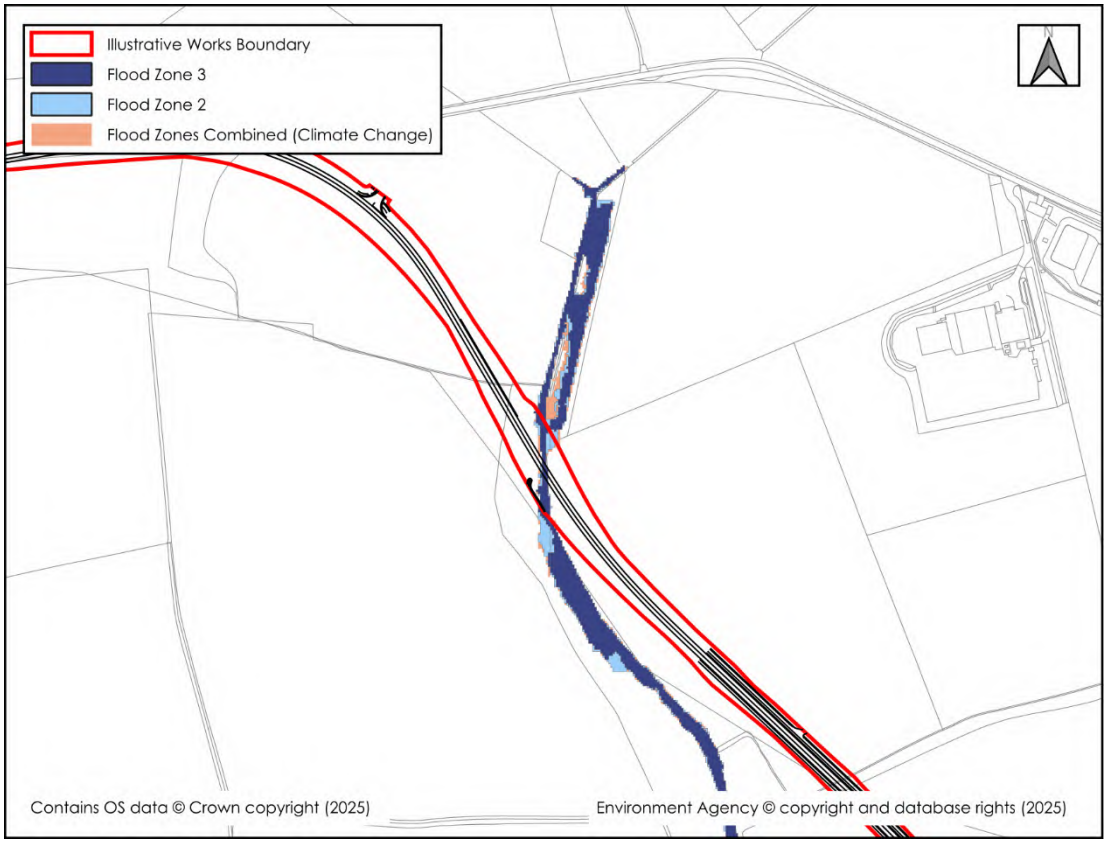

Figure 3.2: EA Flood Map for Planning – Works No. 12

3.4 A bespoke hydraulic modelling exercise of the Gagle Brook, Ashgrove Brook and Ashgrove Brook Tributary has been undertaken to inform the SRFI Main Site FRA and includes representation of the Ashgrove Brook at the point of the proposed crossing. Full details of the hydraulic modelling exercise are included within the hydraulic modelling report (reference: OXSRFI-BWB-ZZ-XX-T-W-1001_HMR (GB)). The existing modelled flood extents, shown in **Figure 3.3**, demonstrates that the predicted flood flows remain in channel at the point of the proposed crossing during all modelled flood events.

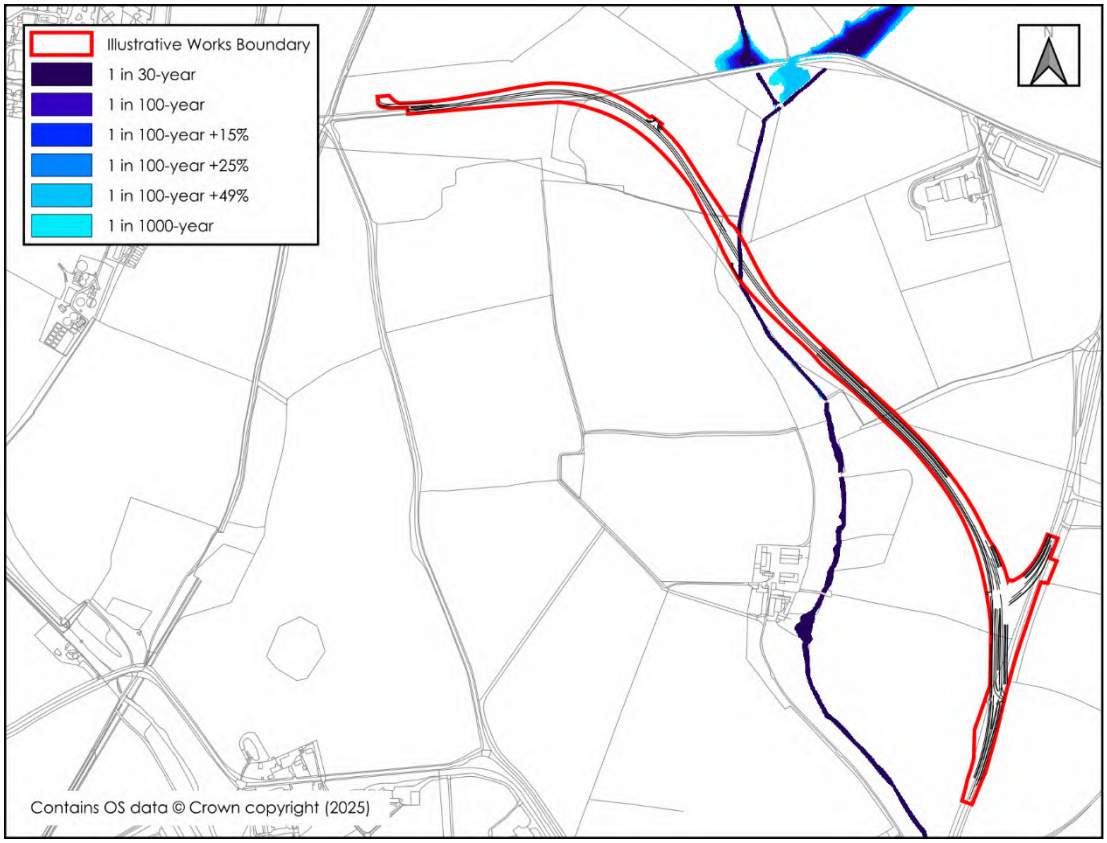

Figure 3.3: BWB Baseline Modelled Flood Extents – Works No. 12

3.5 To facilitate the proposed highway crossing, a new culvert is required on the Ashgrove Brook. The baseline hydraulic model has been updated to include the proposed culvert and the proposed ground levels for the link road. The proposed structure comprises a 1.2m diameter circular culvert with 200mm freeboard and sedimentation allowance in line with CIRIA C786 guidance[5]. The proposed model results are shown in **Figure 3.4**, with impact mapping for the 1 in 100-year +15% climate change design event shown in **Figure 3.5**.

3.6 The comparison mapping shows that upstream of the proposed culvert there is a minor increase in flood levels; however, flows are shown to remain in channel with no new floodplain extents, this was deemed acceptable by the Environment Agency and Lead Local Flood Authority following review of the SRFI Main Site FRA.

[5] Culvert, screen and outfall manual C786 (CIRIA 2019)

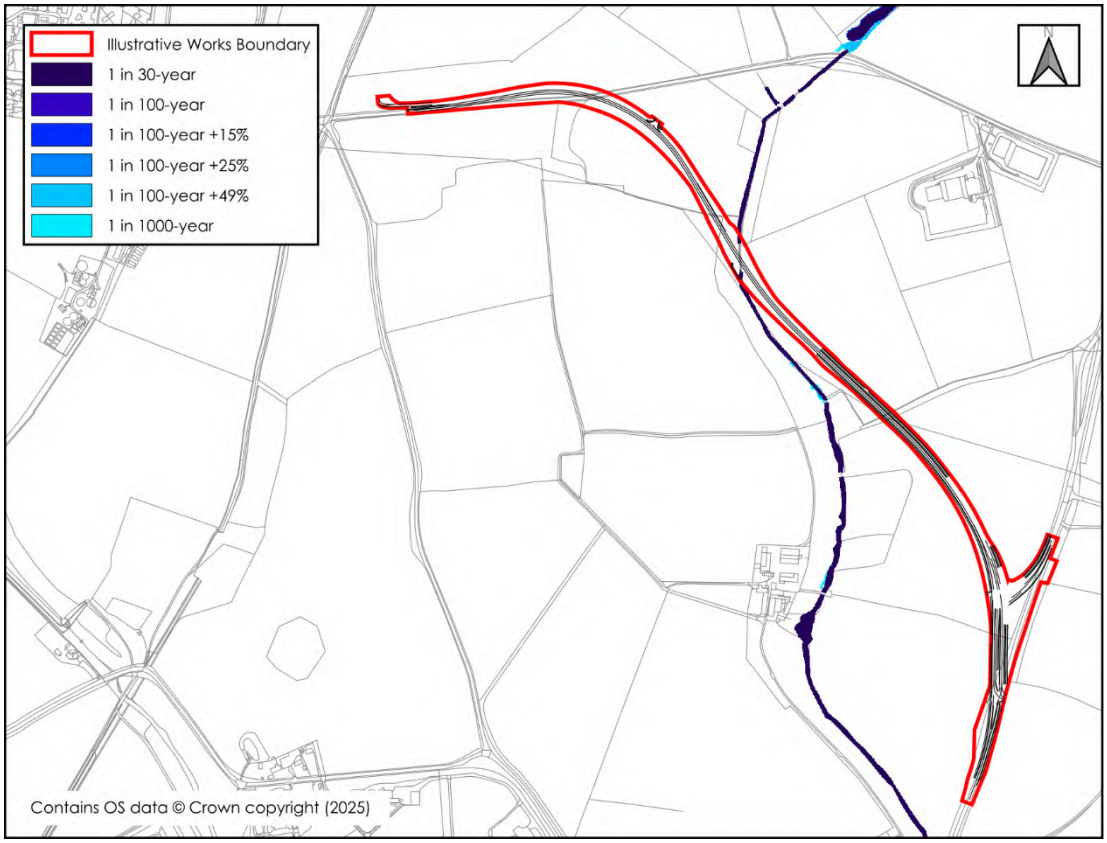

Figure 3.4: BWB Proposed Modelled Flood Extents – Works No. 12

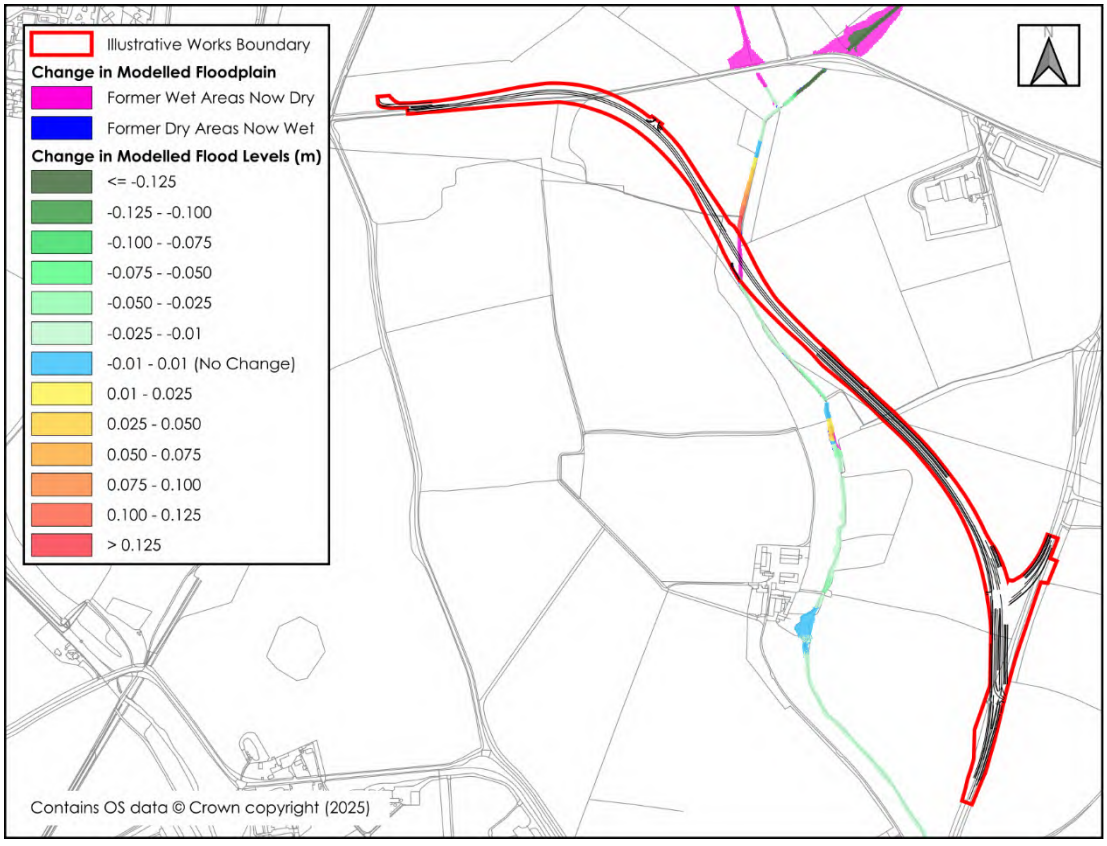

Figure 3.5: 1 in 100-year +15% Floodplain Comparison – Works No. 12

Surface Water Flood Risk

3.7 There is shown to generally be a very low probability of surface water flooding along the alignment of the proposed works, as shown in **Figure 3.6**. There is an area at a low to high probability of surface water in the east, the majority of the proposed works lie with the area of low probability flooding with only minor encroachment of the medium and high probability areas.

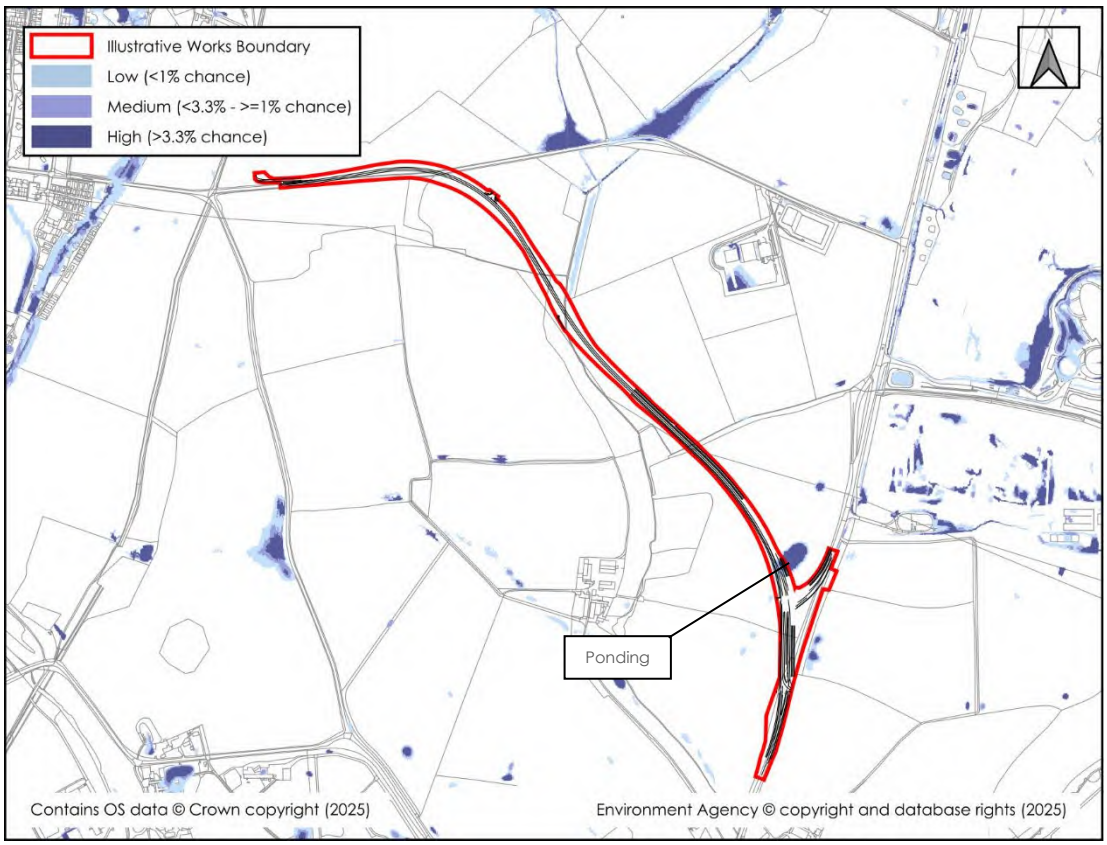

Figure 3.6: EA RoFSW - Works No. 12

3.8 The area of ponding is expected to be associated with an existing topographic low spot, there is a very low probability of surface water depths exceeding 0.3m in this area. The area of risk is considered to originate within the SRFI Main Site or along the route of the proposed link road. It is, therefore expected that the proposed reprofiling and surface water strategy (reference: OXSRFI-BWB-ZZ-XX-T-W-1051_SDS) will provide mitigation for this risk.

3.9 The proposals will lead to an increase in the area of impermeable surfaces. However, new surface drainage is included in the proposals that will provide the necessary attenuated storage for runoff from the new impermeable surfaces, preventing an adverse impact on downstream flood risk. The drainage will include an appropriately restricted discharge rate and attenuated storage for the 1 in 100-year plus climate change event.

Groundwater Flood Risk

3.10 BGS mapping identifies the proposed works are underlain by White Limestone Formation. Areas Susceptible to Groundwater Flooding mapping appended to the Cherwell District Council Level 1 SFRA (2017) shows the study site to lie in a cell at no risk of groundwater flooding. Based on the available data, the proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

3.11 Other sources of flood risk have been reviewed including the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

3.12 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the works are not expected to negatively affect flood risk in the surrounding area, as shown by the proposed hydraulic modelling and subject to appropriate surface water management.

4. WORKS NO. 14 TO 18 M40 JUNCTION 10 TO A43 AND B430 HIGHWAY IMPROVEMENT WORKS

Illustrative Proposals

4.1 In this location the proposed works comprise a series of upgrades/improvements to junction 10 of the M40 at its link with the A43 and B430, the extent of the works are shown in **Figure 4.1**.

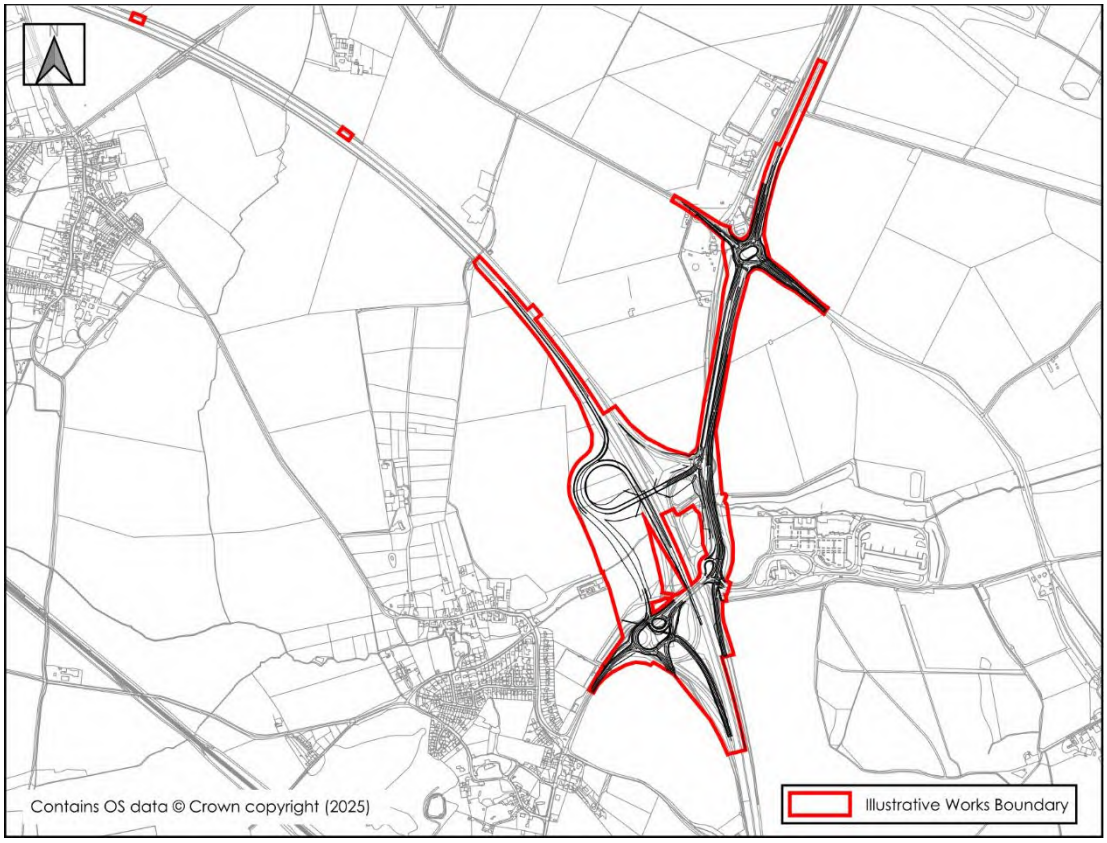

Figure 4.1: Illustrative Works – Works No. 14 to 18

Historical Flooding Incidents

4.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

4.3 The proposed works are located primarily within Flood Zone 1 including with climate change, which is land defined as being at a low probability of flooding from rivers and sea. An area of Flood Zones 2, 3 and combined climate change Flood Zones are present where the proposed works or existing highways cross the Padbury Brook. The Flood Map for Planning is shown in **Figure 4.2**.

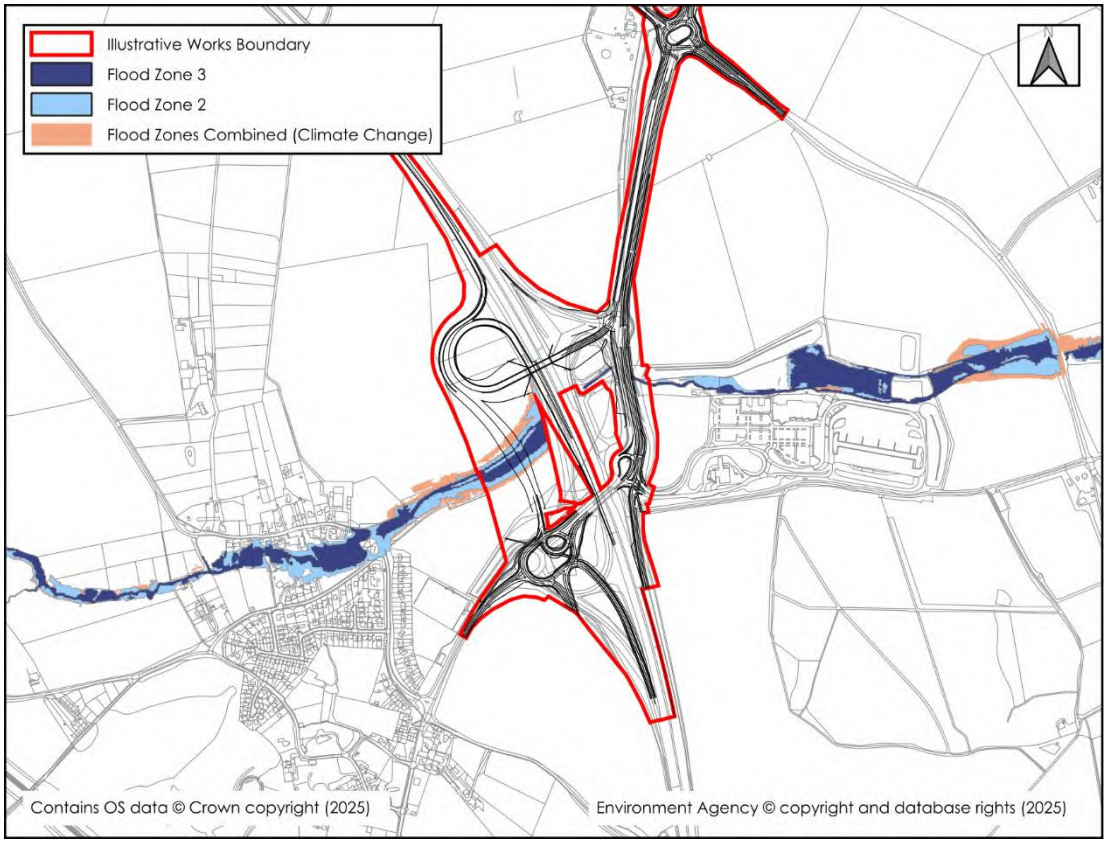

Figure 4.2: EA Flood Map for Planning - Works No. 14 to 18

4.4 A bespoke hydraulic modelling exercise has been undertaken for this reach of the Padbury Brook (reference: OXSRFI-BWB-ZZ-XX-T-W-1003_HMR (PB)), further details are included as **Appendix 1**. The baseline flood extents from this exercise are shown in **Figure 4.3**. The model outputs show that in the area of the proposed works the Padbury Brook remains in channel during all modelled flood events.

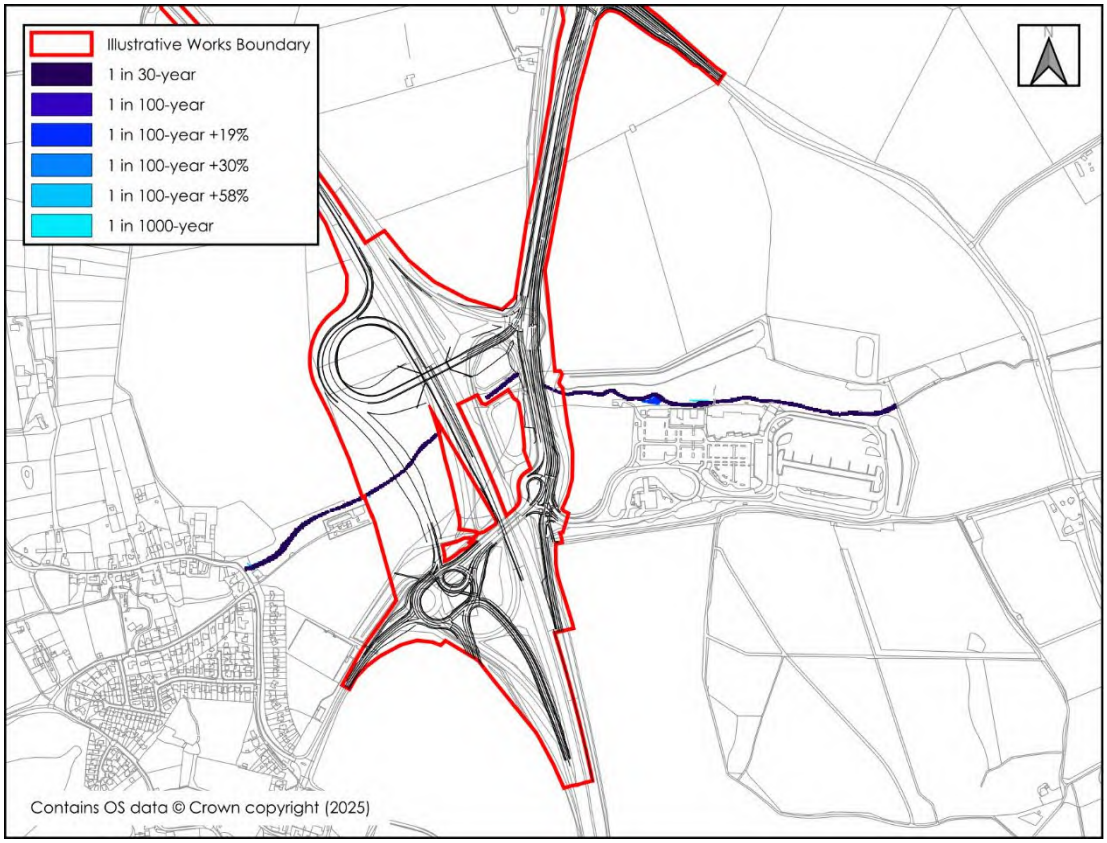

Figure 4.3: BWB Baseline Modelled Flood Extents - Works No. 14 to 18

4.5 The proposed works include for a new crossing of the Padbury Brook at the upstream end of the works boundary. The baseline hydraulic model was updated to include the proposed twin 1.2m circular culvert crossing and associated ground model to understand the potential impact of the works. The proposed modelled flood extents are shown in **Figure 4.4**, with impact mapping for the 1 in 100-year +19% climate change event shown in **Figure 4.5**.

4.6 The proposed crossing is shown to result in a minor decrease in flood levels immediately upstream and downstream of the proposed culvert, due to improved conveyance. Consequently, there is a minor increase of in channel flood levels on the short reach between the M40 and A43; however, there is no increase in modelled flood extents or flood risk. There are no impacts predicted outside of the Order Limits.

4.7 The modelled culvert is shown to provide a minimum 300mm freeboard in all modelled flood events up to and including the 1 in 1000-year.

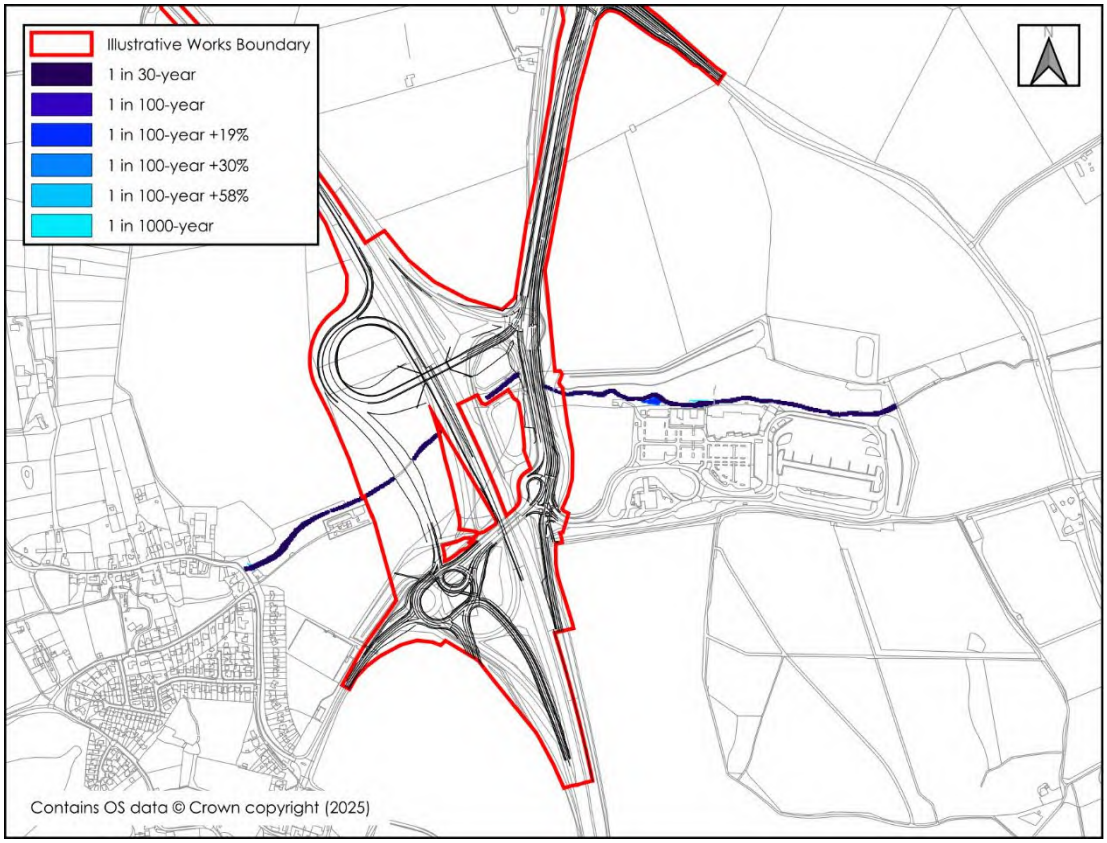

Figure 4.4: BWB Proposed Modelled Flood Extents - Works No. 14 to 18

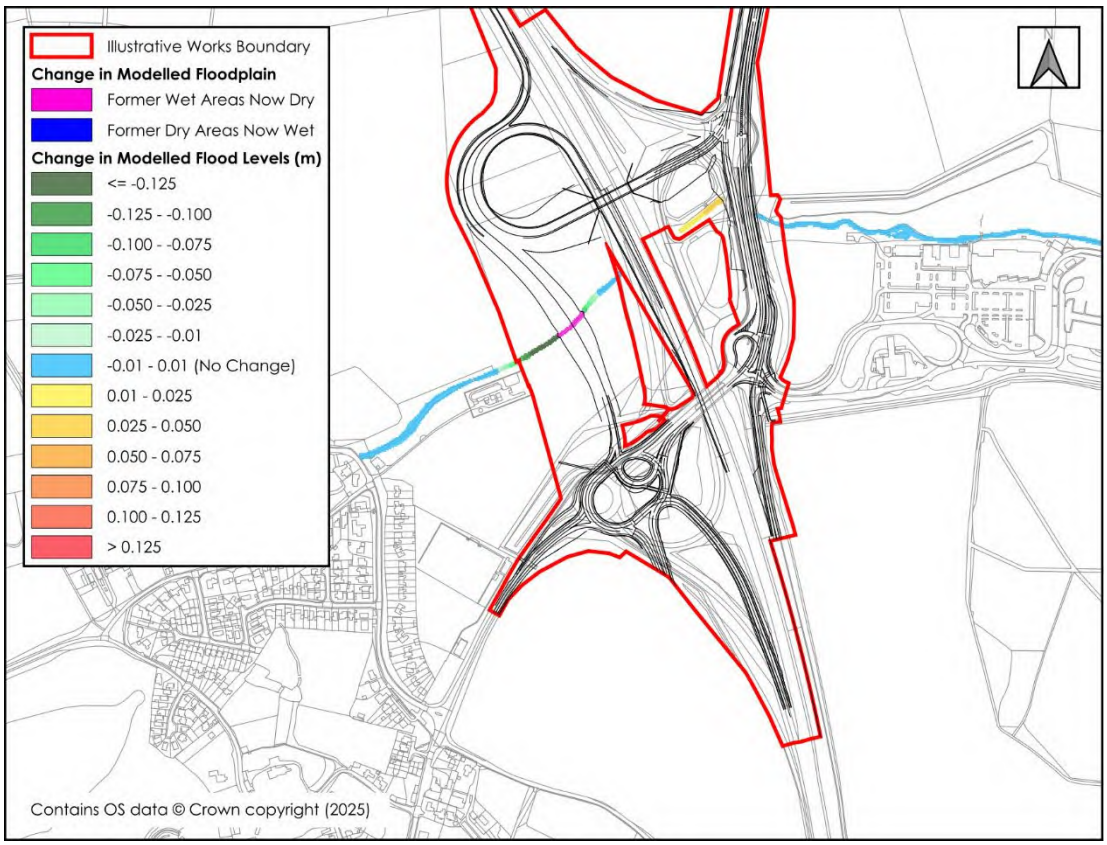

Figure 4.5: 1 in 100-year +19% Floodplain Comparison - Works No. 14 to 18

Surface Water Flood Risk & Highway Drainage

4.8 The vast majority of the works area has a very low to low risk of surface water flooding, as shown in **Figure 4.6**. However, there are several isolated areas with a medium to high probability of flooding, for ease of review these have been split into areas illustrated in **Figure 4.6**, and discussed below.

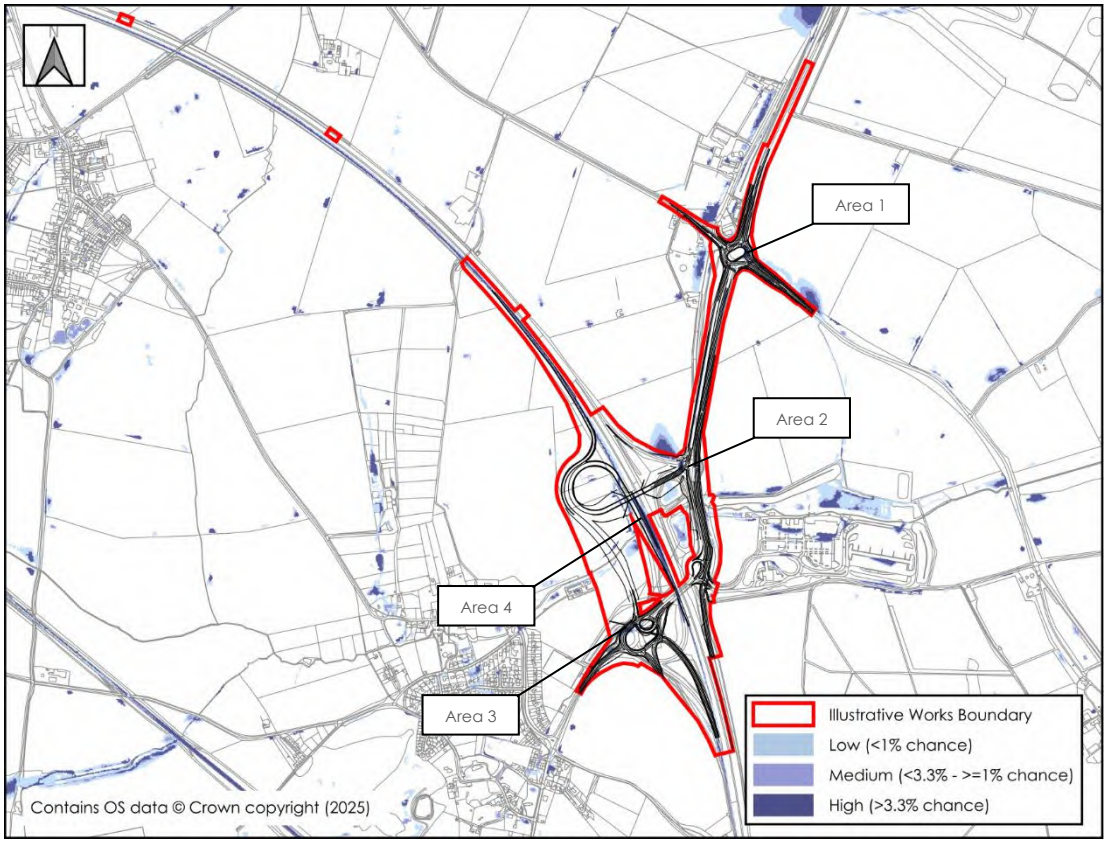

Figure 4.6: EA Risk of Flooding from Surface Water - Works No. 14 to 18

Area 1

4.9 Area 1 shows a high probability of localised surface water ponding on the north side of Baynards Green Roundabout, with a low probability of depths exceeding 0.3m. This is an isolated area of probable flooding and does not form any wider flow routes. However, in reality the roundabout is positively drained which will manage the surface water runoff, limiting potential depths and flood risk to users. An example of the drainage is provided as **Figure 4.7**.

4.10 In the event of exceedance of the highway drainage, relatively shallow surface water would likely remain on the highway at nominal depths. However, it is common for the carriageway to be used to accommodate exceedance flows and so this is considered an acceptable source of flood risk. Therefore, the potential source of flood risk is not considered a barrier to the proposed works.

Figure 4.7: Baynards Green Roundabout Kerb Drainage (Source: Google Street View)

Area 2

4.11 Area 2 shows a high probability of surface water ponding on the north side of the M40 northbound exit slip road roundabout, with a low probability of depths exceeding 0.6m. This is an isolated area of probable flooding and does not form any wider flow routes. However, in reality the roundabout is positively drained which will manage the surface water runoff, limiting potential depths and flood risk to users. An example of the drainage is provided as **Figure 4.8**.

Figure 4.8: M40 Southbound Exit Roundabout Gully Drainage (Source: Google Street View)

Area 3

4.12 Area 2 shows a high probability of surface water ponding on the west and east sides of the M40 southbound exit slip road roundabout, with a low probability of depths exceeding 0.3m. However, the existing kerbs are not raised significantly, it is expected that above kerb height flows would be shed onto the verge. This is an isolated area of probable flooding and does not form any wider flow routes. Furthermore, the roundabout is positively drained which will manage the surface water runoff, limiting potential depths and flood risk to users. An example of the drainage is provided as **Figure 4.9**.

Figure 4.9: M40 Northbound Exit Roundabout Gully Drainage (Source: Google Street View)

Area 4

4.13 Area 4 shows a high probability of surface water ponding along the western edge of the M40 northbound carriageway with a low probability of depths exceeding 0.6m. This is expected to be a result of the highway camber directing flows to the west where existing ground levels rise steeply away from the highway allowing flows to pond. This is an isolated area of probable flooding and does not form any wider flow routes.

Surface Water Drainage

4.14 The works will introduce new impermeable surfaces. The additional surface water runoff generated will either be directed into the existing highway drainage or supported with a new surface water drainage system (reference: OXSRFI-BWB-ZZ-XX-T-W-1051_SDS). The proposals will be designed to provide the necessary attenuated storage for runoff from the new impermeable surfaces, preventing an adverse impact on downstream flood risk. The drainage will include an appropriately restricted discharge rate and attenuated storage for the 1 in 100-year plus climate change event. Following a review, there is no apparent formal highway drainage on the M40 carriageway, it is, therefore, expected that the proposed surface water drainage to support the works will provide a level of betterment to surface water flood risk on the existing motorway

Groundwater Flood Risk

4.15 BGS mapping identifies the proposed works are underlain by Whites Limestone Formation, and Bladon Member-Mudstone and limestone, interbedded. Mapping from the Cherwell District Council Level 1 SFRA (2017) shows the works to lie across two 1km^2 square cells where <25% or >=25% - <50% of the area is potentially susceptible to groundwater flooding. However, it is considered the susceptible areas are most likely to comprise the lower lying surrounding land which generally comprises the floodplain of the local watercourses, including the Padbury Brook. Given the elevated nature of the highway infrastructure at this location the risk of groundwater flooding is low.

4.16 The proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area; however, groundwater monitoring should be undertaken during the construction phase and dewatering undertaken if necessary.

Other Sources of Flood Risk

4.17 Other sources of flood risk have been reviewed including, the sea, canals, reservoirs and public sewers, and none have been identified as posing a flood risk in this location.

Summary

4.18 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the works are not expected to negatively affect flood risk in the surrounding area, subject to appropriate surface water management.

5. WORKS NO. 19 TO 21: ARDLEY BYPASS

Illustrative Proposals

5.1 The proposals include for construction of the B430 Ardley Bypass and associated works, this is shown in **Figure 5.1**.

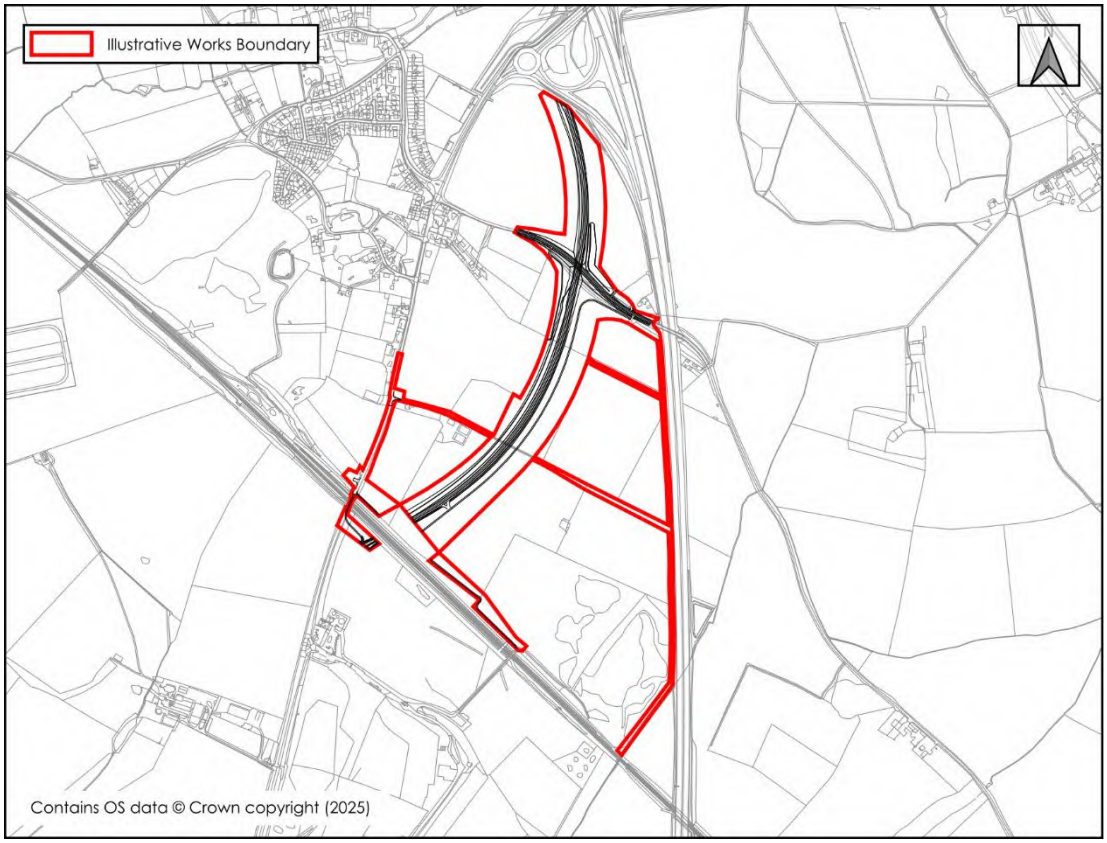

Figure 5.1: Illustrative Works Boundary - Works No. 19 to 21

Historical Flooding Incidents

5.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

5.3 The proposed works are located predominantly within Flood Zone 1 under present day as well as climate changes conditions, which is land defined as having a low probability of flooding from rivers and sea. A small area in the south-east of the works is shown to be located across Flood Zones 2 and 3 and the combined climate change Flood Zones, this is illustrated in **Figure 5.2**.

5.4 The works in the area of Flood Zone 2 and 3 are non-material and relate to signage associated with the existing bridleway. As such it is considered that there will be no increase in flood risk as a result.

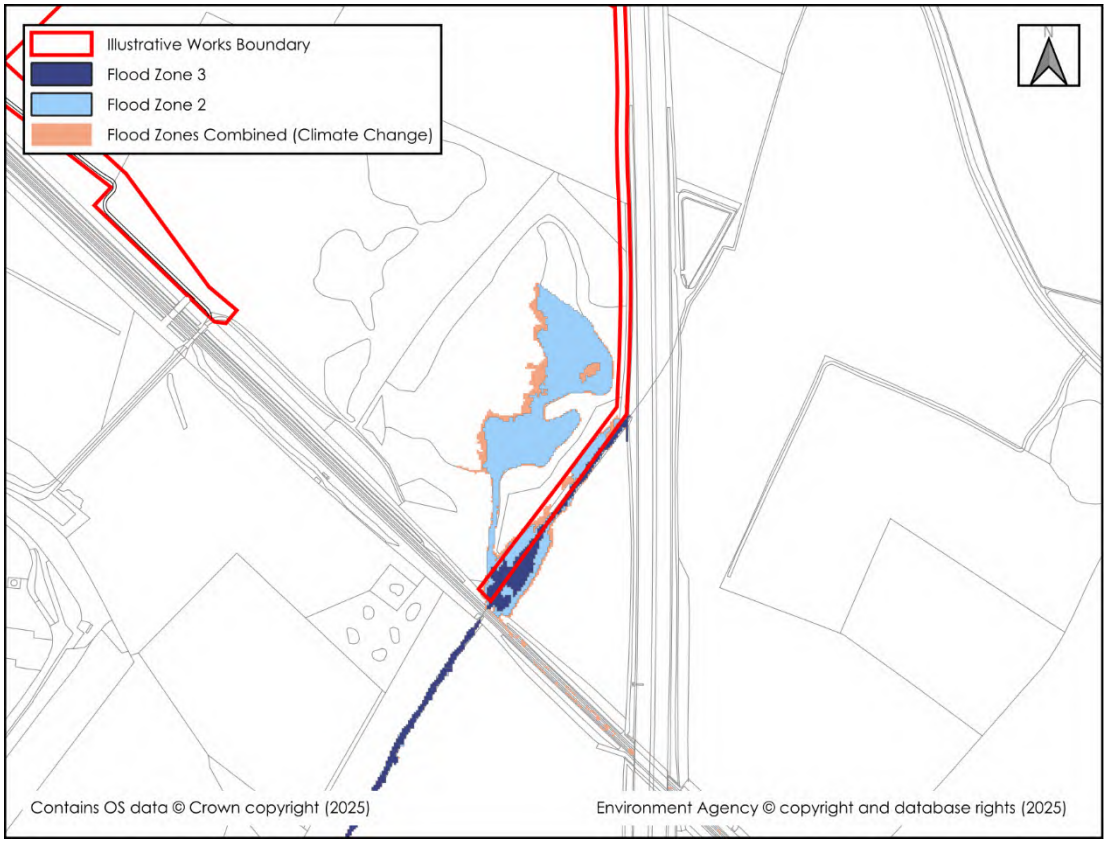

Figure 5.2: EA Flood Map for Planning – Works No. 19 to 21

Surface Water Flood Risk

5.5 EA RoFSW data identifies that there is largely a very low to low probability of surface water flooding, as shown in **Figure 5.3**.

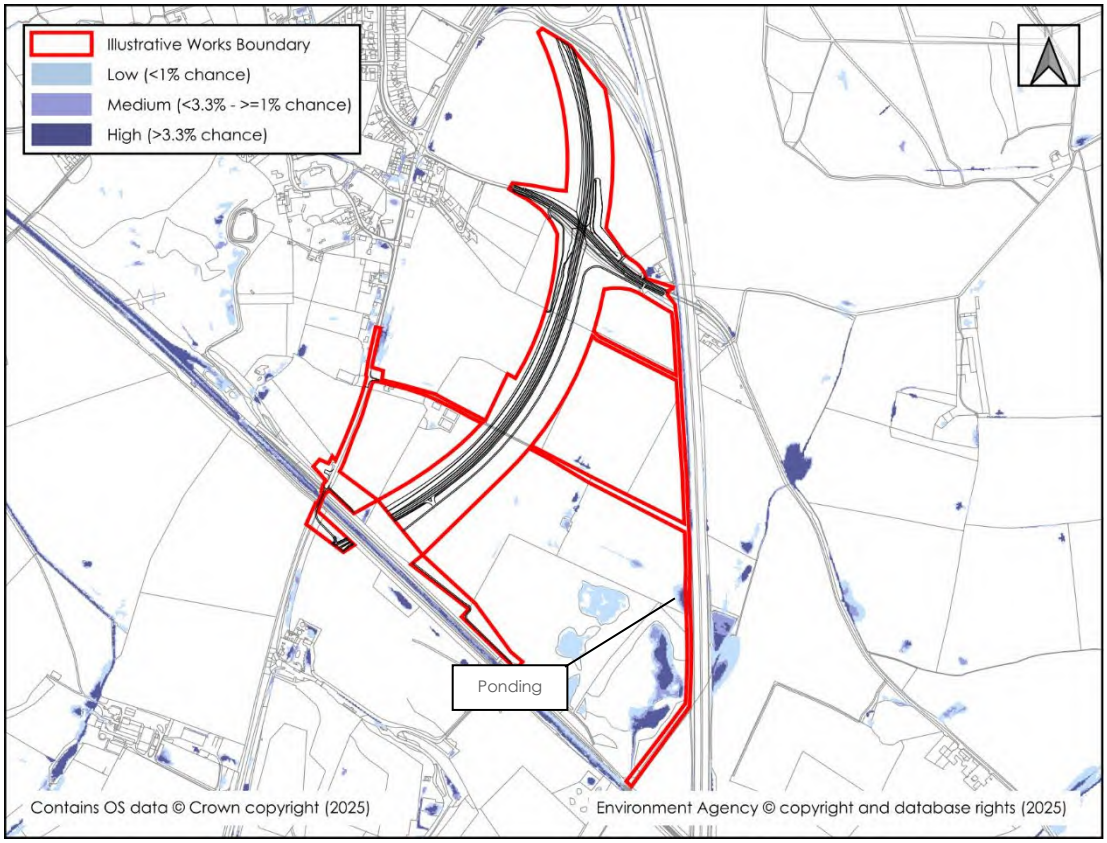

Figure 5.3: EA Risk of Flooding from Surface Water - Works No. 19 to 21

5.6 There is a small, isolated area in the east of the works with a high probability of surface water flooding. Flows pond against the M40 where ground levels are higher than surrounding land. As above, the works in this area are non-material and relate to signage associated with the existing bridleway. As such it is considered that there will be no increase in flood risk as a result.

5.7 The works will introduce new impermeable surfaces. The additional surface water runoff generated will be addressed through a proposed surface water drainage strategy (reference: OXSRFI-BWB-ZZ-XX-T-W-1051_SDS) providing attenuated storage, preventing an adverse impact on downstream flood risk. The drainage strategy will include an appropriately restricted discharge rate and attenuated storage for the 1 in 100-year plus climate change event. Following a review, there is no apparent formal highway drainage on the M40 carriageway. It is, therefore expected that the proposed surface water drainage to support the works will provide a level of betterment to surface water flood risk on the existing motorway.

Groundwater Flood Risk

5.8 BGS mapping identifies the proposed works are underlain entirely by Whites Limestone Formation. Areas Susceptible to Groundwater Flooding mapping appended to the Cherwell District Council Level 1 SFRA (2017) shows the study site to lie across a 1km^2 cell at no risk of groundwater flooding or <25% of the area susceptible. The proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

5.9 Other sources of flood risk have been reviewed including, the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

5.10 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the works are not expected to negatively affect any flood risk in the surrounding area, subject to appropriate surface water management.

6. WORKS NO. 22: M40 JUNCTION 9

Illustrative Proposals

6.1 The proposed improvements in this location include alterations of the existing M40 Junction 9 roundabout. The extent of the works is illustrated in **Figure 6.1**.

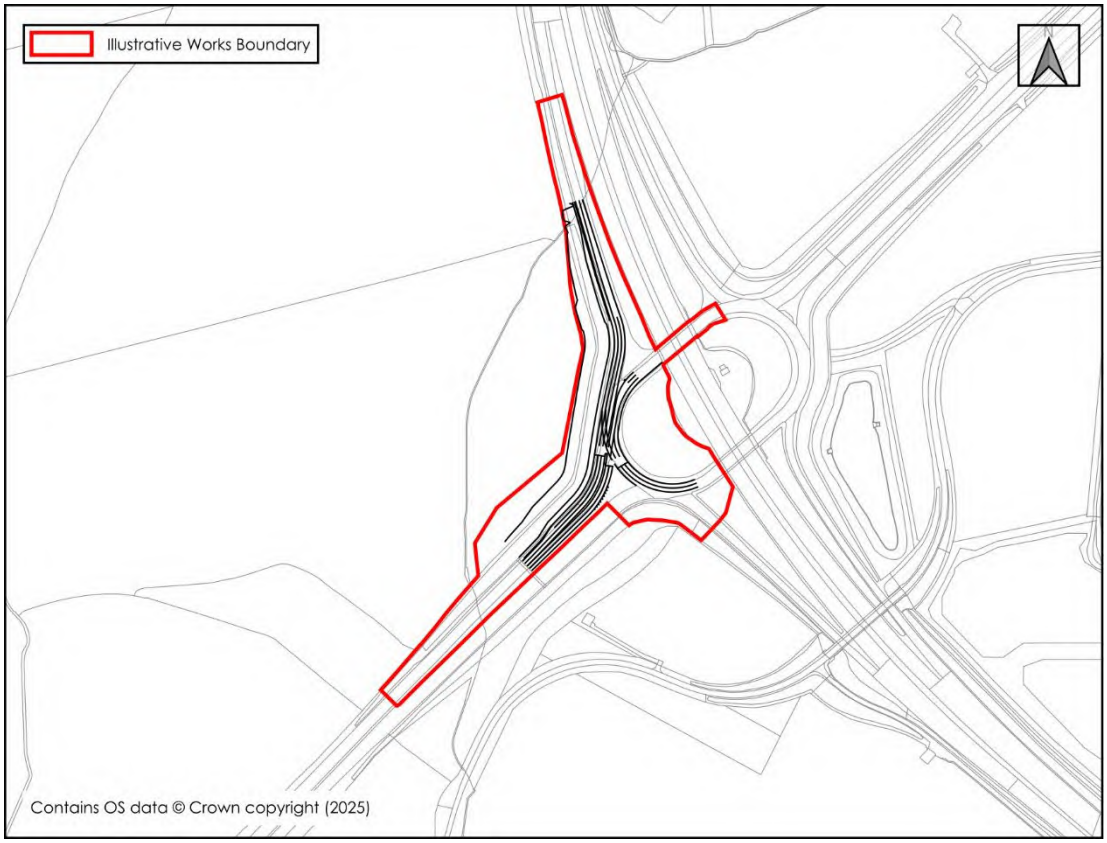

Figure 6.1: Illustrative Works Boundary - Works No. 22

Historical Flooding Incidents

6.2 The EA Historical Flood Map does not show any recorded flood outlines within close proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

6.3 The proposed works are located predominantly within Flood Zone 1; however, as seen in **Figure 6.2**, there is an area of present day Flood Zone 2 and combined climate change Flood Zones which encroach on the works boundary. The proposed works are such that widening of the existing highway requires an extension to the surrounding earthworks where levels tie into the existing surrounding ground levels.

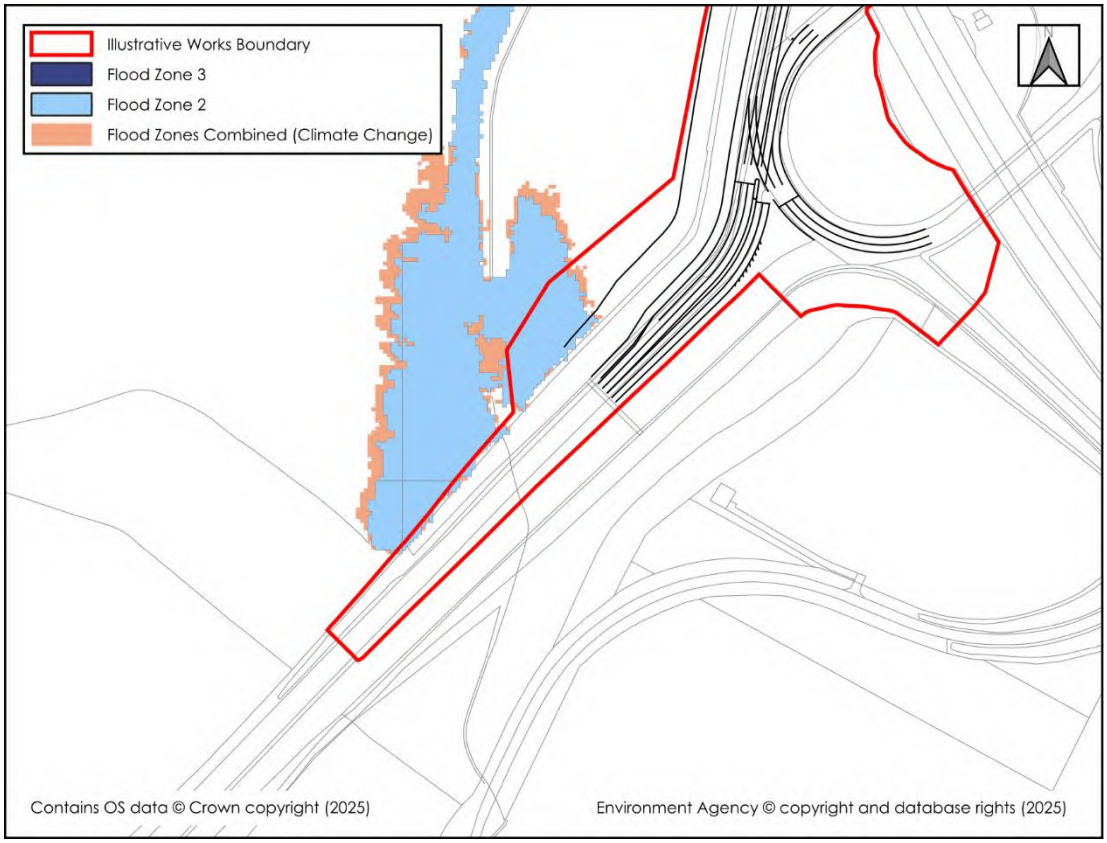

Figure 6.2: EA Flood Map for Planning – Works No. 22

6.4 This extension encroaches into the mapped Flood Zones which implies there is potential for a loss of floodplain volume as a result of the proposed works. However, following further review it is considered that the Flood Zones in this area are not representative of the actual floodplain or the alignment of the watercourse. In addition, the Flood Zones are based on strategic scale modelling which does not account for the existing culvert which conveys flows under the A34. It is therefore considered that the extent of flooding will be reduced in comparison to the Flood Map for Planning such that the proposed works are not expected to encroach upon the floodplain. In the absence of detailed modelling the EA's Risk of Flooding from Rivers and Sea has been reviewed and the proposed works lie outside of the medium probability (less than 3.3% (1 in 30) but greater than or equal to 1% (1 in 100) chance in any given year) areas including with climate change, as shown in **Figure 6.3**. Therefore, it is concluded that in line with this and the minor encroachment of the works into the 1 in 1000-year floodplain, compensatory storage will not be required.

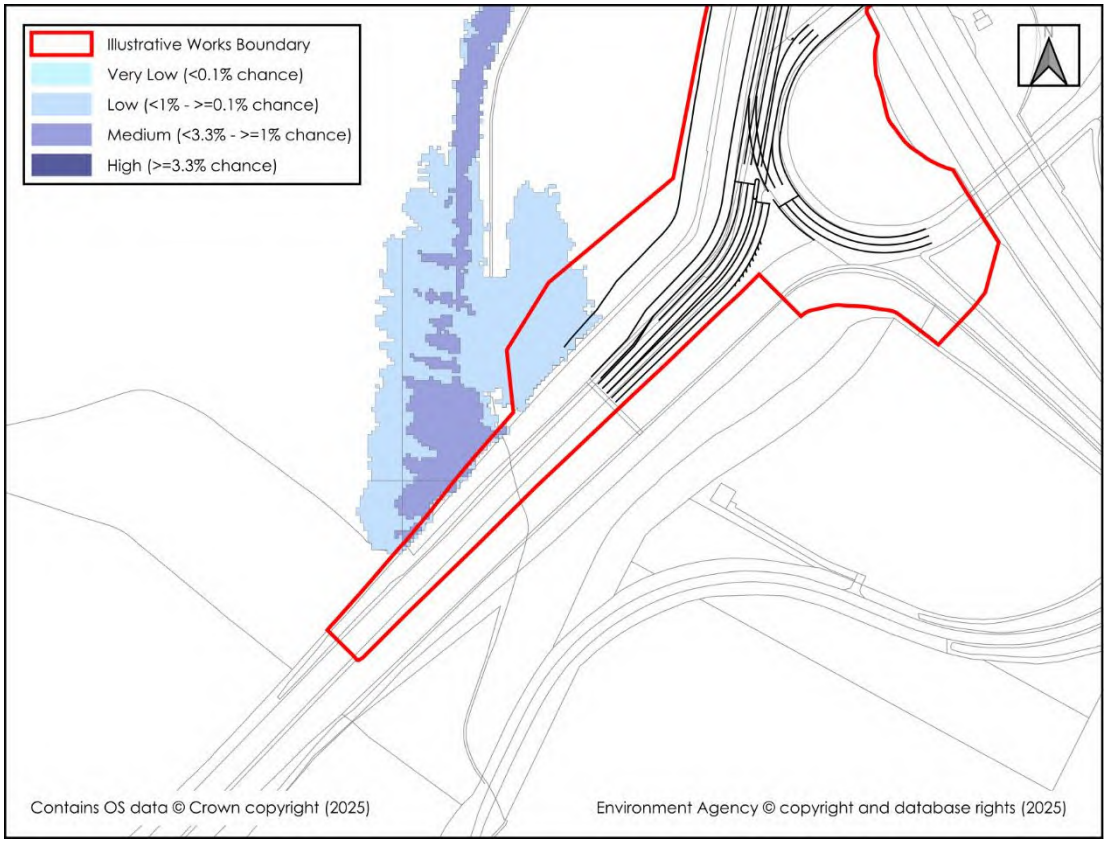

Figure 6.3: EA Risk of Flooding from Rivers and Sea – Works No. 22

Surface Water Flood Risk

6.5 The EA RoFSW mapping, included as **Figure 6.4**, shows there to be predominantly a very low to low probability of surface water flooding within the area of the proposed works. An area of high probability flooding within the works area is associated with the low lying ground to the north of the existing highway; however, this mapping is also not considered representative of the actual conditions as the RoFSW mapping does not account for connectivity .

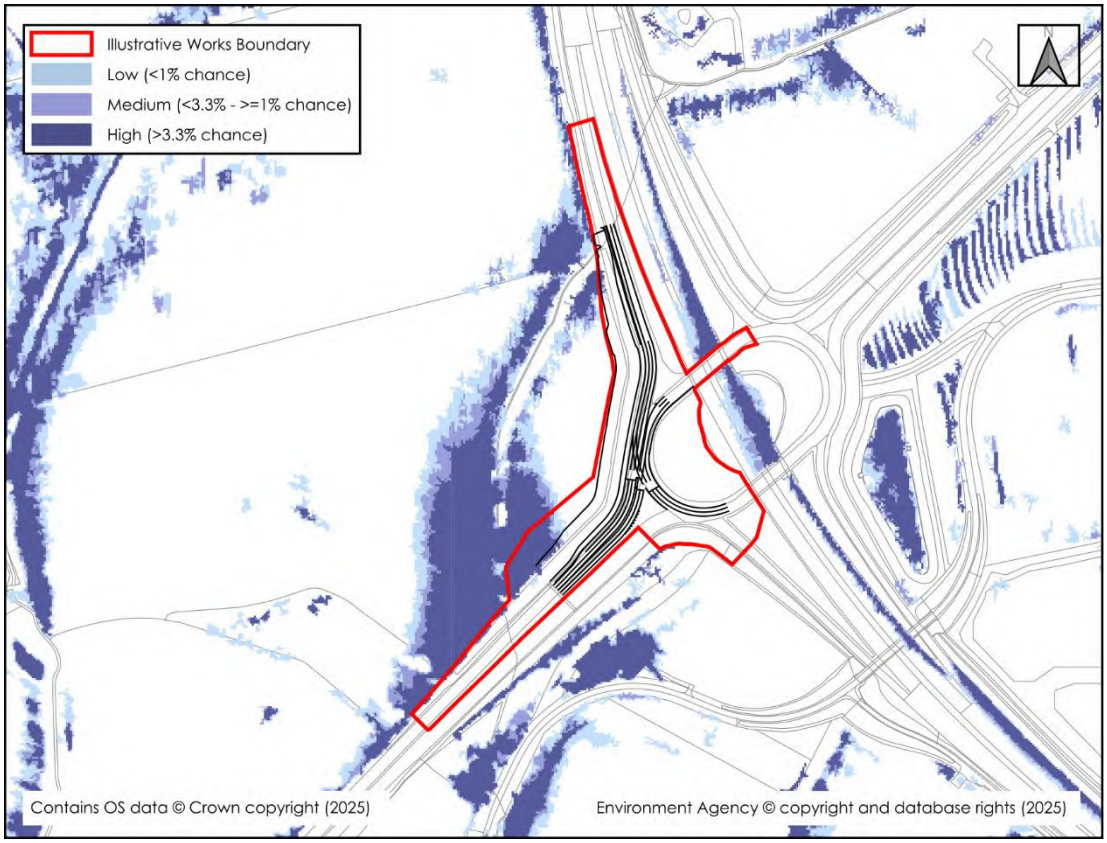

Figure 6.4: EA Risk of Flooding from Surface Water – Works No. 22

6.6 The works will introduce new impermeable surfaces. The additional surface water runoff generated will be appropriately managed through extension of the existing highway drainage which takes the form of an existing filter drain feature. The surface water proposals are outlined within the indicative drainage strategy drawing (reference: OXSRFI-BWB-ZZ-XX-T-W-1051_SDS).

Groundwater Flood Risk

6.7 BGS mapping identifies the proposed works are underlain by Oxford Clay Formation. Mapping from the Level 1 SFRA (2017) shows the works to lie in a 1km^2 square grid where <25% of the area is potentially susceptible to groundwater flooding. The relatively minor proposed improvement works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

6.8 Other sources of flood risk have been reviewed including, the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

6.9 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works.

Additionally, the proposed highway works are not expected to negatively affect any flood risk in the surrounding area, subject to appropriate surface water management.

7. WORKS NO 23 AND 24: MIDDLETON STONEY RELIEF ROAD

Illustrative Proposals

7.1 The proposals include for construction of the MSRR connecting B430 and B4030 including a shared use cycle track. The extent of the proposed works is shown in **Figure 7.1**.

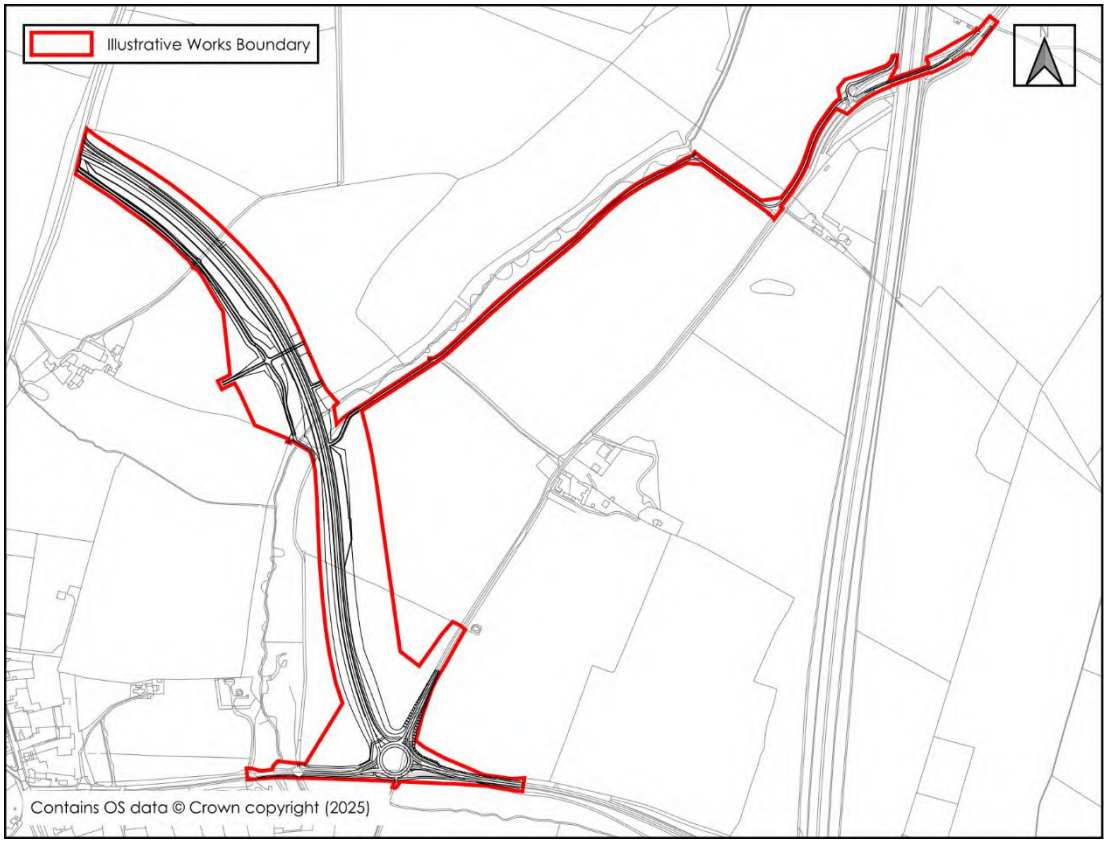

Figure 7.1: Illustrative Works Boundary - Works No. 23 and 24

Historical Flood Incidents

7.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

7.3 The proposed works are located largely within Flood Zone 1. Areas of Flood Zones 2 and 3, including combined climate change Flood Zones are present where the proposed works cross the Gagle Brook watercourse or where the bridleway runs relatively parallel to the channel alignment, these are illustrated in **Figure 7.2**. The modelled flood extents, shown in **Figure 7.3**, demonstrates that within proximity to the proposed works flows remain in channel for the Gagle Brook during all modelled events.

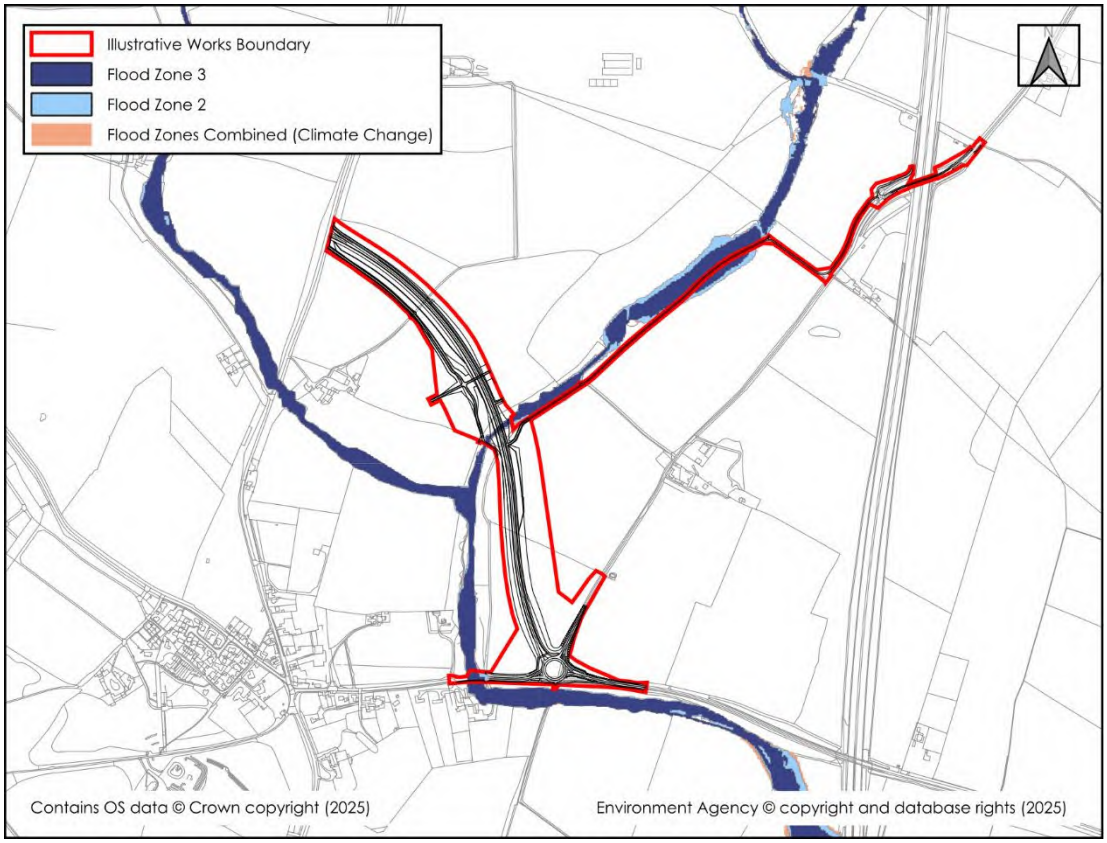

Figure 7.2: EA Flood Map for Planning – Works No. 23 and 24

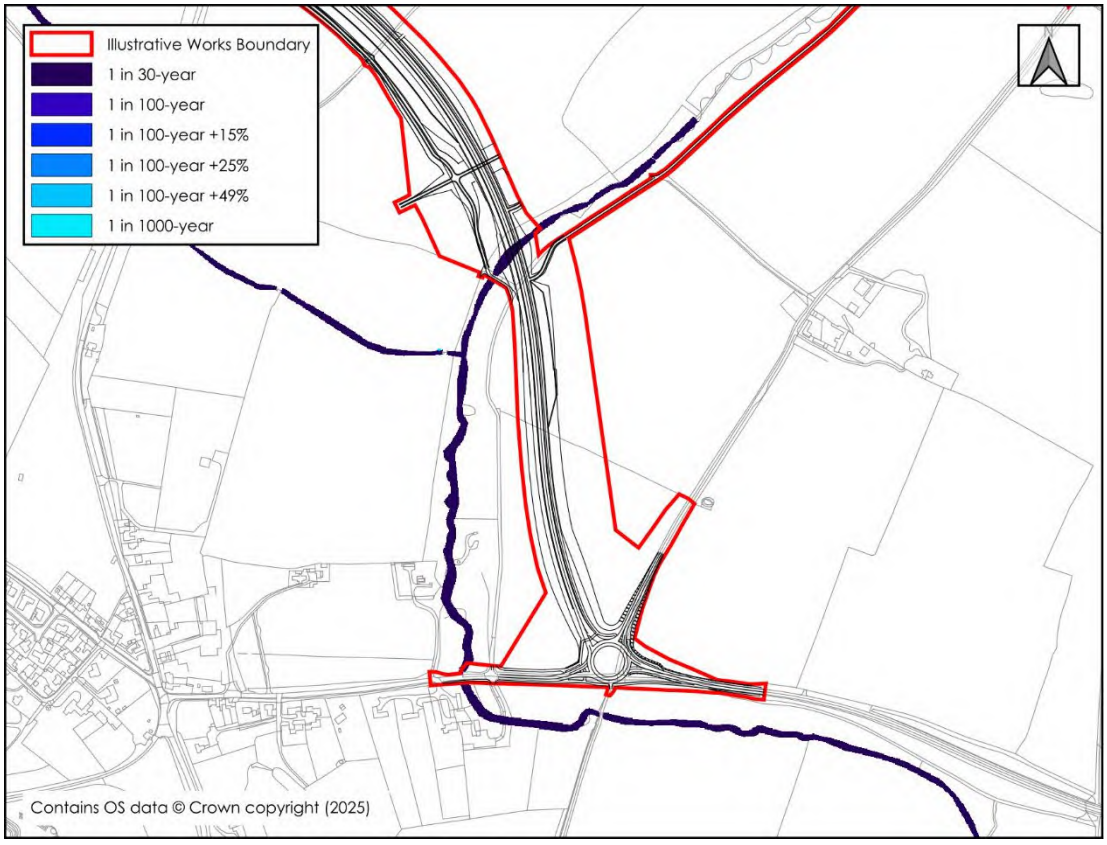

Figure 7.3: BWB Baseline Modelled Flood Extents – Works No. 23 and 24

7.4 The modelled flood extents are not shown to fully extend upstream on the Gagle Brook for the full bridleway/cycle track; however, existing ground levels are to be retained in this area such that there will be no impact on the existing Gagle Brook floodplain.

7.5 To facilitate the proposed crossings two new culverts are required on the Gagle Brook. The baseline hydraulic model has been updated to include the proposed culverts and the proposed ground levels for the link road. Further details on the culvert are included within the hydraulic modelling report (reference: OXSRFI-BWB-ZZ-XX-T-W-1001_HMR (GB)). The proposed model results are shown in **Figure 7.4**, with impact mapping for the 1 in 100-year +15% climate change design event shown in **Figure 7.5**.

7.6 The comparison mapping shows that upstream and downstream of the proposed culverts there is no change (within model tolerances), elsewhere on the Gagle Brook there is a minor reduction in flood levels of 0.01m.

7.7 The proposed culverts demonstrate the required freeboard in all events up to and including the 1 in 1000-year event.

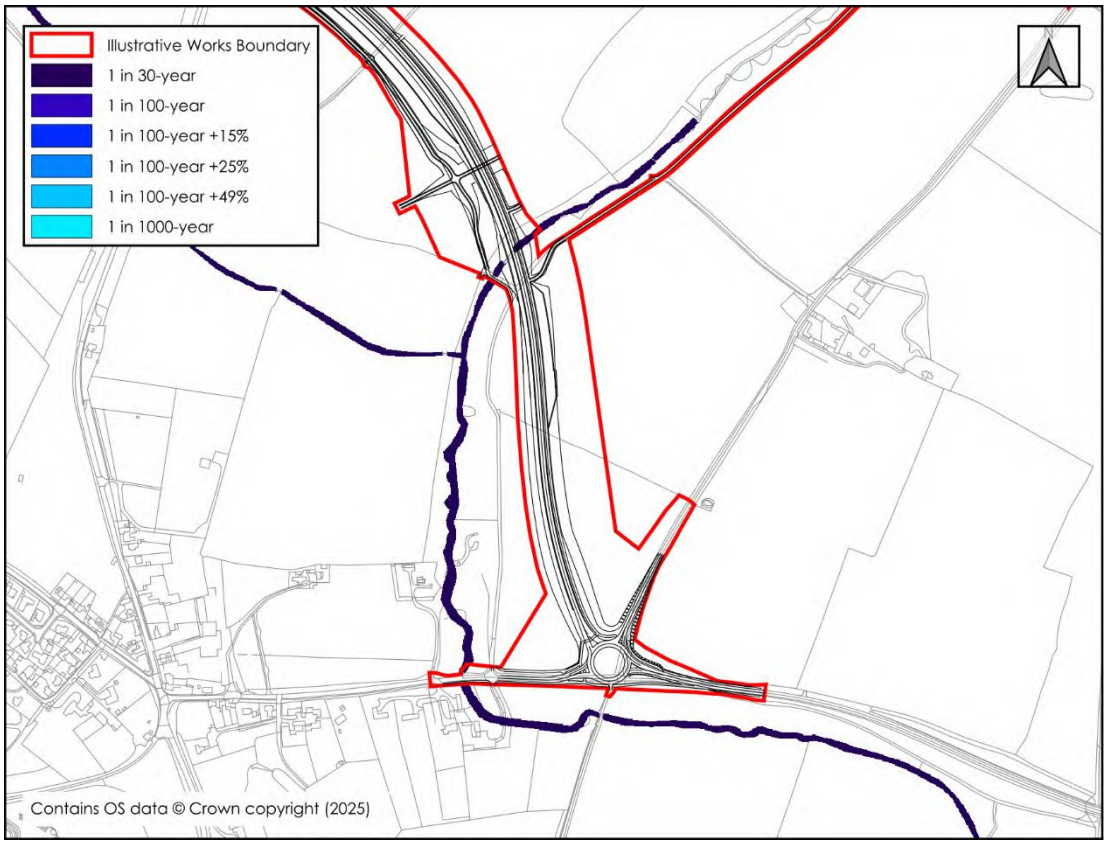

Figure 7.4: BWB Proposed Modelled Flood Extents – Works No. 23 and 24

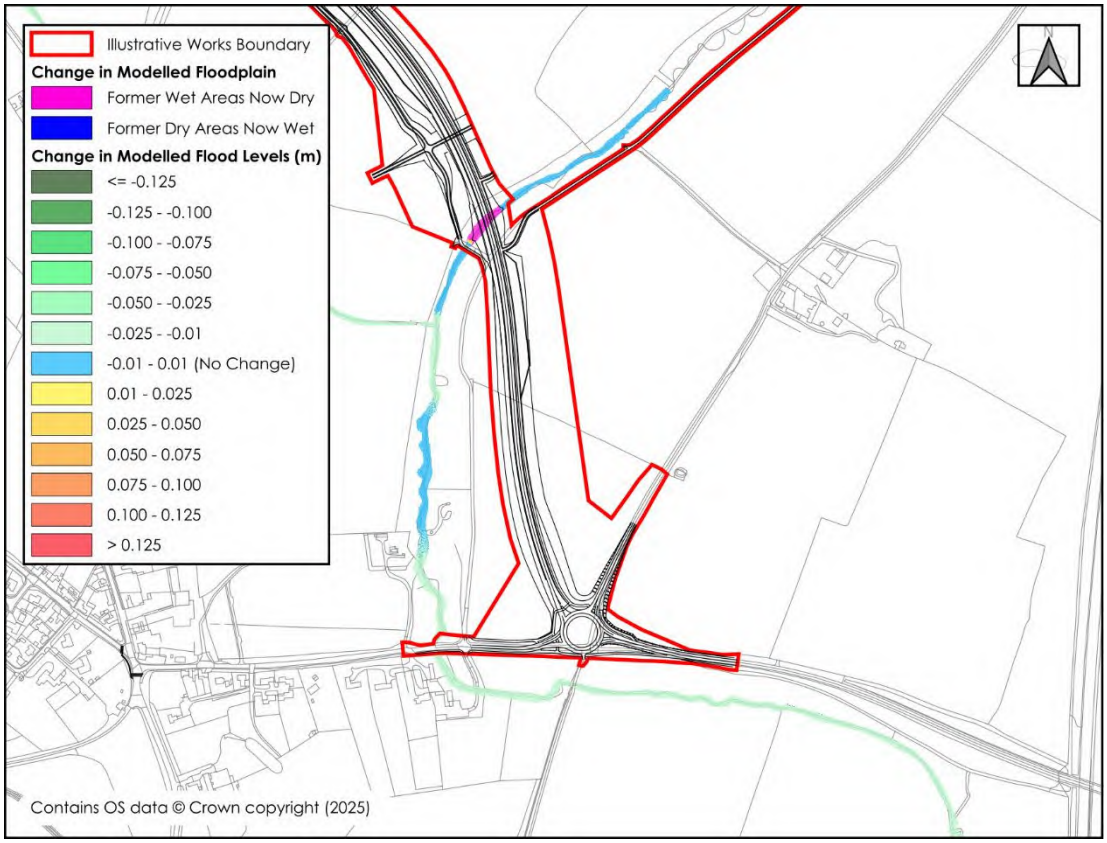

Figure 7.5: 1 in 100-year +15% Floodplain Comparison – Works No. 23 and 24

Surface Water Flood Risk

7.8 The EA RoFSW mapping (**Figure 7.6**) shows there to be a very low probability of flooding from surface water within the area of the proposed works

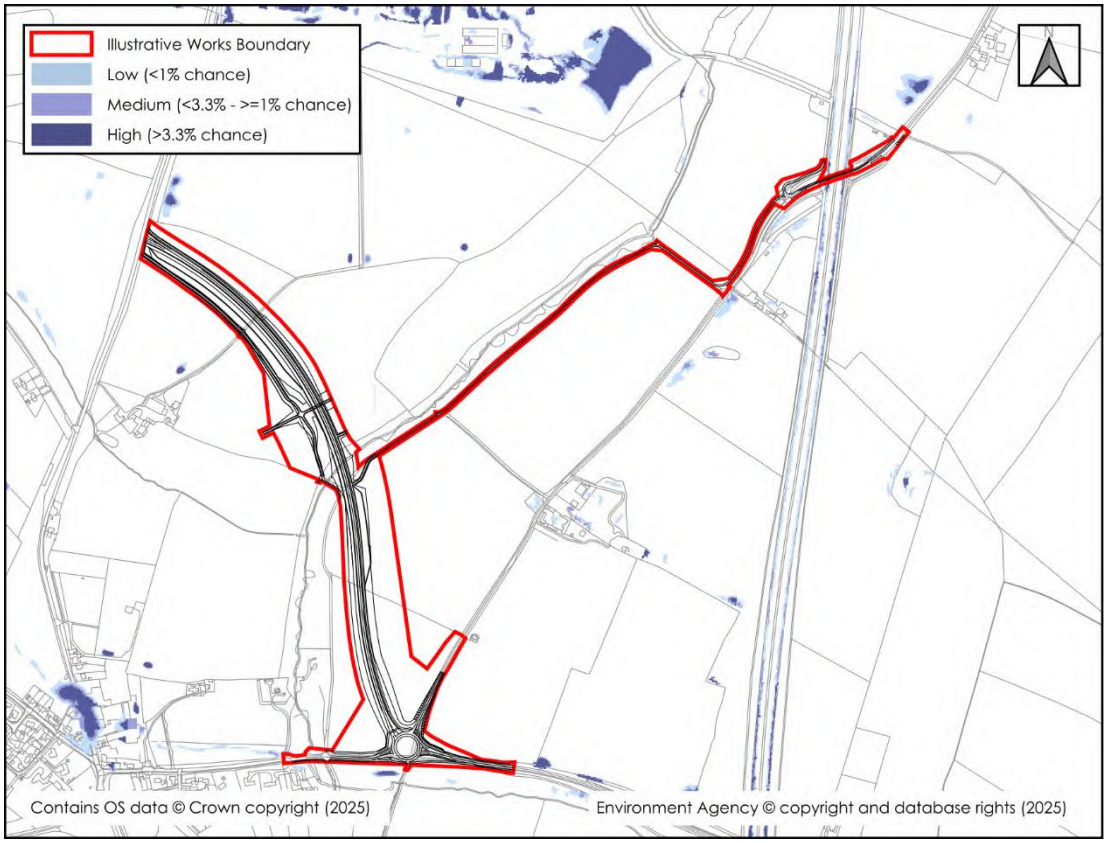

Figure 7.6: EA Risk of Flooding from Surface Water – Works No. 23 and 24

7.9 The works will introduce new impermeable surfaces. The additional surface water runoff generated will be manged through a new surface water drainage (reference: OXSRFI-BWB-ZZ-XX-T-W-1051_SDS) that will provide the necessary attenuated storage for runoff from the new impermeable surfaces, preventing an adverse impact on downstream flood risk. The drainage will include an appropriately restricted discharge rate and attenuated storage for the 1 in 100-year plus climate change event.

Groundwater Flood Risk

7.10 BGS mapping identifies the proposed works are underlain by Whites Limestone Formation and Forest Marble Formation. Areas Susceptible to Groundwater Flooding mapping appended to the Cherwell District Council Level 1 SFRA (2017) shows the study site to lie across a 1km^2 cell at no risk of groundwater flooding or <25% of the area susceptible. The proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

7.11 Other sources of flood risk have been reviewed including the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

7.12 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the proposed improvements are not expected to negatively affect flood risk in the surrounding area.

8. WORKS NO 27: MIDDLETON STONEY CROSSROADS

Illustrative Proposals

8.1 The proposals include for primarily for surface level highway works and a small extension of existing footway. The extent of the proposed works is shown in **Figure 8.1**.

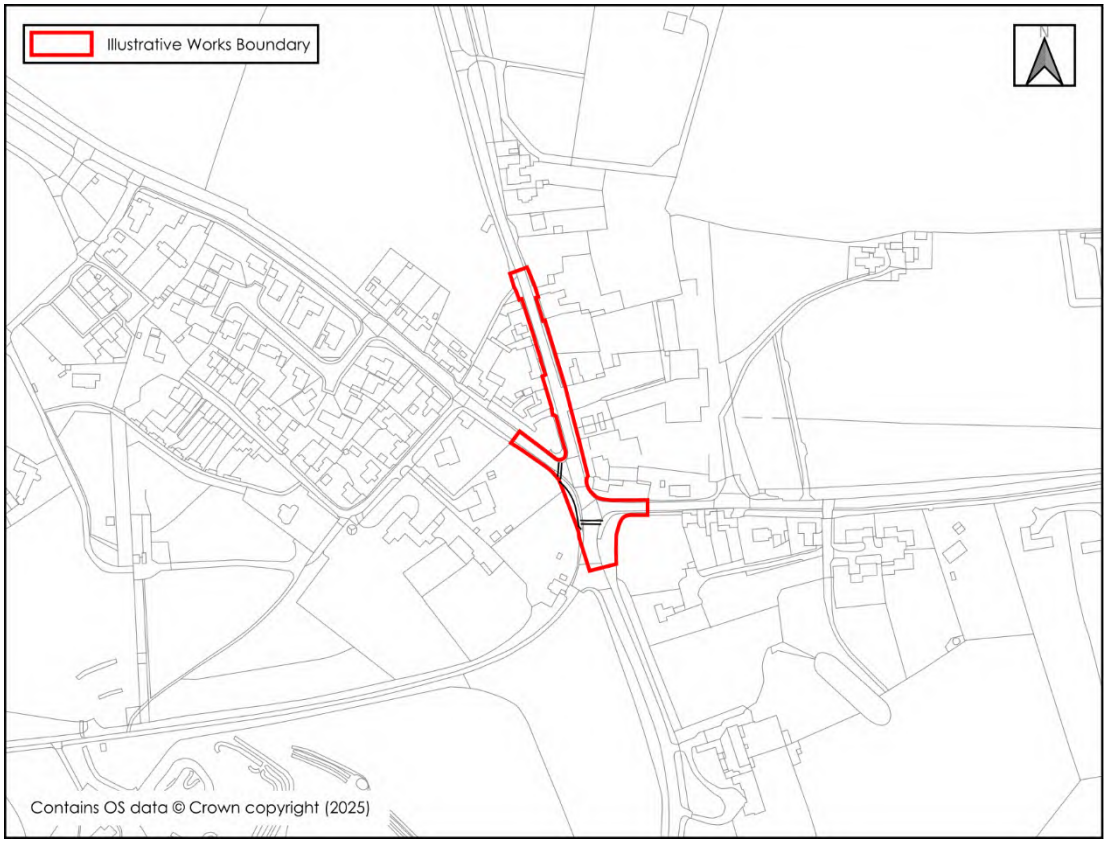

Figure 8.1: Illustrative Works Boundary - Works No. 27

Historical Flood Incidents

8.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

8.3 The proposed works are located entirely within Flood Zone 1 under present day which is land defined as having a low probability of flooding from rivers and sea. Additionally, the works are well removed from the combined Flood Zones with climate change.

Surface Water Flood Risk

8.4 The EA RoFSW mapping (**Figure 8.2**) shows there to be largely a very low probability of flooding from surface water within the area of the proposed works in the south. There is

an area with a high probability in the north, where levels fall to a low point in the existing highway.

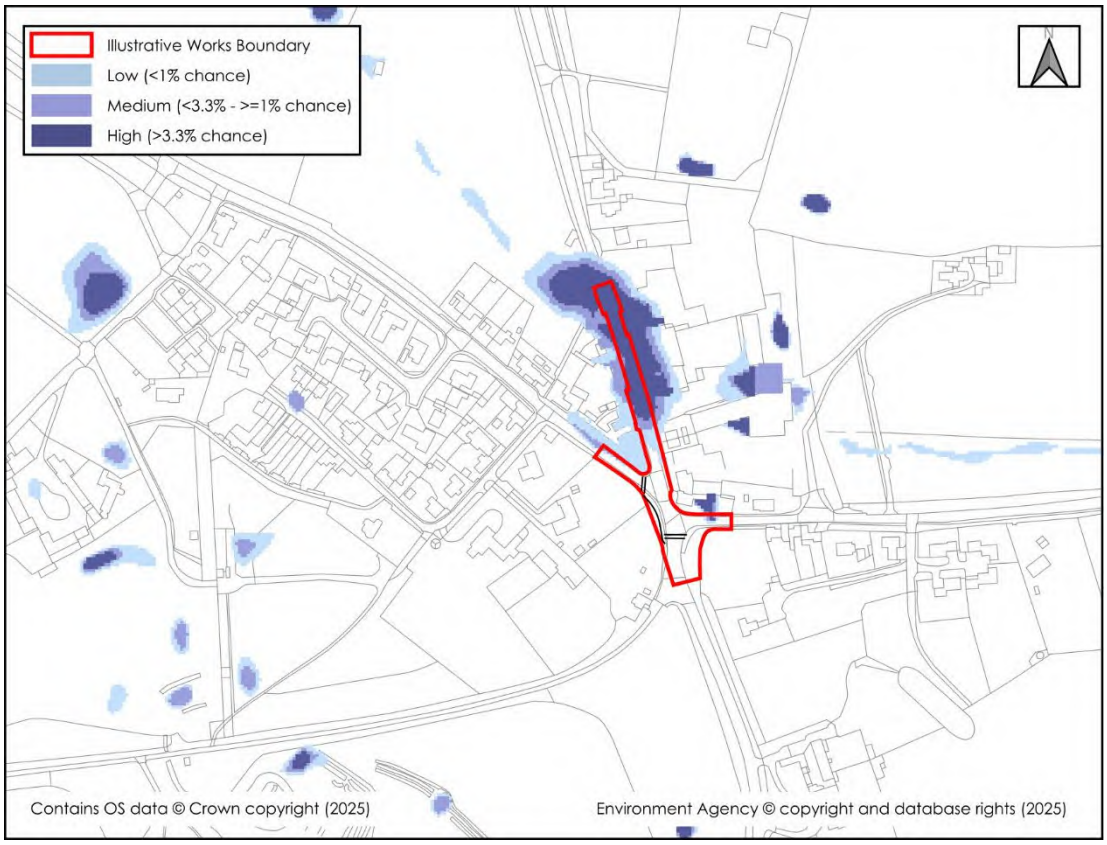

Figure 8.2: EA Risk of Flooding from Surface Water – Works No. 27

8.5 The proposed works with the area of low to high probability flooding are superficial surface works with no changes to existing levels and no change in the area of impermeable surfaces. Therefore, it is considered there will be no increase in flood risk in this area.

8.6 The western arm of the junction is to include a small extension of existing footway. The proposed extension will result in a negligible increase in the area of impermeable surfaces. It is proposed that the minor increase in surface water runoff will be retained within the capacity of the existing highway drainage.

Groundwater Flood Risk

8.7 BGS mapping identifies the proposed works are underlain by Whites Limestone Formation and Forest Marble Formation. Areas Susceptible to Groundwater Flooding mapping appended to the Cherwell District Council Level 1 SFRA (2017) shows the study site to lie within a 1km^2 cell at no risk of groundwater flooding. The proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

8.8 Other sources of flood risk have been reviewed including the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

8.9 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the proposed improvements are not expected to negatively affect flood risk in the surrounding area.

9. WORKS NO 34: LANDFILL WORKS

Illustrative Proposals

9.1 The proposals include for construction of the MSRR connecting B430 and B4030 including a shared use cycle track. The extent of the proposed works is shown in **Figure 9.1**.

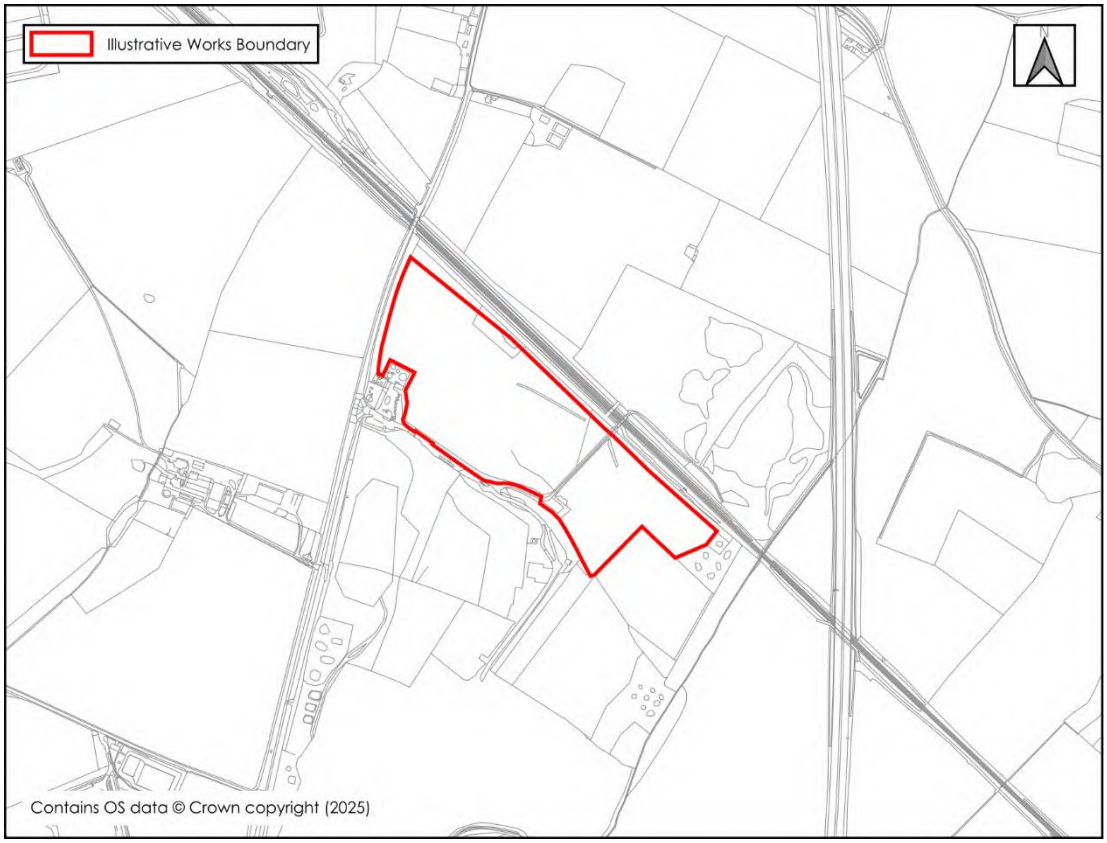

Figure 9.1: Illustrative Works Boundary - Works No. 34

Historical Flood Incidents

9.2 The EA Recorded Flood Outlines data does not show any recorded incidents within proximity to the proposed works. Furthermore, a review of historical incidents collated and listed in the PFRA and SFRAs did not identify any which had affected the area.

Fluvial Flood Risk

9.3 The proposed works are located entirely within Flood Zone 1 under present day which is land defined as having a low probability of flooding from rivers and sea. Additionally, the works are well removed from the combined Flood Zones with climate change.

Surface Water Flood Risk

9.4 The EA RoFSW mapping (**Figure 9.2**) shows there to be predominately a very low probability of flooding from surface water within the area of the proposed works. There

are three small, isolated areas with a high probability in the north associated with existing topographic low spots.

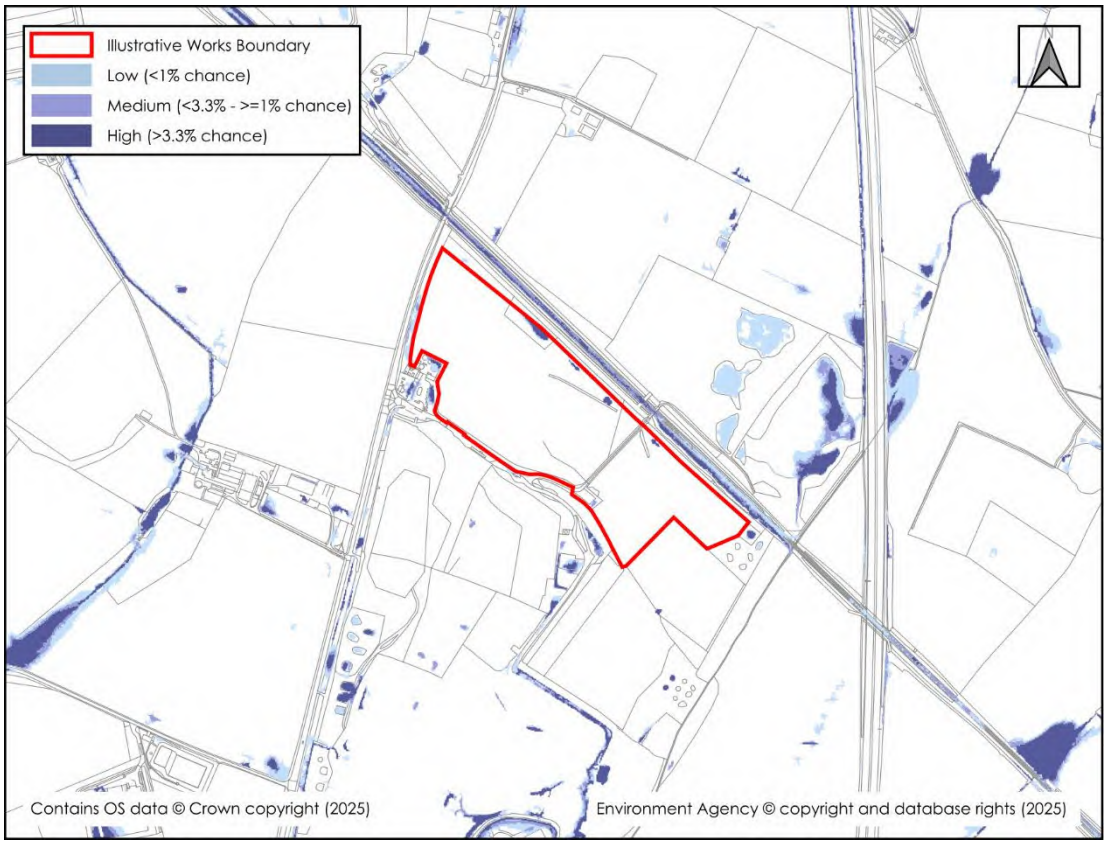

Figure 9.2: EA Risk of Flooding from Surface Water – Works No. 34

9.5 The existing waste management site and landfill area operate under an existing permit and acts as a self-contained site such that any surface water originating within the site will remain on-site. Post-development there we will remain a requirement for the works to remain self-contained such that there we will be no change in off-site flood risk as a result of the proposed works. There will be no increase in the area of impermeable surfaces as a result of the works

Groundwater Flood Risk

9.6 BGS mapping identifies the proposed works are underlain by Whites Limestone Formation and Forest Marble Formation. Areas Susceptible to Groundwater Flooding mapping appended to the Level 1 SFRA (2017) shows the study site to lie within a 1km^2 cell at no risk of groundwater flooding. The proposed works will not detrimentally affect the risk of groundwater flooding in the surrounding area.

Other Sources of Flood Risk

9.7 Other sources of flood risk have been reviewed including the sea, canals, reservoirs and large waterbodies, and public sewers, and none have been identified as posing a flood risk in this location.

Summary

9.8 Overall, the risk of flooding from the reviewed sources in this area are all considered to be at an acceptable level; therefore, they will not pose a barrier to the proposed works. Additionally, the proposed improvements are not expected to negatively affect flood risk in the surrounding area.

10. SUMMARY

10.1 This Flood Risk Screening Report has been prepared in accordance with the requirements set out in the NPSNN. It has been produced on behalf of Oxfordshire Railfreight Limited in respect of a DCO for the proposed Oxfordshire SRFI.

10.2 This report focuses on the 'Offsite/Highway Works' which are removed from the SRFI Main Site works. The SRFI Main Site works have been reviewed under separate cover (reference: OXSRFI-BWB-ZZ-XX-T-W-0006).

10.3 A desktop review of the potential flood risk sources at each location has been undertaken. As the proposals are generally associated with improvements to existing infrastructure, the principle of a road, footway or new signage in each location has not been discussed. Instead, the assessment has reviewed the presence of a potential flood risk source and the potential impact of the proposals on that flood risk source.

10.4 The results of the desktop review are summarised within **Table 10.1**. Given the proposed works are anticipated to have a negligible impact on flood risk, it is not considered necessary to undertake a more detailed assessment of flood risk.

Table 10.1: Summary of Flood Risk Screening

Works No.	Flood Risk Source						
	Fluvial	Surface Water & Highway Drainage	Groundwater	Reservoirs	Canal	Public Sewers	Sea
11	No Risk	Low Risk – subject to implementation of proposed surface water drainage management.	Low Risk	No Risk	No Risk	No Risk	No Risk
12	Low Risk – subject to inclusion of new culvert on the Ashgrove Brook.	Low Risk – subject to implementation of proposed surface water drainage management.	Low Risk	No Risk	No Risk	No Risk	No Risk
13	Screened Out – The proposals include realignment of the existing junction, the area of impermeable surfacing is to remain unchanged such that existing highway drainage is sufficient and therefore not considered to result in a material impact on flood risk.						
14 to 18	Low Risk – subject to inclusion of new culvert on the Padbury Brook.	Low Risk – subject to retainment of existing highway drainage infrastructure, and implementation of proposed surface water drainage management.	Low Risk	No Risk	No Risk	No Risk	No Risk
19, 20 and 21	Low Risk	Low Risk – subject to implementation of proposed surface water drainage management.	Low Risk	No Risk	No Risk	No Risk	No Risk
22	No Risk	Low Risk – subject to improvements being made to the local highway drainage infrastructure.	Low Risk	No Risk	No Risk	No Risk	No Risk

Works No.	Flood Risk Source						
	Fluvial	Surface Water & Highway Drainage	Groundwater	Reservoirs	Canal	Public Sewers	Sea
23 and 24	Low Risk – subject to inclusion of new culverts on the Gagle Brook.	Low Risk – subject to implementation of proposed surface water drainage management.	Low Risk	No Risk	No Risk	Low Risk	No Risk
25	Screened Out - No material changes to existing ground levels and no change to the area of impermeable surfaces.						
26	Screened Out - No material changes to existing ground levels and no change to the area of impermeable surfaces.						
27	Low Risk	Low Risk	Low Risk	No Risk	No Risk	No Risk	No Risk
28	Screened Out - No material changes to existing ground levels and no change to the area of impermeable surfaces.						
31, 32 and 33	Screened Out – Biodiversity enhancements comprise provision of new grassland types this is not considered to result in a material impact on flood risk						
34	Low Risk	Low Risk – all surface water to be retained within the landfill site in line with existing permit.	Low Risk	No Risk	No Risk	Low Risk	No Risk
35	Screened Out – underground works to provide foul water connection points, no fundamental changes to surface. Therefore, there is considered to be no impact on flood risk.						
36	Screened Out – underground works to provide foul water connection points, no fundamental changes to surface. Therefore, there is considered to be no impact on flood risk.						
37	Screened Out – Biodiversity enhancements comprise provision of new grassland types this is not considered to result in a material impact on flood risk.						

Works No.	Flood Risk Source						
	Fluvial	Surface Water & Highway Drainage	Groundwater	Reservoirs	Canal	Public Sewers	Sea
38	Screened Out – Underground tunnel works are not considered to have a material impact on flood risk.						

APPENDICES

Appendix 1: Padbury Brook Hydraulic Modelling Report

A CAF GROUP COMPANY

ADVISORY

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Hydraulic Model Report

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GLOSSARY & NOTATION

1D – one-dimensional hydraulic model, good for representing the hydraulics of a definitive channel or flow pathway and hydraulic structure.

2D – two-dimensional hydraulic model, good for representing complex flow routing present within the floodplain.

Annual Exceedance Probability (AEP) - the probability (%) of a flood event occurring in any year.

Catchment - the land area that drains (normally naturally) to a given point on a river, drainage system or body of water.

CME – Cumulative Mass Error

Design flood event - magnitude of the flood adopted for the design of the whole or part of a development, usually defined in relation to the severity of the flood in terms of its return period. Typically, the 1 in 100-year return period event including an allowance for future climate change for fluvial flood events.

DTM – Digital Terrain Model

EA – Environment Agency

ESTRY - a 1D hydraulic modelling software package published by BMT.

Flood Estimation Handbook (FEH) – industry standard guidance on rainfall and river flood frequency estimation across the UK.

Floodplain - any area of land over which water flows or is stored during a flood event.

FRA – Flood Risk Assessment

Freeboard - the height of the top of a bank, floodwall or other flood defence structure, above the design water level. Freeboard can be seen as a safety margin that makes allowance for uncertainty associated with the potentially damaging effects of flood rise or wave action.

Hydraulic Model - a mathematical (generally computer based) model of a water/sewer/storm system which is used to analyse the system's hydraulic behaviour.

LiDAR – Light Detection and Ranging aerial survey data

LLFA – Lead Local Flood Authority

mAOD – metres above Ordnance Datum

m BGL – metres below ground level

Main River - a statutory type of watercourse in England and Wales, usually larger streams and rivers. The EA can carry out maintenance, improvement or construction work on main rivers to manage flood risk as part of its duties and powers.

NRFA – National River Flow Archive

OS – Ordnance Survey

Preliminary Flood Risk Assessment (PFRA) - an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authority.

ReFH – Revitalised Flood Hydrograph rainfall-runoff hydrological model

Return period - a statistical term defining the probability of occurrence of a flood event. Thus a 1 in 50-year flood is one likely to be equalled or exceeded on average only once in a 50-year period: a flood with a 2.0% annual probability exceedance (AEP).

Strategic Flood Risk Assessment (SFRA) - a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.

TUFLOW – a 2D fixed grid hydraulic modelling software package published by BMT.

UOW – Unnamed Ordinary Watercourse

Watercourse – a natural or man-made open channel for the conveyance of water.

Z-line – a break line layer in TUFLOW which can be used to reinforce linear features in the 2D model domain such as a riverbank, flood defence, or channel bed.

Z-Shape – a layer in TUFLOW which can be used to manipulate the 2D model geometry.

1. INTRODUCTION

1.1 BWB Consulting Ltd (BWB) has been commissioned by Oxfordshire Railfreight Limited (the Client) to undertake a site-specific hydraulic modelling exercise of the Padbury Brook to support the development of the Oxfordshire Strategic Rail Freight Interchange (SRFI), Oxfordshire (NGR: SP537269).

Site Description

1.2 The Order Limits of the DCO are located approximately 4.3km north-west of Bicester town centre. The M40 motorway and the A43 form the north-eastern boundary and the Ardley Road (B460) forms the south-eastern site boundary. Heyford Park is located to the west of the and Upper Heyford Airfield (disused) is located to the north-west. The extent of the Order Limits is shown in **Figure 1.1.**

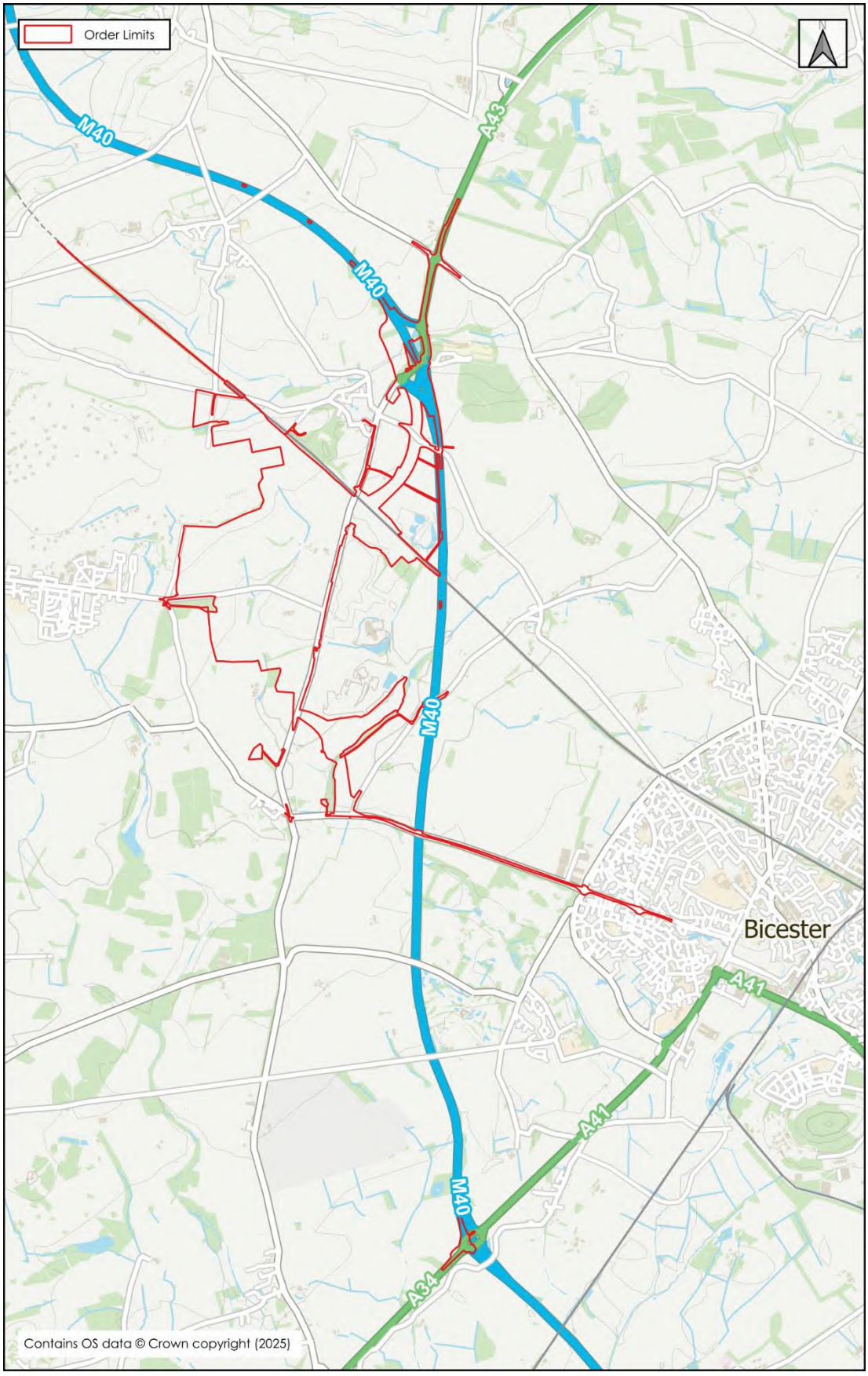


Figure 1.1: Site Location

Local Watercourse Network and Padbury Brook Catchment

1.3 **Figure 1.2** shows the extent of the Padbury Brook to be modelled in this study.

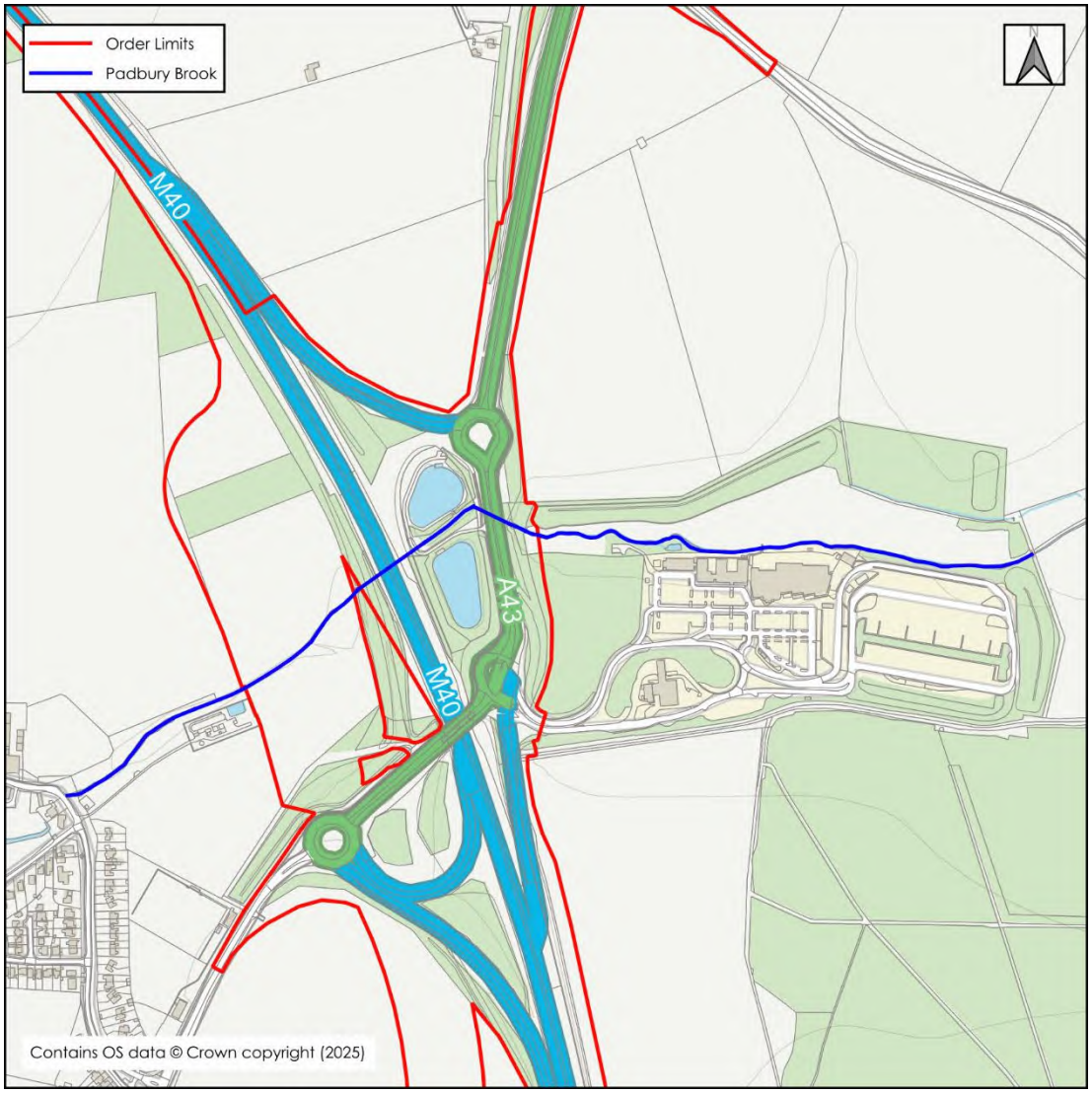


Figure 1.2: Watercourse Network

1.4 The Padbury Brook rises to the west of the Order Limits within agricultural fields, east of Somerton. The watercourse generally flows in an easterly direction where it is culverted beneath the Chiltern Main Line Railway, M40 and A43. The watercourse then continues to flow in an easterly to north-easterly direction to its ultimate confluence with the Great River Ouse, approximately 28km downstream of the Order Limits.

1.5 The upper catchment of the Padbury Brook has elevations of approximately 140mAOD. The watercourse generally flows through wide valley topography with elevations dropping to approximately 108mAOD, downstream of the Cherwell Valley Motorway Service Area. The catchment topography is shown in **Figure 1.3**.

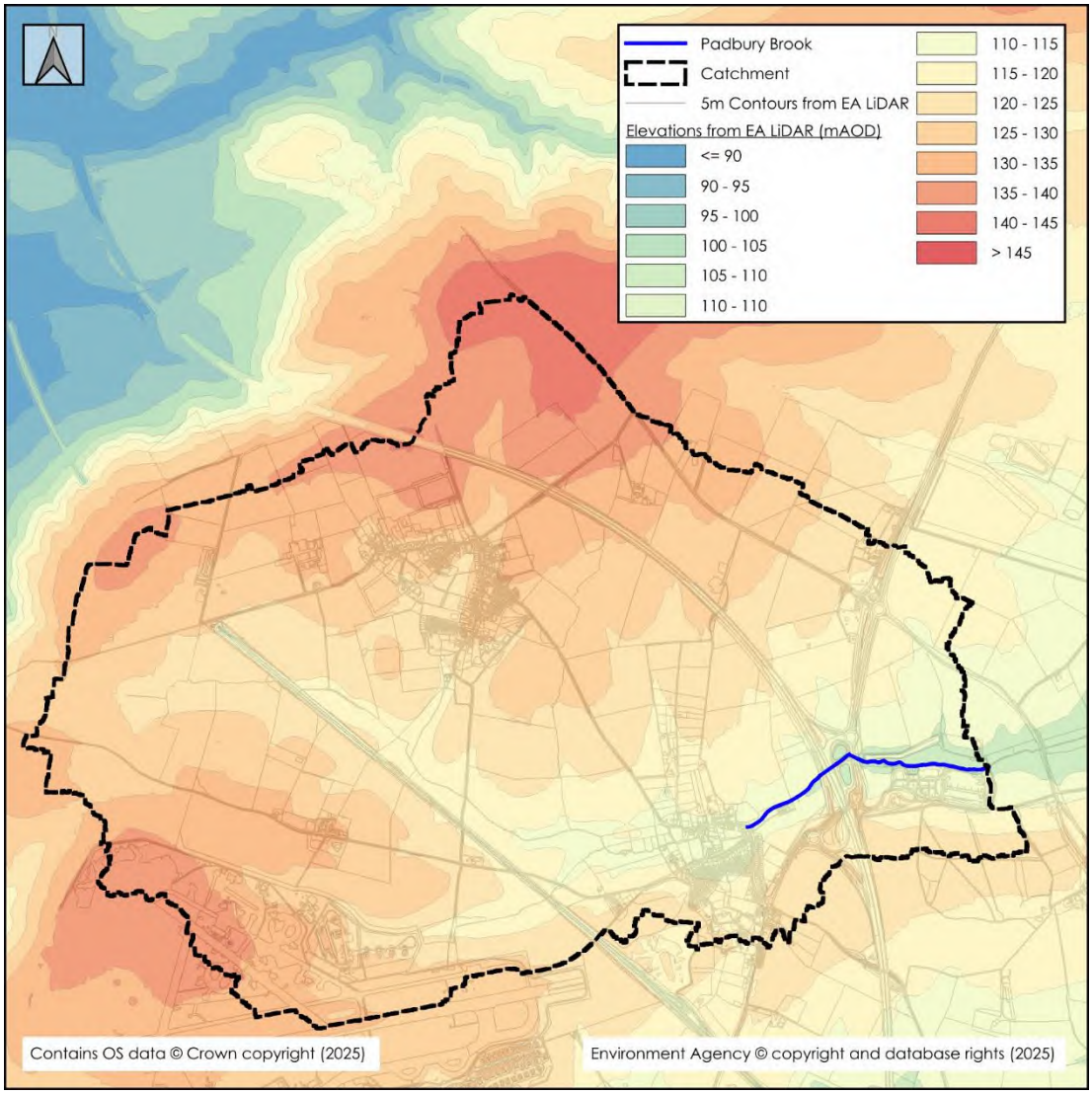


Figure 1.3: Padbury Brook Catchment Topography

Previous Studies & Available Data

Historical Flooding

1.6 A review of the Cherwell Level 1 Strategic Flood Risk Assessment (SFRA)[1], Oxfordshire County Council Preliminary Flood Risk Assessment (PFRA)[2], and Addendum[3], EA recorded flood outlines data, and local news outlets did not return any reports of flooding attributed to the Padbury Brook within the vicinity of the site.

[1] Level 1 Strategic Flood Risk Assessment Update (WHS, November 2022)
[2] Preliminary Flood Risk Assessment (JBA Consulting, June 2011)
[3] Preliminary Flood Risk Assessment Addendum (Oxfordshire County Council, December 2017)

Hydraulic Models

1.7 In 2021 BWB contacted the EA and Oxfordshire County Council, the Lead Local Flood Authority (LLFA), to request any hydraulic model data/files that were held for the area. Both authorities confirmed that they hold no such information at this location.

BWB Site Visit (August 2021)

1.8 A site visit was undertaken by BWB during August 2021 to walk the local watercourse reaches and observe any key features that either needed surveying or needed to be considered during the hydraulic modelling process. The key considerations have been summarised below:

- The Padbury Brook is understood to flow in an easterly direction.
- The watercourse is culverted beneath the M40 motorway and the A43.
- The watercourse runs parallel to the northern extent of the Cherwell Valley Motorway Service Area.

Environment Agency Flood Maps

1.9 Within the Order Limits, the EA Flood Map for Planning shows that upstream of the M40, Flood Zones 2 and 3 exceed the capacity of the channel, expected to be a result of the downstream structure. Between the M40 and A43 the Flood Zones are confined to the channel of the Padbury Brook. The Flood Map for Planning is shown in **Figure 1.4**.

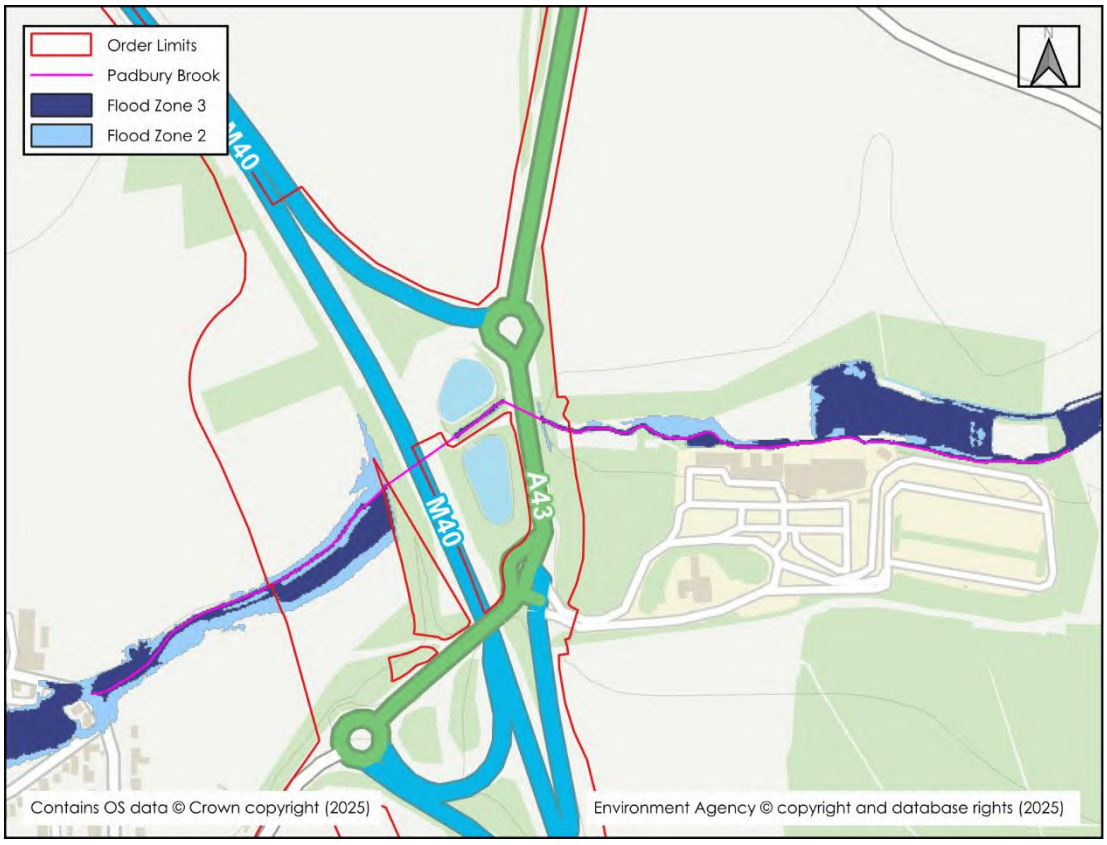


Figure 1.4: EA Flood Map for Planning

Other Sources of Data

1.10 The following additional datasets were used within the hydraulic modelling exercise:

- EA 2022 LiDAR 1m spatial resolution DTM.
- 3D Topographical Survey by Greenhatch Group in July 2022 (drawing reference: 36646_T_REV4).
- Cross-sectional Watercourse Survey, undertaken by BWB Consulting Ltd in October 2021 (included as **Appendix 1**).
- Photographs and observations from site visit undertaken in August 2021 by BWB.
- A hydrological assessment of flood flows undertaken by BWB in May 2025 (included as **Appendix 2**).
- Proposed finished levels surface (model reference: OxSRFI-BWB-HGN-ZZ-M3-CH-0101).

Aims and Objectives.

1.11 This modelling exercise will be used to establish the baseline flood extents and levels within the Order Limits and test development conditions. The following objectives have been identified:

i. Undertake a hydrological review of the Padbury Brook to estimate peak flows and generate flood hydrograph profiles.
ii. Construct a 1D representation of the in-channel environment, including structures, using ESTRY software.
iii. Construct a 2D representation of the floodplain using TULOW software.
iv. Combine and link the 1D and 2D model domains.
v. Undertake simulations of key flood return period events to establish the floodplain extents and peak flood levels within and adjacent to the Order Limits.
vi. Undertake simulations to account for climate change flows within the model.
vii. Undertake simulations of post-development conditions for key flood return period events and compare to baseline conditions.
viii. Undertake sensitivity analysis of post-development conditions.

Approach

1.12 In order to achieve the objectives identified above, a new 1D/2D ESTRY-TUFLOW model was constructed, based on a watercourse survey completed by BWB in October 2021 (reference: OXSRFI-BWB-ZZ-M2-G-0060; see **Appendix 1**).

1.13 The model has been simulated for a series of design storm events. These modelled events include the 1 in 30-year, 1 in 100-year and 1 in 1000-year events that are typically used by the EA to define Flood Zones 3b, 3a and 2 respectively for planning purposes.

1.14 Simulations have been run to account for the impacts of climate change in accordance with the allowances released by the EA[4]. This is necessary to demonstrate that the proposed development can be deemed safe for its lifetime.

Assumptions and Limitations

1.15 Several assumptions were made during the study which may lead to implications on the modelled results. However, the study has been based on the data available at the time of writing. The key assumptions and limitations are as follows:

- The modelling exercise has made use of the available data at the time of construction and simulation. The model represents the floodplain and channel conditions at the time of survey.
- The modelling exercise has made use of the latest hydrological and hydraulic modelling software versions at the time of analysis and completion (the hydrological assessment was completed in May 2025 with the baseline hydraulic modelling completed in May 2025).
- The model contains no formal representation of the conveyance within minor watercourses or ditches other than that captured by the model grid and within the 1D model domain.
- The 2m resolution of the model may negate any small-scale topographic features, although all the significant features are believed to have been captured.
- The floodplain levels are derived from LiDAR which has limited accuracy (+/- 0.15m); however, this is considered to be sufficient for the purpose of this study.
- The bare earth DTM does not include for the presence of walls, buildings or other structures. Buildings have been modelled at ground level with an elevated roughness.
- The modelling exercise has been undertaken to produce a good representation of flood risk mechanisms in and around the study site. It has not been designed to accurately map flooding in the wider catchment.
- Access to the upstream face of the A43 culvert was unavailable at the time of surveying. The cross-section for the channel at this point has been derived from (PB_00864) immediately downstream of the M40 culvert, with appropriate adjustments to levels based on the channel gradient.
- Due to the M40 motorway acting as a topographical barrier and effectively splitting the Padbury Brook catchment, two inflow points have been utilised within the hydraulic model. The inflows used within the hydraulic model use the same hydrograph generated from the hydrological assessment (see **Appendix 2**) but have been pro-rated such that 75% of the hydrograph is applied to the inflow at the upstream extent of the model and the remaining 25% of the hydrograph is applied immediately downstream from the A43, as shown within **Figure 2.1**.
- It is assumed that the proposed culvert under the new slip road will be the same diameter as the existing culvert beneath the M40.

[4] https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow

2. HYDROLOGY

Flood Flow Estimation

2.1 A hydrological review of the catchment was undertaken using Flood Estimation Handbook (FEH) methodologies to estimate peak flood flows and derive an appropriate hydrograph shape. This was undertaken in relation to the EA's latest guidance[5]. This assessment is documented within **Appendix 2**.

2.2 In summary, there were no hydrometric data available in the area to inform the hydrological analysis. Therefore, the industry standard FEH statistical method and Revitalised Flood Hydrograph (ReFH2 Version 4.1) rainfall-runoff model were both reviewed, and a comparative analysis undertaken.

2.3 The FEH statistical method was the chosen method to provide peak flows into the model. This method was chosen as it benefits from an up-to-date peak flood dataset and is the preferred method for groundwater-dominated catchments. ReFH2 was used to provide a hydrograph shape; the hydrographs were subsequently scaled to the statistical peaks.

2.4 ReFH2 was used to provide a hydrograph shape for the model inflows, scaled to the Statistical peak. Flood flow estimates were derived for a range of return period events; the adopted peak flow estimates are provided within **Table 2.1** and the division of flow is shown in **Figure 2.1**.

Table 2.1: Adopted Peak Flood Flows

Return Period Event (Yrs)	Annual Exceedance Probability	Catchment Peak Flow (m^3/s)
1 in 2	50%	0.50
1 in 5	20%	0.70
1 in 10	10%	0.86
1 in 30	3.3%	1.15
1 in 50	2.0%	1.31
1 in 75	1.3%	1.46
1 in 100	1.0%	1.57
1 in 200	0.5%	1.87
1 in 1000	0.1%	2.80

[5] LIT 11832 Flood Estimation Guidelines Version 9, Environment Agency (November 2023)

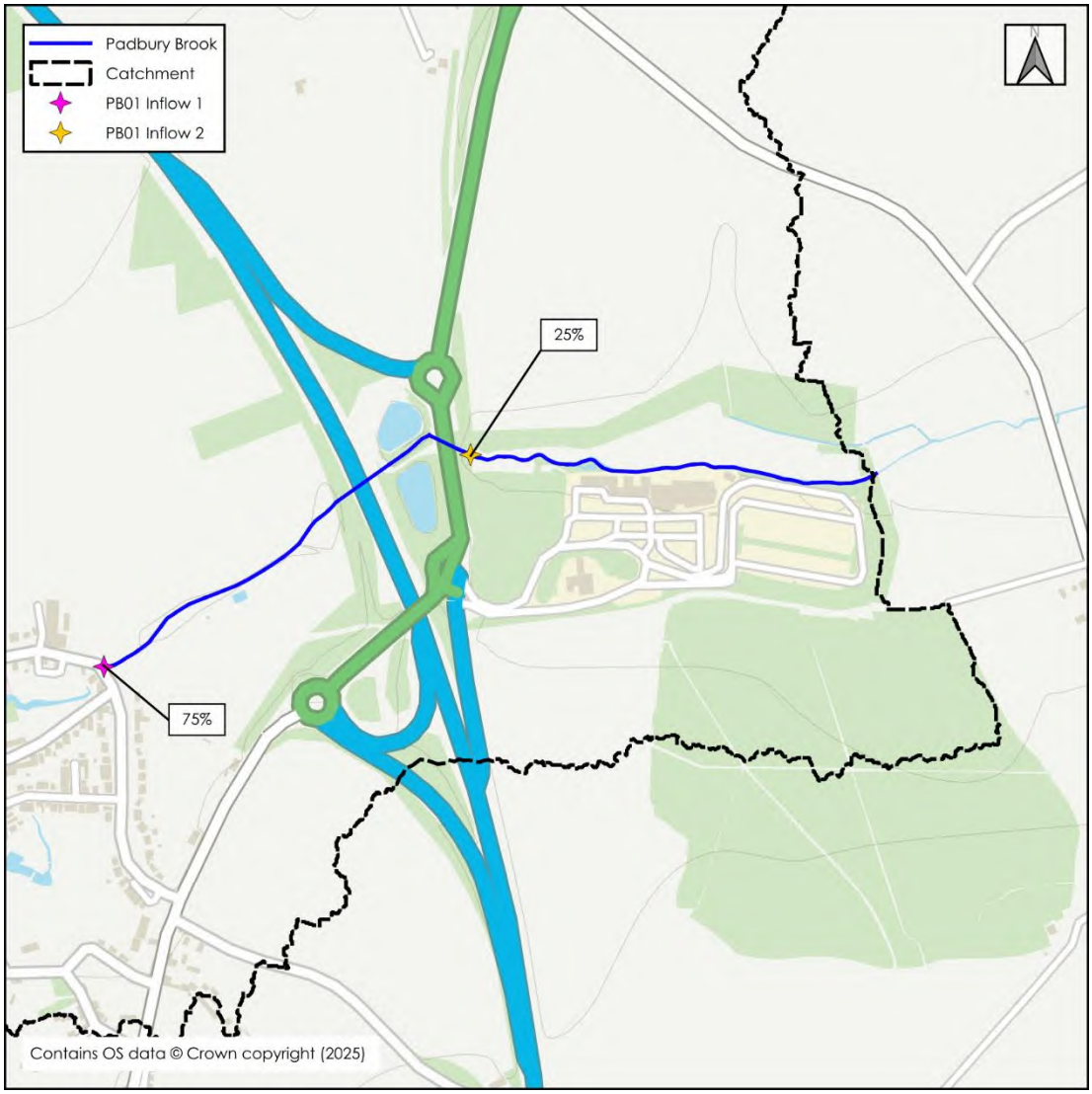


Figure 2.1: Distribution of Model Inflows

Climate Change

2.5 Predicted future change in peak river flows caused by climate change are provided by the EA within their online guidance[6], with a range of projections applied to regionalised 'River Basin Districts'. These districts are further split into 'Management Catchments'. The Padbury Brook falls across two Management Catchments, the Cherwell and Ray and the Upper and Bedford Ouse Management Catchment.

2.6 The Upper and Bedford Ouse Management Catchment has the more conservative peak river flow allowances and so these have been adopted in this assessment. **Table 2.2** identifies the relevant peak river flow allowances.

Table 2.2: Peak River Flow Allowance for the Upper and Bedford Ouse Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	58%
Higher Central	10%	11%	30%
Central	5%	4%	19%

2.7 To estimate the potential future design floodplain under a range of scenarios, the Central, Higher Central and Upper End climate change allowances for the '2080s' will be applied to the 1% AEP flood flows.

[6] Environment Agency, Flood risk assessments: climate change allowances: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1

3. THE HYDRAULIC MODEL

Software and Solver

3.1 TUFLOW version 2025.01.0-iDP was used for all model runs. The model was simulated using TUFLOW's double precision Classic solver. TUFLOW's built in 1D component, ESTRY, was used to model the 1D domain/channel.

The 1D Domain

Extent

3.2 The 1D model domain begins immediately to the east of Fritwell Road. The Padbury Brook channel is represented within the 1D domain until the downstream boundary, which is located adjacent to the north-eastern extents of the Cherwell Valley Motorway Services Heavy Goods Vehicle (HGV) parking area. The extent can be seen in the model schematic illustrated in **Figure 3.1.**

Figure 3.1: Baseline Model Schematic

Channel Geometry

3.3 The river channel geometry is based on a watercourse survey carried out by BWB in October 2021. The survey also captured hydraulic structures that were present, such as bridges and culverts.

3.4 Access to the upstream face of the A43 culvert was unavailable at the time of surveying. The cross-section for the channel at this point has been derived from (PB_00864) immediately downstream of the M40 culvert, with appropriate adjustments to levels based on the channel gradient.

3.5 The maximum distance between cross-sections is 140m. However, sections are more generally spaced 40m to 80m apart. The river channel survey is available as **Appendix 1**.

3.6 The channel sections were truncated at top-of-bank from survey data, at what would be the interface with the 2D domain.

Hydraulic Roughness

3.7 Hydraulic roughness has been represented using the Manning's n coefficient. The values applied are based on those stipulated in the literature, using Chow (1959)[7]. This study documents appropriate values based on channel bed material, sinuosity and presence of vegetation.

3.8 The guideline values are chosen using engineering judgement, based on photographs of the channel condition taken at the time of survey. Each cross-section has a Manning's roughness value applied in the same way as the channel geometry and is read into TUFLOW within a TMF file.

3.9 The Padbury Brook was observed to be free flowing. At the upstream extent of the watercourse, the channel was observed to be clean and straight with no riffles, pools and very light bank vegetation. Towards the middle reach of the watercourse, the channel was observed to be clean, but with winding pools and riffles, and light bank vegetation, increasing to medium bank vegetation towards the downstream extent of the watercourse. As such, a Manning's n coefficient of between 0.035 to 0.05 was deemed suitable to represent in-channel roughness for the majority of the cross-sections.

3.10 The banks and top of banks were, in some instances, lined with long grass and in other instances, bordered by light to medium dense brush and trees. Manning's n coefficient values of between 0.045 to 0.07 were used to represent the varying conditions.

3.11 Some example photos taken from the watercourse survey used to inform the Manning's n coefficient values are highlighted in **Table 3.1** below.

[7] http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

Table 3.1: Manning's n Examples

Model ID	Values chosen and description	Photograph
PB_00440	0.035 Main Channels Clean straight no riffles or pools, very light bank vegetation but some stones and weeds	
PB_01069	0.05 Main Channels Winding with pools and riffles and stones/weeds, medium bank vegetation	
PB_00614	0.045 Floodplain Grass - long	

Model ID	Values chosen and description	Photograph
PB_01369	0.07 Floodplain Brush – medium density	

Hydraulic Structures

3.12 A number of hydraulic structures were represented in the 1D domain, the data for which was collected during the watercourse survey.

3.13 In total, three bridges and two culverts were included in the baseline model. Weirs were also added to the bridges where the length was appropriate to be modelled in the 1D domain. These weirs act as spills, that allow water to spill over the deck level of the structure when the water levels are high enough. The details of the modelled structures are included as **Appendix 3**.

Boundary Conditions

3.14 Boundary conditions were applied to the 1D domain to both allow flow in and out of the model.

3.15 QT (flow vs time) boundaries were used to represent the fluvial inflows (**Section 2**) as hydrographs. These consisted of point inflows at the upstream extents of the watercourse (75%) and immediately downstream of the M40 motorway culvert (25%). **Figure 2.1** shows where these boundaries were applied.

3.16 A HT (water level vs time) boundary was applied at the downstream limit of the 1D domain. This was set to 107.01m AOD, which is set 300mm below the top of bank at the downstream cross-section (PB_00000). Sensitivity testing has been undertaken on this boundary and is discussed further in **Section 6**.

Initial Conditions

3.17 Initial conditions have been applied at each cross-sections to the model through initial water levels informed by the river channel survey is available as **Appendix 1**. Where

cross-sections were interpolated the initial water levels have been interpolated with the same approach.

1D/2D Links

3.18 The 1D channel was linked to the floodplain using "HX" links. These transfer the calculated water level from the 1D cross-sections into the 2D floodplain, providing that the water level is above the level of the cell that the "HX" link is located in. Therefore, "HX" links should be digitised along the top of bank of the watercourse visible in LiDAR data or along the crest of any embankments if present.

3.19 The average modelled width of the channel was approximately 7 to 9m along the modelled extent of the Padbury Brook.

The 2D Model Domain

Extent and Active Area

3.20 The main influence on the 2D domain extent is generally the expected width of the floodplain, meaning that it should be large enough to allow for flows to be routed through the floodplain where necessary and so that no "glass walling" occurs within the model domain.

3.21 The river channel was deactivated to ensure that it was modelled in the 1D domain. This deactivated area may appear fragmented in places where the deck of a structure is modelled in the 2D domain. The active area is displayed in **Figure 3.1.**

Grid Size and Orientation

3.22 The grid cell size should be chosen in order to sufficiently represent the average width of the modelled channel and its ability to capture key floodplain topographic features.

3.23 The selected grid size of 2m provides a high enough resolution to capture the capacity of the channel (7m to 9m width = 2 to 4 number of 2m cells) as well as provide appropriate representation of key floodplain features.

3.24 The orientation of the grid is important for flow routing as flow cannot pass to the neighbouring cell via its corner, only via the cell sides. Therefore, the location line (2d_loc) was drawn to orientate the grid in the predominant direction of flow.

Floodplain Roughness

3.25 Floodplain roughness is defined by the Manning's n coefficient, as per the 1D domain. However, the method in which it is applied differs.

3.26 Roughness has been applied by polygons using land use types as defined by OS Master Map data. These are linked to a coefficient listed in a TUFLOW Materials File (TMF).

3.27 The values applied for different land use types are listed in **Table 3.2**.

Table 3.2: Floodplain Roughness Values

Land Use Type	Manning's n Coefficient
Long grass	0.035
Short grass	0.030
Roads	0.025 - 0.030
Woodland	0.080
Buildings	0.500

Floodplain Topography and Amendments

3.28 The general floodplain topography is based on the topographical survey (where available) and the latest available EA LiDAR data, which was downloaded from the DEFRA Open Survey website at a 1m resolution.

3.29 The following amendments to the base topography were made:

- River bank levels were reinforced through the use of a 'THICK' Z-Line. Bank elevations were provided at 5m intervals along the Z-Line. The levels were informed by surveyed cross-section data, topographical survey and LiDAR data (where survey data is unavailable).

Floodplain Structures

3.30 There were no floodplain structures within the model. All hydraulic structures were in line with the channel and hence modelled in the 1D domain.

Boundary Conditions

3.31 Boundary conditions within the 2D domain are often used to prevent "glass walling" at the downstream end of the model through use of a "HQ" boundary. This is a flow vs stage relationship automatically defined in TUFLOW when the user inputs a slope value, to allow water to flow out of the model.

3.32 A "HQ" boundary was applied to the downstream extent of the model to allow water to flow out of the model. The slope in the "HQ" boundary was calculated by assessing the fall in floodplain levels on both banks using EA LiDAR. The fall in levels was divided by the distance measured over to determine a slope value.

Initial Water Levels

3.33 No initial water levels have been applied to the hydraulic model within the 2D Domain.

Calibration/Verification

3.34 A lack of detailed flow or level data for the catchment meant that there was limited opportunity to calibrate the model.

3.35 Due to the lack of documentation on previous historical instances of flooding, the model cannot be verified against historical events. A conservative approach adopted to the model build mitigates this. A high level comparison has been undertaken against the EA Flood Zones.

Stability, Warnings and Messages

3.36 TUFLOW has a number of indicators available to assess the stability of a model. These differ slightly between the Classic and HPC solver. The following indicators were checked to ensure the model was performing as expected:

- **Stage and flow time series** – A number of spot checks should be completed to ensure that conveyance through the channel is as expected and that both the stage and flow time series are reasonably smooth, particularly around the study area.
- **1D negative depths** – Significant negative depths indicate that instabilities are present.
- **CME** – A value of +/-2% is considered acceptable.
- **Velocities** – Unusually high velocities or circulating vectors are usually a sign of instabilities.

3.37 The time series graphs were reviewed along the modelled reaches. The river channel stages were shown to peak approximately 13 hours into the event. Some 'spikes' in flows were present in the model; however, these did not affect the peak. The stage time series were considered to be relatively smooth overall and the long profiles were sense checked to ensure the results were representative.

3.38 CME has been reviewed for all events and is illustrated for the duration of each simulation in **Figure 3.2**. The 1 in 30-year and 1 in 100-year simulations are shown to have peak CME values outside of the tolerance stated above. However, upon review, the higher values occur relatively early on in the model simulation (at around 2 hours) and return to acceptable values quickly. Therefore, the peak CME values outside of the acceptable range are not considered to affect the peak flood flows at approximately 13 hours into the simulation and are not expected to impact the results. Values for the remaining events remain within acceptable limits for the full duration of the simulations.

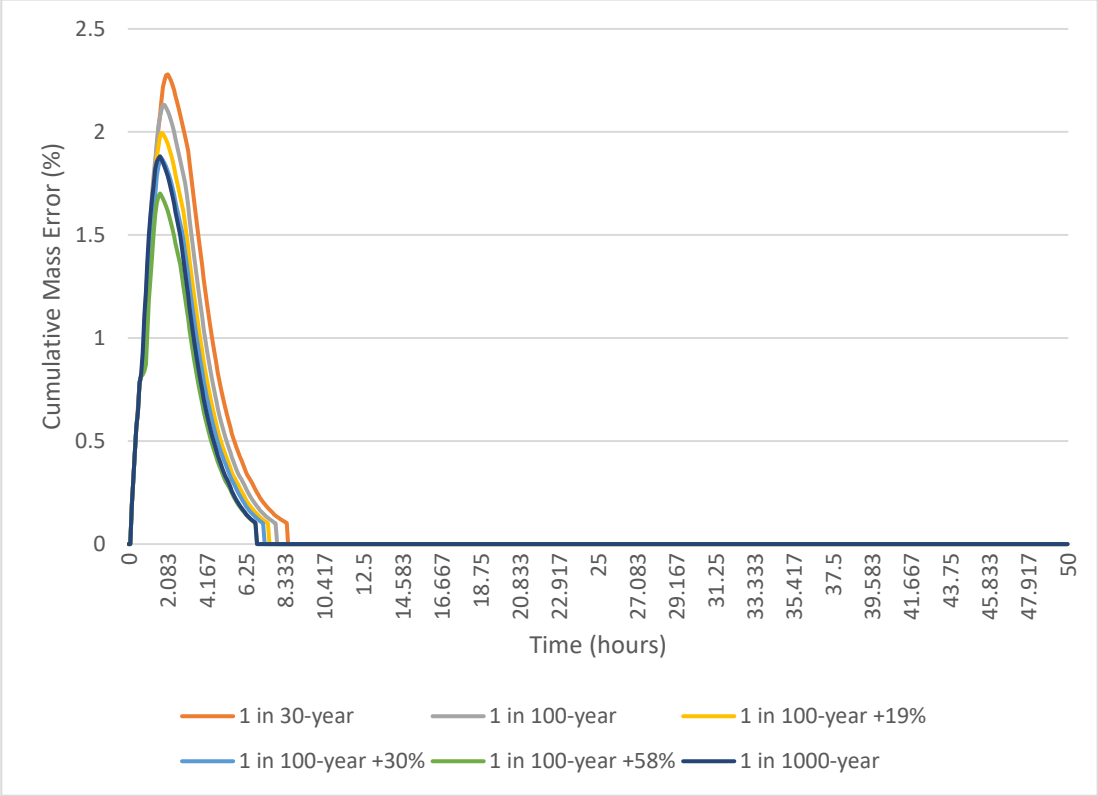


Figure 3.2: Cumulative Mass Error

3.39 No 1D or 2D negative depths were reported during all simulations.

3.40 The remaining indicators highlighted above were considered acceptable.

3.41 There were a maximum of 15 warnings recorded prior to the simulation in all modelled events. The warnings produced by the hydraulic model prior to the simulation, are outlined below:

- 'Warning 2073' message relate to null shape objects. These are not expected to have an impact on the model results.
- 'Warning 1191' messages relate to initial water levels points not being snapped; however, a review of the long profile results show that the initial water levels are still applied and, therefore, this was not expected to impact on the model results.

3.42 No warnings are reported during any of the simulations.

Model Runs

3.43 In order to achieve the study objectives, the simulations summarised in **Table 3.3** were completed.

Table 3.3: Model Runs

Model Geometry	Return Periods	Comments
Baseline	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year+19%CC 1 in 100-Year+30%CC 1 in 100-Year+58%CC	Representative of 'as surveyed' conditions.
Proposed	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year+19%CC 1 in 100-Year+30%CC 1 in 100-Year+58%CC	Representative of 'post-development' conditions
Roughness + 20%	1 in 100-Year	Floodplain, channel and structure roughness increased by 20%
Roughness - 20%	1 in 100-Year	Floodplain, channel and structure roughness decreased by 20%
Downstream Boundary -	1 in 100-Year	20% decrease of gradient at downstream boundary and 20% increase in water depth at downstream boundary
Blockage 1 (PB_PROP_1104)	1 in 100-Year	50% blockage of culvert

4. BASELINE RESULTS

4.1 Mapping of the existing conditions is included within **Appendix 4** and summarised below. The flood mechanisms are discussed further within the forthcoming section. The floodplain extents are shown in **Figure 4.1**, with modelled flood levels within the Order Limits outlined within **Table 4.1**.

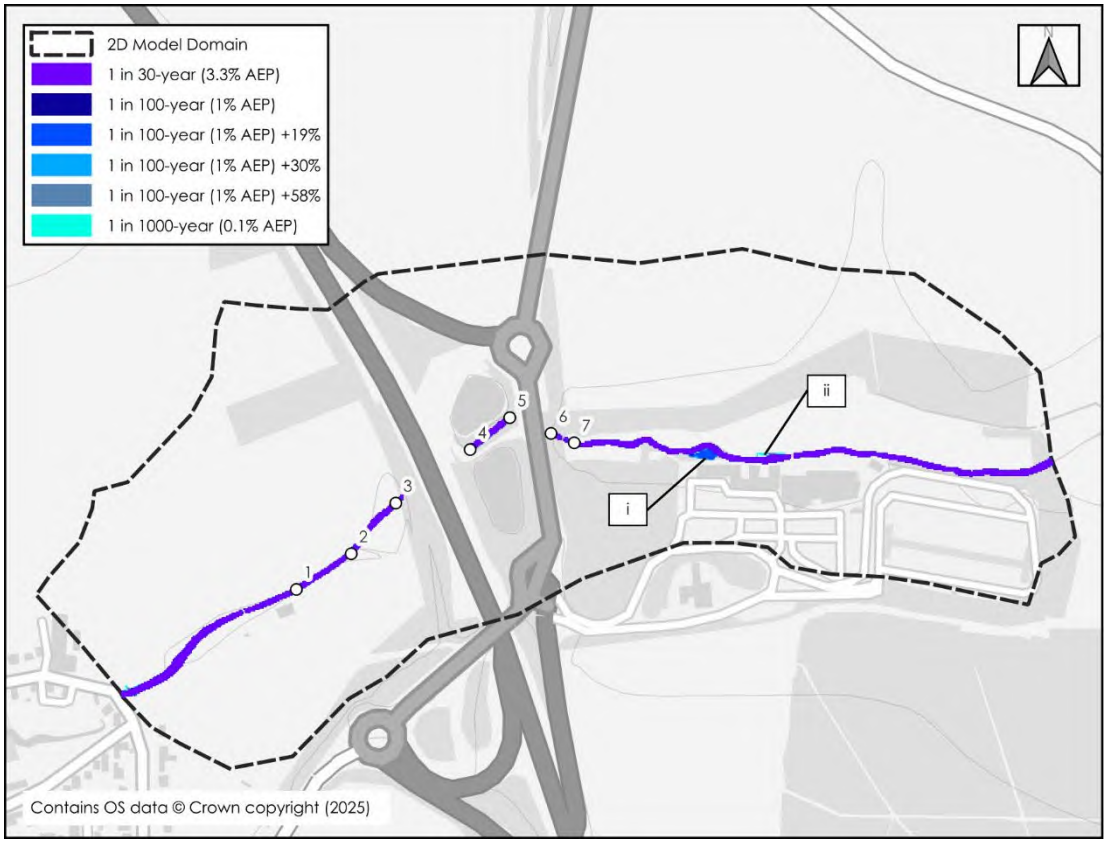


Figure 4.1: Baseline Fluvial Flood Extents

Table 4.1: Baseline Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%CC	1 in 100-Year + 30%CC	1 in 100-Year + 58%CC	1 in 1000-Year
1	109.70	109.79	109.84	109.87	109.94	109.98
2	109.58	109.65	109.69	109.71	109.76	109.80
3	109.27	109.33	109.37	109.40	109.46	109.52
4	108.78	108.89	108.95	108.99	109.07	109.13
5	108.71	108.82	108.89	108.93	109.02	109.07
6	108.69	108.80	108.87	108.90	108.98	109.04
7	108.66	108.77	108.84	108.87	108.95	109.00

4.2 The Padbury Brook is shown to remain in channel for modelled events up to and including the 1 in 100-year event.

4.3 From the 1 in 100-year +19% climate change event, flows overtop the right bank of Padbury Brook, where bank levels are lower; this results in a small area of floodplain within an existing pond to the north of the services (see location 'i' on **Figure 4.1**).

4.4 From the 1 in 1000-year event, flows overtop the left bank of the watercourse, forming a small area of floodplain immediately adjacent to the channel (see location 'ii' on **Figure 4.1**).

4.5 Within the Order Limits flows are shown to be confined to the channel of the Padbury Brook in all modelled event.

4.6 The modelled outputs show a reduction in flood extents in comparison to the EA Flood Zones. This is considered to be as a result of improved channel representation within the hydraulic model providing more accurate channel geometry and capacity.

5. PROPOSED DEVELOPMENT MODELLING

Philosophy

5.1 The development comprises the construction of a SRFI which includes the construction of several warehouses, a new slip road off the M40 motorway, and an intermodal rail terminal with a new track that connects to the existing railway.

5.2 The new slip road from the M40 will cross the Padbury Brook. An earthworks exercise has been undertaken to determine the extent and proposed levels of the crossing. A reach of the Padbury Brook is to be culverted to facilitate this slip road.

Representation in Hydraulic Model

5.3 The baseline hydraulic model was updated to include the proposed development levels. The proposed levels were added to the hydraulic model as a DTM and enforced along its reach using a 2D Z-Shape.

5.4 The Padbury Brook is proposed to be culverted beneath the new slip road. It is assumed that the culvert will be the same diameter as the existing culvert beneath the M40, downstream from the proposed slip road.

5.5 Cross-sections for the upstream and downstream faces of the proposed culvert have been derived from the nearby upstream face of the M40 culvert (PB_00974). Channel levels have been interpolated based on the channel gradient between the surveyed cross-sections along this reach.

5.6 Floodplain roughness was amended in this area to represent the proposed land use of the slip road.

5.7 No further changes were made to the existing model. A model schematic is illustrated in **Figure 5.1**.

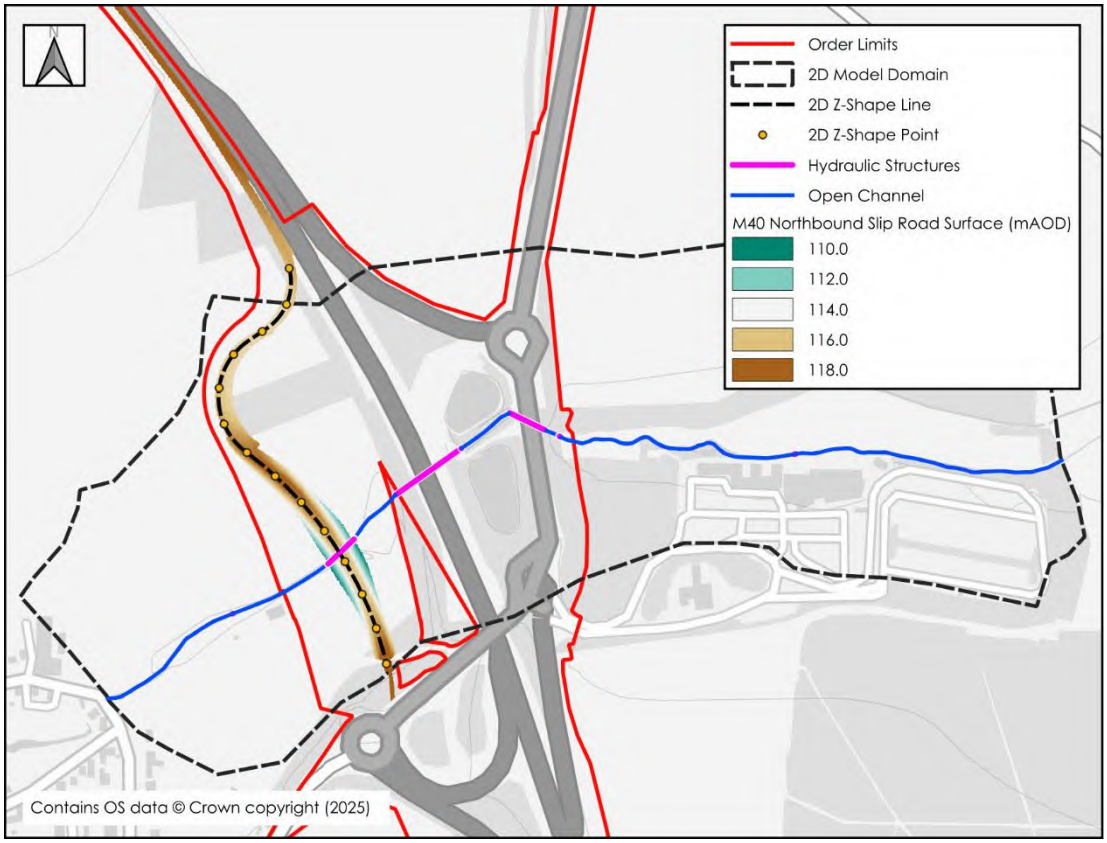


Figure 5.1: Proposed Model Schematic

Stability, Warnings and Messages

5.8 The indicators for assessing stability outlined in **Section 3** have been reviewed for all proposed development simulations. Any differences from the baseline simulations are outlined below:

- The peak CME for the 1 in 100-year event is within the tolerance range for the entire simulation.
- One new warning is reported prior to the simulation, 'Warning 1100', which relates to the invert of the proposed culvert being below the bed of the channel; however, this is considered to be acceptable and by design to provide a soft bed on the proposed culvert.

Model Results

5.9 Mapping of the proposed development conditions is included within **Appendix 5** and summarised below. The floodplain extents at the Order Limits are shown in **Figure 5.2**, with modelled flood levels within the Order Limits outlined within **Table 5.1**.

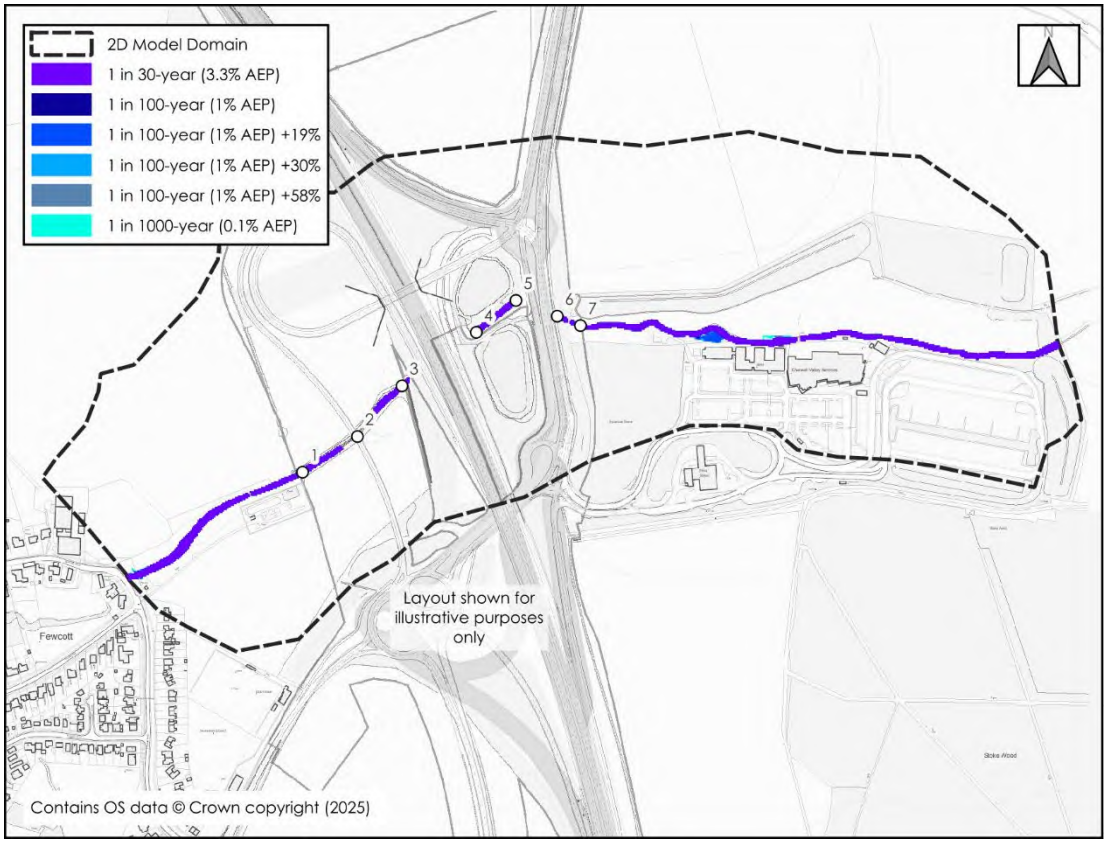


Figure 5.2: Proposed Development Floodplain Extents

Table 5.1: Proposed Development Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%CC	1 in 100-Year + 30%CC	1 in 100-Year + 58%CC	1 in 1000-Year
1	109.61	109.69	109.74	109.77	109.84	109.89
2	Node located in place of proposed culvert.					
3	109.24	109.32	109.37	109.40	109.46	109.51
4	108.85	108.93	108.98	109.00	109.09	109.15
5	108.80	108.88	108.92	108.95	109.03	109.10
6	108.69	108.80	108.87	108.90	108.98	109.04
7	108.66	108.77	108.84	108.87	108.95	109.00

5.10 The results show that under the proposed development conditions, flows remain in channel for all modelled events. The proposed culvert has been reviewed and demonstrates a minimum 300mm freeboard in all events up to and including the 1 in 1000-year event.

Impact Analysis

5.11 The proposed development modelled peak flood levels have been compared to the equivalent baseline peak flood levels to establish off site impacts. Mapping for all events is included in **Appendix 6**; the comparison mapping for the design event (1 in 100-year +19% climate change event) is illustrated in **Figure 5.3** and discussed below.

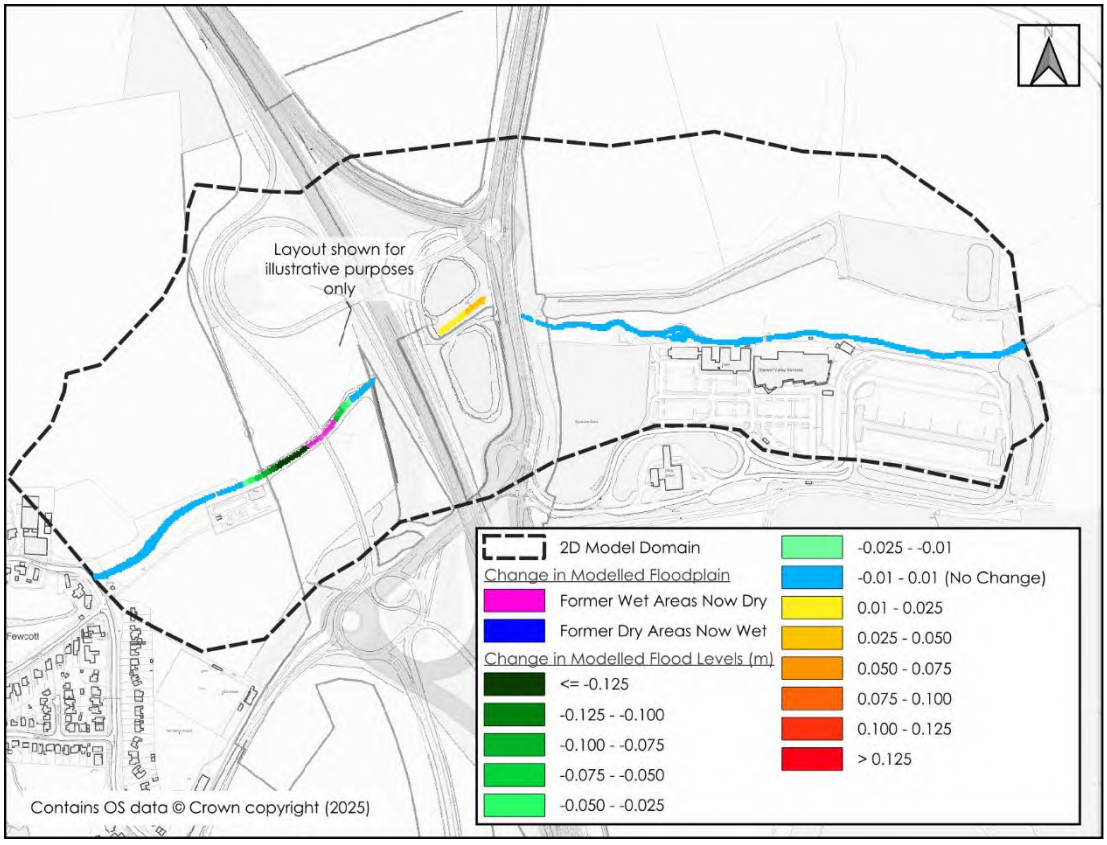


Figure 5.3: Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 19% Climate Change

5.12 The mapping shows that the proposed slip road culvert results in no detriment downstream in all modelled flood events. During the 1 in 100-year + 19% climate change design event, flood levels upstream and immediately downstream of the proposed slip road culvert are shown to decrease by up to 80mm within the Order Limits. There is shown to be a minor increase in levels downstream between the M40 and A43; however, this is within the Order Limits and flows are shown to still remain in channel, with no additional floodplain extents.

6. SENSITIVITY TESTING

6.1 To account for seasonal variations in vegetation, test the blockage of proposed structures and to ensure the robustness of boundary conditions, a series of sensitivity tests were conducted using the proposed scenario 1 in 100-year flood return period event. Comparison mappings for the sensitivity tests are included in **Appendix 7**.

Flow Estimates

6.2 As climate change allowances have been assessed, it was not considered necessary to test further variations on the predicted flood flows.

Roughness

6.3 The modelled roughness coefficients were determined from aerial imagery, site photographs and OS mapping. Increasing and decreasing the roughness values in the channel and at structures, as well as in the floodplain, tests how seasonal variation and maintenance regimes may affect the flood risk posed to the proposed development.

6.4 A 20% increase in Manning's n roughness coefficient, representative of a period without maintenance, shows an increase in peak flood levels of up to 60mm. There is a minor increase in floodplain north of the motorway services where flows were predicted to spill into the existing pond, similar to events in excess of the 1 in 100-year +19% climate change. This is to be expected as an increase in roughness values across the floodplain would be associated with greater frictional forces against the flow of water. There is no increase in floodplain extent within the Order Limits.

6.5 A 20% decrease in Manning's n roughness coefficient, representative of a period with maintenance generally leads to reduced peak flood levels within the channel of the Padbury Brook. Within the Order Limits, peak flood levels are expected to decrease by up to 80mm compared to the equivalent proposed development scenario. This is to be expected, as the reduced roughness will increase conveyance through the floodplain and culverts, allowing water to flow more freely through the system.

6.6 These results show that the model results are not significantly sensitive to changes in roughness. There is potential for seasonal variations in vegetation and maintenance periods to alter the peak flood levels within the channel; however, there is negligible impact on any flood extents.

Downstream Boundary

6.7 To test the implications on variations in the downstream boundary parameters, a sensitivity test has been undertaken increasing the 1D HT boundary by 300mm to bank full. It was not necessary to test the 2D boundary parameters as flows remain in channel in all events.

6.8 The results show that these changes result in an increase of in-channel levels by up to 280mm which propagates approximately 240m upstream. There is no change in in-channel water levels within the Order Limits. The results show the model is not sensitive

to changes to the downstream boundary and also provides confidence in its parameters and location.

6.9 It was not considered necessary to test a reduction of the 1D HT boundary as this would only result in betterment of in-channel levels.

Blockage Scenarios

6.10 Blockage testing was undertaken on the proposed culvert to assess the robustness of its design parameters.

6.11 Smaller culverts are more at risk of a significant blockage due to their limited capacity to convey flows and debris, whereas large culverts are less at risk. Therefore, the magnitude of the tested blockage was determined by the size of the culvert, as shown in **Table 6.1**.

Table 6.1: Sensitivity Test Blockage Percentages

Culvert Diameter (m)	Blockage Applied
< 0.5	100%
0.5 – 1.0	75%
1.0 – 1.5	50%
1.5 >	25%

6.12 In line with the above, a 50% blockage has been applied to the twin 1.5m diameter culvert. In the blockage scenario, the flood levels upstream of the culvert are predicted to increase by up to 40mm. During this scenario, flood extents are predicted to remain in channel. It is therefore, expected that blockage of the culvert will bot significantly affect flood levels and extents within the Order Limits; however, it is recommended that the proposed culvert should be regularly maintained to ensure it remains free of blockages.

7. SUMMARY & RECOMMENDATIONS

7.1 Please note that this conclusion should be read in conjunction with the study limitations and assumptions in **Section 1**.

7.2 BWB has been commissioned by Oxfordshire Railfreight Limited to undertake a site-specific hydraulic modelling exercise of the Padbury Brook to support the development of the Oxfordshire SRFI.

7.3 The modelled flood flows have been informed by a hydrological review of the catchment associated with the Padbury Brook. The latest climate change allowances have been incorporated into the hydrological assessment.

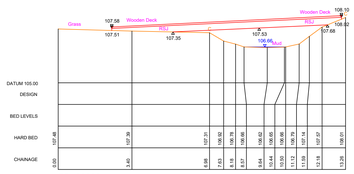
7.4 The baseline results show water to largely remain in channel within the Order Limits, with the exception of a small area of ponding adjacent to the Cherwell Valley Motorway Service Area downstream of the site during the 1 in 100-year +19% climate change and above return periods.

7.5 The proposed model results show that the proposed slip road culvert results in no detriment downstream of the site in all modelled flood events. The proposed culvert also demonstrates a minimum 300mm freeboard in all events up to and including the 1 in 1000-year event.

7.6 Sensitivity testing has shown the model to be robust with respect to changes in seasonal variations in vegetation, blockage of the proposed structure and robustness of boundary conditions.

APPENDICES

Appendix 1: River Channel Survey



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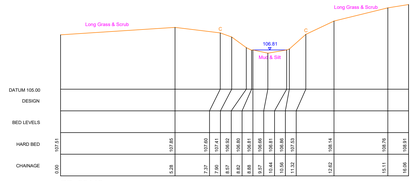
455496.20Em 228291.62Nm BEARING 161Dgr
0.014 M
Footbridge



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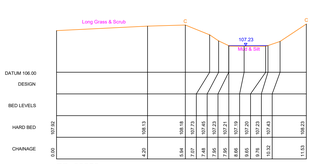

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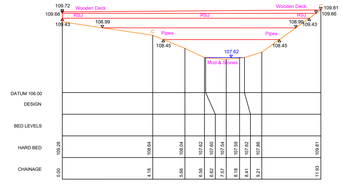

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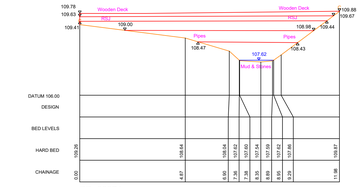

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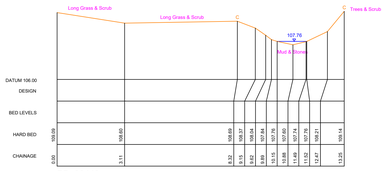

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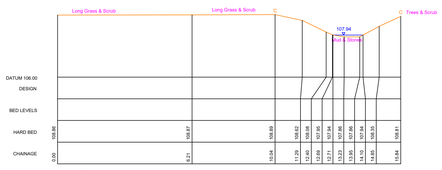

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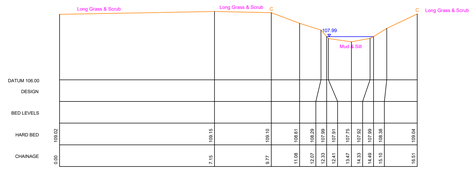

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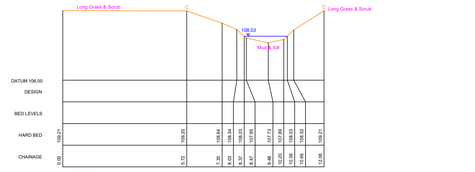

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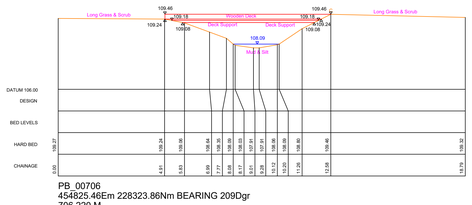

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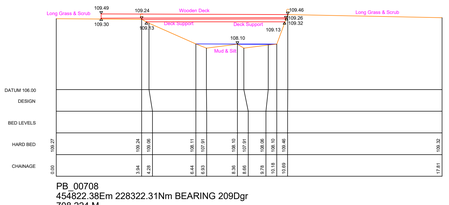

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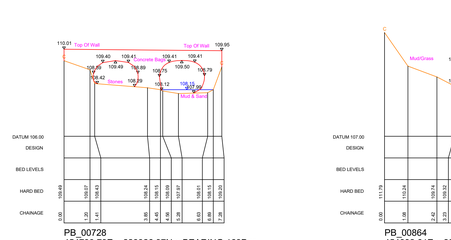

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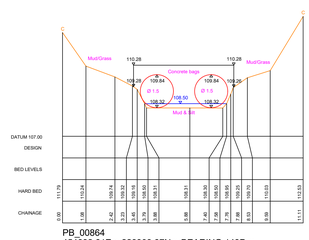

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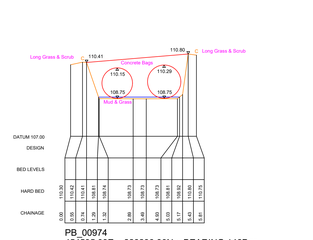

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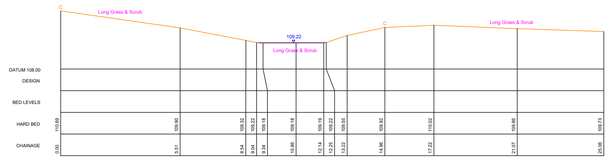

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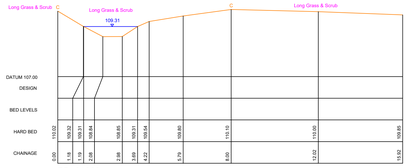

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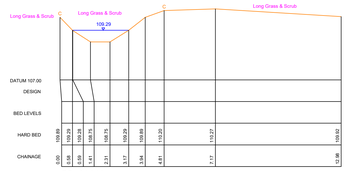

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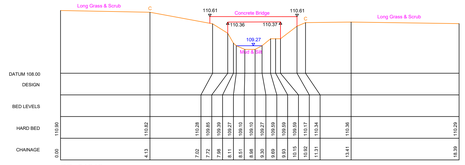

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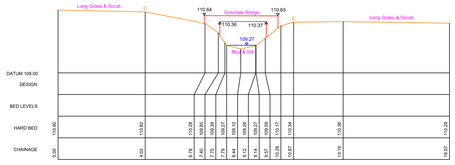

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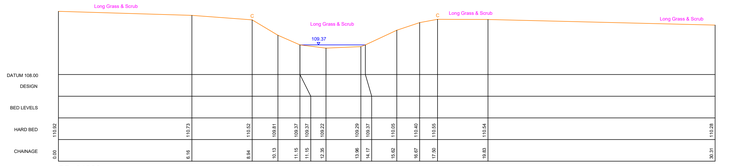

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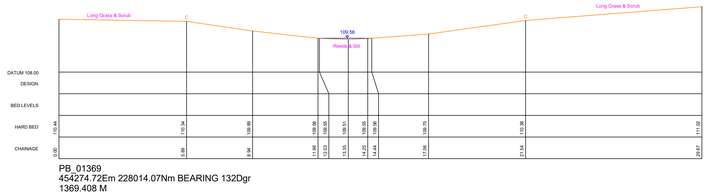

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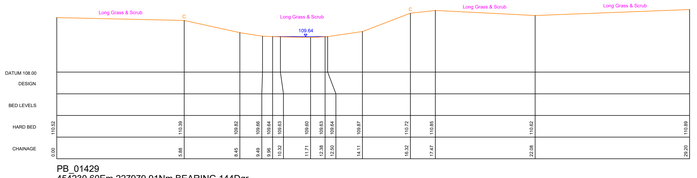

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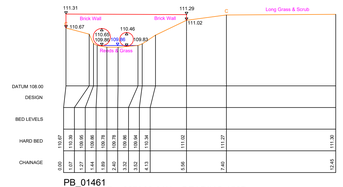

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Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are constructed by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Call Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY PADBURY BROOK TRIBUTARY SHEET 9 OF 13

Drawn:	I.Riley	Reviewed:	D.Smith		
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-09-ZZ-M2-G-0060	**S2**	**P1**

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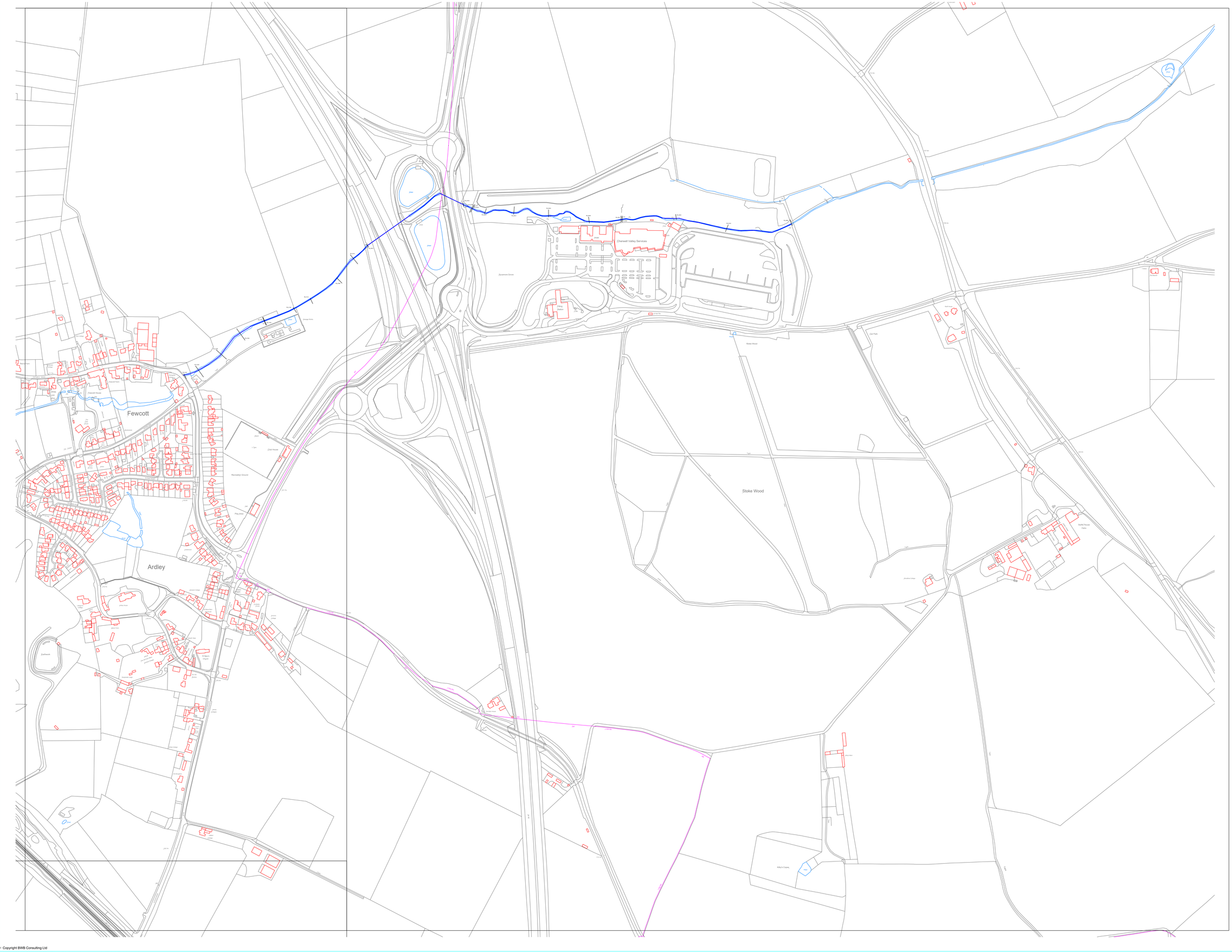
Fewcott
Ardley
Stoke Wood
Cherwell Valley Services
Hotel
Filling Station
Jctn
Fewcott House
French Farm
Club House
Recreation Ground
Play Area
Pond
Sewage Works
Earthwork
Ardley Fields
Ardley Cottage
Ardley Wood
Ardley Lodge
Ardley Grange
Ardley Manor
Ardley House
Ardley Hill
Ardley Hill Farm
Oil Park
Stoke Wood
Stoke Wood Farm
Stoke Wood Cottage
Stoke Wood Lodge
Stoke Wood Farm
Stoke Wood Cottages

Appendix 2: Hydrological Assessment

A CAF GROUP COMPANY

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Oxfordshire RFI
Oxfordshire
Flow Estimation Record

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August 2025

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Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	21/08/25	S2	Preliminary Issue	CC	CG	MD

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(ii) The date on which the final report is delivered

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All Environment Agency mapping data used under special license. Data is current as of August 2025 is subject to change.

The information presented, and conclusions drawn, are based on statistical data and are for guidance purposes only. The study provides no guarantee against flooding of the study site or elsewhere, nor of the absolute accuracy of water levels, flow rates and associated probabilities.

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1. METHOD STATEMENT

Overview of Requirements

1.1 Flow estimates are required for input into a hydraulic model of the Padbury Brook, to support to support a Development Consent Order (DCO) application for a Strategic Rail Freight Interchange (SRFI) in Oxfordshire.

1.2 The Padbury Brook flows through the Order Limits in an easterly direction. The location of the site of interest and the watercourses to be modelled are provided in **Figure 1.1.**

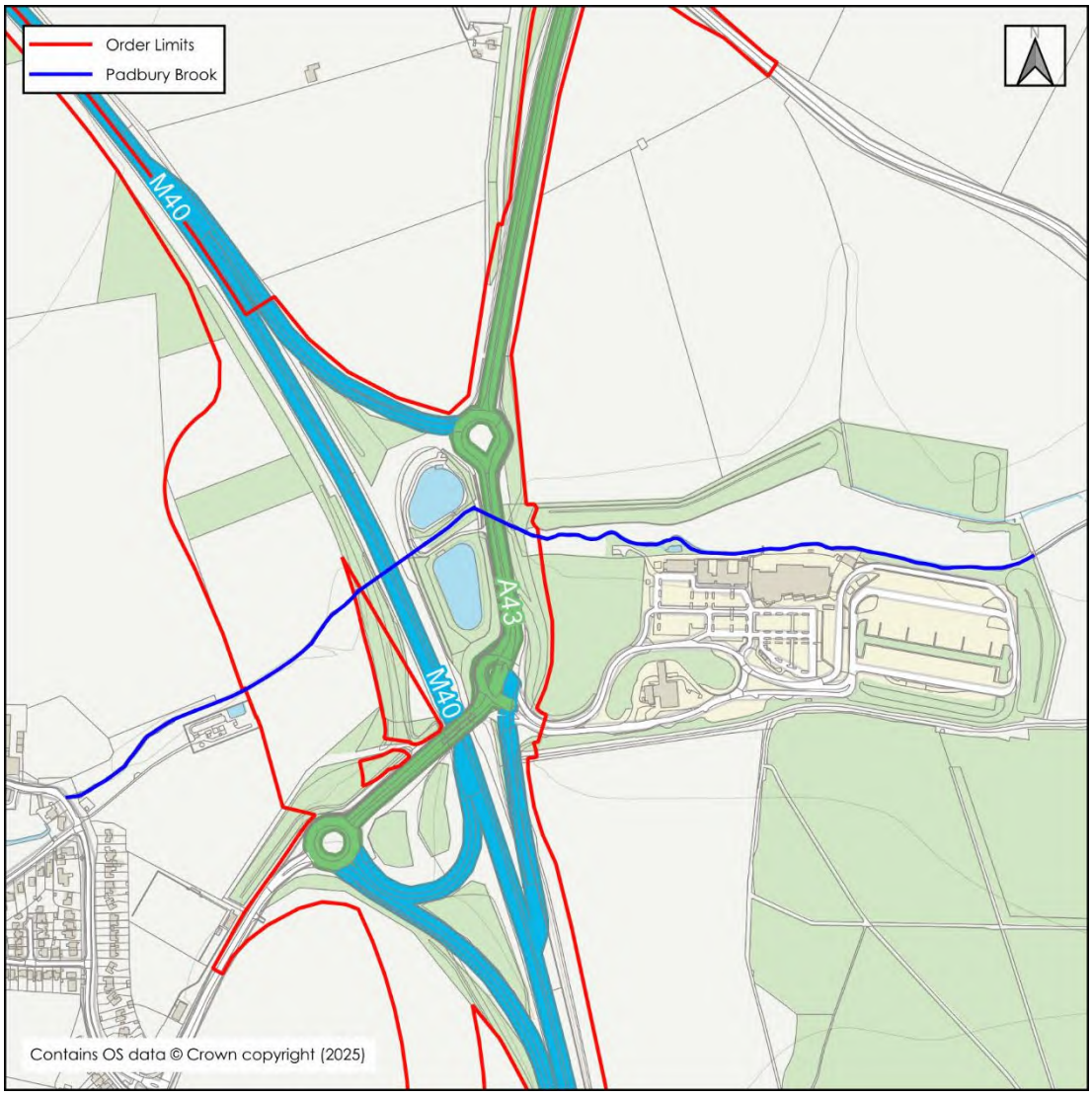

Figure 1.1: Site Location Plan

1.3 Return periods to be assessed include: 2, 5, 10, 30, 50, 75, 100, 200 and 1000-years. To inform the design event and potential future floodplain, the 1 in 100-year event with a range of climate change allowances applied will also be simulated. Hydrographs are required as well as peak flows.

1.4 The Client's agreed project scope does not include for detailed gauging station data quality review, rating reviews or updates, detailed flood history review or ReFH model parameter estimation.

1.5 The hydrological assessment was undertaken in May 2025. The Environment Agency (EA) Flood Estimation Guidelines[1] and River Modelling: Technical Standards and Assessment Guidance (Estimate Flood Flow from rainfall and river flow data)[2] were referred to throughout the hydrological analysis.

Study Complexity

Table 1.1: Study Complexity

Complexity	Category for this Study
Simple	☐
Moderate	✓
Difficult	☐
Very Difficult	☐

Catchment Description

1.6 The Padbury Brook rises to the west of the Order Limits within agricultural fields, east of Somerton. The watercourse generally flows in an easterly direction where it is culverted notably beneath the Chiltern Main Line Railway, M40 and A43. The watercourse then continues to flow in an easterly to north-easterly direction to its ultimate confluence with the Great River Ouse approximately 28km downstream of the Order Limits.

1.7 The upper catchment of the Padbury Brook has elevations of approximately 140m Above Ordnance Datum (AOD). The watercourse generally flows through wide valley topography with elevations dropping to approximately 108m AOD downstream of Cherwell Valley services. The catchment topography is shown in **Figure 1.2**.

[1] LIT 11832 Flood Estimation Guidelines Version 9, Environment Agency (November 2023)
[2] River Modelling: technical standards and assessment (estimate flood flow from rainfall and ricer flow data, Environment Agency (December 2023)

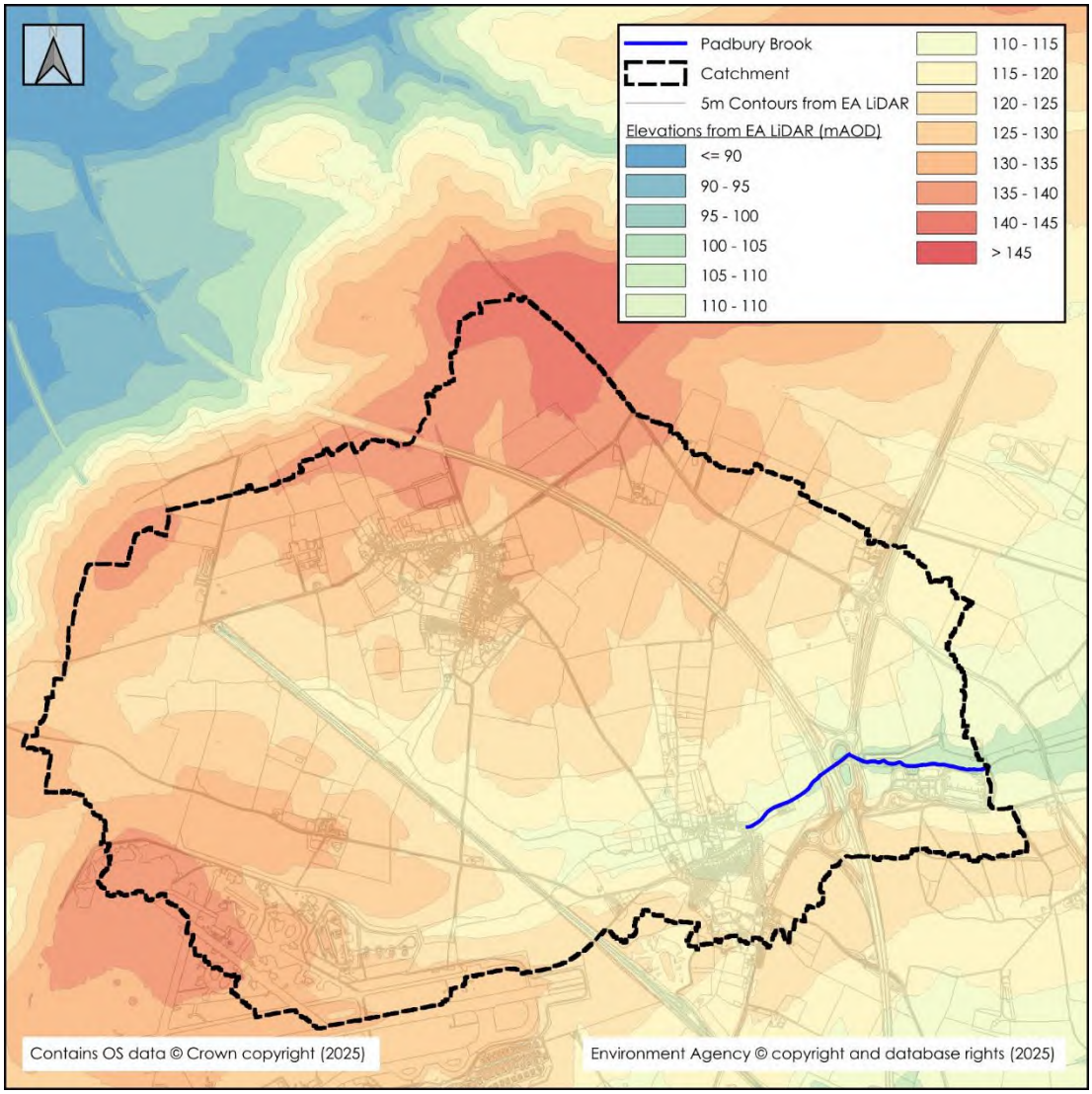

Figure 1.2: Catchment Topography

1.8 British Geological Survey (BGS) mapping indicate that the catchment is predominantly underlain by White Limestone Formation (Limestone). The following bedrock is also present within the catchment:

- Forest Marble Formation (Limestone);
- Bladon Member (Mudstone and Limestone Interbedded);
- Rutland Formation (Mudstone); and
- Horsehay Sand Formation (Sandstone).

1.9 Superficial deposits of Alluvium (Clay, Silt, Sand and Gravel) and Head (Clay, Silt, Sand and Gravel) are mapped within the lower elevations generally aligned to the routes of the watercourses.

1.10 Soils within the catchment are expected to largely consist of freely draining lime-rich loamy soils.

1.11 Land use within the catchment is predominantly rural, comprising agricultural land. Suburban areas of Fewcott and Fritwell are present in the south and north of the catchment respectively.

1.12 OS mapping shows the presence of a few small ponds within the catchment, some of which are online. Given the location of these feature within the context of the catchment and small size, they are not considered to have a significant attenuation effect on the catchment.

1.13 No further features that may impact hydrology have been identified

Climate Change

1.14 Predicted future change in peak river flows caused by climate change are provided by the EA, with a range of projections applied to regionalised 'River Basin Districts' which are subdivided into Management Catchments.

1.15 The catchment falls across the Cherwell and Ray and Upper Bedford Ouse Management Catchments of the Thames River Basin District. The Upper Bedford Ouse Management Catchment provides the more conservative peak river flow allowances and, as such, these allowances have been used in this study and are summarised in **Table 1.2**.

Table 1.2: Peak River Flow Allowance for the Upper Bedford Ouse Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	58%
Higher Central	10%	11%	30%
Central	5%	4%	19%

Available Hydrometric Data

1.16 The National River Flow Archive (NRFA) Peak Flow Dataset Version 13.0.2 (released August 2024) will be utilised in this assessment for the purposes of identifying any potential donor stations and for the development of pooling groups. This contains data up to water year 2022-23.

1.17 There are no hydrometric gauges within the catchment. Therefore, there are no current hydrometric records of river flows or levels for the watercourse on which a hydrological assessment of flood flows can be made.

Other Data

Table 1.3: Other Data Sources

Type of Data	Data relevant to this study?	Data available?	Source of Data	Details
Check flow gaugings	There are no gauges within the study catchment and the project scope does not include for a review of the gauging stations			
Historical flood data	Yes	See **Section 7**		
Flow or river level data for events	The project scope does not include for a review of gauging stations/data. However, NRFA data will be used, where available and applicable.			
Rainfall data for events	The lack of flow/level gauge data for the study catchments means it is not possible to use rainfall data to define ReFH2 model parameters.			
Potential evaporation data	No	N/A		
Results from previous studies	No	No previous assessments undertaken.		
Other data or information	N/A			

Conceptual Model

Table 1.4: Conceptual Model

Where is the main site(s) of interest?	The main site of interest is the proposed highway component works as a product of the proposed SFRI in Oxfordshire. The watercourse to be modelled are shown in **Figure 1.1**. The Padbury Brook flows through the Order Limits in an easterly direction.
What is likely to cause flooding at those locations? (e.g. peak flows, flood volumes, combination of peaks, groundwater, snowmelt, tides…)	Peak flows from fluvial sources are likely to be the main cause of flooding at the site. The Padbury Brook flows through a number of hydraulic structures as it flows through the Order Limits, which means there is the potential for backing up of flows if there is insufficient capacity. The EA Flood Map for Planning suggests the floodplain associated with the watercourses shows the potential for out of bank flooding.
Might these locations flood from runoff generated on part of the catchment only e.g. downstream of a reservoir?	There are several small ponds in the catchment. Due to the small size of these features and their location within the catchment, they are not expected to have a significant attenuation effect.

Are there any unusual catchment features? E.g. highly permeable (BFIHOST19>0.66), heavily urbanised, pumped, major reservoir influence (FARL<0.9), FSAs, historical or operational mining?	The catchment is classed as highly permeable with a BFIHOST of 0.954. Due to the permeable nature of the study catchment, the Statistical method will be the preferred approach for estimating peak flows. This is because floods in groundwater dominated catchments are influenced by hydrogeological factors not adequately represented in rainfall-runoff approaches. The catchment is not classed as heavily urbanised (URBEXT greater than 0.6) and there is no major reservoir influence or attenuation features.

Initial Choice of Approach

Table 1.5: Method Statement

Is FEH appropriate?	Yes
Initial choice of method(s) and reason	Flows will be estimated using both Statistical and ReFH2 methods. Both methods are suitable for the catchment and using both will enable comparison between results before choosing the final method.
How will hydrograph shapes be derived?	It is anticipated that ReFH2 will be used to provide hydrograph shapes.
Will different storm durations need to be considered?	No, a uniform storm duration will be applied to the modelling
Lumped or Distributed approach for model inputs	Flow estimates will be undertaken for lumped catchments. **Section 6**. provides detail on how these will be applied to the model (i.e., distributed via area weighting, intervening hydrographs etc).
Software to be used	WINFAP version 5.1, ReFH2 version 4.1, Wallingford Hydro Solutions Non Flood Years Spreadsheet Beta v2.2

Previous Hydrological Assessments

1.18 There are no previous hydrological assessments with which to compare results.

2. LOCATIONS WHERE FLOOD ESTIMATES ARE REQUIRED

Location of Flow Estimates

Table 2.1: Summary of Subject Sites

Site code	Watercourse	Site	Easting	Northing	Area on FEH Webservice (km^2)	Revised area (if altered) (km^2)
PB01	Padbury Brook	Downstream extent of modelled open channel.	455450	228300	12.7	12.5
Reasons for choosing locations		The location is based on the downstream extent of the hydraulic model of the Padbury Brook. One flow estimation point is considered appropriate given the relatively small difference in catchment area along the modelled reach.				

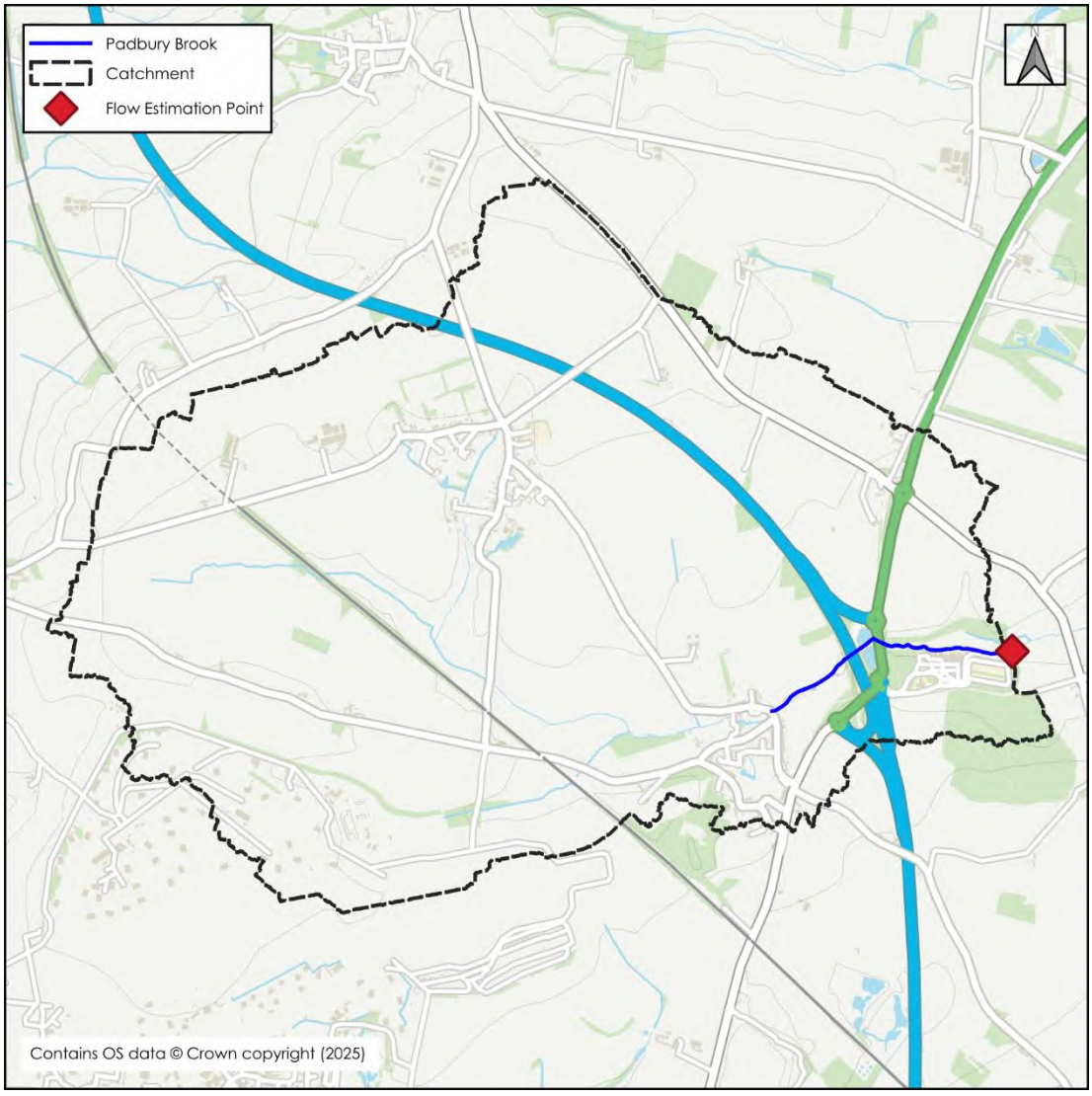

Figure 2.1: Flow Estimation Locations

Checking Catchment Descriptors

Table 2.2: Catchment Descriptor Checks

Record how catchment boundary was checked and describe any changes.	The catchment boundary was initially identified using the FEH Web Service. The boundary was reviewed using EA 2022 1m Light Detection and Ranging (LiDAR) data and updated where necessary (**Figure 2.2**).
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	As the changes to catchment area are relatively small, with no significant change to the catchment shape, as well as the limitations of the standard DPLBAR equation within FEH Volume 5, the DPLBAR in the original FEH catchment descriptors has been retained. BFIHOST and SPRHOST values are reasonable based on the geology and soils of the catchments. There are several small ponds in the catchment. Due to the small size of these features and their location within the catchment, they are not expected to have a significant attenuation effect and are reflected within the FARL value for the catchment.
Source of URBEXT	The URBAN50k method has been used to calculate $URBEXT_{2000}$ for the revised catchment boundary
Method for updating of URBEXT to present day.	An update to the current year is not required as the URBAN50k method has been used to calculate $URBEXT_{2000}$. As such the current urban extent will be implicitly accounted for in the latest mapping

Table 2.3: Important Catchment Descriptors (Changes made are highlighted in red)

Site Code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR	SPRHOST	URBEXT 2000	FPEXT
PB01	0.997	0.32	0.848	3.64	16.8	674	5.93	**0.0189**	0.0924

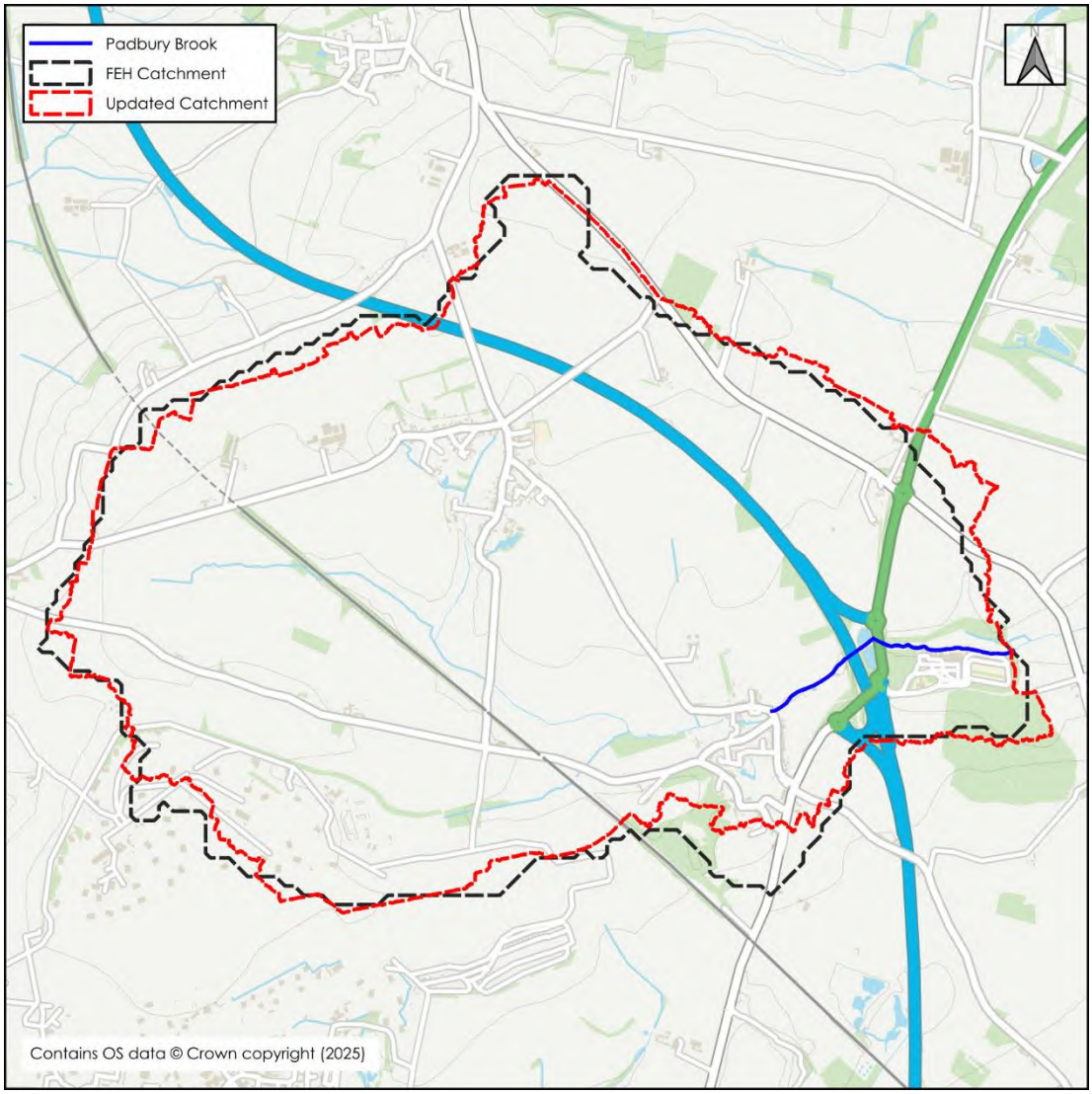

Figure 2.2: Original and Amended Catchment Boundaries

3. STATISTICAL METHOD

3.1 WINFAP was utilised to undertake a statistical analysis of the catchment using a hydrometric record of gauged catchments with similar characteristics.

QMED Development

3.2 Catchment descriptors were originally used to estimate the rural QMED of the study site using the revised equation from Science Report (SC050050). The FEH states that flood frequency is best estimated by gauged data and estimation of key variables from catchment descriptors alone should be a method of last resort. As such, a search was undertaken to identify any potential donor sites that could be used to adjust QMED.

3.3 Phase 2 of Science Report SC090031[3] recommends using a single donor, chosen based on proximity, to adjust QMED for 'small catchments' (defined as catchments with an area of less than 25km^2). This method can also be applied to catchments less than 40km^2 and is implemented in WINFAP5.

3.4 With the guidance in mind, a search was undertaken within WINFAP to identify the closest station to the flow estimation point(s). The data quality of potential donor(s) was also reviewed. Of the recommended donors, the following were rejected:

- 33005 – This station was closed in 1991; therefore, more recent flood events would not have been captured within the record.
- 39021 – This station has limited utility for flood analysis; level measurement imprecise prior to 1967 and bypassing has varied in magnitude through time.

3.5 Station 39034 was the next closest donor to the subject site and was considered suitable for donor transfer following the review.

3.6 Details for the donor station(s) used to adjust QMED, and which flow estimation point(s) they have been applied to, are provided in **Table 3.1**. Details of the donor adjustment(s) and final QMED estimation are provided in **Table 3.2**.

3.7 Adjustment for climatic variation was not required as the donor station has a record length greater than 14 years.

Table 3.1: Donor Station Details

Station Number	QMED from 'as rural' Observed Data (A)* (m^3/s)	'As rural' QMED from Catchment Descriptors (B)** (m^3/s)	Adjustment Ratio (A/B)	Flow estimation point(s) donor is applied to
39034	20.12	21.14	0.95	PB01

[3] Science Report SC090031/R0: Estimating flood peaks and hydrographs for small catchments (Phase 2), Environment Agency (2019).

Table 3.2: Overview of Estimation of QMED at Each Subject Site

Site Code	Method	Initial Estimate of QMED (m^3/s) (Rural)	Data Transfer				Final estimate of QMED (m^3/s) (URBAN)
			Donor site NRFA no	Distance between centroids d_j (km)	Power term, a	Moderated QMED adjustment factor (A/B)[a]	
	Donor Transfer	0.47	39034	21.11	0.301	0.99	0.50*
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?		QMED is consistent with the size and characteristics of the catchment.					
Which version of the urban adjustment was used for QMED?		Urban adjustment was applied using Kjeldsen (2010), as applied in WINFAP.					

*Quoted to two decimal places to show changes in values and is not an indication of a greater degree of accuracy.

Derivation of Pooling Groups

3.8 A pooled group of hydrologically similar gauged sites was generated by the WINFAP software for the subject sites using the 'OK for Pooling' dataset. WINFAP uses the deurbanised pooling group L-moments as default.

3.9 The 'small catchment' pooling procedure implemented within WINFAP has been used. This procedure selects the pooling group using a similarity measure that only considers AREA and SAAR, as recommended by SC090031.

Pooling Group Review

3.10 The pooling group was reviewed to identify sites which may be inappropriate due to being significantly hydrologically dissimilar to the study site, or if they have any inaccuracies, uncertainties, or limitations in their data record.

Adjustment for Non-Flood Years

3.11 For some catchments there are years in which no floods occur (non-flood years), and the annual maximum flow is due to baseflow alone. To avoid a bias in the flood frequency analysis in which growth factors reach an upper limit (the growth curve is bounded above), the L-moments have been adjusted to remove the influence of non-flood years (classed as annual maximum flows smaller than 0.5QMED).

3.12 The adjustment for non-flood years has been undertaken using Wallingford HydroSolutions 'WHS Non-flood Years Spreadsheet Beta v2.2'.

Urban Adjustment

3.13 Growth curves were also adjusted for to reflect the urban influence, using the methods adopted in WINFAP[4] which is based on those published by Kjeldsen 2010[5].

Choice of Distribution

3.14 In accordance with the EA FEH Guidelines, the distribution has been chosen based on which gives the best fit from Generalised Logistic (GL), Generalised Extreme Value (GEV) and Kappa 3.

3.15 The only exception to this is when a pooling group has been adjusted for non-flood years as the procedure for the adjustment uses the GL distribution.

Growth Curve Comparison

3.16 Further detail on pooling group composition is provided in **Section 8.**

Table 3.3: Derivation of Pooling Groups: PB01

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
PB01_Non Flood Years	PB01	GL	**Stations Removed:** 26016 - non-flood years over 15% of the record. Following a review of the station on the NRFA, the station was removed from the group as the channel is known to run dry and is, therefore, considered dissimilar from the subject site. 26014 – following a review of the station on the NRFA, the station was removed from the group as the watercourse is known to regularly dry up and is, therefore, considered dissimilar from the subject site. 7011 – removed due to an unusually steep growth curve that gives significantly higher than normal growth factors (100 year growth factor >10) which are not considered	L-CV: 0.267 L-Skew: 0.211

4 Wallingford HydroSolutions (2016), WINFAP 4 Urban adjustment procedures, Wallingford HydroSolutions Ltd 2016.
5 Kjeldsen, T.K., 2010. Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrology Research, volume 41, issue 5, pp391-405

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
			representative of the study catchment. **Stations Added:** 25013 – Added to get the pooling group record above 500 years. 36004 - Added to get the pooling group record above 500 years. **Comments:** The pooling group is heterogeneous, and a review of the pooling group is desirable. It is not considered possible to improve the pooling group any further.	

Table 3.4: Final Choice of Flood Growth Curves at Subject Sites

Site code	Method (SS, P, ESS)	Name of pooling group	Distribution used and reason for choice	Urban adjustment and/or non-flood years adjustment applied?	Growth factor for 1% AEP event
PB01	P	PB01_Non Flood Years	GL distribution was chosen because it is the default distribution used for the adjustment for non-flood years.	Urban adjustment and adjustment for non-flood years applied.	3.14

Table 3.5: Flood Estimates from the Statistical Method

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities*								
	2 (50%)	5 (20%)	10 (10%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
PB01	0.50	0.70	0.86	1.15	1.31	1.46	1.57	1.87	2.80

*Quoted to two decimal places to show changes in values and is not an indication of a greater degree of accuracy.

4. REVITALISED FLOOD HYDROGRAPH (ReFH) METHOD

4.1 The ReFH2 Revitalised Flood Hydrograph Modelling Tool (Version 4.1) was used to undertake an estimation of the peak flows for the subject sites.

Table 4.1: Overview of Parameters for ReFH2 Method

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
PB01	Parameters calculated using catchment descriptors				
Description of flood event analysis carried out			Flood event analysis is not possible as the catchments are ungauged.		

Table 4.2: Design Events

Site code	Rainfall DDF model	Season of design event	Storm duration	Selected interval	Initial soil moisture (Cini)	Initial baseflow (BFO)
PB01	FEH22	Winter	11.0hr	1.0hr	Default value	Default value
Comments	The ReFH2 recommended storm duration at the downstream extent of the model is 11hrs; therefore, a uniform storm duration of 11hrs will be used to derive the model inflow hydrographs.					

Table 4.3: Flood Estimates from the ReFH Method (based on recommended duration for individual catchments)

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities*								
	2 (50%)	5 (20%)	10 (10%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
PB01	0.51	0.70	0.85	1.11	1.26	1.40	1.51	1.82	2.79

*Quoted to two decimal places to show changes in values and is not an indication of a greater degree of accuracy.

5. DISCUSSION AND SUMMARY OF RESULTS

Comparison of Method

5.1 A comparison of the peak flow results for the different estimation methods for the 1 in 2-year and 1 in 100-year events is provided in **Table 5.1**. Comparisons of the growth curves for both methods are shown in **Figure 5.1**.

5.2 The Statistical method provides a generally slightly steeper growth curve when compared to the ReFH2 method. Peak flows are broadly similar between the methods with the Statistical method presenting slightly higher peak flows from the 1 in 10-year event.

Table 5.1: Comparison of Results

Site code	1 in 2-year peak flows (50% Annual Exceedance Probability)			1 in 100-year peak flows (1% Annual Exceedance Probability)		
	Statistical	ReFH	Ratio	Statistical	ReFH	Ratio
PB01	0.50	0.51	0.98	1.57	1.51	0.06

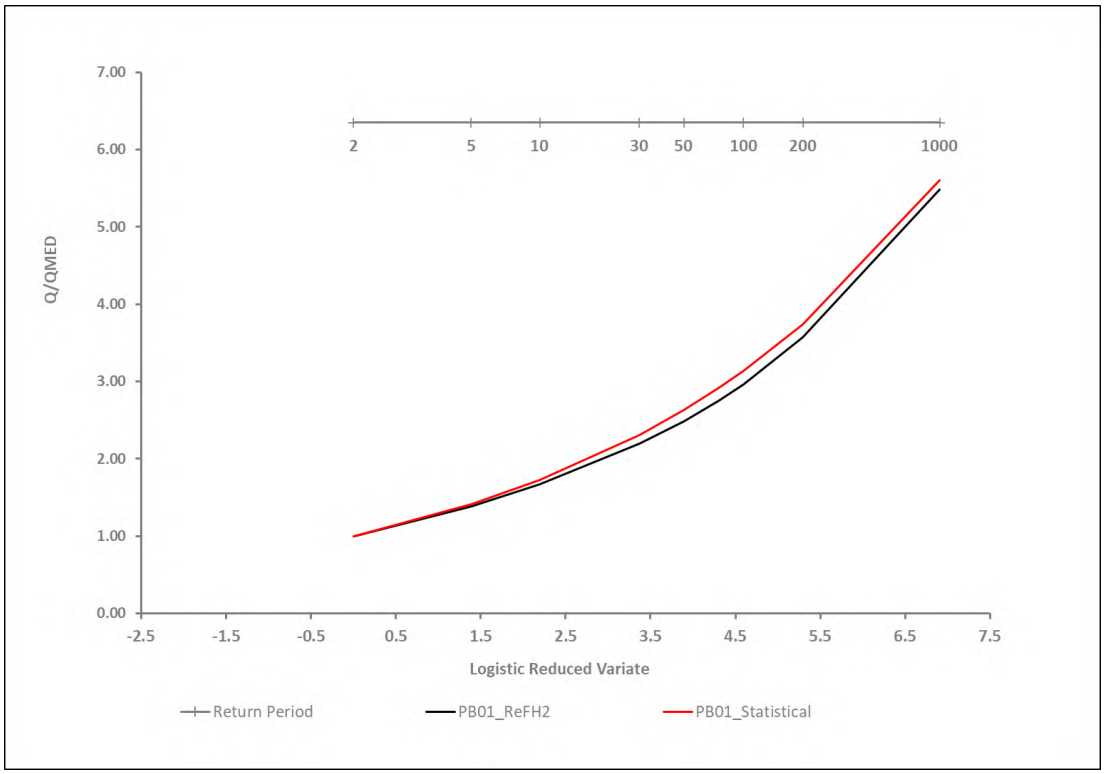

Figure 5.1: Comparison of Statistical Method and ReFH Growth Curves

Final Method and Flows

Table 5.2: Final choice of method

Choice of method and justification	The final choice of peak flows for input into the model is the Statistical method, in line with EA FEH Guidelines recommendation that it is normally a more appropriate choice for groundwater-dominated catchments. The Statistical method benefits from an up-to-date flood peak dataset, using growth curves from hydrologically similar catchments to derive a growth curve. Flow estimates have been improved by utilising a catchment with similar characteristics from the QMED adjustment. In the absence of any suitable observed data with which to derive a hydrograph shape, ReFH2 will be used to provide a hydrograph shape for the model inflows, scaled to the statistical peak. Section **6** describes how flows will be applied to the model.

Table 5.3: Final Peak Flows from Chosen Method (Statistical)

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities*								
	2 (50%)	5 (20%)	10 (10%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
PB01	0.50	0.70	0.86	1.15	1.31	1.46	1.57	1.87	2.80

*Quoted to two decimal places to show changes in values and is not an indication of a greater degree of accuracy.

Table 5.4: Assumptions, Limitations and Uncertainty

List the main assumptions made	• The pooling groups are representative of the catchments. • The ReFH2 hydrograph shape is representative of the catchment response. • Tp and storm duration are representative of the catchment response. • The flow estimate derived at the downstream extent of the Padbury Brook is applicable to the upstream catchment as there is no significant changes in the catchment characteristics between the upstream and downstream extent. • There are no swallow-holes or springs within the catchment and the groundwater catchment corresponds to the topographical catchment. • The ponds within the catchment are not expected to have a significant attenuative effect on peak flows.
Discuss any limitations e.g. applying methods outside the range of catchment types or return periods for which they were developed	• The FEH Statistical and ReFH2 methods are believed to be suitable up to the 1 in 200-year event. Estimates of flow beyond these events are extrapolations and, therefore, have a higher level of uncertainty.

	• There are only a small number of gauged sites in the UK. As such the representation in the pooling group is not ideal given the small size of some of the study catchments. • There is no observed flow data within the catchment with which to verify the flow estimates. • The FEH regression equation for QMED can result in overestimates on groundwater-dominated catchments. However, the calculated QMED value has been improved using donor transfer and appear sensible for the size and characteristics of the catchment. • The adjustment for non-flood years methodology uses a GL distribution. However, WINFAP showed Kappa 3 provided the better fit.
Give what information you can on uncertainty in the results	According to Table 2 of the EA FEH Guidelines, confidence intervals for the 1 in 100-year event for a rural site when calculated from catchment descriptors are quoted as 0.45-2.23 (for the 95% confidence interval). Confidence is improved when using observed data from a donor site. When one donor is used in the assessment, the confidence intervals changes to 0.47-2.12 (for the 95% confidence interval). It is more difficult to quantity uncertainty in design flows estimated from the ReFH rainfall-runoff model. However, evidence[6] suggests the factorial standard errors from ReFH2 are comparable to those observed for the FEH pooled Statistical method when the catchment is treated as ungauged.
Comment on the suitability of the results for future studies	The design flow estimates have been derived for the purpose of providing flow hydrographs into a hydraulic model to support a planning application. Users for different studies, should, as a minimum, review results to assess suitability for the purpose of the study.
Give any other comments on the study	While the installation of temporary flow gauges would provide local data which may better inform the design peak flows and hydrograph shapes, this would not align with the scope and timescales of this project.

Table 5.5: Checks

Are the results consistent?	Peak flows are consistent with the size and characteristics of the catchment.
What do the results imply regarding the return periods of floods during the period of record?	It is not possible to imply return periods of floods due to the lack of gauged data within the study catchment and sufficient information on any historical flooding events.

[6] Wallingford Hydrosolutions (2019) ReFH2 Science Report: Evaluation of the Rural Design Event Model.

What is the 1 in 100-year growth factor? (the guidance suggests a typical range or 2.1 to 4.0)	The Statistical Method 1 in 100-year growth factor is 3.14. The ReFH2 method 1 in 100-year growth factor is 2.97. These fall within the typical range.
If 1 in 1000-year flows have been derived, what is the range of ratios for 1 in 1000-year flow over 1 in 100-year flow?	Statistical Method: 1.79 ReFH2 method: 1.85
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred	There are no previous studies with which to compare results.
Are the results consistent with the longer-term flood history?	There is not a long-term flood record for the catchment with which to compare the modelled results to.
Describe any other checks on the results	Sensibility checks of modelled outlines will be undertaken at the modelling stage.

6. APPLICATION OF FLOWS TO MODEL

6.1 Flows will be applied to the model in the following way.

i. To derive the hydrographs, the ReFH2 hydrographs for PB01 were scaled to meet the Statistical Method peak flows.

ii. The hydrograph will be prorated based on the catchment area for PB01, as outlined within **Figure 6.1**. In short, 75% of the hydrograph will be applied at the upstream extent of the model, with 25% applied immediately downstream of the A43.

6.2 The proportion of the hydrograph applied at each inflow, as well as the type of inflow, is shown in **Table 6.1. Figure 6.1** demonstrates how the flows will be applied to the model.

Table 6.1: Hydrograph Proportions

Sub Catchment	Type of inflow	Proportion of Hydrograph
PB01 Inflow 1	Point	75%
PB01 Inflow 2	Point	25%

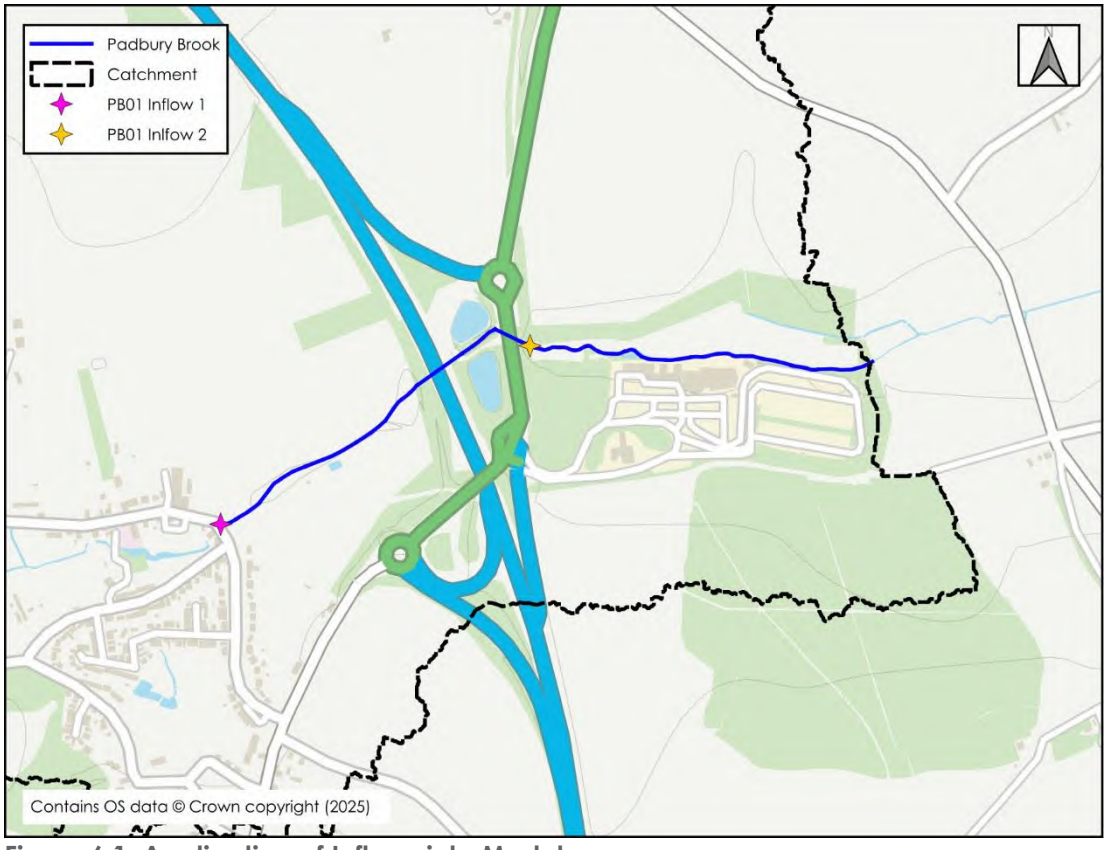

Figure 6.1: Application of Inflows into Model

7. FLOOD HISTORY

Flood History

7.1 A flood history review has been undertaken for the catchment. **Table 7.1** sets out the findings from this review.

Table 7.1: Flood History Review

Data Source	Flood Event Details
Strategic Flood Risk Assessments (SFRA)	Mapping appended to the Cherwell District Council Level 1 SFRA[7] reflects the EA recorded flood outlines. There are shown to be no recorded events within the catchment of the Padbury Brook. The nearest recorded flood outlines are located west of the catchment attributed to the River Cherwell.
EA Recorded Flood Outlines	
Section 19 Flood Investigations	Oxfordshire have produced 41 Section 19 Flood Investigation Reports; however, there are no records of flood investigations with the catchment.
British Chronology of Hydrological Events	No flood history relevant to the catchment was found.
Online News Articles	An online news article[8] references flooding of the Padbury Brook in November 2024; however, the areas influenced are suitably downstream of the study catchment.
Other Sources	No additional records of historical flooding has been identified.

[7] Cherwell District Council Level 1 Strategic Flood Risk Investigation (WHS, November 2022)
[8] https://www.oxfordmail.co.uk/news/24747366.flood-warnings-flooding-oxfordshire-storm-bert/

8. DETAILED POOLING GROUP INFORMATION

Table 8.1: Default Pooling Group: PB01

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
26016 (Gypsey Race @ Kirby Grindalythe)	0.382	26	0.1	0.318	0.253	0.091
27073 (Brompton Beck @ Snainton Ings)	0.397	43	0.812	0.213	0.032	0.861
25019 (Leven @ Easby)	0.615	45	5.09	0.342	0.372	0.322
36010 (Bumpstead Brook @ Broad Green)	0.737	56	7.855	0.35	0.106	2.477
27051 (Crimple @ Burn Bridge)	0.76	51	4.564	0.217	0.141	0.227
26014 (Water Forlornes @ Driffield)	0.778	25	0.424	0.319	0.204	0.54
7009 (Mosset Burn @ Wardend Bridge)	0.818	25	7.053	0.365	0.329	0.441
7011 (Black Burn @ Pluscarden Abbey)	0.992	11	4.298	0.495	0.58	2.393
39033 (Winterbourne Stream @ Bagnor)	1.034	61	0.399	0.337	0.377	0.938
33054 (Babingley @ Castle Rising)	1.074	47	1.129	0.228	0.194	0.767
26015 (Driffield Canal @ Wansford Bridge)	1.092	13	2.49	0.173	0.088	2.024
24007 (Browney @ Lanchester)	1.116	15	10.981	0.222	0.211	0.859
41020 (Bevern Stream @ Clappers Bridge)	1.138	54	13.78	0.2	0.162	1.038
27010 (Hodge Beck @ Bransdale Weir)	1.14	41	9.42	0.224	0.293	1.023
Total		513				
Weighted Means				0.285	0.229	
H2 value	2.9419					
Goodness of Fit	**Generalised Logistic**		**General Extreme Value**		**Kappa 3**	
	0.7508		-0.8468		0.1939	

Table 8.2: Final Pooling group (adjusted for non-flood years): PB01

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	0.397	43	0.812	0.213	0.032	1.006
25019 (Leven @ Easby)	0.615	45	5.09	0.342	0.372	0.824
36010 (Bumpstead Brook @ Broad Green)	0.737	56	7.855	0.35	0.106	2.209
27051 (Crimple @ Burn Bridge)	0.76	51	4.564	0.217	0.141	0.215
7009 (Mosset Burn @ Wardend Bridge)	0.818	25	7.053	0.365	0.329	1.14
39033 (Winterbourne Stream @ Bagnor)	1.034	61	0.399	0.337	0.377	1.143
33054 (Babingley @ Castle Rising)	1.074	47	1.129	0.228	0.194	0.632
26015 (Driffield Canal @ Wansford Bridge)	1.092	13	2.49	0.173	0.088	1.494

24007 (Browney @ Lanchester)	1.116	15	10.981	0.222	0.211	0.48
41020 (Bevern Stream @ Clappers Bridge)	1.138	54	13.78	0.2	0.162	1.013
27010 (Hodge Beck @ Bransdale Weir)	1.14	41	9.42	0.224	0.293	0.943
26013 (Driffield Trout Stream @ Driffield)	1.15	13	2.7	0.27	0.28	1.3
36004 (Chad Brook @ Long Melford)	1.168	56	4.799	0.302	0.18	0.6
Total		520				
Weighted Means				0.267	0.211	
H2 value	2.217					

Goodness of Fit	**Generalised Logistic**	**General Extreme Value**	**Kappa 3**
	0.4892	-1.2696	-0.1323

Adjusted L-Moments following Adjustment for Non-Flood Years

Station	Adjusted L-CV	Adjusted L-Skew
27073 (Brompton Beck @ Snainton Ings)	0.199	0.066
25019 (Leven @ Easby)	0.327	0.404
36010 (Bumpstead Brook @ Broad Green)	0.287	0.174
27051 (Crimple @ Burn Bridge)	0.209	0.158
7009 (Mosset Burn @ Wardend Bridge)	0.353	0.335
39033 (Winterbourne Stream @ Bagnor)	0.309	0.440
33054 (Babingley @ Castle Rising)	0.214	0.242
26015 (Driffield Canal @ Wansford Bridge)	0.173	0.088
24007 (Browney @ Lanchester)	0.222	0.211
41020 (Bevern Stream @ Clappers Bridge)	0.187	0.208
27010 (Hodge Beck @ Bransdale Weir)	0.220	0.306
26013 (Driffield Trout Stream @ Driffield)	0.270	0.280
36004 (Chad Brook @ Long Melford)	0.255	0.292

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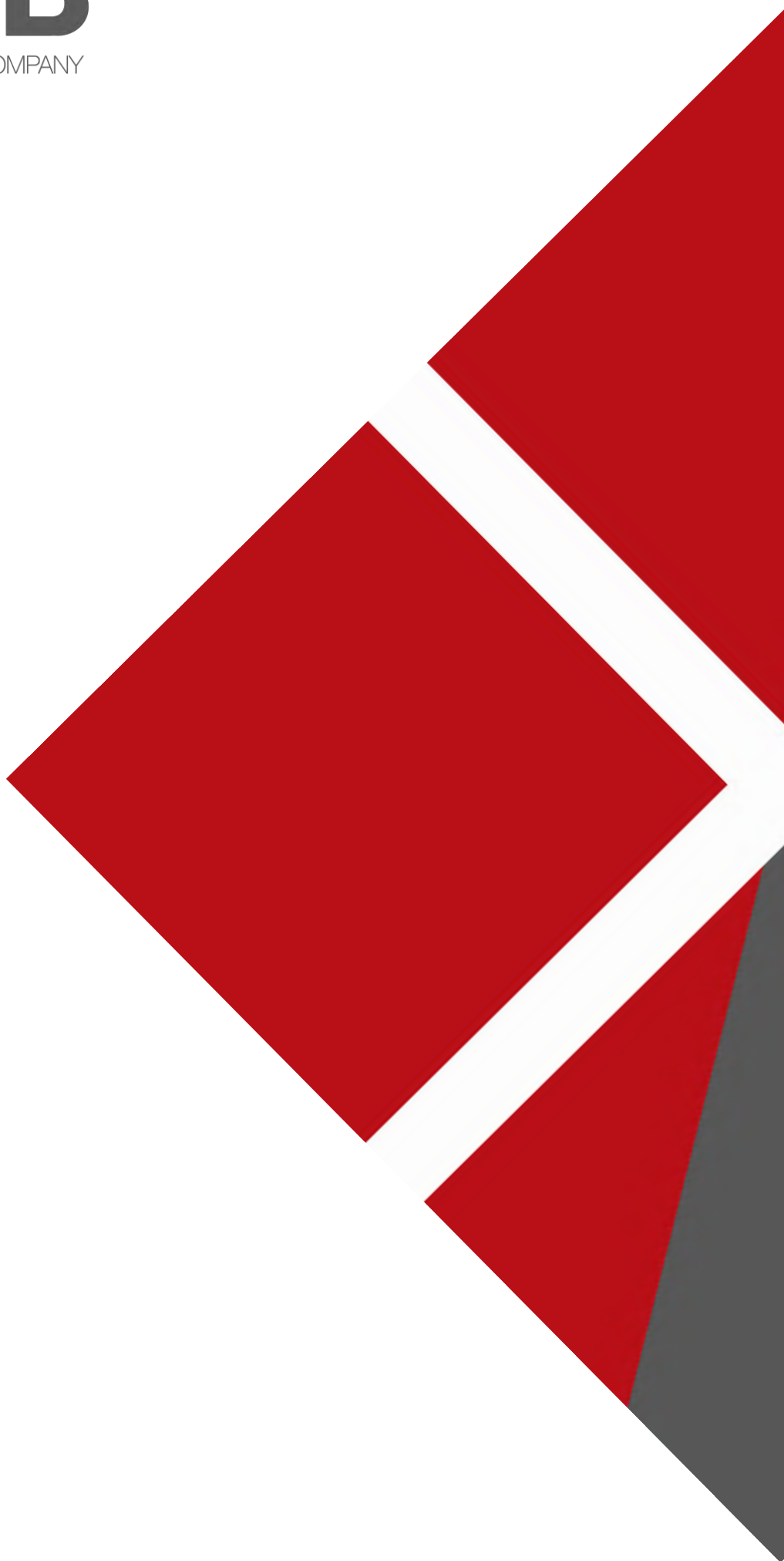

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Appendix 3: Table of Hydraulic Structures

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
PB_01250	**Description:** Concrete Bridge **NGR:** 454377, 228086 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 109.10m AOD **Downstream Invert Level:** 109.10m AOD **Length:** 1m **Manning's N:** 0.05 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PB_00974	**Description:** M40 Culvert **NGR:** 454597, 228236 **Domain:** 1D ESTRY **Unit Type:** Circular Conduit **Dimensions:** 1.5m x 2 **Upstream Invert Level:** 108.75m AOD **Downstream Invert Level:** 108.32m AOD **Length:** 110m **Manning's N:** 0.025 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PB_00728	**Description:** A43 Culvert **NGR:** 454801, 228323 **Domain:** 1D ESTRY **Unit Type:** Circular Conduit **Dimensions:** Irregular shaped twin pipes. Maximum width of approximately 4m. **Upstream Invert Level:** 108.30m AOD **Downstream Invert Level:** 107.97m AOD **Length:** 55m **Manning's N:** 0.025 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PB_00708	**Description:** Wooden Bridge **NGR:** 454818, 228315 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 107.91m AOD **Downstream Invert Level:** 107.91m AOD **Length:** 1m **Manning's N:** 0.035 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
PB_00371	**Description:** Wooden Bridge **NGR:** 455137, 228291 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 107.54m AOD **Downstream Invert Level:** 107.54m AOD **Length:** 1m **Manning's N:** 0.035 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	

Appendix 4: Baseline Floodplain Maps

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.

2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- 1 in 30-Year
- 1 in 100-Year
- 1 in 100-Year + 19%CC
- 1 in 100-Year + 30%CC
- 1 in 100-Year + 58%CC
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P02	23.06.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Baseline Model Floodplain Extents

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1101	S2	P02

0 50 100 150 200 250 m

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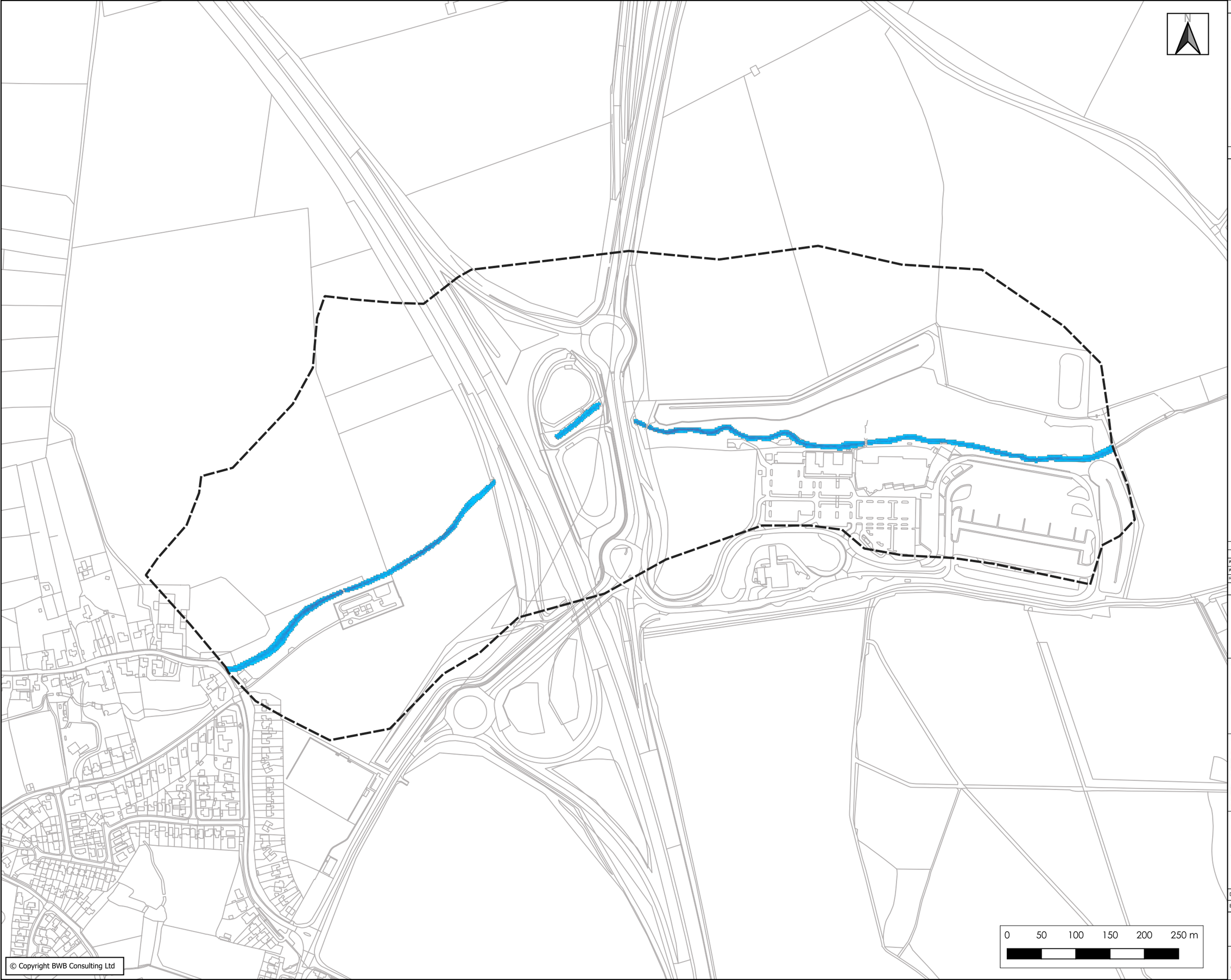

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Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	23.06.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
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Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

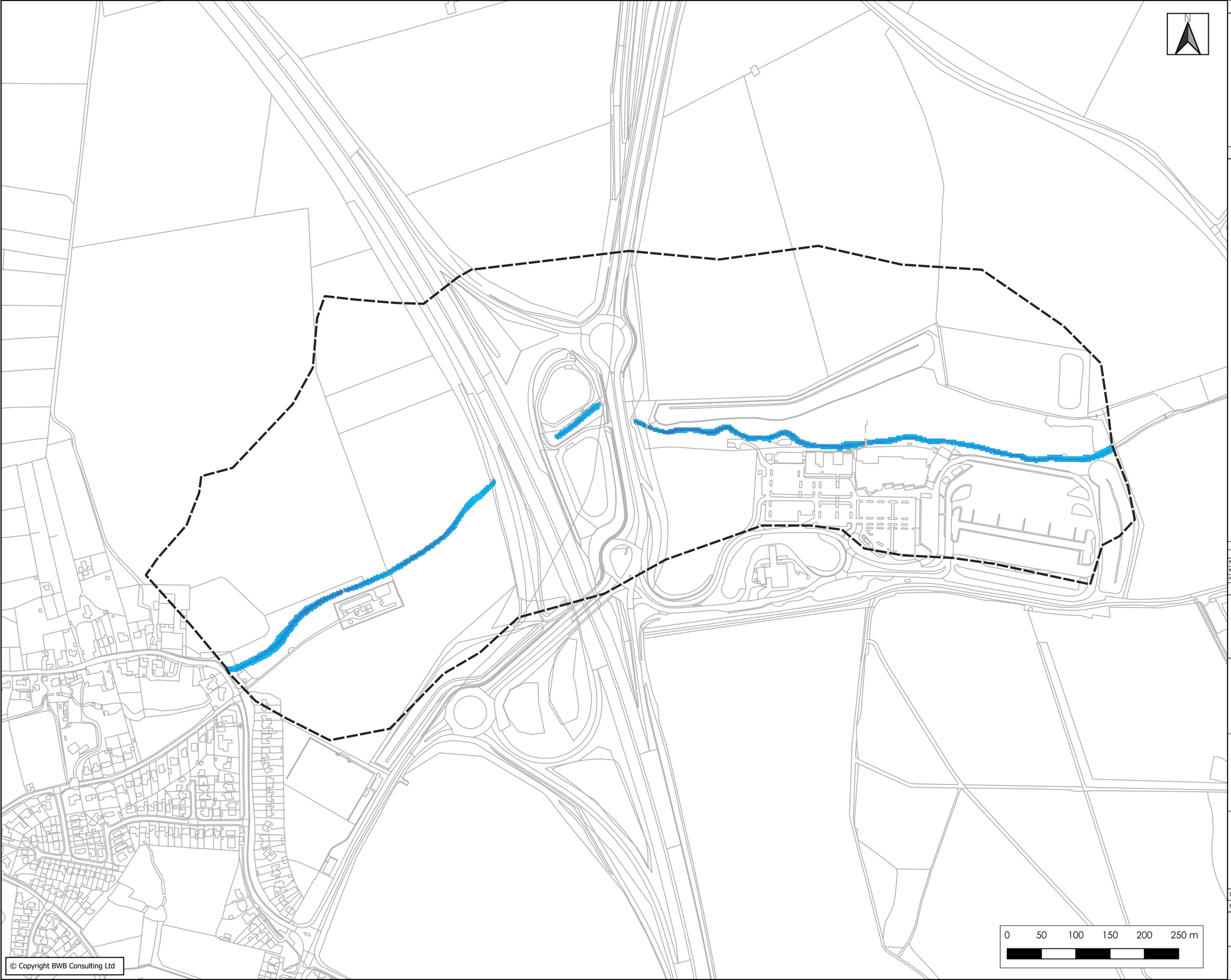
Baseline Modelled Flood Depths 1 in 30-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1102	S2	P02



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Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Baseline
Modelled Flood Depths
1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1103	S2	P02

Notes

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Baseline
Modelled Flood Depths
1 in 100-Year + 19%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1104	S2	P02

Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

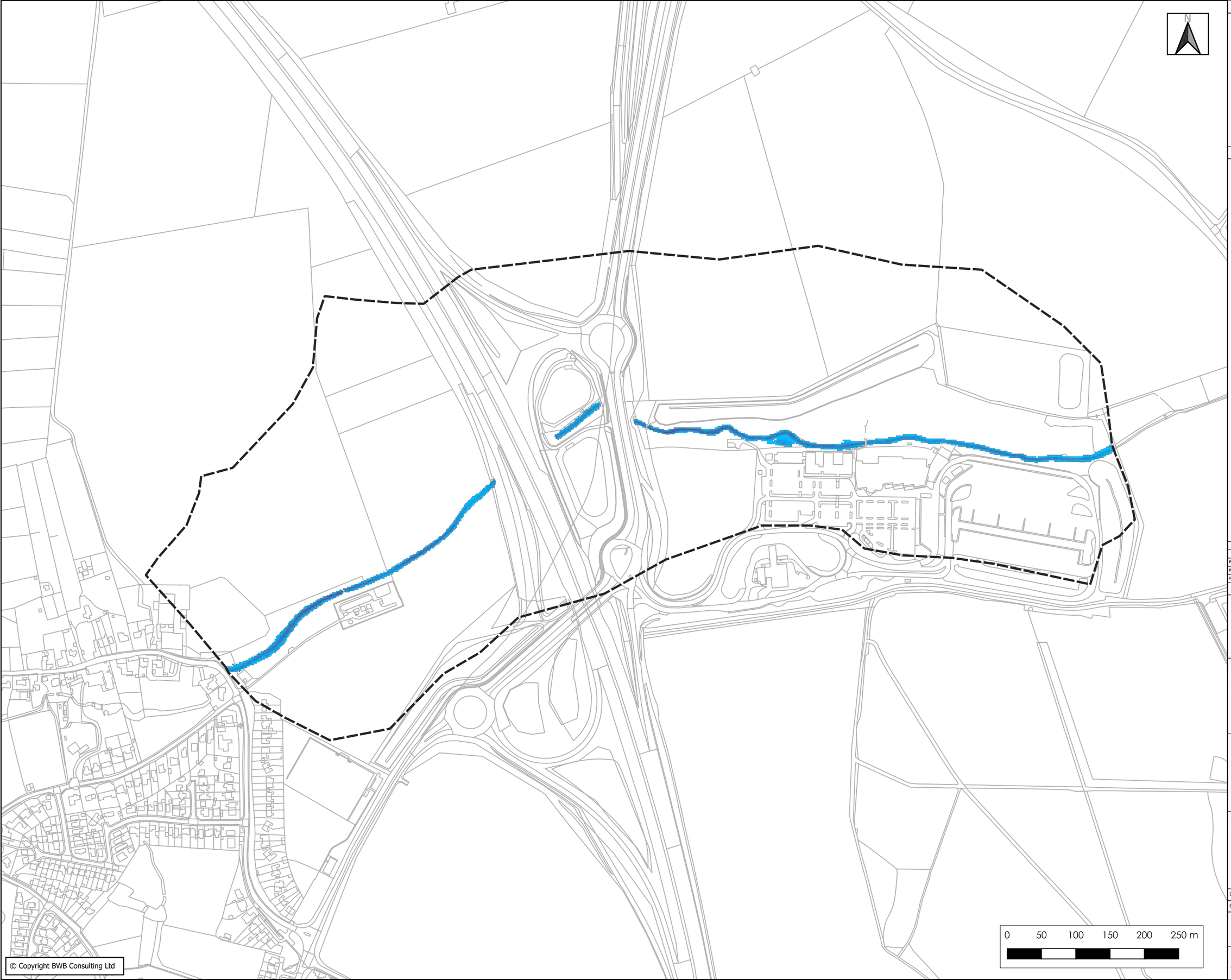
Baseline
Modelled Flood Depths
1 in 100-Year + 30%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1105	S2	P02



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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
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Project Title

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Drawing Title

Baseline
Modelled Flood Depths
1 in 100-Year + 58%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:		Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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Project Title

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Baseline Modelled Flood Depths 1 in 1000-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1107	S2	P02

Appendix 5: Proposed Floodplain Maps

N

0 50 100 150 200 250 m

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Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- 1 in 30-Year
- 1 in 100-Year
- 1 in 100-Year + 19%CC
- 1 in 100-Year + 30%CC
- 1 in 100-Year + 58%CC
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P02	10.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
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Client

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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Model Floodplain Extents

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1121	S2	P02

Notes

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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P02	28.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
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Project Title

OxSRFI
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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 30-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1122	S2	P02

Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1123	S2	P02

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.

2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year + 19%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1124	S2	P02

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.

2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year + 30%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1125	S2	P02

Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 50 100 150 200 250 m

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Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year + 58%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:		Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1126	S2	P02

N

0 50 100 150 200 250 m

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Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

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5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 1000-Year

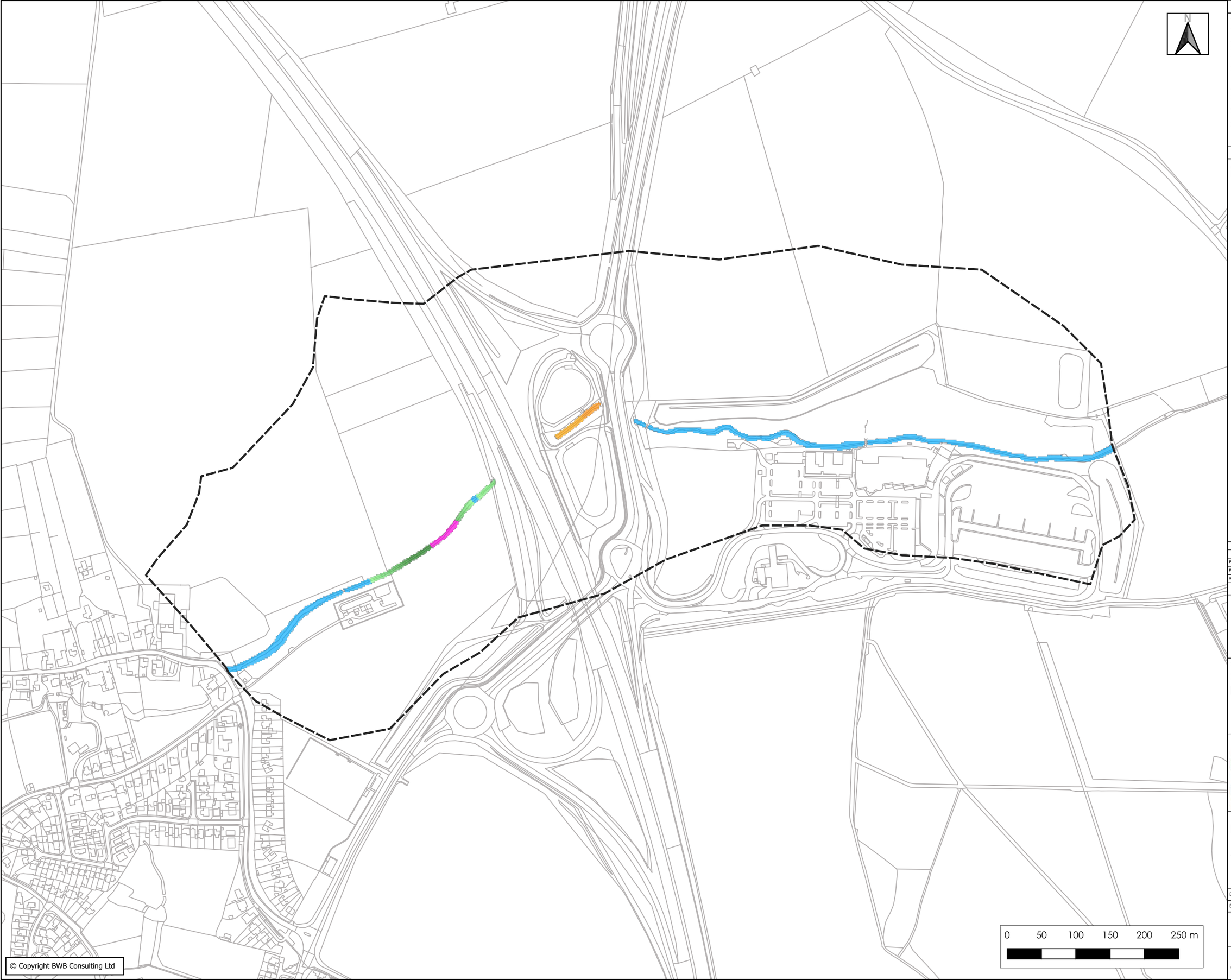
Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1127	S2	P02

Appendix 6: Comparison Mapping



Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 30-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1128	S2	P02

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N

0 50 100 150 200 250 m

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5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
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Client

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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

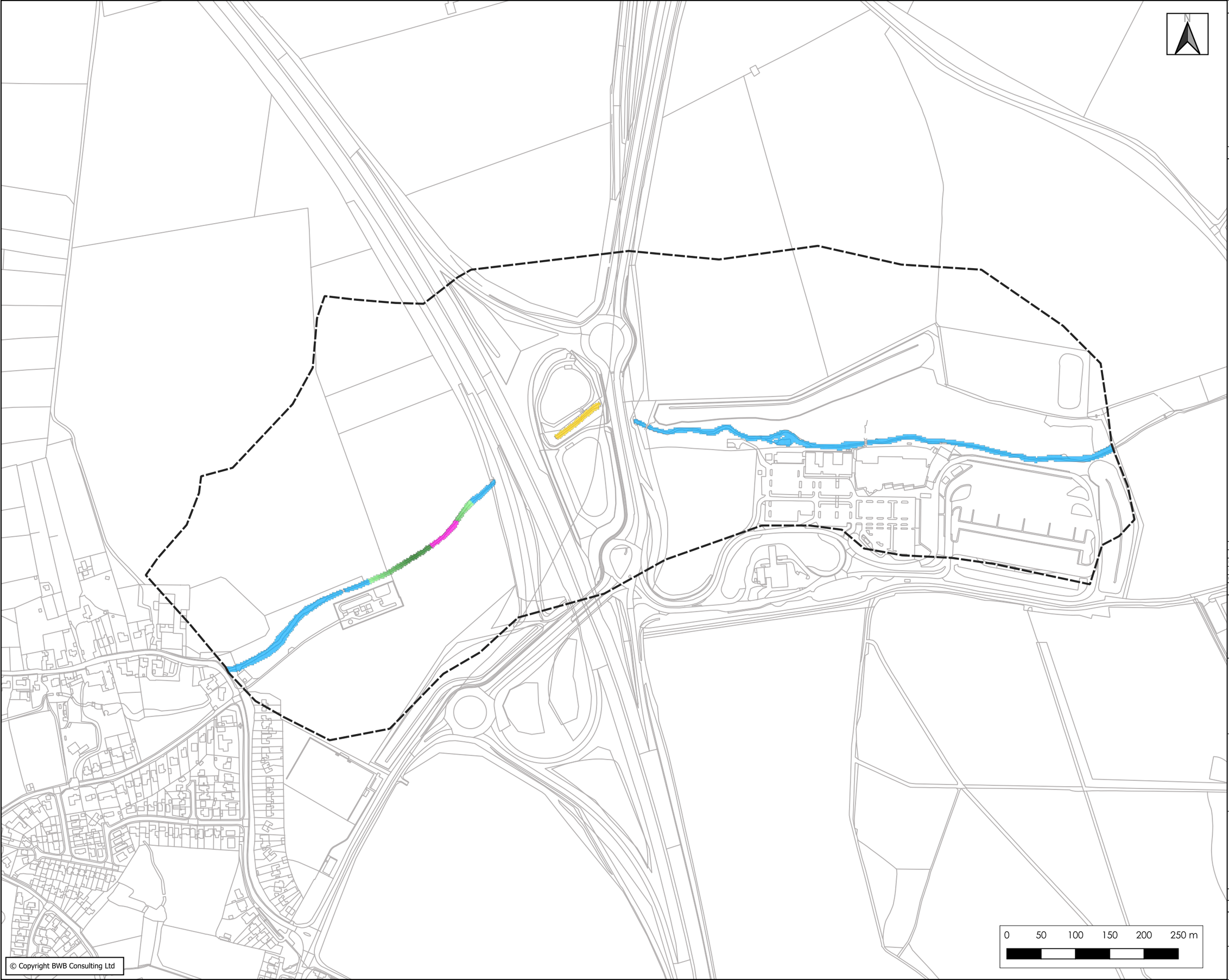
Proposed Impact Analysis 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1129	S2	P02



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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
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Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 100-Year + 19%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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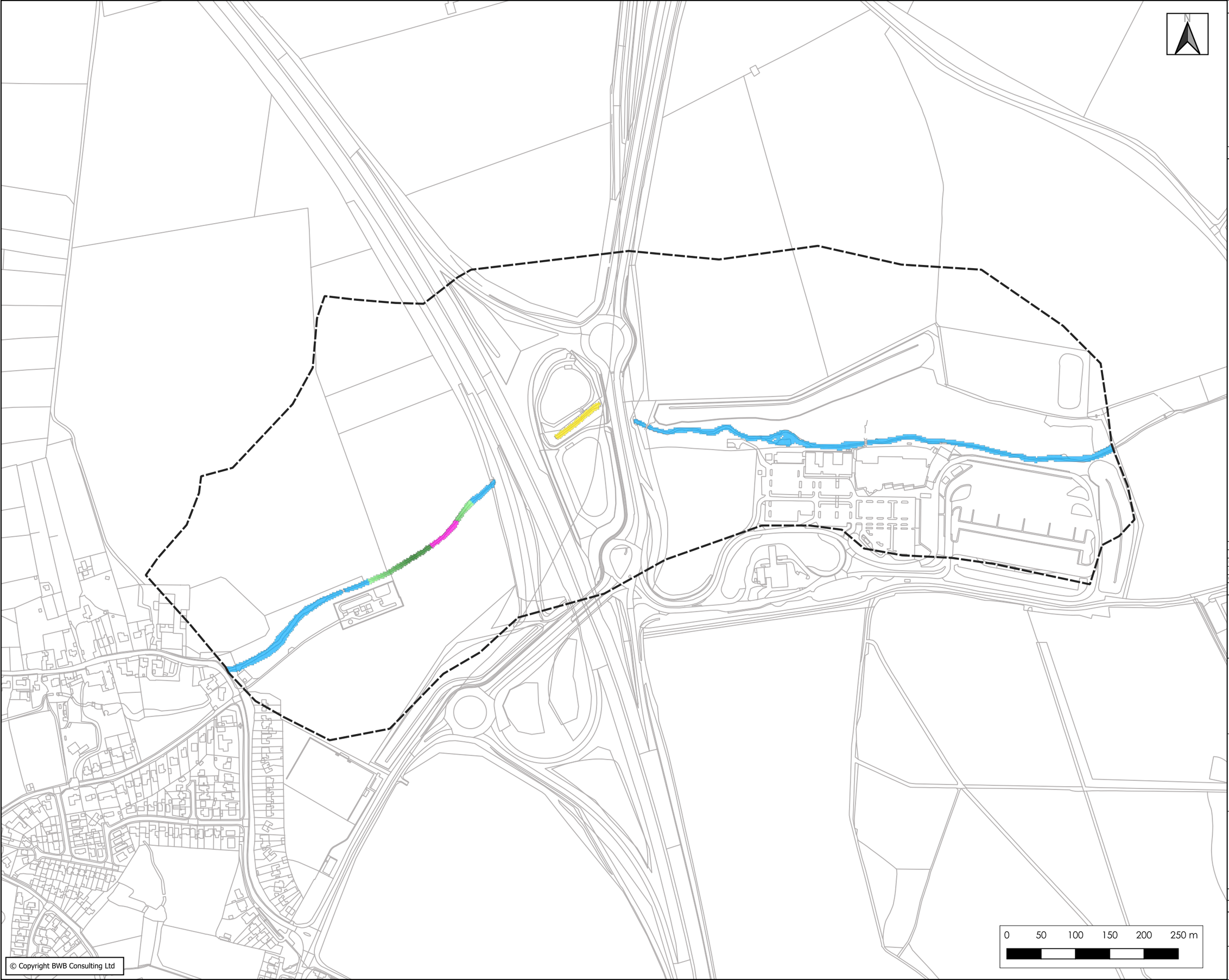

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

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Oxfordshire Railfreight Limited

Project Title

OxSRFI
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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 100-Year + 30%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1131	S2	P02

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N

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

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Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

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Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 100-Year + 58%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1132	S2	P02

N

0 50 100 150 200 250 m

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
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Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 1000-Year

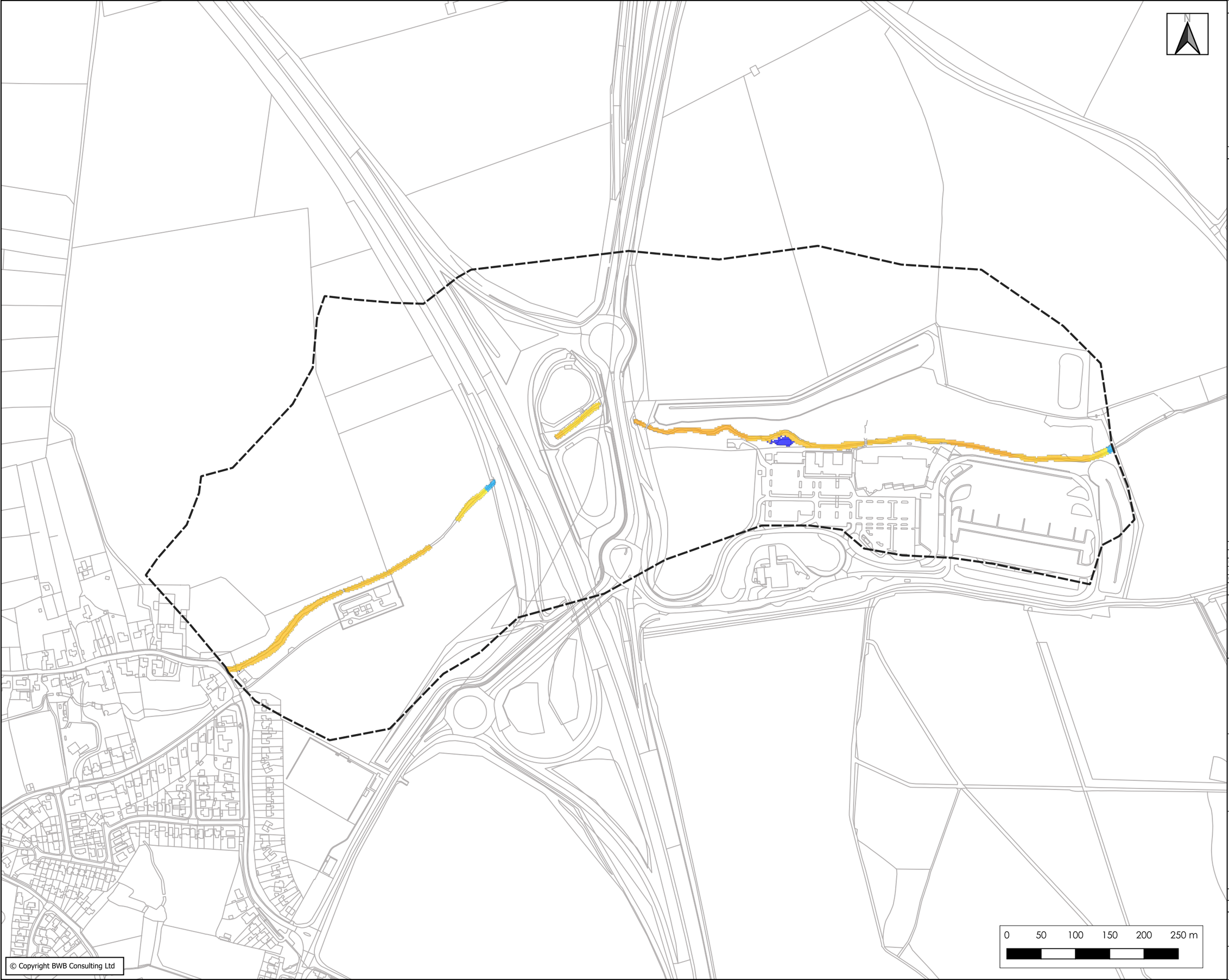
Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1133	S2	P02

Appendix 7: Sensitivity Testing



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5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Increased Roughness (20%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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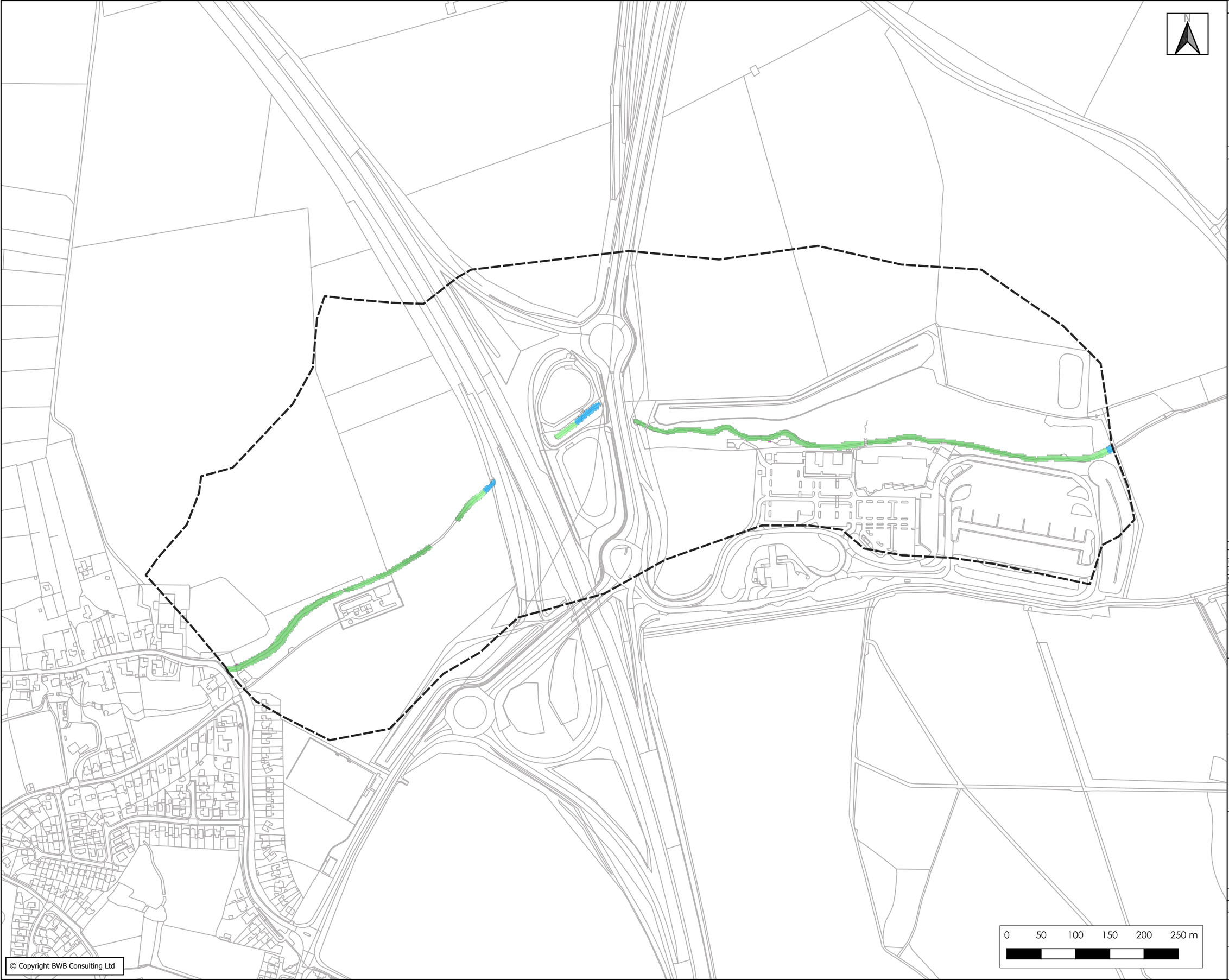

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: M40 Culvert Blockage (50%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1146	S2	P02

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

0 50 100 150 200 250 m

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Increased Downstream Boundary (20%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1142	S2	P02

Notes

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5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

0 50 100 150 200 250 m

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	CC
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: M40 Culvert Blockage (50%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:5,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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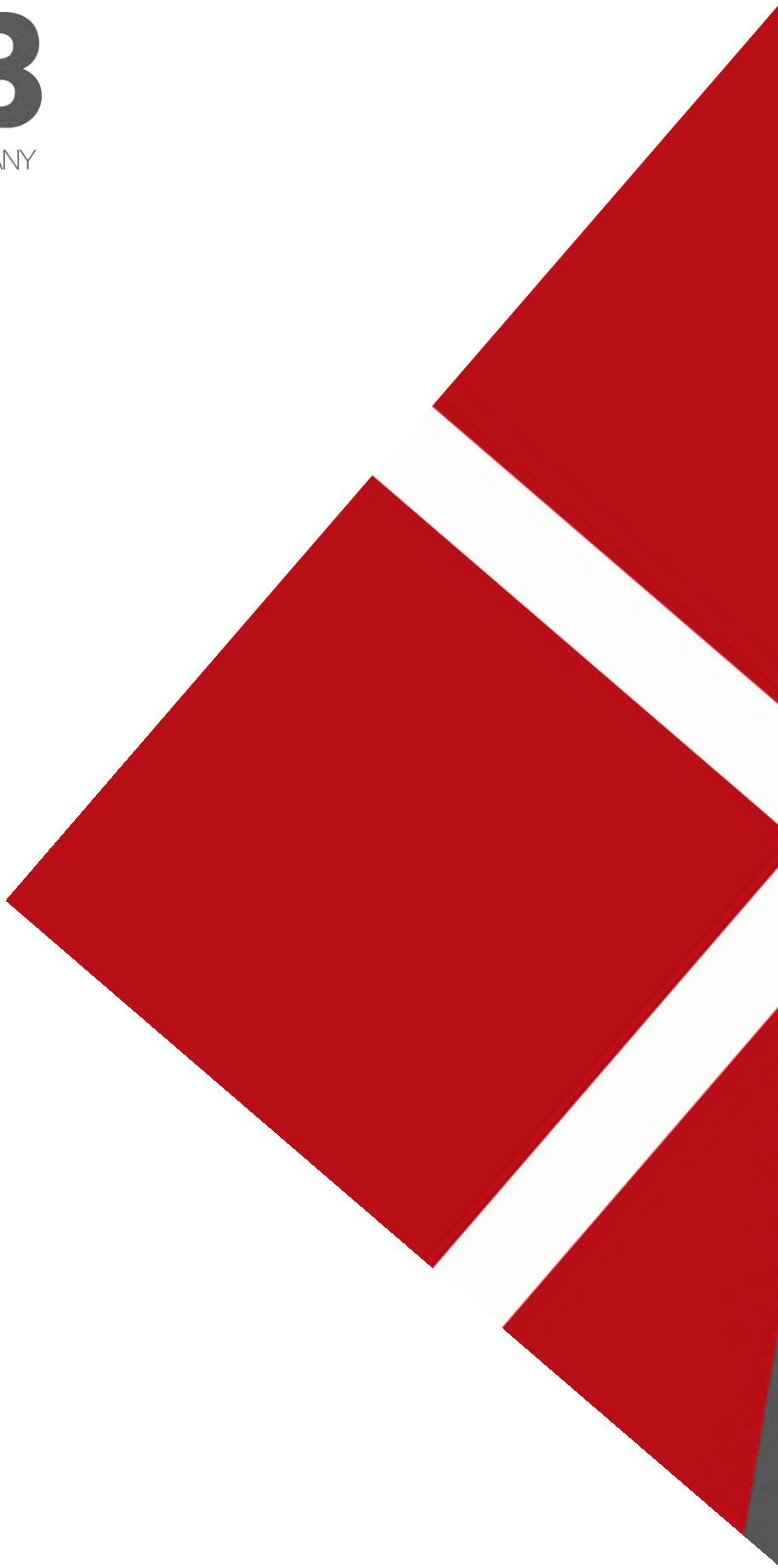

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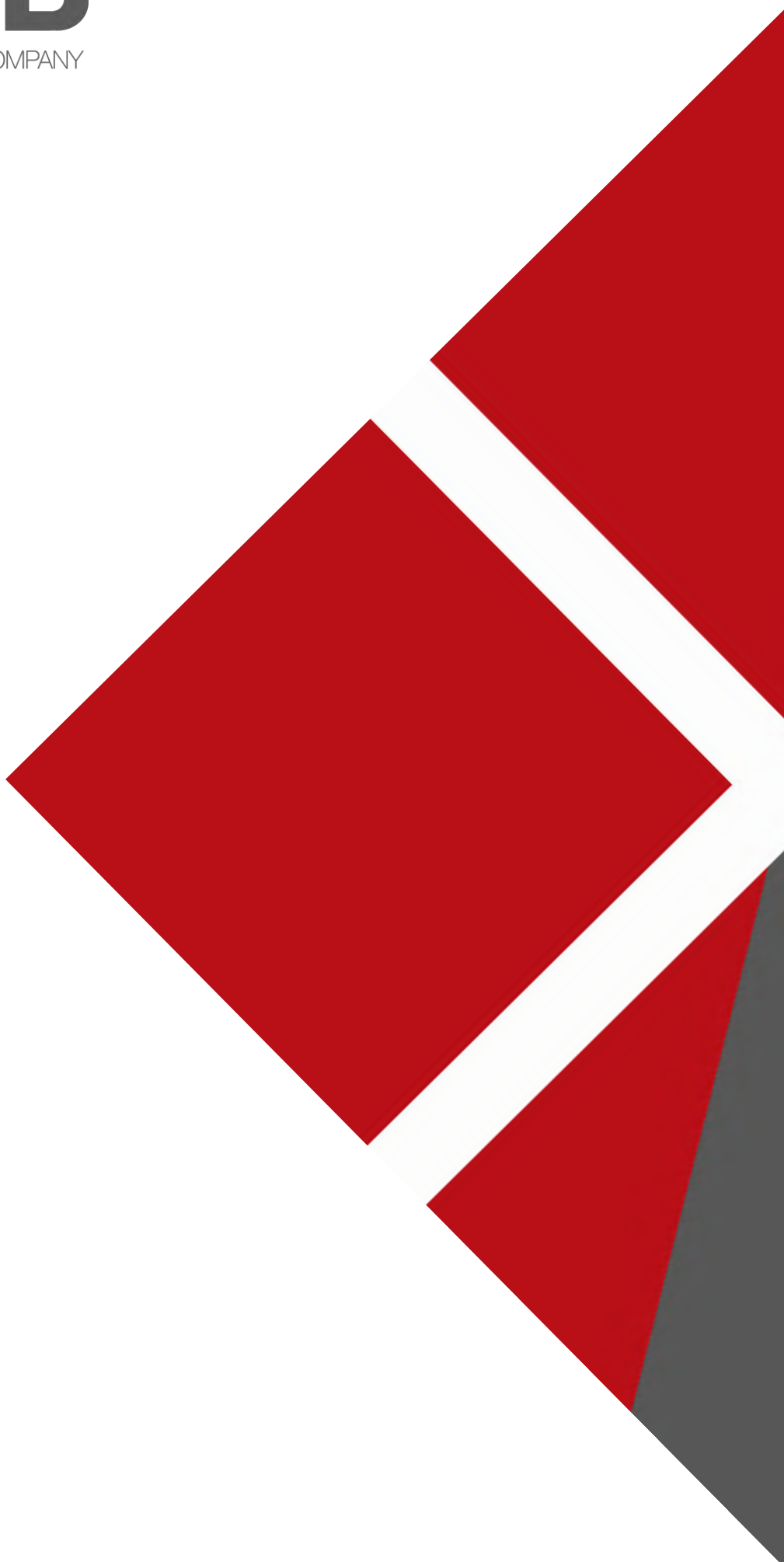

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Appendix 2: Topographical Survey

Fritwell
Fewcott
Upper Heyford Airfield
(disused)
Caulcott
Stoke Wood
Kilby's Copse
Kilby's Barn
Middleton Stoney
Sandyhill Clump
Timberyard Clump
Pedigree Plantation
Needles Farm
Allington Farm
Sewage Works
Recycling Centre
Quarry (disused)
RAILWAY LAND NO VISIBILITY FROM SURROUNDING AREA
EXISTING ACCESS ARRANGEMENTS
Motorway Service Area
Sycamore Grove
Baynard's Green
Willowbank Farm
Cross Roads Farm
Kennel Copse
Cleveleys Piece
Earthworks
Ardley Wood
Ardley Hill
Workings (disused)
Ardley Cottages
Ardley Bungalow
Ardley College
Ardley Field Farm
Playing Field
Gordon 10
Manor Farm Cottages
Manor Farm
Park Farm
New Nursery
Quarry (disused)
Sewage Works
Heyford Park
Caravan Park
Heyford Farm
Leachmere Farm
Field Barn Farm
Hill View House
Caulcott Farm
Caulcott Lodge
Caulcott Mill
Home Farm
Manor Farm Barn
Old Nursery
Cricket Ground
Gardeners Cottages
Home Wood
Villiers Piggeries
Hawthorn Farm
Clipping Copse
Woodfield Farm
The Plantation
Swan Farm Quarry
Quarry
The Gorse
The Heath
Lodge Farm
Grange Farm
Oxford Canal
Ardley Road
Fewcott Road
Caulcott Road
Middleton Road
Station Road
Mill Lane
Church Lane
Chapel Lane
Village Road
Fritwell Road
Ardley Road
Ardley Hill
Ardley Wood

Appendix 3: NPPF Flood risk Vulnerability and Flood Zone Compatibility

Flood Risk Vulnerability Classifications (recreated from the NPPF Planning Practice Guidance)

Vulnerability Classification	Description
Essential infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including infrastructure for electricity supply including generation, storage and distribution systems; including electricity generating power stations, grid and primary substations storage; and water treatment works that need to remain operational in times of flood. • Wind turbines. • Solar farms.
Highly Vulnerable	• Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'.)
More Vulnerable	• Hospitals • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill* and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill* and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place. • Car parks.
Water-Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Flood Zone Compatibility (recreated from the NPPF Planning Practice Guidance)

Flood Zone	Vulnerability Classification				
	Essential infrastructure	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**	**Water Compatible**
Flood Zone 1 (Low Probability)	Development is appropriate	Development is appropriate	Development is appropriate	Development is appropriate	Development is appropriate
Flood Zone 2 (Medium Probability)	Development is appropriate	To be deemed appropriate an exception test is required to demonstrate: • The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk • the sustainability benefits of the development to the community outweigh the flood risk.	Development is appropriate	Development is appropriate	Development is appropriate
Flood Zone 3a (High Probability)	To be deemed appropriate an exception test is required to demonstrate: • The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk the sustainability benefits of the development to the community outweigh the flood risk. Additionally, essential infrastructure should be designed and constructed to remain operational and safe in times of flood.	Development should not be permitted	To be deemed appropriate an exception test is required to demonstrate: • The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk • the sustainability benefits of the development to the community outweigh the flood risk.	Development is appropriate	Development is appropriate

Flood Zone	Vulnerability Classification				
	Essential infrastructure	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**	**Water Compatible**
Flood Zone 3b (The Functional Floodplain)	To be deemed appropriate an exception test is required to demonstrate: • The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk • the sustainability benefits of the development to the community outweigh the flood risk. Additionally, development should be designed and constructed to: • remain operational and safe for users in times of flood; • result in no net loss of floodplain storage; • not impede water flows and not increase flood risk elsewhere.	Development should not be permitted	Development should not be permitted	Development should not be permitted	Development is appropriate if designed and constructed to: • remain operational and safe for users in times of flood; • result in no net loss of floodplain storage; • not impede water flows and not increase flood risk elsewhere.

Appendix 4: Hydraulic Modelling Reports

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The information presented, and conclusions drawn, are based on statistical data and are for guidance purposes only. The study provides no guarantee against flooding of the study site or elsewhere, nor of the absolute accuracy of water levels, flow rates and associated probabilities.

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GLOSSARY & NOTATION

1D – one-dimensional hydraulic model, good for representing the hydraulics of a definitive channel or flow pathway and hydraulic structure.

2D – two-dimensional hydraulic model, good for representing complex flow routing present within the floodplain.

Annual Exceedance Probability (AEP) - the probability (%) of a flood event occurring in any year.

Catchment - the land area that drains (normally naturally) to a given point on a river, drainage system or body of water.

Design flood event - magnitude of the flood adopted for the design of the whole or part of a development, usually defined in relation to the severity of the flood in terms of its return period. Typically, the 1 in 100-year return period event including an allowance for future climate change for fluvial flood events.

DTM – Digital Terrain Model

EA – Environment Agency

ESTRY - a 1D hydraulic modelling software package published by BMT.

Flood Estimation Handbook (FEH) – industry standard guidance on rainfall and river flood frequency estimation across the UK.

Floodplain - any area of land over which water flows or is stored during a flood event.

FRA – Flood Risk Assessment

Freeboard - the height of the top of a bank, floodwall or other flood defence structure, above the design water level. Freeboard can be seen as a safety margin that makes allowance for uncertainty associated with the potentially damaging effects of flood rise or wave action.

Hydraulic Model - a mathematical (generally computer based) model of a water/sewer/storm system which is used to analyse the system's hydraulic behaviour.

LiDAR – Light Detection and Ranging aerial survey data

LLFA – Lead Local Flood Authority

mAOD – metres above Ordnance Datum

m BGL – metres below ground level

Main River - a statutory type of watercourse in England and Wales, usually larger streams and rivers. The EA can carry out maintenance, improvement or construction work on main rivers to manage flood risk as part of its duties and powers.

NRFA – National River Flow Archive

OS – Ordnance Survey

Preliminary Flood Risk Assessment (PFRA) - an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authority.

ReFH – Revitalised Flood Hydrograph rainfall-runoff hydrological model

Return period - a statistical term defining the probability of occurrence of a flood event. Thus a 1 in 50-year flood is one likely to be equalled or exceeded on average only once in a 50-year period: a flood with a 2.0% annual probability exceedance (AEP).

Strategic Flood Risk Assessment (SFRA) - a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.

TUFLOW – a 2D fixed grid hydraulic modelling software package published by BMT.

UOW – Unnamed Ordinary Watercourse

Watercourse – a natural or man-made open channel for the conveyance of water.

Z-line – a break line layer in TUFLOW which can be used to reinforce linear features in the 2D model domain such as a riverbank, flood defence, or channel bed.

Z-Shape – a layer in TUFLOW which can be used to manipulate the 2D model geometry.

1. INTRODUCTION

1.1 BWB Consulting Ltd (BWB) has been commissioned by Oxfordshire Railfreight Limited (the Client) to undertake a site-specific hydraulic modelling exercise of the Gagle Brook and a tributary of the Gagle Brook, known as the Ashgrove Brook, to support the development of the Oxfordshire Strategic Rail Freight Interchange (SRFI), Oxfordshire (NGR: SP537269).

Site Description

1.2 The Order Limits of the DCO are located approximately 4.3km north-west of Bicester town centre. The M40 motorway and the A43 form the north-eastern boundary and the Ardley Road (B460) forms the south-eastern site boundary. Heyford Park is located to the west of the and Upper Heyford Airfield (disused) is located to the north-west. The extent of the Order Limits is shown in **Figure 1.1.**

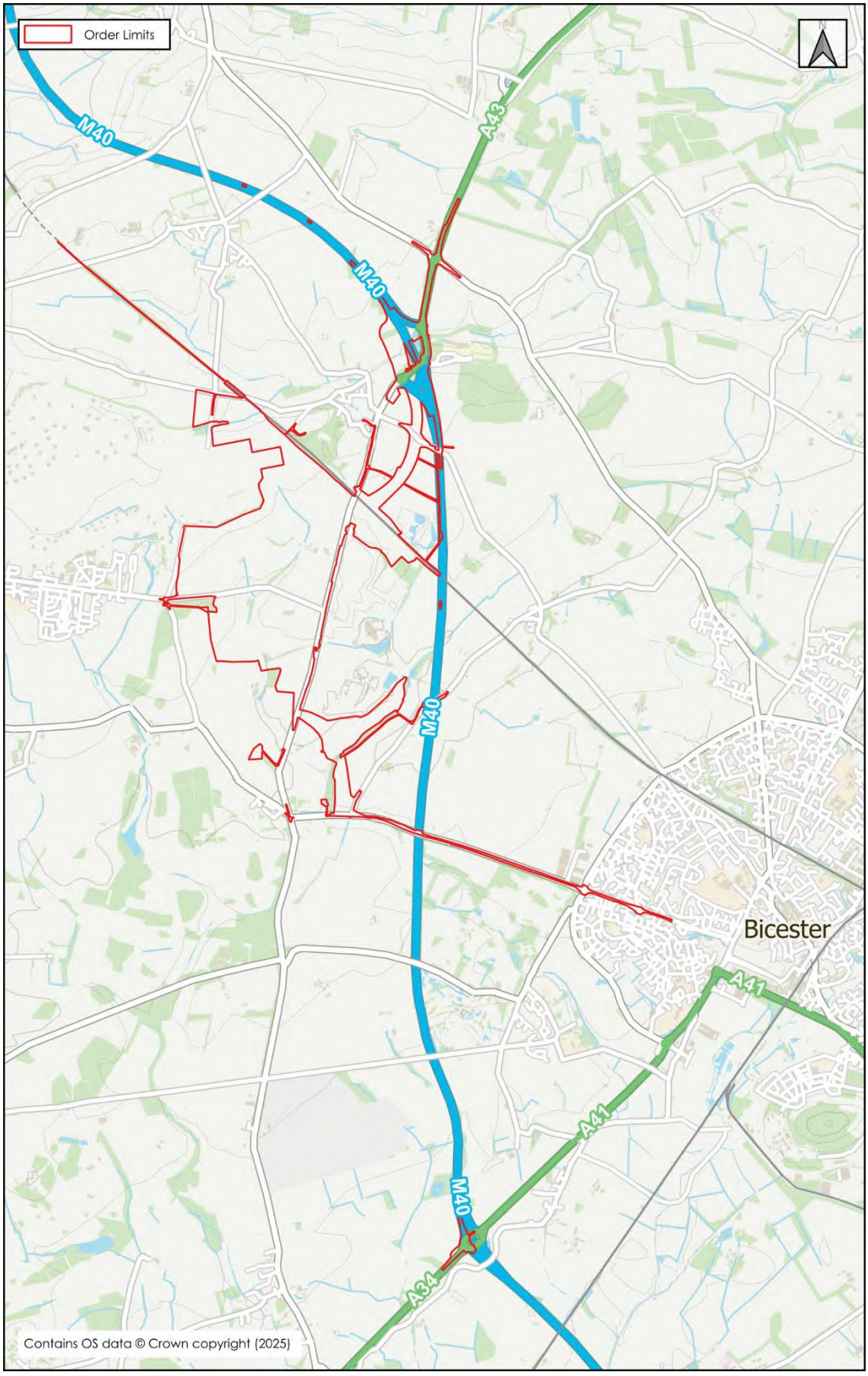


Figure 1.1: Site Location

Gagle Brook and Ashgrove Brook

1.3 **Figure 1.2** shows the extent of the Gagle Brook and Ashgrove Brook to be modelled in this study.

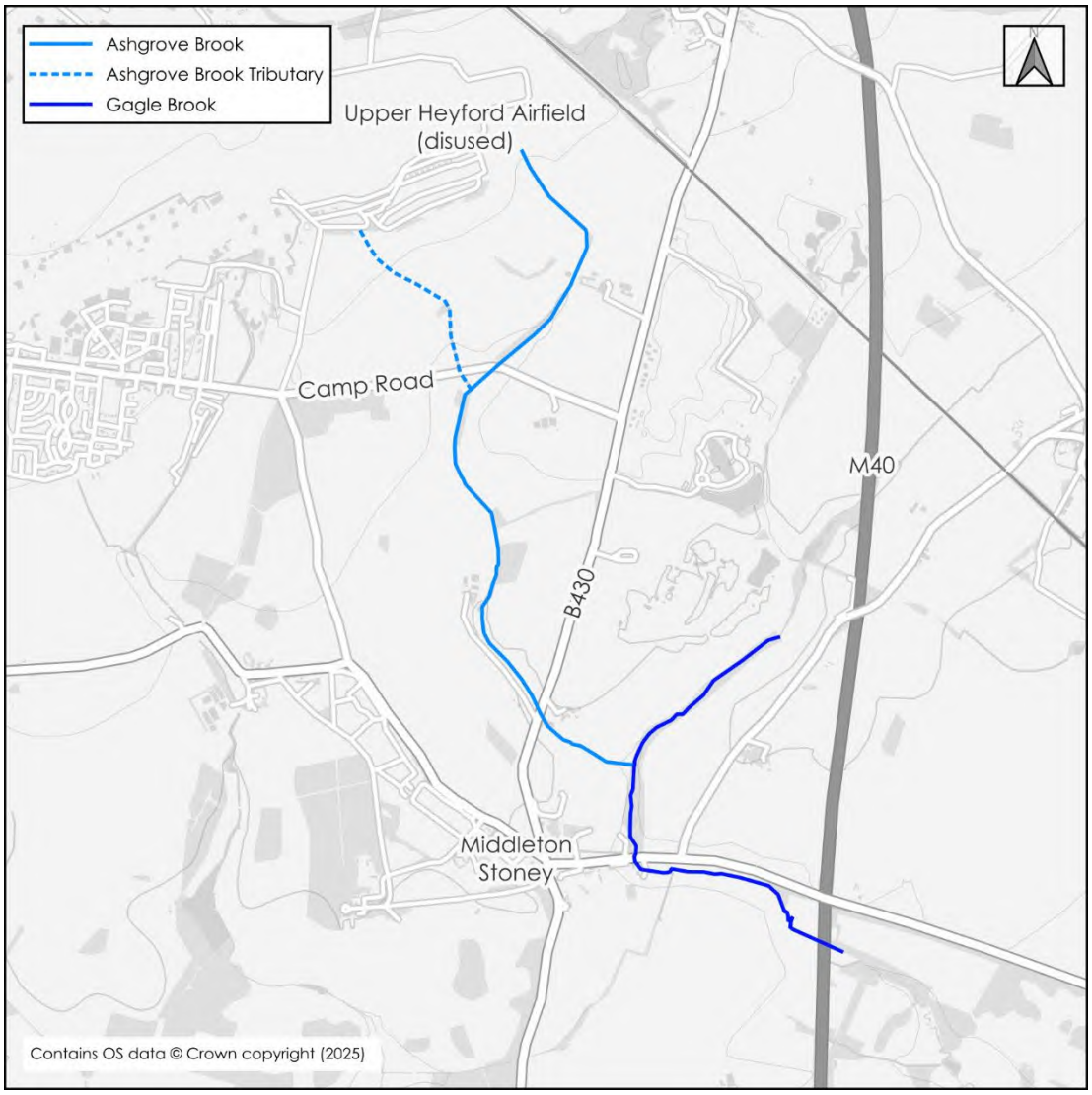


Figure 1.2: Watercourse Network

1.4 The Ashgrove Brook initially flows from Upper Heyford Airfield through the Order Limits in a south easterly direction. The watercourse then flows in a south westerly and southerly direction where it is culverted beneath Camp Road and the B430 where it continues east to its confluence with the Gagle Brook.

1.5 A tributary of the Ashgrove Brook also flows from Upper Heyford Airfield, through the Order Limits, in a south easterly direction. The tributary of the Ashgrove Brook is culverted beneath Camp Road where it then outfalls to the Ashgrove Brook.

1.6 The modelled reach of the Gagle Brook flows in a south westerly and southerly direction to the east of Middleton Stoney. The watercourse is culverted beneath the B4030 where it then flows in a easterly direction towards and beneath the M40.

1.7 The upper catchment of the Gagle Brook and the Ashgrove brook has elevations of approximately 130mAOD, with the upper reaches flowing through narrow, defined channels. Within the Order Limits the watercourses flow through a wider valley with elevations dropping to approximately 81mAOD just upstream of the M40. The total modelled catchment area of both the Gagle Brook and Ashgrove Brook is approximately 13.5km^2. The catchment areas associated with this study are illustrated within **Figure 1.3**.

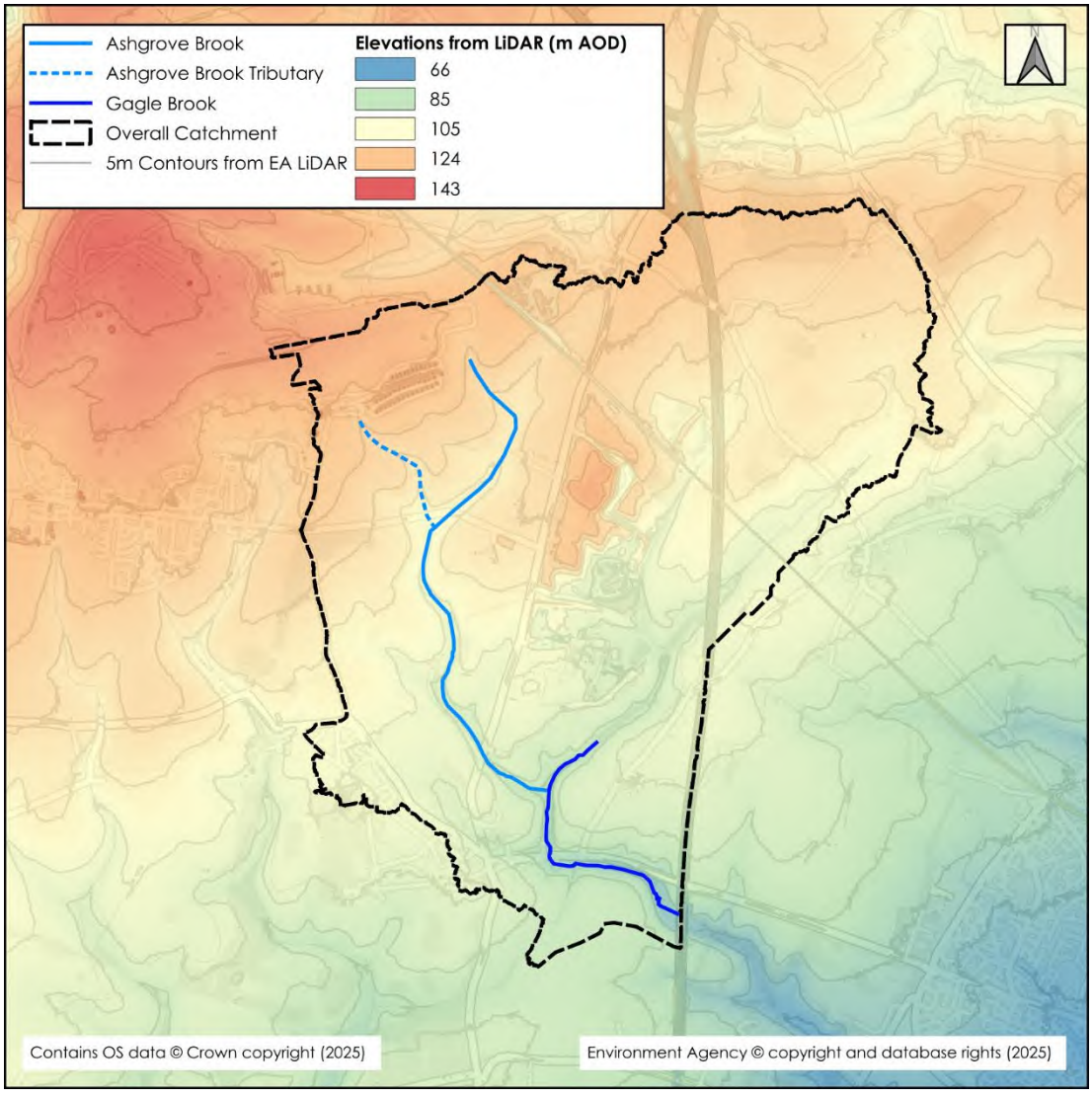


Figure 1.3: Gagle Brook and Ashgrove Brook Catchment Topography

1.8 This report will focus on the Gagle Brook and the Ashgrove Brook. Detailed information on the Padbury Brook is included in BWB ref: OXSRFI-BWB-ZZ-XX-T-W-1003 and detailed information on the Padbury Brook Tributary is included in BWB ref: OXSRFI-BWB-ZZ-XX-T-W-1005.

Previous Studies & Available Data

Historical Flood Events

1.9 A review of the Cherwell Level 1 Strategic Flood Risk Assessment (SFRA) Update[1], Cherwell Level 2 SRFA[2], Oxfordshire County Council Preliminary Flood Risk Assessment[3] (PFRA), Oxfordshire County Council PFRA Addendum[4], EA Historical Flood map, and local news outlets did not return any reports of flooding within the vicinity of the site.

Hydraulic Models

1.10 In 2021 BWB contacted the EA and Oxfordshire County Council, the Lead Local Flood Authority (LLFA), to request any hydraulic model data/files that were held for the area. Both authorities confirmed that they hold no such information at this location.

BWB Site Visit (March 2025)

1.11 A site visit was undertaken by BWB in March 2025 to walk the local watercourse reaches and observe any key features that either needed surveying or needed to be considered during the hydraulic modelling process. The key considerations have been summarised below:

- The Ashgrove Brook is a heavily modified watercourse with a typical width of 2m-3m. It is generally incised with a high gradient and steep banks within the upper catchment (**Figure 1.4**).
- Towards Camp Road, the gradient along the Ashgrove Brook reduces as it flows southwards towards the confluence with the tributary. There are a couple of small offline ponds in this reach.
- As discussed above, the Ashgrove Brook tributary flows from Upper Heyford Airfield. However, there were no flows leaving the airfield at time of the site visit (**Figure 1.5**), with water only found within the channel approximately 200m downstream of this point. Flows appeared to enter the watercourse at this point via a network of field drains.

[1] Cherwell Level 1 Strategic Flood Risk Assessment (WHS, November 2022)
[2] Cherwell Level 2 Strategic Flood Risk Assessment (AECOM Ltd, May 2017)
[3] Oxfordshire County Council Preliminary Flood Risk Assessment (JBA Consulting, June 2011)
[4] Oxfordshire County Council Preliminary Flood Risk Assessment Addendum (Oxfordshire County Council, December 2017)

Figure 1.4 Ashgrove Brook (Upper Catchment)

Figure 1.5 Tributary of Ashgrove Brook

EA Flood Maps

1.12 The EA Flood Map for Planning, shown in **Figure 1.6,** indicates areas of Flood Zones 2 and 3, associated with the Ashgrove Brook downstream of Camp Road and along the Gagle Brook. The Flood Zones are shown to be relatively confined to the watercourse corridor. The upstream extent of the Ashgrove Brook, including the tributary, is not included within the Flood Map for Planning due to the small catchment associated with the upper reaches of these watercourses (<3km^2).

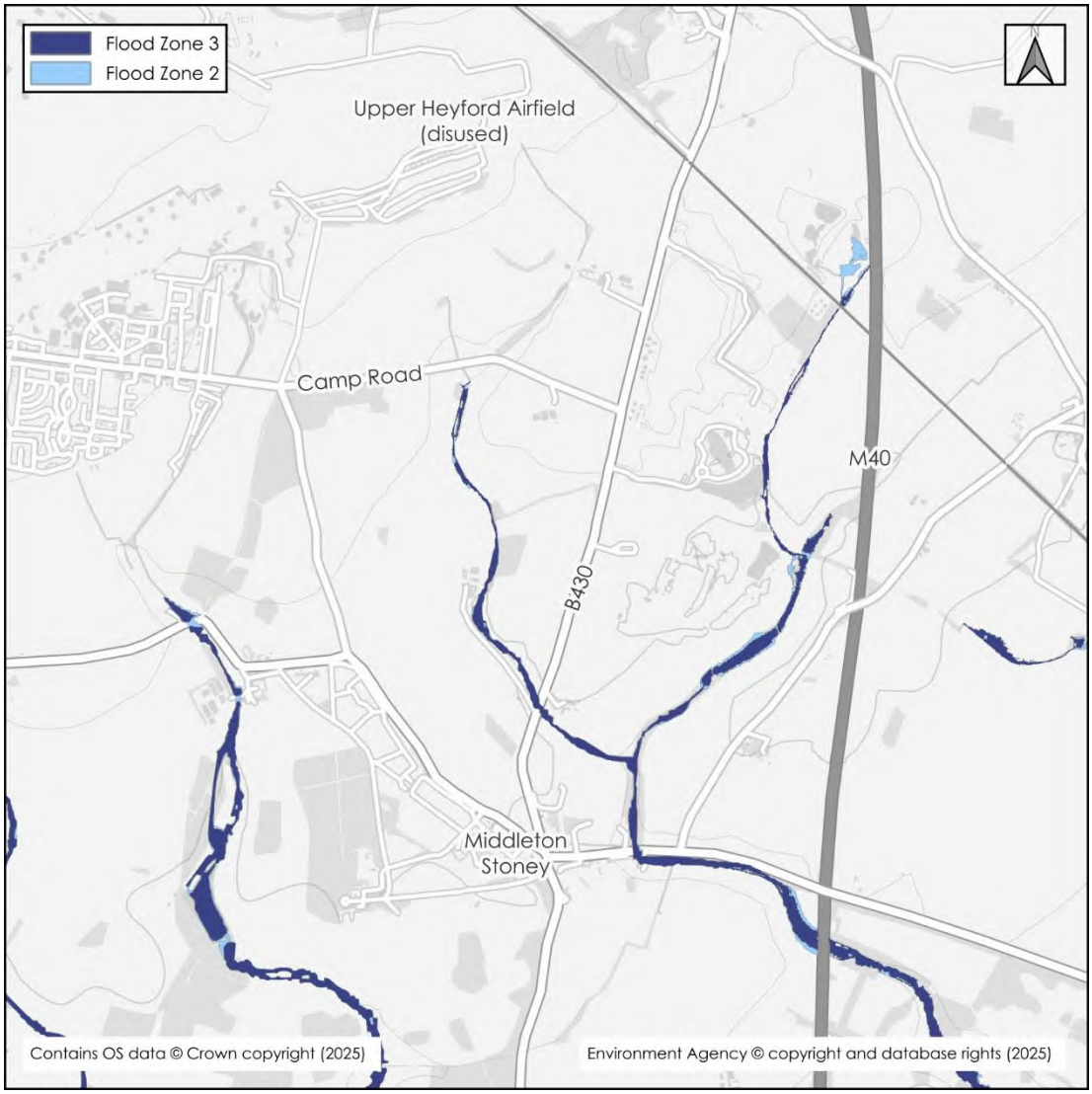


Figure 1.6: Flood Map for Planning

Other Sources of Data

1.13 The following additional datasets were used within the hydraulic modelling exercise:

- EA 2022 LiDAR 1m spatial resolution DTM.
- 3D Topographical Survey by Greenhatch Group in July 2022 (drawing reference: 36646_T_REV4).

- Cross-sectional watercourse survey, undertaken in October 2021 (included as **Appendix 1**).
- Photographs and observations from site visit undertaken in March 2025 by BWB Consulting.
- A hydrological assessment of Flood Flows undertaken by BWB in April 2025 (included as **Appendix 2**).
- Proposed finished levels surface (model reference: OxSRFI-BWB-HGN-ZZ-M3-CH-0101).
- Heyford Park Link Road Culvert General Arrangement (drawing reference: OxSFRI-BWB-SMN-10-DR-CB-1700).
- Middleton Stoney Relief Road Culvert General Arrangement (drawing reference: OxSFRI-BWB-SMN-23-DR-CB-1705).

Aims and Objectives

1.14 This modelling exercise will be used to establish a good hydrological and hydraulic representation of the fluvial flooding mechanisms and magnitude within the vicinity of the Order Limits and test development conditions. The following objectives have been identified:

i. Undertake a hydrological review of the Gagle Brook and Ashgrove Brook to estimate peak flows and generate flood hydrograph profiles.
ii. Construct a 1D representation of the in-channel environment, including structures using ESTRY software.
iii. Construct a 2D representation of the floodplain using TULOW software.
iv. Combine and link the 1D and 2D model domains.
v. Undertake simulations of key flood return period events to establish the floodplain extents and peak flood levels within and adjacent to the Order Limits.
vi. Undertake simulations to account for climate change flows within the model.
vii. Undertake simulations of post-development conditions for key flood return period events and compare to baseline conditions.
viii. Undertake sensitivity analysis of post-development conditions.

Approach

1.15 In order to achieve the objectives identified above, a new 1D/2D ESTRY-TUFLOW model was constructed, based on a watercourse survey completed by BWB in October 2021 (reference: OXSRFI-BWB-ZZ-M2-G-0060, see **Appendix 1**).

1.16 The model has been simulated for a series of design storm events. These modelled events include the 1 in 30-year, 1 in 100-year and 1 in 1000-year events that are typically used by the EA to define Flood Zones 3b (Functional Floodplain), 3a and 2 respectively.

1.17 Simulations have been run to account for the impacts of climate change in accordance with the allowances released by the EA[5]. This is necessary so that any future FRA can assess the risk of flooding over the anticipated lifetime of the proposed development.

[5] https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow

Assumptions and Limitations

1.18 Several assumptions were made during the study which may lead to implications on the modelled results. However, the study has been based on the data available at the time of writing. The key assumptions and limitations are as follows:

- The modelling exercise has made use of the available data at the time of construction and simulation. The model represents the floodplain and channel conditions at the time of survey.
- The modelling exercise has made use of the latest hydrological and hydraulic modelling software versions at the time of analysis and completion (the hydrological assessment was completed in April 2025 with the baseline hydraulic modelling completed in June 2025).
- The model contains no formal representation of the conveyance within minor watercourses or ditches other than that captured by the model grid and within the 1D model domain.
- The 2m resolution of the model may negate any small-scale topographic features, although all the significant features are believed to have been captured.
- The floodplain levels are derived from LiDAR, where topographical survey information is unavailable, which has limited accuracy (+/- 0.15m). However, this is considered to be sufficient for the purpose of this study.
- The bare earth DTM does not include for the presence of walls, buildings or other structures. Buildings have been modelled at ground level with an elevated roughness in line with best practice.
- The modelling exercise has been undertaken to produce a good representation of flood risk mechanisms in and around the study site. It has not been designed to accurately map flooding in the wider catchment.
- Where no pipe opening was visible at structures, assumptions have been made on the size and invert of the structure.
- The proposed culvert at section GBT1_02793_A has been assumed to be a 900mm circular culvert, with a buried bed in line with CIRIA c786 guidance. The downstream sections are based on the geometry of section GBT1_02793_A with the bed level lowered based on the average gradient between sections GBT1_02793_A and GBT1_02749. It is understood that this item will be designed post-DCO.
- The proposed culvert at section GBT1_02298_P has been assumed to be a 1m x 1m rectangular culvert, with a buried bed in line with CIRIA c786 guidance. The upstream and downstream sections are based on the geometry of GBT1_02289 with the bed level raised/lowered based on an average gradient. The bed level has been lowered and widened to the existing invert level of 105.581mAOD (upstream) and 105.536m AOD (downstream) in order to accommodate the 1m wide proposed structure.
- The proposed culvert at section at GBT1_01517_P has been assumed to be a 1m x 1m rectangular culvert, with a buried bed in line with CIRIA c786 guidance. The upstream and downstream sections are based on the geometry of GBT1_01504 with the bed level raised/lowered based on an average gradient. The bed level has been lowered and widened to the existing invert level of 101.285mAOD (upstream) and 101.125mAOD (downstream) in order to accommodate the 1m wide proposed structure.

2. HYDROLOGY

Flood Flow Estimation

2.1 A hydrological review of the catchment was undertaken using Flood Estimation Handbook (FEH) methodologies to estimate peak flood flows and derive an appropriate hydrograph shape. This was undertaken in relation to the EA's latest guidance[6]. This assessment is documented within **Appendix 2**.

2.2 In summary, there is no hydrometric data available in the area to inform the hydrological analysis. Therefore, the industry standard FEH statistical method and Revitalised Flood Hydrograph (ReFH2 Version 4.1) rainfall-runoff model were both reviewed, and a comparative analysis undertaken.

2.3 The final choice of peak flows for input into the model was the FEH Statistical Method, in line with EA FEH Guidelines recommendation that it is normally a more appropriate choice for groundwater-dominated catchments. The Statistical Method benefits from an up-to-date flood peak dataset, using growth curves from hydrologically similar catchments to derive a growth curve. ReFH2 was used to provide a hydrograph shape for the model inflows, scaled to the Statistical peak.

2.4 Flood flow estimates were derived for a range of return period events, the adopted peak flow estimates are provided within **Table 2.1** and the division of flow is shown in **Figure 2.1**. The hydrograph for the Ashgrove Brook will be applied as two point inflows, at the upstream extent of each watercourse, and a lateral flow downstream of the confluence. The hydrograph for the Gagle Brook will be applied as a point inflow at the upstream extent of the model and a lateral flow along the modelled reach.

Table 2.1: Adopted Peak Flood Flows

Return Period Event (Yrs)	Annual Exceedance Probability	Catchment Peak Flow (m^3/s)	
		GB_DS	AB_DS
1 in 2	50%	0.5	0.2
1 in 5	20%	0.7	0.3
1 in 10	10%	0.8	0.3
1 in 30	3.3%	1.1	0.5
1 in 50	2.0%	1.2	0.5
1 in 75	1.3%	1.3	0.6
1 in 100	1.0%	1.4	0.6
1 in 200	0.5%	1.7	0.7
1 in 1000	0.1%	2.4	1.0

[6] LIT 11832 Flood Estimation Guidelines Version 9, Environment Agency (November 2023)

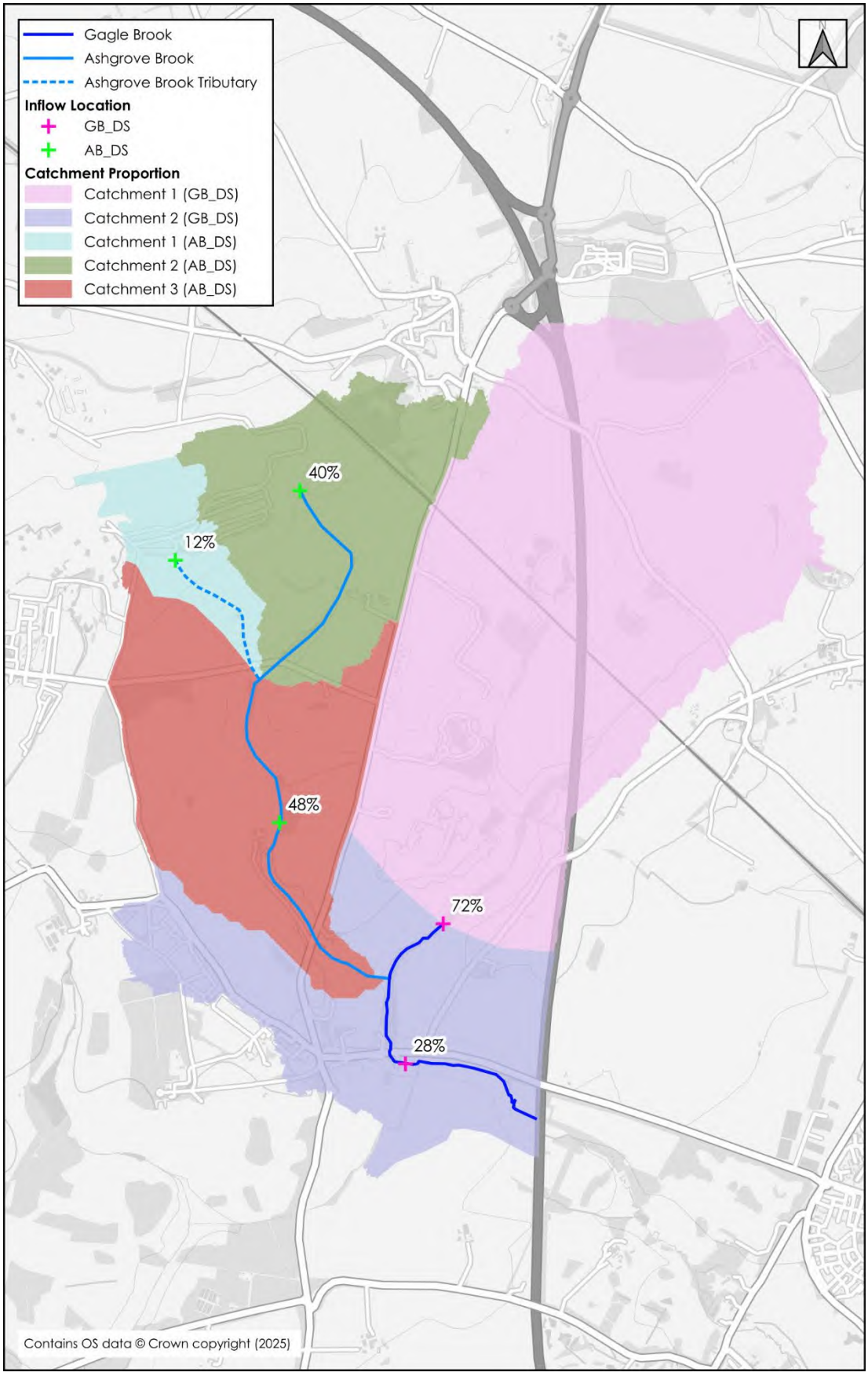


Figure 2.1: Distribution of Model Inflows

Climate Change

2.5 Predicted future change in peak river flows caused by climate change are provided by the EA within their online guidance[7], with a range of projections applied to regionalised 'River Basin Districts'. These districts are further split into 'Management Catchments'. The Gagle Brook and associated tributaries falls within the Cherwell and Ray Management Catchment. **Table 2.2** identifies the relevant peak river flow allowances.

Table 2.2: Peak River Flow Allowance for the Cherwell and Ray Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	27%	49%
Higher Central	11%	10%	25%
Central	6%	4%	15%

2.6 Nationally Significant Infrastructure Projects (NSIPs) may need to assess the flood risk from a credible maximum climate change scenario. Or, in other cases, such as new settlements or significant urban extensions, the flood risk may need to be assessed from a high impact climate change scenario. In these circumstances the upper end allowance for peak river flow should be used.

2.7 It should be noted that use of the credible maximum should be treated as a sensitivity test to help assess how sensitive the proposals are to changes in the climate and ensure the development can be adapted to large-scale climate change over its lifetime.

2.8 To estimate the potential future design floodplain under a range of scenarios, the Central, Higher Central and Upper End climate change allowances for the '2080s' will be applied to the 1% AEP flood flows.

[7] Environment Agency, Flood risk assessments: climate change allowances: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1

3. THE HYDRAULIC MODEL

Software and Solver

3.1 TUFLOW version 2025.0.2-iDP was used for all model runs. The Heavily Paralysed Compute (HPC) solver was used within a Graphics Processing Unit (GPU) environment. This uses an adaptive timestep to solve the equations. TUFLOW'S built in 1D component, ESTRY, was used to model the 1D domain/channel.

The 1D Domain

Extent

3.2 The 1D domain of the Gagle Brook begins approximately 1km north east of Middleton Stoney and continues to the M40. The 1D domain of the Ashgrove Brook and tributary begins within the Order Limits, south of the airfield and continues to the confluence with the Gagle Brook. The watercourses are represented within the 1D domain until the downstream boundary. The extent can be seen in **Figure 3.1**.

Channel Geometry

3.3 The river channel geometry is based on a watercourse survey carried out by BWB in October 2021. The survey also captured hydraulic structures that were present such as bridges and culverts. A series of cross sections are based on LiDAR where survey was unavailable of two online ponds.

3.4 The maximum distance between cross sections is approximately 280m. However, sections are more generally spaced 50-80m apart. The river channel survey is available as **Appendix 1**.

3.5 The channel sections were truncated at top-of-bank from survey data, at what would be the interface with the 2D domain.

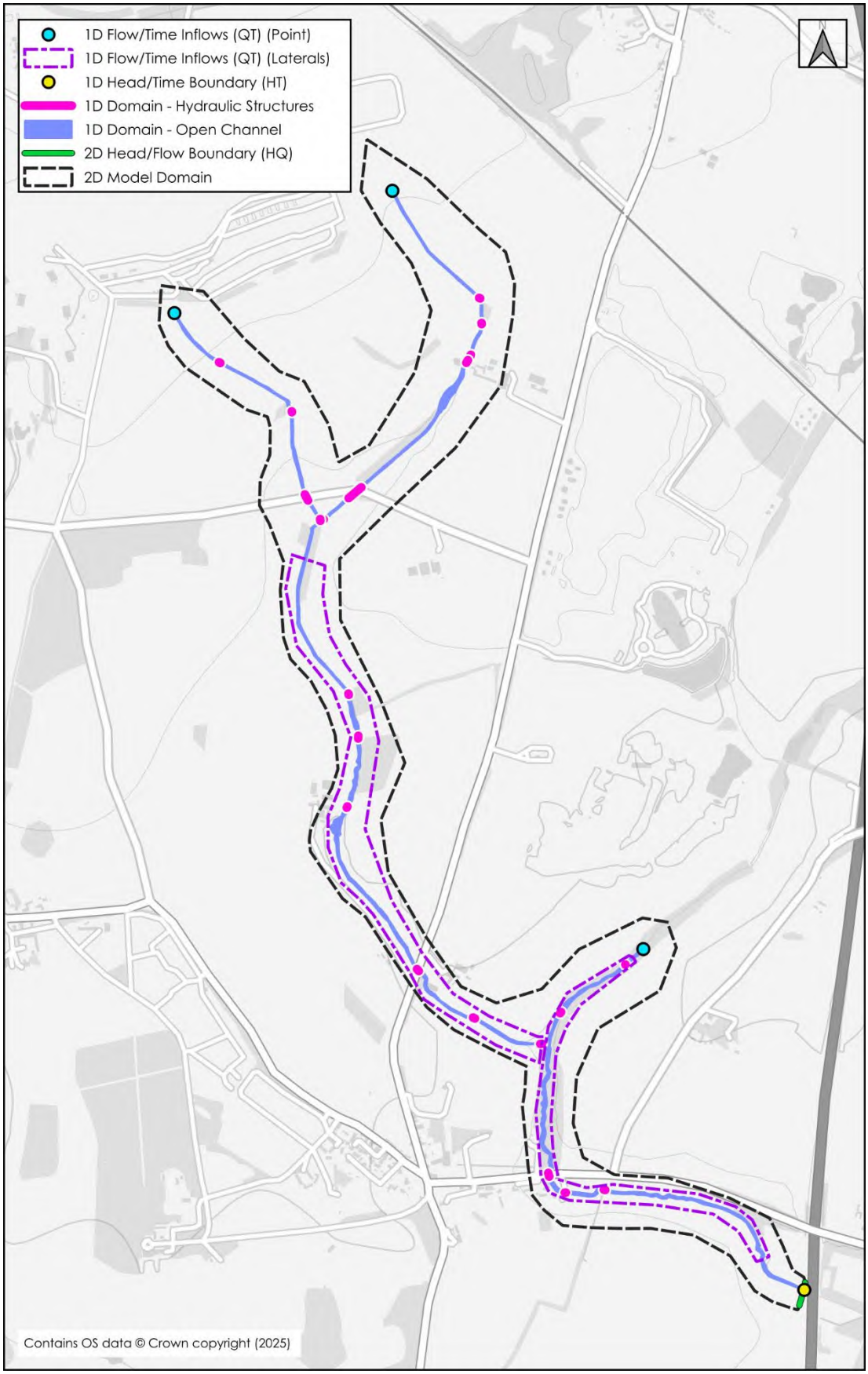


Figure 3.1: Baseline Model Schematic

Hydraulic Roughness

3.6 Hydraulic roughness has been represented using the Manning's n coefficient. The values applied are based on those stipulated in the literature, using Chow (1959)[8]. This study documents appropriate values based on channel bed material, sinuosity and presence of vegetation.

3.7 The guideline values are chosen using engineering judgement, based on photographs of the channel condition taken at the time of survey. Each cross section has a Manning's roughness value applied in the same way as the channel geometry and is read into TUFLOW within a CSV file.

3.8 The majority of the Ashgrove Brook and the Gagle Brook channels were considered to be clean, but winding with pools and riffles, with light bank vegetation. As such, a Manning's n coefficient of between 0.035 and 0.04 was generally deemed to be suitable to represent in-channel roughness for the majority of the cross sections. The majority of the banks and top of banks were lined by light brush and medium density trees. Values between 0.05 and 0.1 were used to represent the varying conditions. Some examples are highlighted in **Table 3.1** below.

Table 3.1: Manning's N Examples

Model ID	Values chosen and description	Photograph
GB_00674	**0.04** Main Channels Clean, but winding with pools and riffles, light bank vegetation	

[8] http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

Model ID	Values chosen and description	Photograph
GBT1_00732	**0.05** Floodplains Brush - light	
GBT2_00549	**0.06** Floodplains Trees – medium density with sprouts	

Hydraulic Structures

3.9 A number of hydraulic structures were represented in the 1D domain, the data for which was collected during the watercourse survey.

3.10 In total, 5 bridges and 16 culverts were included in the model. Weirs were also added to the bridges and culverts where the length was appropriate to be modelled in the 1D domain. These weirs act as spills, that allow water to spill over the deck level of the structure when the water levels are high enough. The details of the modelled structures are included as **Appendix 3**.

Boundary Conditions

3.11 Boundary conditions were applied to the 1D domain to both allow flow in and out of the model.

3.12 QT (flow vs time) boundaries were used to represent the fluvial inflows (**Section 2**) as hydrographs. These consisted of point inflows at the upstream extents of the Gagle Brook and Ashgrove Brook, and tributary, and lateral regions to represent the intervening catchments. **Figure 2.1** and **Figure 3.1** shows where these boundaries were applied.

3.13 A HT (water level vs time) boundary was applied at the downstream limit of the 1D domain. This was set to 81.01mAOD which is the surveyed water level at the downstream cross section. Sensitivity testing has been undertaken on this boundary and is discussed further in **Section 6**.

Initial Conditions

3.14 Initial conditions were applied by modelling a constant baseflow through the model and writing a TUFLOW restart file a nominal time into the simulation. This restart file was then read in during storm events to ensure the channel was not dry at the first timestep.

1D/2D Links

3.15 The 1D channel was linked to the floodplain using "HX" links. These transfer the calculated water level from the 1D cross sections into the 2D floodplain, providing that the water level is above the level of the cell that the HX link is located in. Therefore, HX links should be digitised along the top of bank of the watercourse visible in the topographical survey, watercourse survey and LiDAR data.

3.16 The average modelled width of the channel was approximately 5-7m along the Gagle Brook and Ashgrove Brook.

The 2D Model Domain

Extent and Active Area

3.17 The main influence on the 2D domain extent is generally the expected width of the floodplain, meaning that it should be large enough to allow for flows to be routed through the floodplain where necessary and so that no "glass walling" occurs within the model domain.

3.18 The river channel was deactivated to ensure that it was modelled in the 1D domain. This deactivated area may appear fragmented in places where the deck of a structure is modelled in the 2D domain. The active area is displayed in **Figure 3.1.**

Grid Size and Orientation

3.19 The grid cell size should be chosen in order to sufficiently represent the average width of the modelled channel and its ability to capture key floodplain topographic features.

3.20 The selected grid size of 2m provides a high enough resolution to capture the capacity of the channel (5-7m width = 2-3 number of 2m cells) as well as provide appropriate representation of key floodplain features.

3.21 The orientation of the grid is important for flow routing as flow cannot pass to the neighbouring cell via its corner, only via the cell sides. Therefore, the location line (2d_loc) was drawn to orientate the grid in the predominant direction of flow.

Floodplain Roughness

3.22 Floodplain roughness is defined by the Manning's n coefficient, as per the 1D domain. However, the method in which it is applied differs.

3.23 Roughness has been applied by polygons using land use types as defined by OS Master Map data. These are linked to a coefficient listed in a TUFLOW Materials File (TMF). However, a global roughness value has also been set based on the predominant land use (long grass) in the catchment.

3.24 The values applied for different land use types are listed in **Table 3.2**.

Table 3.2: Floodplain Roughness Values

Land Use Type	Manning's n Coefficient
Long grass	0.035
Short grass	0.030
Roads	0.015
Rail	0.050
Woodland	0.150
Buildings	0.500

Floodplain Topography and Amendments

3.25 The general floodplain topography is based topographical survey (where available) and the latest available LiDAR data, which was downloaded from the DEFRA Open Survey website at a 1m resolution.

3.26 The following amendments to the base topography were made:

- River bank levels were reinforced through the use of a 'THICK' z-line. Bank elevations were provided at intervals along the Z-Line. The levels are informed by surveyed cross-section data, topographical survey and LiDAR (where survey data is unavailable).
- A ditch is shown to be located downstream of the confluence between the two branches of the Ashgrove Brook. The ditch has been reinforced through the use of a Z-Shape. Z-Shape points were used to define levels along the ditch with elevations informed by LiDAR.
- Several ponds are shown to be located adjacent to the watercourses which have been reinforced using a Z-Shape with Z-Shape points used to define the levels at the top of banks.

Floodplain Structures

3.27 There were no floodplain structures within the model. All hydraulic structures were in line with the channel and hence modelled in the 1D domain.

Boundary Conditions

3.28 Boundary conditions within the 2D domain are often used to prevent "glass walling" at the downstream end of the model through use of a "HQ" boundary. This is a flow vs stage relationship automatically defined in TUFLOW when the user inputs a slope value, to allow water to flow out of the model.

3.29 A "HQ" boundary was applied to the downstream extent of the model to allow water routing down to flow out of the model. The "HQ" boundary was calculated by assessing the fall in floodplain levels on both banks. The fall in levels, informed by LiDAR, was divided by the distance measured to determine a slope value (0.002 to 0.022). **Figure 3.1** shows where these boundaries were applied. Sensitivity testing has been undertaken on these boundaries and is discussed further in **Section 6**.

Initial Water Levels

3.30 Initial water levels are often applied to features such as lakes, ponds or canals to represent them containing water of a nominal depth at the start of the model run.

3.31 For ponds within the model domain, an initial water level was simulated which was taken as a minimum of 300mm below the bank elevation shown by LiDAR at the most downstream end of the bank.

Calibration/Verification

3.32 A lack of detailed flow or level data for the catchment meant that there was limited opportunity to calibrate the model.

3.33 Due to the lack of documentation on previous historical instances of flooding, the model cannot be verified against historic events. A conservative approach adopted to the model build mitigates this.

Stability, Warnings and Messages

3.34 TUFLOW has a number of indicators available to assess the stability of a model. These differ slightly between the Classic and HPC solver (the HPC solver was used for this model). The following indicators were checked to ensure the model was performing as expected:

- **Stage and flow time series** – A number of spot checks should be completed to ensure that conveyance through the channel is as expected and that both the stage and flow time series are reasonably smooth, particularly around the study area.
- **1D negative depths** – Significant negative depths indicate that instabilities are present.
- **Cumulative Mass Error** – A value of +/-2% is considered acceptable.
- **Velocities** – Unusually high velocities or circulating vectors are usually a sign of instabilities.
- **Timestep** – or "dt" shows the timestep used to reach a solution over the duration of the model, as the HPC simulation used an adaptive timestep. A timestep lower than 1/10th of a TUFLOW classic timestep is considered to indicate instabilities. A TUFLOW classic timestep is typically up to half of the model grid size, so 1/10th of this value would be 0.1s.
- **Nu values** – 1.0 or greater may indicate unusually high velocities.
- **Nc values** – Higher than 1.0 might indicate unusually high-water depths caused by a low cell elevation.
- **Nd values** – 0.3 or higher might suggest poor boundary setup.
- **High Control Numbers** – or HCN will require timesteps to be repeated if there is an instability.

3.35 The time series graphs were reviewed along the modelled reaches and no significant issues were present that could compromise results at the site. The river channel stages were shown to peak approximately 14 hours into the event along the Gagle Brook and approximately 12 hours into the event along the Ashgrove Brook.

3.36 No HCN's, or 1D negative depths were reported.

3.37 The remaining values highlighted above were considered acceptable.

Model Runs

3.38 In order to achieve the study objectives, the simulations summarised in **Table 3.3** were completed.

Table 3.3: Model Runs

Model Geometry	Return Periods	Comments
Baseline	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year+15%CC 1 in 100-Year+25%CC 1 in 100-Year+49%CC	Representative of 'as surveyed' conditions
Proposed	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year+15%CC 1 in 100-Year+25%CC 1 in 100-Year+49%CC	Representative of 'as built' conditions
Roughness +20%	1 in 100-Year	Floodplain, channel and structure roughness increased by 20%
Roughness -20%	1 in 100-Year	Floodplain, channel and structure roughness decreased by 20%
Downstream Boundary +	1 in 100-Year	20% increase of gradient at downstream boundary and 20% decrease in water depth at downstream boundary
Downstream Boundary -	1 in 100-Year	20% decrease of gradient at downstream boundary and 20% increase in water depth at downstream boundary
Storm Duration (7.5hr)	1 in 100-Year	Storm duration of 7.5hrs used to derive hydrograph
Blockage 1 (GBT1_02793_A)	1 in 100-Year	75% blockage of culvert
Blockage 2 (GBT1_02298_P)	1 in 100-Year	75% blockage of culvert
Blockage 3 (GBT1_01968_P)	1 in 100-Year	50% blockage of culvert
Blockage 4 (GBT1_01517_P)	1 in 100-Year	75% blockage of culvert
Blockage 5 (GBT_01875_Pa & GBT_01875_Pb)	1 in 100-Year	75% blockage of twin culvert

4. BASELINE RESULTS

4.1 The results from the existing conditions model are mapped in **Appendix 4** and shown in **Figure 4.1.** The flood mechanisms are discussed further within the forthcoming section.

4.2 Generally, flows remain in channel for large stretches along the Ashgrove Brook, and tributary, and the Gagle Brook, as shown in **Figure 4.1**.

4.3 Where flows are shown to overtop the banks, the flooding mechanisms are summarised below with the floodplain extents shown in **Figure 4.2** and **Figure 4.3** with flood levels in **Table 4.1** and **Table 4.2**.

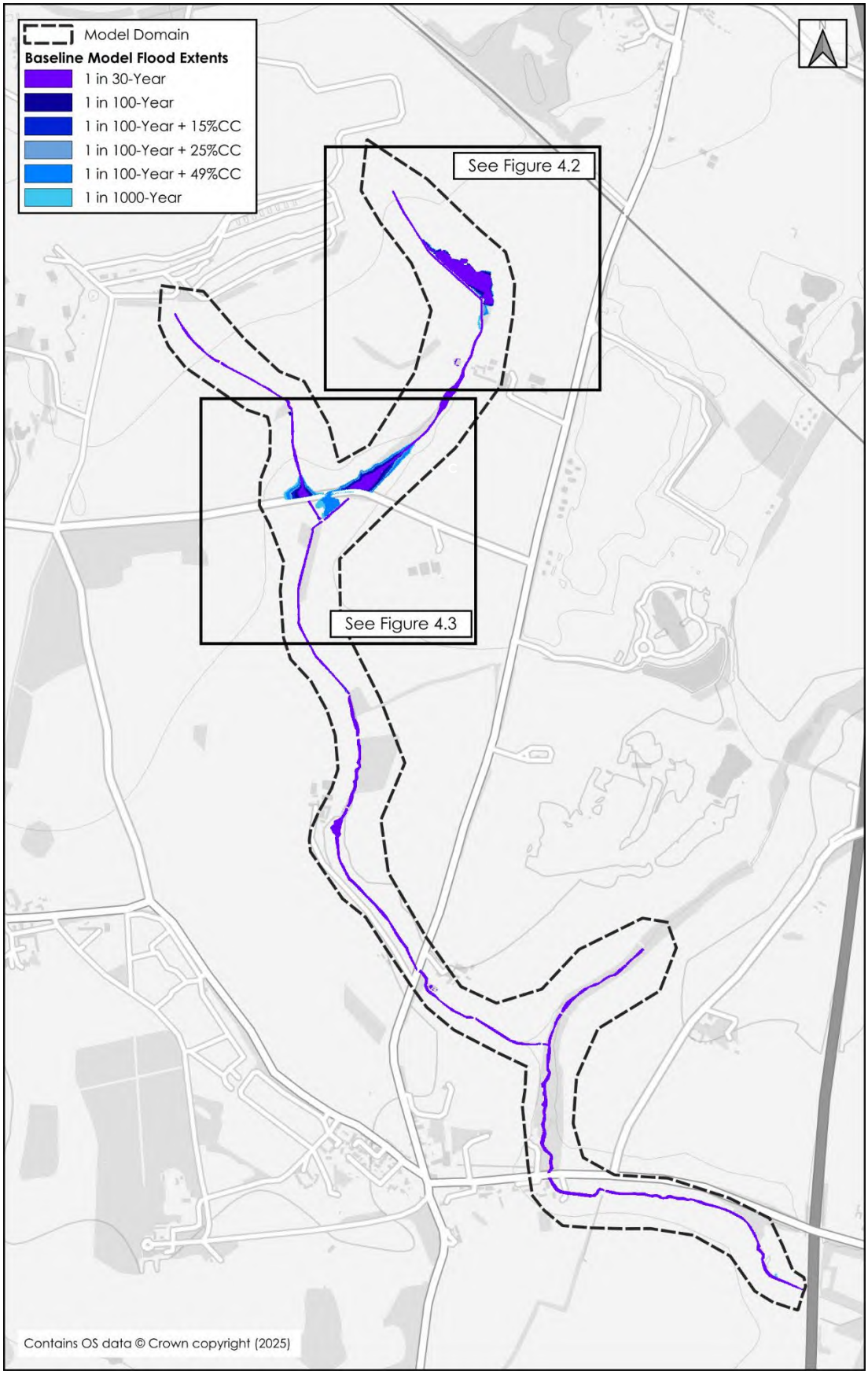


Figure 4.1: Baseline Modelled Flood Extents

Location 1

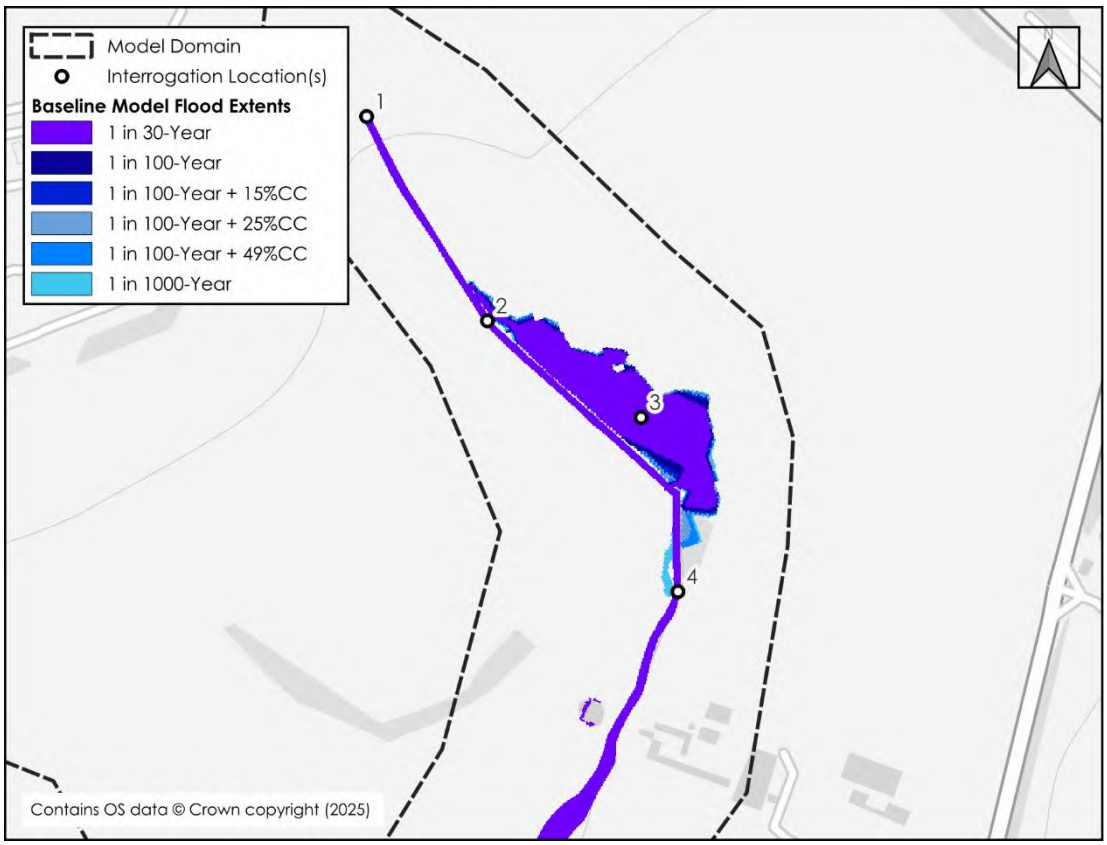


Figure 4.2: Baseline Modelled Flood Extents - Location 1

Table 4.1: Modelled Flood Levels - Location 1

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 15%CC	1 in 100-Year + 25%CC	1 in 100-Year + 49%CC	1 in 1000-Year
1	118.11	118.14	118.16	118.17	118.20	118.23
2	115.17	115.18	115.19	115.19	115.20	115.21
3	112.83	112.83	112.83	112.83	112.83	112.84
4	110.58	110.60	110.62	110.63	110.66	110.68

4.4 Flows overtop the left bank of the Ashgrove Brook during all modelled flood events and travel along the left floodplain.

4.5 During the 1 in 1000-year event, flows also overtop the right bank for a short distance before re-joining the channel.

Location 2

Figure 4.3: Baseline Modelled Flood Extents - Location 2

Table 4.2: Modelled Flood Levels - Location 2

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 15%CC	1 in 100-Year + 25%CC	1 in 100-Year + 49%CC	1 in 1000-Year
5	109.82	109.84	109.85	109.86	109.87	109.88
6	107.78	107.94	108.07	108.14	108.29	108.39
7	108.42	108.44	108.46	108.47	108.53	108.56
8	107.90	108.09	108.23	108.32	108.49	108.54
9	N/A	N/A	N/A	N/A	N/A	107.21
10	105.41	105.41	105.42	105.42	105.43	105.47

4.6 Flows back up behind restrictive structures beneath Camp Road on both the Ashgrove Brook and the tributary during all modelled flood events. During the 1 in 100-year + 49%CC and 1 in 1000-year events flows overtop Camp Road and pool at the confluence between the two watercourses.

5. PROPOSED DEVELOPMENT MODELLING

Philosophy

5.1 The proposed development comprises a SRFI which includes the construction of several warehouses, a new slip road off the M40 motorway, and an intermodal rail terminal with a new track that connects to the existing railway.

5.2 To facilitate the proposed development and accesses, several new culverts are required along the Ashgrove Brook, and tributary, and the Gagle Brook. The location of the proposed structures are detailed within **Table 5.1** and shown in **Figure 5.1**. At this stage, it is understood that the upstream reaches of the Ashgrove Brook and tributary will be diverted to allow for the proposed development. It is assumed that the culverts will be designed to mimic the conditions of the existing culvert inflows and therefore, they have not been included within the model. Instead, the 1D domain has been amended to begin at the downstream end of the culverts, where the watercourses flow as open channel. It is recommended that the proposed diversions are included within the hydraulic model once the design has been confirmed.

5.3 The proposed culverts will be designed to provide sufficient freeboard and be buried in line with CIRIA c786 sedimentation allowance guidance[9].

5.4 An earthworks exercise has been undertaken to determine the proposed levels at the site.

Table 5.1: Proposed Structures to be Modelled

Structure ID	Culvert Type	Size	Sedimentation Allowance (buried bed)	Freeboard Required
GBT1_02909_P	Clear Span Bridge	-	-	-
GBT1_02793_A	Circular Culvert	0.9m	225mm	225mm
GBT1_02298_P	Rectangular Culvert	1m x 1m	250mm	250mm
GBT1_01968_P	Circular Culvert	1.2m	200mm	200mm
GBT1_01517_P	Rectangular Culvert	1m x 1m	250mm	250mm
GB_01875_P	Circular Culverts	2x 1.2m	200mm	200mm

[9] Culvert, screen and outfall manual C786 (CIRIA 2019)

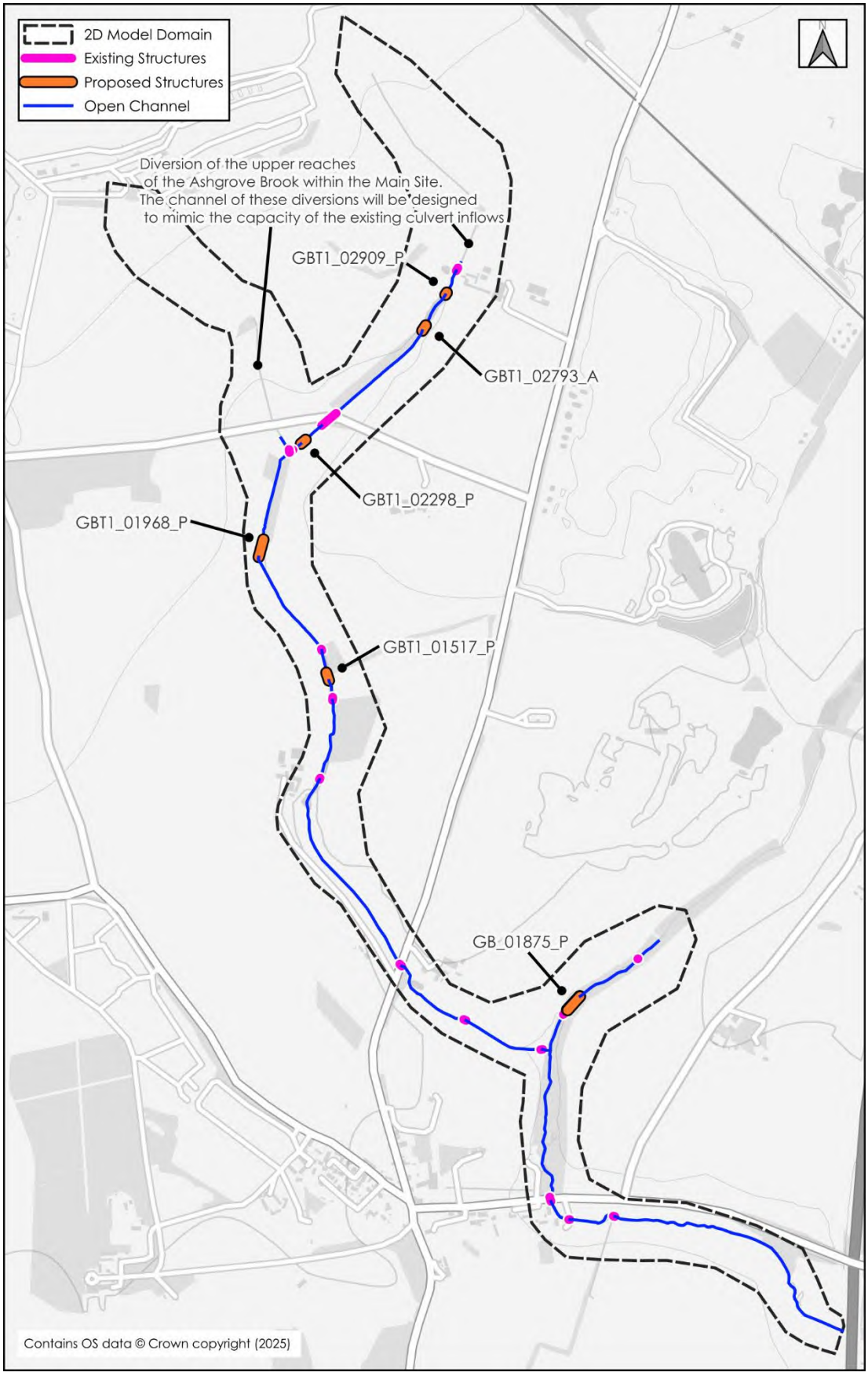


Figure 5.1: Proposed Structures

Representation in Hydraulic Model

5.5 The baseline model was updated to include:

- The proposed culverts, detailed in **Table 5.1**, were represented within the 1D model domain, including the sedimentation allowance in line with CIRIA guidance.
- The 1D model domain was revised for the Ashgrove Brook and tributary to begin at the location where the watercourses flow as open channel.
- The deck levels of the structures were reinforced through the proposed levels/earthworks which was added to the model as a DTM.
- Floodplain roughness was amended in the model to represent the proposed land uses.
- The hydrology was adjusted to remove the proposed development as this will be served by proposed drainage infrastructure.
- The modelled inflow locations were revised for the Ashgrove Brook and tributary to move them to where the revised 1D model domain begins.

5.6 No further changes were made to the existing model.

Stability, Warnings and Messages

5.7 The indicators for assessing stability outlined in **Section 3** have been reviewed for all proposed development simulations. Similar to the baseline, no HCN's, 1D or 2D negative depths were reported.

Model Results

5.8 Mapping of the proposed development conditions is included within **Appendix 5** and summarised below. The floodplain extents are shown in **Figure 5.2** and **Figure 5.3**, with modelled flood levels outlined within **Table 5.2**.

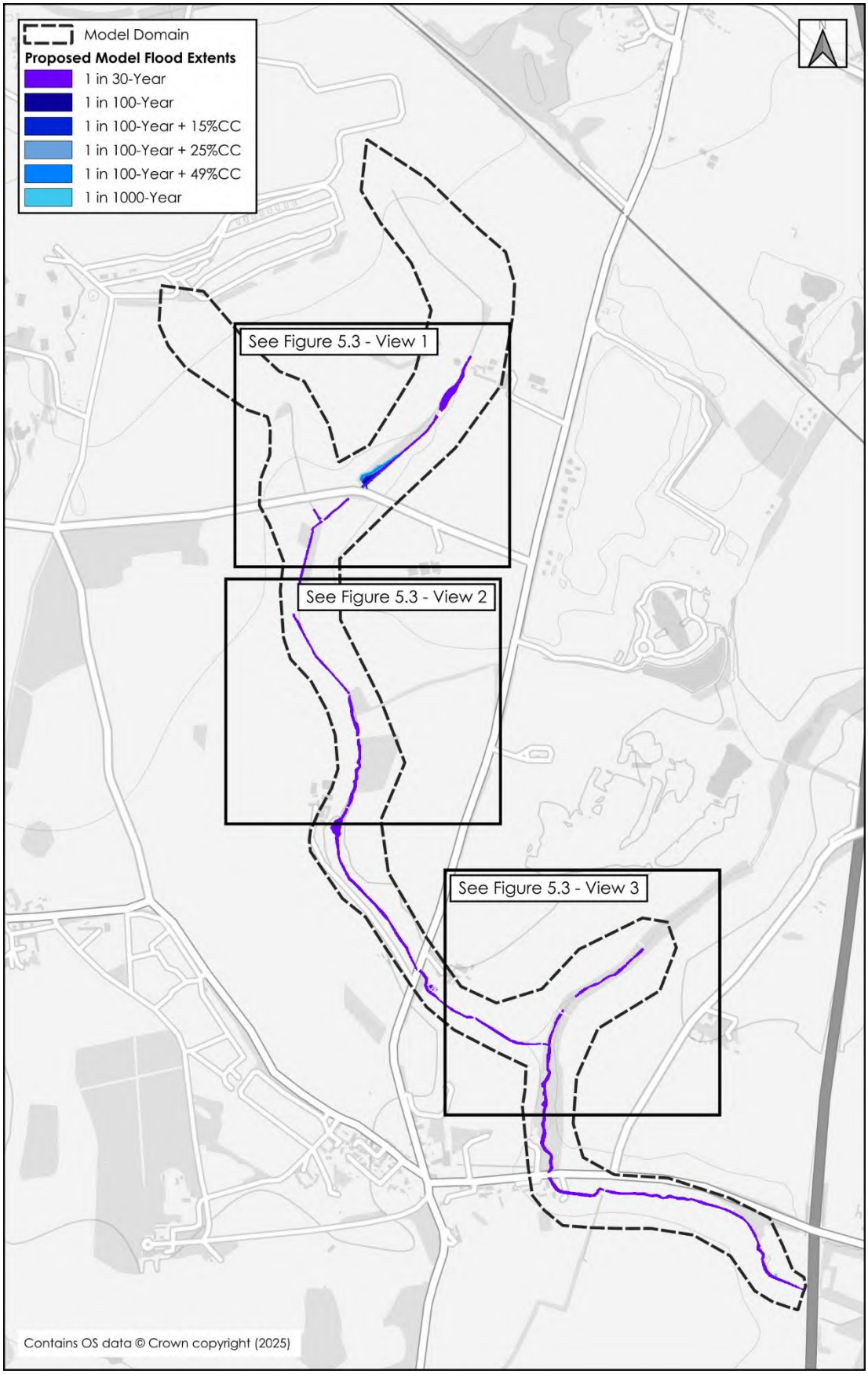


Figure 5.2: Proposed Modelled Flood Extents

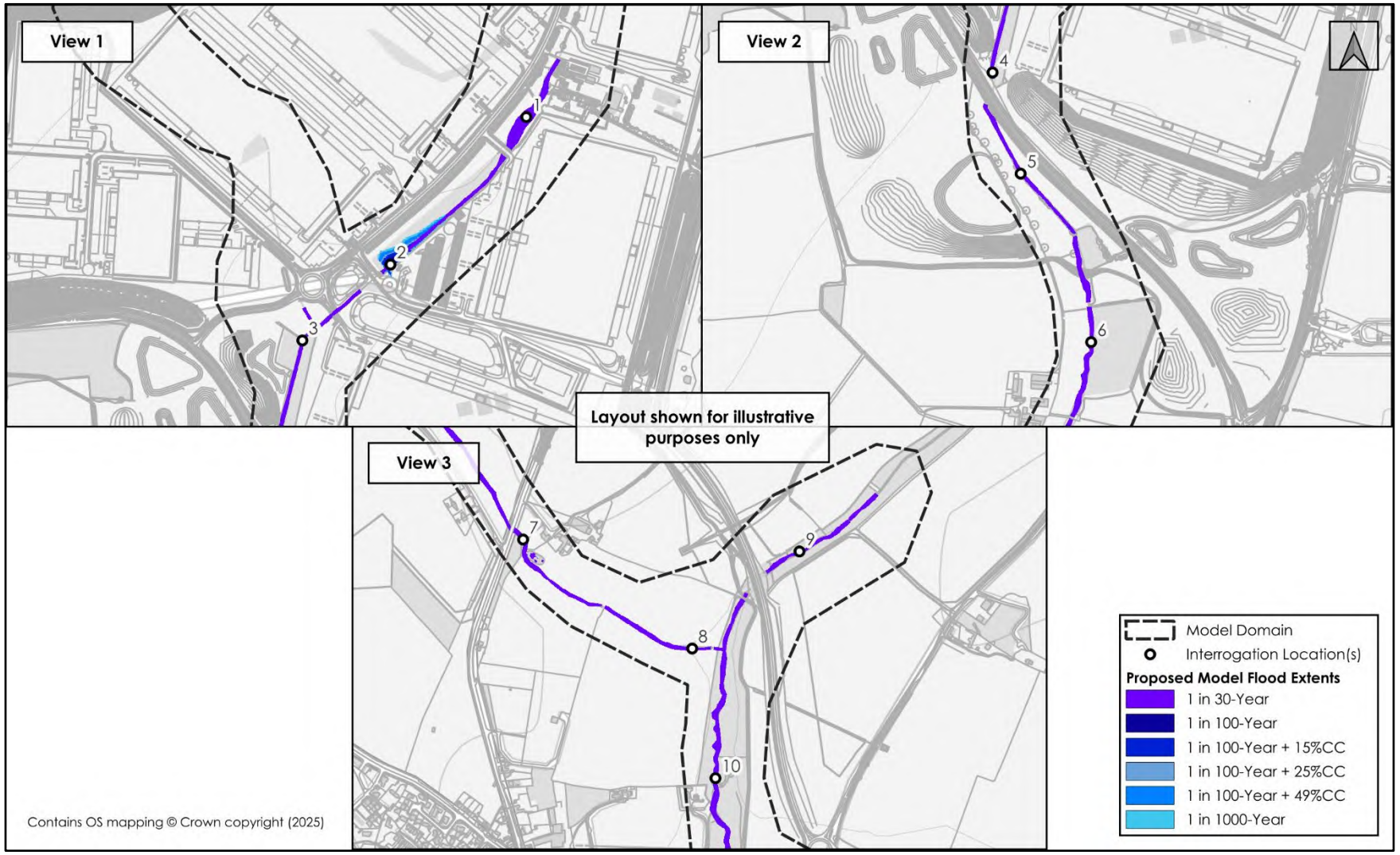


Figure 5.3: Proposed Modelled Flood Extents – Location 1, 2 and 3

Table 5.2: Proposed Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 15%CC	1 in 100-Year + 25%CC	1 in 100-Year + 49%CC	1 in 1000-Year
1	108.95	108.96	108.96	108.97	108.97	108.97
2	106.84	107.54	107.73	107.84	108.07	108.21
3	105.38	105.39	105.40	105.40	105.42	105.42
4	104.69	104.70	104.71	104.72	104.74	104.75
5	102.92	102.94	102.94	102.95	102.96	102.97
6	100.39	100.41	100.42	100.43	100.45	100.46
7	94.94	94.96	94.97	94.98	95	95.02
8	88.93	88.94	88.96	88.97	89.03	89.05
9	89.47	89.51	89.53	89.54	89.57	89.60
10	86.32	86.36	86.38	86.40	86.43	86.46

5.9 The results under the proposed development conditions are similar to the baseline flood extents. Out of bank flows upstream of Camp Road are shown to decrease in the proposed scenario.

5.10 The proposed culverts demonstrate the required freeboard in all events up to and including the 1 in 1000-year event.

Impact Analysis

5.11 The proposed development modelled peak flood levels have been compared to the equivalent baseline peak flood levels to establish off site impacts. Mapping for all events is included in **Appendix 6**; the comparison mapping for the design event (1 in 100-year + 15%CC) is illustrated in **Figure 5.4** and discussed below.

5.12 The mapping shows that the along the upstream reaches of the Ashgrove Brook and tributary flood levels and extents are shown to decrease. Flood levels are also shown to decrease along the Gagle Brook.

5.13 Upstream of structure GBT1_01968_P and GBT1_01517_P, flood levels are shown to increase as a result of the proposed culverts. However, flows are shown to be remain in channel, with no additional floodplain extents.

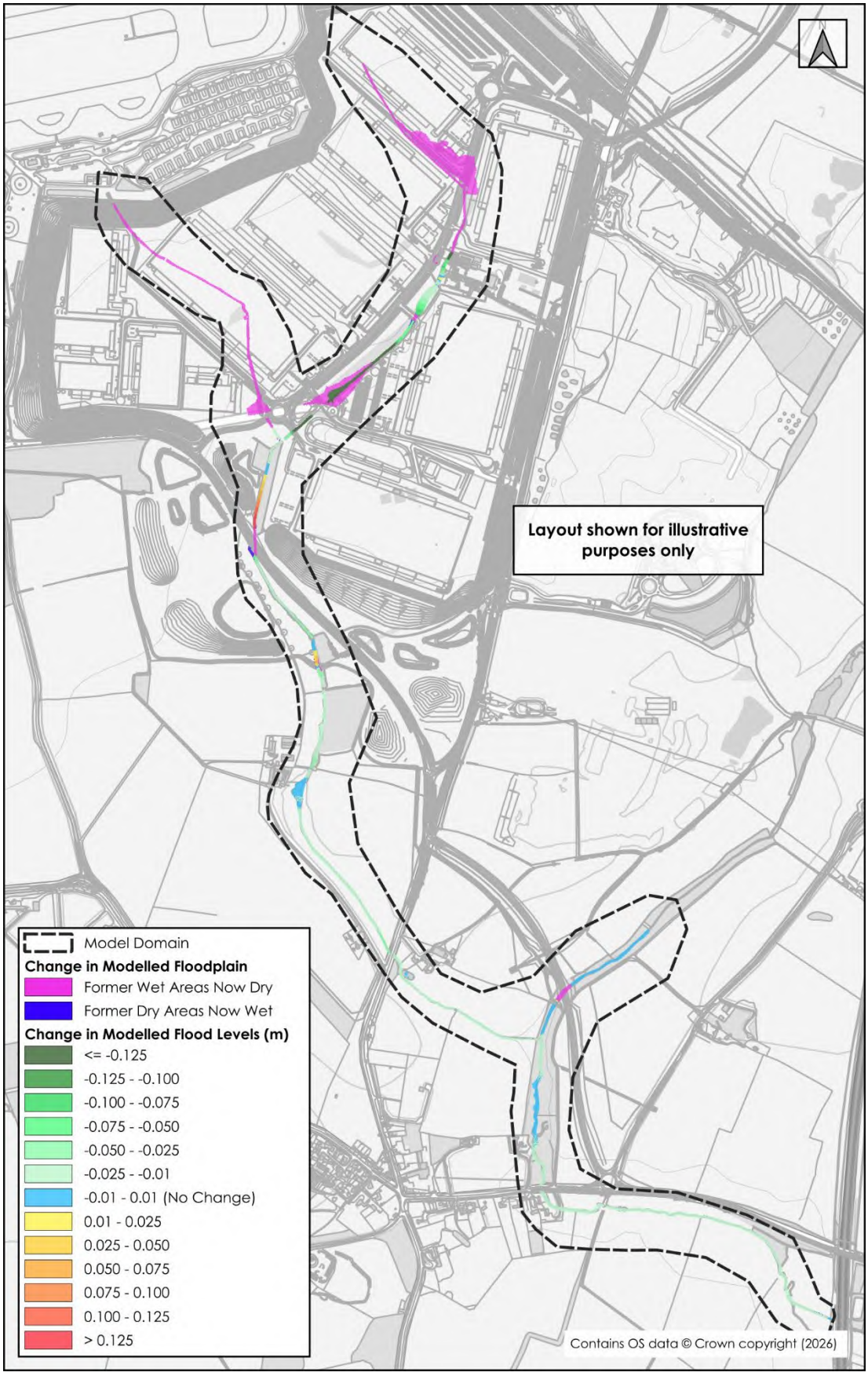


Figure 5.4: Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 15%CC

6. SENSITIVITY TESTING

6.1 To account for seasonal variations in vegetation, ensure the robustness of boundary conditions and blockage of key structures, a series of sensitivity tests were conducted using the 1 in 100-year flood return period event. The difference in peak water level and floodplain extent between the sensitivity test scenarios and the 1 in 100-year proposed scenario are mapped in **Appendix 7**.

Flow Estimates

6.2 The recommended storm duration at the downstream extent of the Ashgrove Brook is 7.5hrs and at the downstream extent of the Gagle Brook is 11hrs. The ReFH2 recommended storm duration at the downstream extent of the model is 11hrs and therefore this uniform storm duration was used to derive the model inflows.

6.3 A sensitivity test has been undertaken for the 7.5hr storm duration.

6.4 The 7.5hr storm duration generally leads to no change in peak flood levels, within model tolerances, across the modelled domain. There are minor decreases in modelled flood level, of up to 20mm, along the upstream reach of Gagle Brook. The changes are isolated and do not result in a change in floodplain extent.

6.5 Therefore, the model results are considered to be robust to changes in storm duration, which increases the confidence in the model outputs and the use of the 11hr event as the critical duration for this study.

Roughness

6.6 The modelled roughness coefficients were determined from aerial imagery, site photographs and OS mapping. Increasing and decreasing the roughness values in the channel and at structures, as well as in the floodplain, tests how seasonal variation and maintenance regimes may affect the flood risk posed to the proposed development.

6.7 A 20% increase in Manning's n roughness coefficient, representative of a period without maintenance, generally leads to increased peak flood levels across the model domain. Changes to the flood extent are not considered to be significant. Upstream of Camp Road flood levels are shown to increase by up to 170mm compared to baseline conditions. This is to be expected as an increase in roughness values across the floodplain and in channel would result in greater frictional forces against the flow of water.

6.8 A 20% decrease in Manning's n roughness coefficient, representative of a period with maintenance generally leads to reduced peak flood levels across the model domain. Changes to the flood extent are not considered to be significant. Upstream of Camp Road flood levels are shown to decrease by up to 250mm compared to baseline conditions. This is to be expected, as the reduced roughness will increase conveyance through the floodplain, channel and culverts, allowing water to flow more freely through the system.

6.9 Although there are changes to the peak water level, these result in limited changes to the flood extents and therefore the model results are considered to be robust to changes in Manning's n roughness, which increases confidence in the model outputs.

Downstream Boundary

6.10 The modelled downstream boundary comprises a 2D HQ boundary, based upon an average gradient, and a 1D HT boundary, based on the surveyed water level at the downstream cross section.

6.11 The 2D boundary gradients were increased/decreased by 20% and the depth of water was calculated at the 1D boundary and this was increased/decreased by 20% with the water level then updated.

6.12 A 20% increase in slope and a 20% decrease in water depth leads to a decrease in peak flood levels towards the downstream boundary, which propagates approximately 10m upstream. Approximately 30m upstream of the downstream boundary there is a minor increase in peak flood levels, however, this is noted to be just outside of the model tolerances (0.015m). There is no change in peak flood levels or flood extents, within model tolerances, across the majority of the model domain.

6.13 A 20% decrease in slope and a 20% increase in water depth leads to an increase in peak flood levels towards the downstream boundary, which propagates approximately 40m upstream. There is no change in peak flood levels or flood extents, within model tolerances, across the majority of the model domain.

6.14 Therefore, the model results are considered to be robust to changes in the downstream boundary, which increases confidence in the model outputs.

Blockage Scenarios

6.15 Blockage was undertaken at five individual locations over five blockage scenarios to understand the impacts of blocking key proposed structures. The locations of the blockages are annotated on the respective mapping, included as **Appendix 7**.

6.16 Smaller culverts are more at risk of a significant blockage due to their limited capacity to convey flows and debris, whereas large culverts are less at risk. Therefore, the magnitude of the tested blockage was determined by the size of the culvert, as shown in **Table 6.1**.

Table 6.1: Sensitivity Test Blockage Percentages

Culvert Diameter (m)	Blockage Applied
< 0.5	100%
0.5 – 1.0	75%
1.0 – 1.5	50%
1.5 >	25%

Blockage 1 (GBT1_02793_A)

6.17 An access route is proposed along the Ashgrove Brook within the north of the proposed development. A 900mm culvert is proposed in this location and therefore a 75% blockage of this culvert was tested within the hydraulic model.

6.18 The blockage scenario indicates that in channel flood levels upstream of the culvert are predicted to increase by up to 100mm. During this scenario there are no increases in modelled flood extents. There is no change in peak flood levels or flood extents, within model tolerances, across the rest of the model domain.

6.19 Therefore, the model results are considered to be robust to blockages of this culvert, which increases confidence in the model outputs.

Blockage 2 (GBT1_02298_P)

6.20 An access route is proposed along the Ashgrove Brook within the south east of the proposed development. A 1m x 1m culvert is proposed in this location and therefore a 75% blockage of this culvert was tested within the hydraulic model.

6.21 The blockage scenario indicates that in channel flood levels upstream of the culvert are predicted to increase by up to 260mm. During this scenario there are no increases in modelled flood extents. There is no change in peak flood levels or flood extents, within model tolerances, across the rest of the model domain.

6.22 Therefore, the model results are considered to be robust to blockages of this culvert, which increases confidence in the model outputs.

Blockage 3 (GBT1_01968_P)

6.23 A 1.2m culvert is proposed beneath the Heyford Park Link Road, to the south of the proposed development. Therefore, a 50% blockage of this culvert was tested within the hydraulic model.

6.24 The blockage scenario indicates that in channel flood levels upstream of the culvert are predicted to increase by up to 30mm. During this scenario there are no increases in modelled flood extents. There is no change in peak flood levels or flood extents, within model tolerances, across the majority of the model domain.

6.25 Therefore, the model results are considered to be robust to blockages of this culvert, which increases confidence in the model outputs.

Blockage 4 (GBT1_01517_P)

6.26 A pedestrian access, in the form of a bridleway, is proposed to the south of the development. A 1m x 1m culvert is proposed in this location and therefore a 75% blockage of this culvert was tested within the hydraulic model.

6.27 The blockage scenario indicates that in channel flood levels upstream of the culvert are predicted to increase by up to 430mm. During this scenario there are minor increases in flood extents upstream of the culvert. There is no change in peak flood levels or flood extents, within model tolerances, across the majority of the model domain outside of this localised impact.

6.28 Therefore, the model results are considered to be robust to blockages of this culvert, which increases confidence in the model outputs.

Blockage 5 (GBT_01875_Pa & GBT_01875_Pb)

6.29 Twin 1.2m culverts are proposed beneath the Middleton Stoney Relief Road, to the east of the proposed development. Therefore, a 50% blockage of each culvert was tested within the hydraulic model.

6.30 The blockage scenario indicates that in channel flood levels upstream of the culvert are predicted to increase by up to 120mm. During this scenario there are no increases in modelled flood extents. There is no change in peak flood levels or flood extents, within model tolerances, across the rest of the model domain.

6.31 Therefore, the model results are considered to be robust to blockages of this culvert, which increases confidence in the model outputs.

7. SUMMARY & RECOMMENDATIONS

7.1 Please note that this conclusion should be read in conjunction with the study limitations and assumptions in **Section 1**.

7.2 BWB has been commissioned by Oxfordshire Railfreight Limited to undertake a site-specific hydraulic modelling exercise of the Gagle Brook and a tributary of the Gagle Brook, known as the Ashgrove Brook, to support the development of the Oxfordshire SRFI.

7.3 The modelled flood flows have been informed by a hydrological review of the catchment associated with the Gagle Brook, Ashgrove Brook and the tributary of the Ashgrove Brook. The latest climate change allowances have been incorporated into the hydrological assessment.

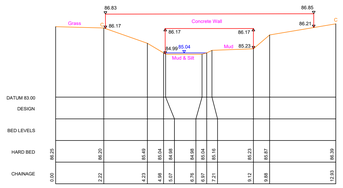
7.4 The baseline results generally show flows to remain in channel for large stretches along the Ashgrove Brook, and tributary, and the Gagle Brook. Along the northern section of the Ashgrove Brook, flows overtop the left and right banks and travel along the floodplain. Flows back up behind restrictive structures beneath Camp Road on both the Ashgrove Brook and tributary. During the higher return periods, flows overtop Camp Road and pool at the confluence between the two watercourses.

7.5 The proposed model results show similar extents to the baseline. Out of bank flows upstream of Camp Road are shown to decrease in the proposed scenario. The required freeboard is also achieved within the proposed culverts during all modelled events. There are some isolated increases in flood levels, as a result of proposed structures, however, there is no increase in floodplain extents.

7.6 Sensitivity testing has shown the model results to be robust with respect to changes in storm duration, seasonal variations in vegetation, blockage of the proposed structures and robustness of boundary conditions.

APPENDICES

Appendix 1: River Channel Survey



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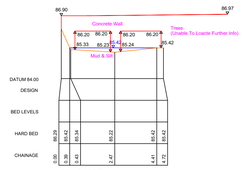

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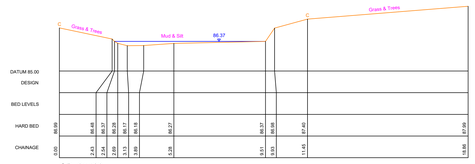

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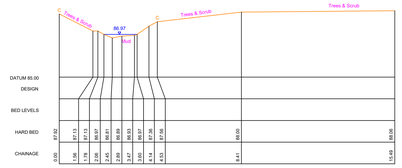

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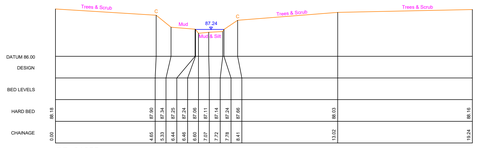

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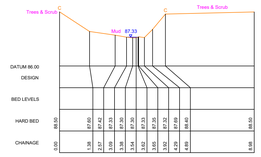

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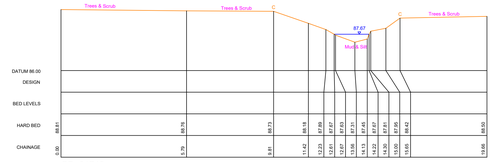

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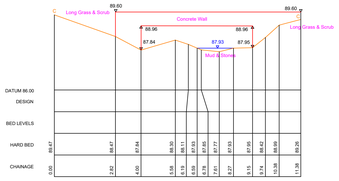

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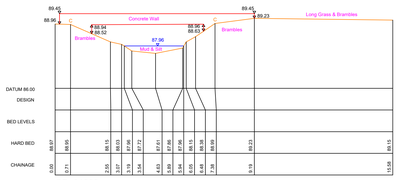

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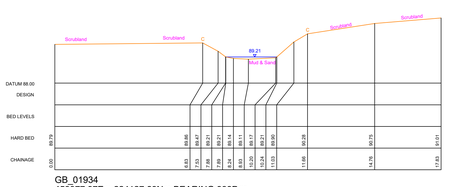

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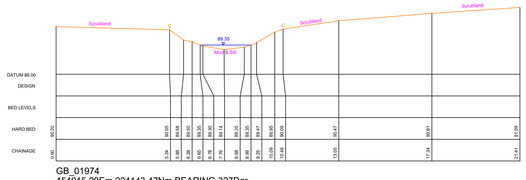

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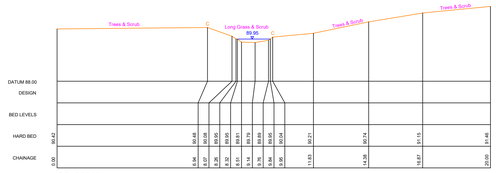

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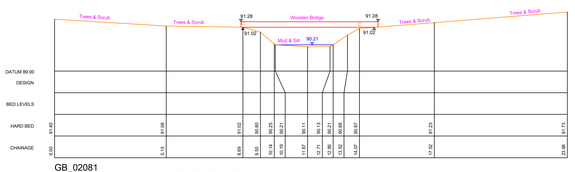

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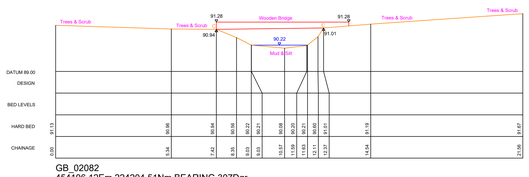

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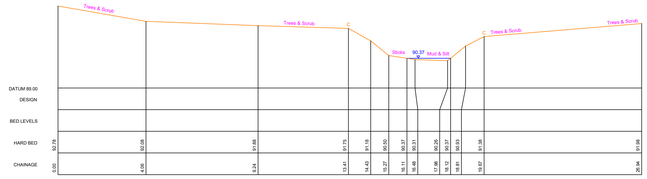

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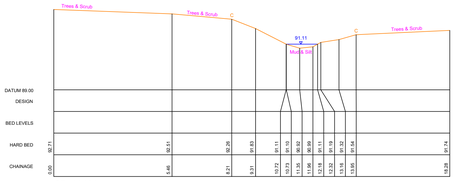

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Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1 Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00 Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Me	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole		
		Gas	Gas	THL	Threshold Level
DK	Drop Kerb	GV	Gas Valve	TL	Traffic Light
DP	Down Pipe	GY	Gully	TP	Telegraph Post
Elec	Electric	Ht	Height	TS	Traffic Signal
EP	Electricity Post	IC	Inspection Chamber	UTS	Unable to Survey
ER	Earth Rod	IFL	Internal Floor Level	WL	Water Level
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WM	Water Meter
FL	Floodlight			WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK SHEET 1 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-01-ZZ-M2-G-0060	S2	P1

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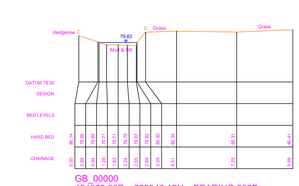

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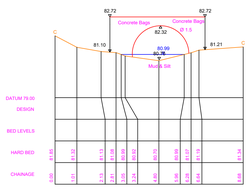

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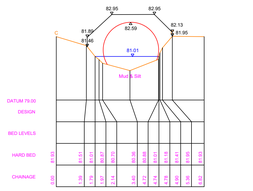

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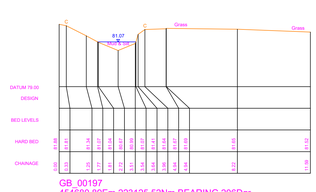

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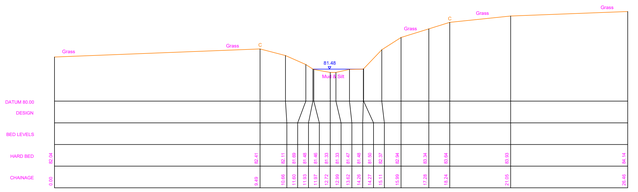

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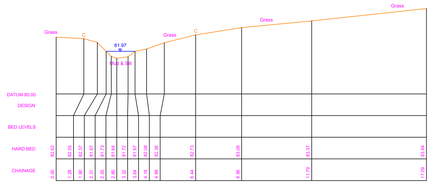

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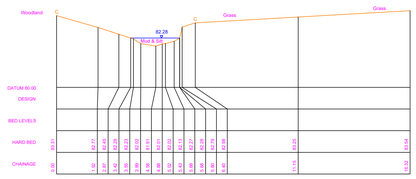

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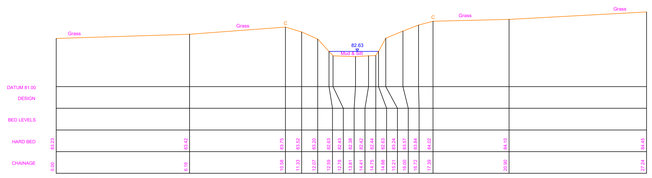

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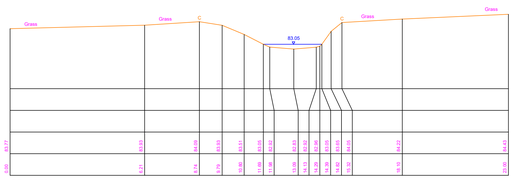

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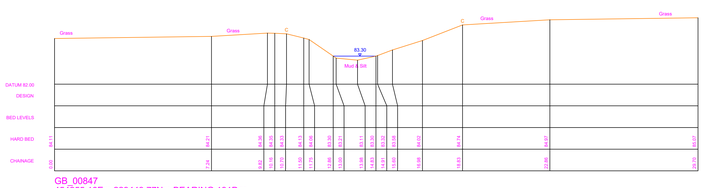

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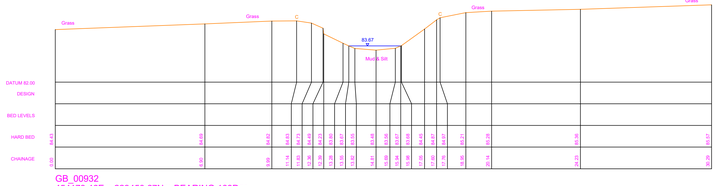

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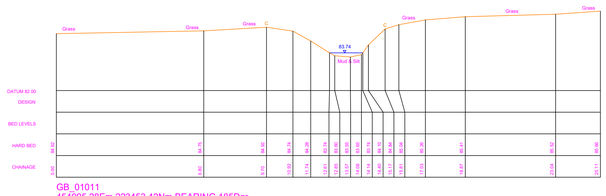

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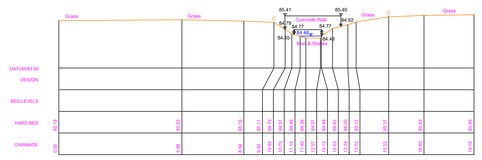

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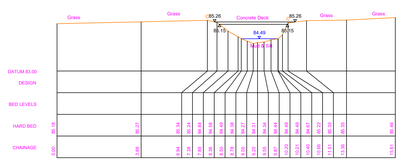

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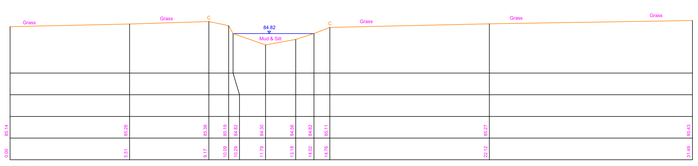

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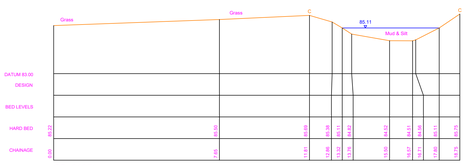

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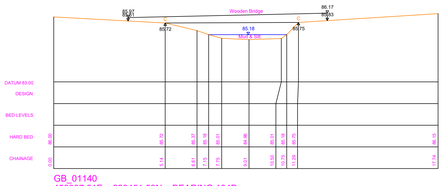

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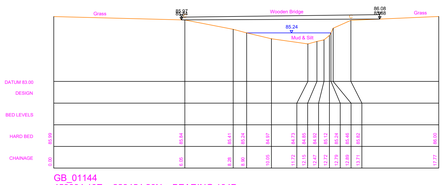

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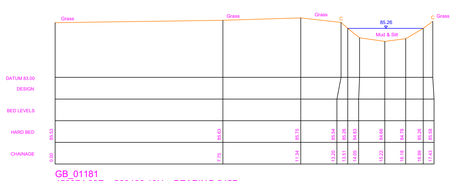

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01/03/2022

Notes

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7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings	Contour Lines
Surveyed Buildings	Inspection Chamber
Building	Flow direction and pipe diameter
Wall	Station and Name
Kerb Channel Line	Monitoring Borehole
Top of Kerb	Tree / Bush / Sapling
Edge of Surface	Area of Vegetation/ Extent of Tree Canopy
Top of Bank	Hedge
Bottom of Bank	Body of Water
Canopy / Overhang	Body of Water from OS
Line Marking	Spot Level
Centre Line	Assumed Surface Water Drainage Line
Watercourse	Surface Water Drainage Line
Centre Line Barrier	
Fence	
Gate	
Overhead Powerline	
Overhead Utilities	

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P2	01.03.22	Extra Sections Added	IR	DS
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK SHEET 1a OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-01-ZZ-M2-G-0060	**S2**	**P2**

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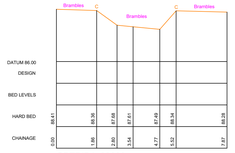

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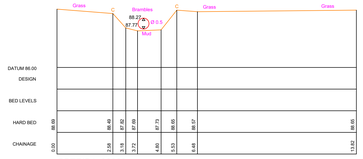

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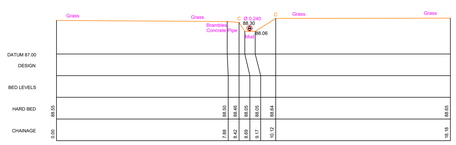

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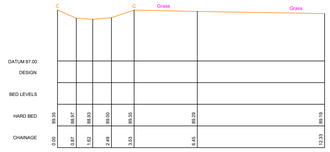

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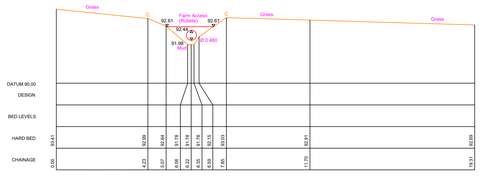

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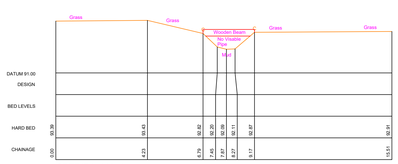
(Farm Access)



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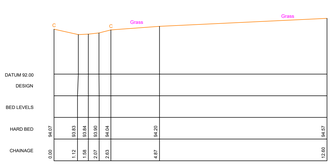

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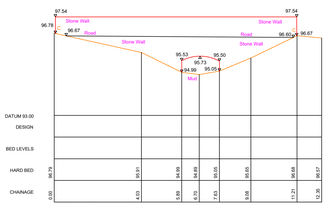

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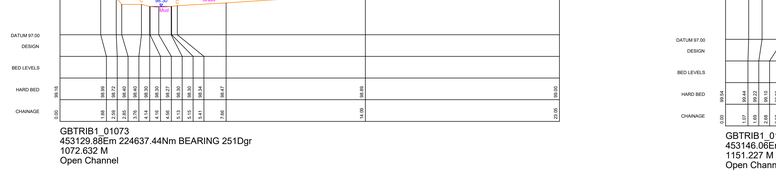
Road Bridge



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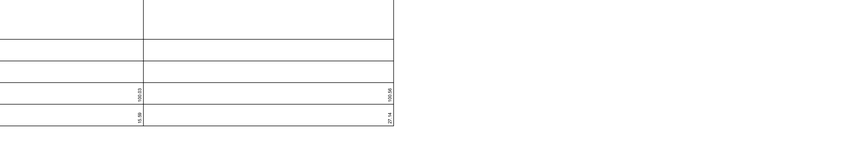

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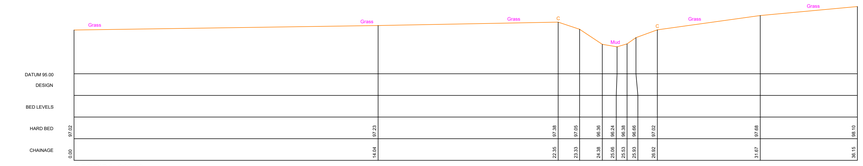

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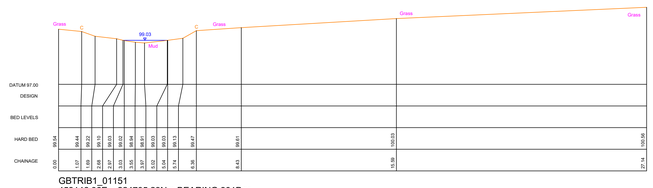

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Open Channel

Notes

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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Me	Service Marker
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C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 2 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-02-ZZ-M2-G-0060	S2	P1

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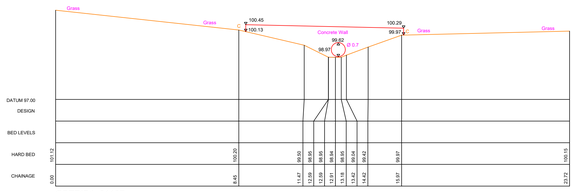

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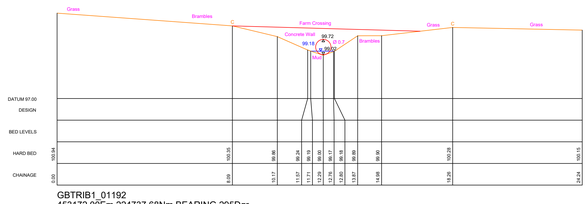

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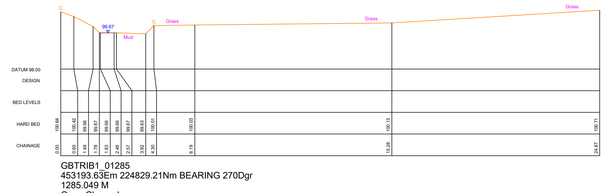

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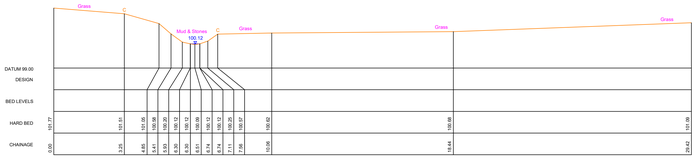

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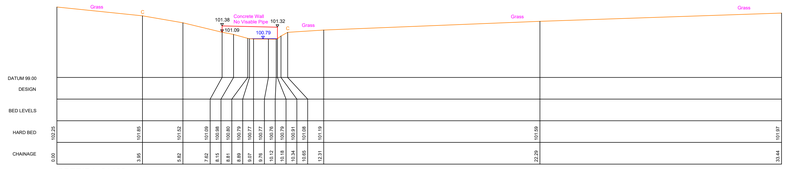

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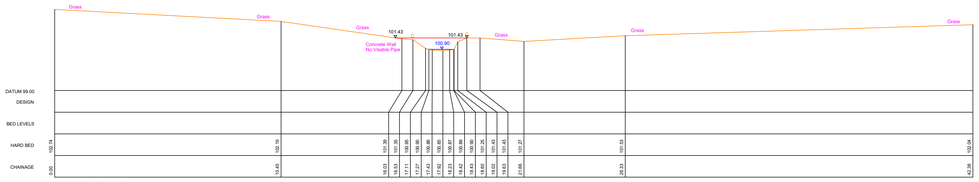

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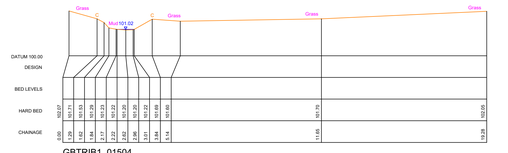

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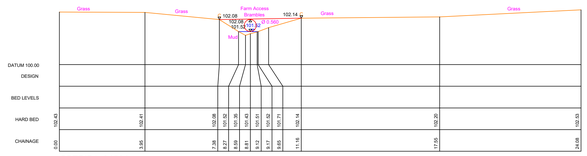

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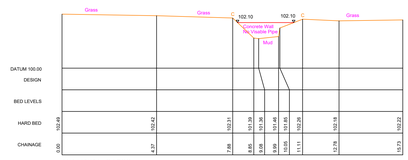

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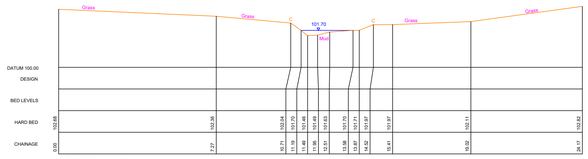

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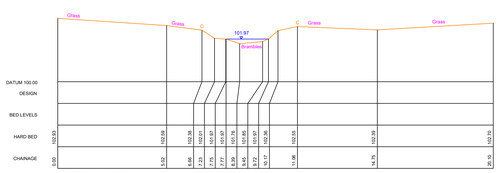

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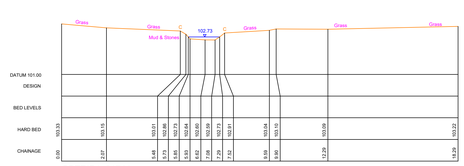

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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
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Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
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CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole		
		Gas	Gas	THL	Threshold Level
DK	Drop Kerb	GV	Gas Valve	TL	Traffic Light
DP	Down Pipe	GY	Gully	TP	Telegraph Post
Elec	Electric	Ht	Height	TS	Traffic Signal
EP	Electricity Post	IC	Inspection Chamber	UTS	Unable to Survey
ER	Earth Rod	IFL	Internal Floor Level	WL	Water Level
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WM	Water Meter
FL	Floodlight			WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
OXFORDSHIRE RAILFRIEGHT LTD

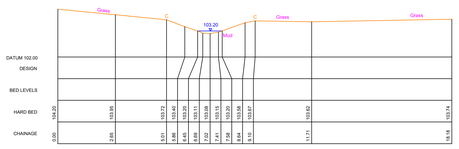
Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 3 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A2:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-03-ZZ-M2-G-0060	**S2**	**P1**



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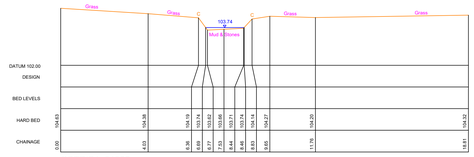

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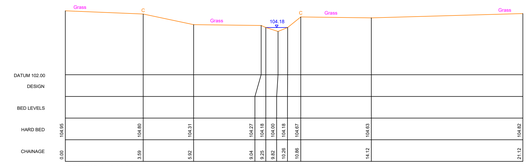

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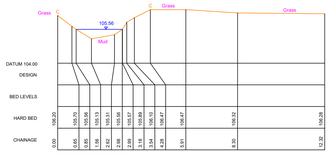
Open Channel



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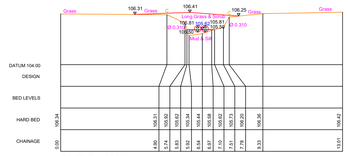

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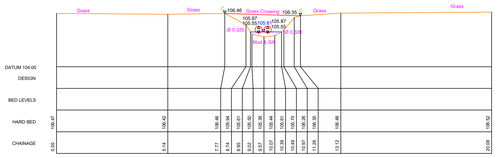

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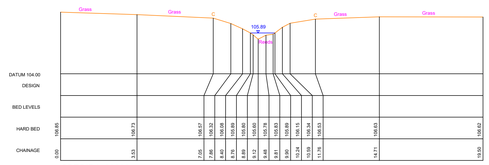
Culvert



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2289.463 M
Open Channel

GBTRIB1_02349
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2348.900 M
Open Channel

GBTRIB1_02365
453168.86Em 225776.55Nm BEARING 320Dgr
2364.728 M
Culvert

GBTRIB1_02422
453211.65Em 225813.53Nm BEARING 325Dgr
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Culvert

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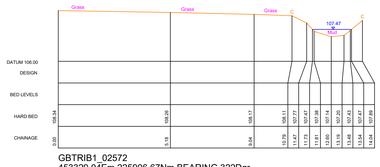
Open Channel



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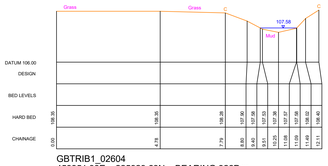

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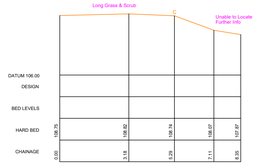
Open Channel



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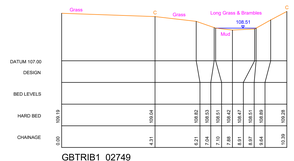
Open Channel



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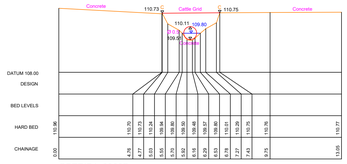

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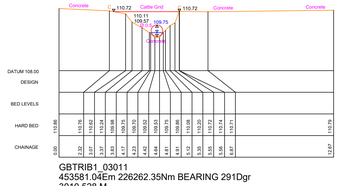

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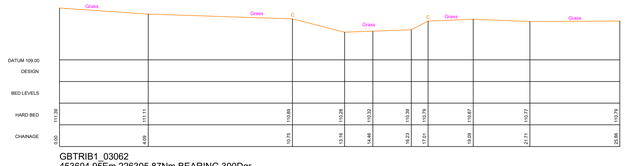

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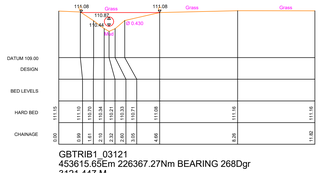
Open Channel



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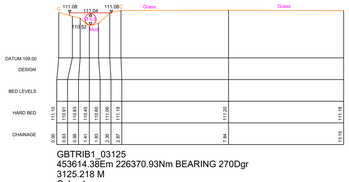

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Culvert

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
		Gas	Gas	TL	Traffic Light
DK	Drop Kerb	GV	Gas Valve	TP	Telegraph Post
DP	Down Pipe	GY	Gully	TS	Traffic Signal
Elec	Electric	Ht	Height	UTS	Unable to Survey
EP	Electricity Post	IC	Inspection Chamber	WL	Water Level
ER	Earth Rod	IFL	Internal Floor Level	WM	Water Meter
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WO	Wash Out
FL	Floodlight				

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 4 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-04-ZZ-M2-G-0060	S2	P1

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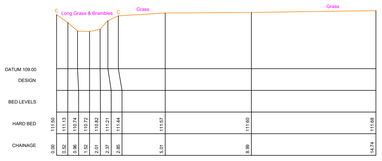

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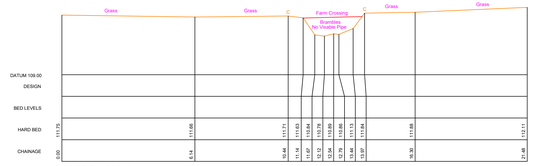

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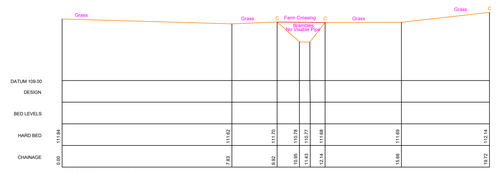
Culvert



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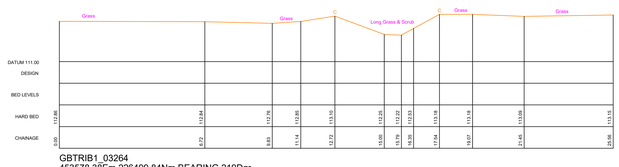

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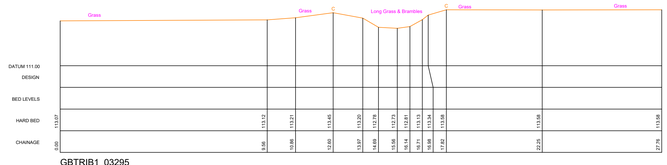

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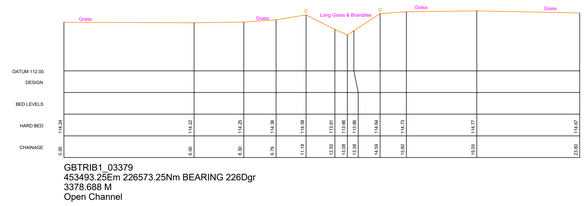

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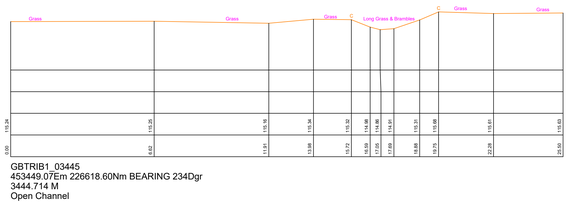

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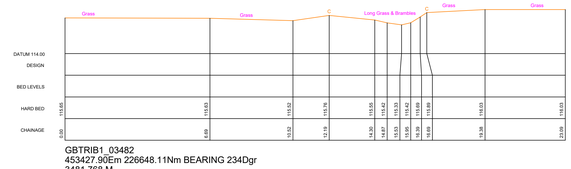
Open Channel



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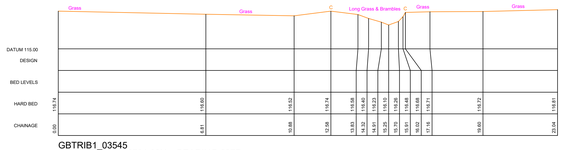

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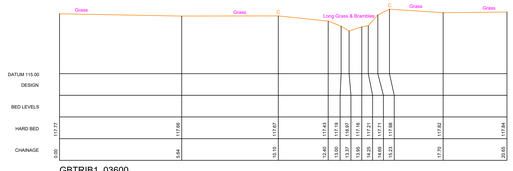

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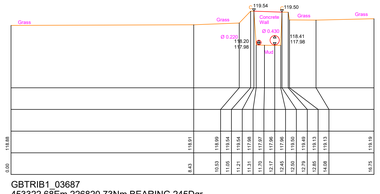

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Culvert

Notes

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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Me	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
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Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 5 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-05-ZZ-M2-G-0060	**S2**	**P1**

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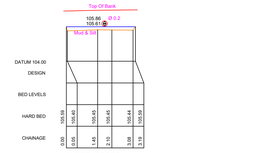

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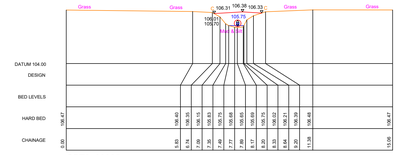
Culvert



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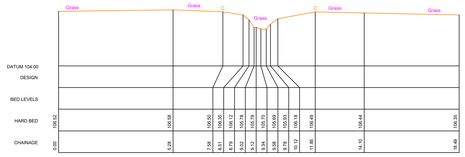

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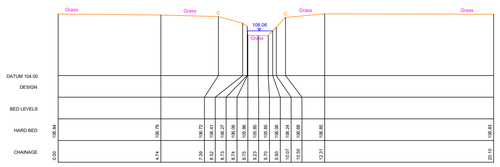

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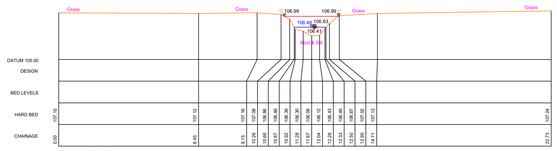

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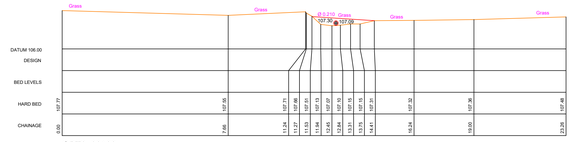

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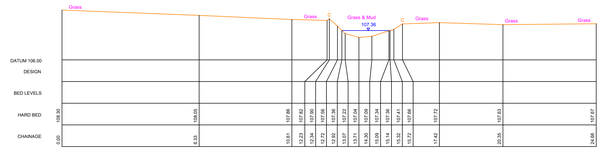

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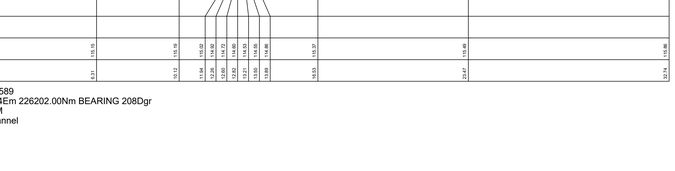

GBT2_00182
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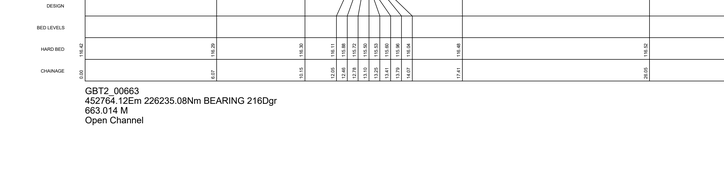
182.446 M
Open Channel



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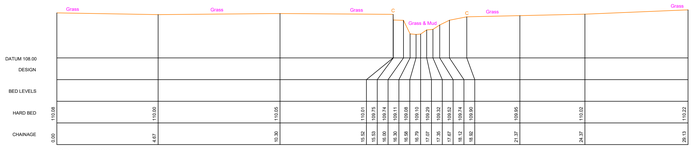
Open Channel



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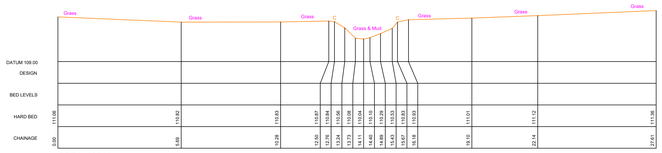

GBT2_00349
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Open Channel

GBT2_00385
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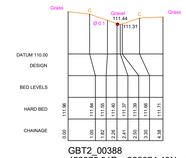
385.028 M
Culvert



GBT2_00388
452975.91Em 226074.43Nm BEARING 250Dgr
388.295 M
Culvert

GBT2_00436
452959.43Em 226122.25Nm BEARING 212Dgr
435.782 M
Open Channel

GBT2_00508
452898.28Em 226160.15Nm BEARING 211Dgr
507.627 M
Open Channel

GBT2_00549
452864.03Em 226180.22Nm BEARING 216Dgr
548.540 M
Open Channel

GBT2_00589
452827.84Em 226202.00Nm BEARING 208Dgr
588.705 M
Open Channel

GBT2_00663
452764.12Em 226235.08Nm BEARING 216Dgr
663.014 M
Open Channel

Notes

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7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY
GAGGLE BROOK
TRIBUTARY 2
SHEET 6 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-06-ZZ-M2-G-0060	**S2**	**P1**

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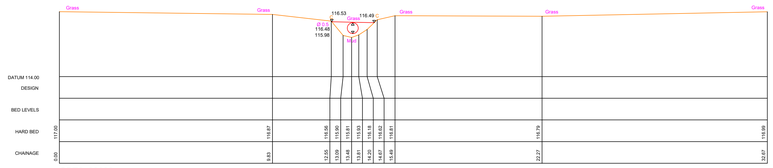

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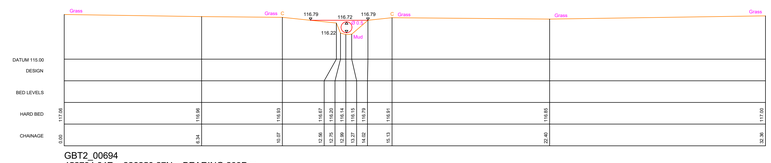
Culvert



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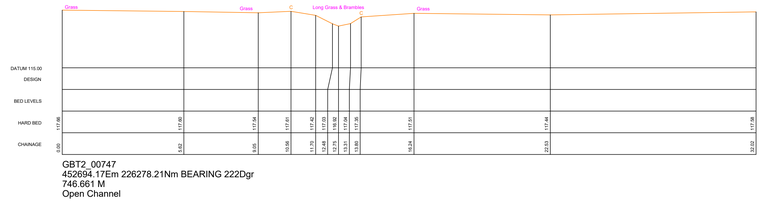
Culvert



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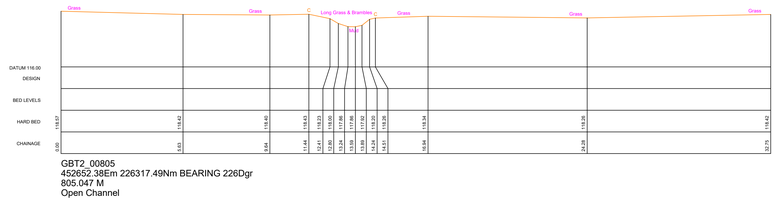
Open Channel



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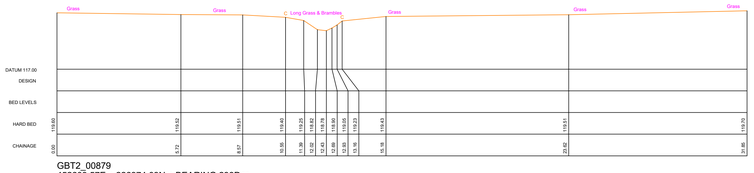
Open Channel



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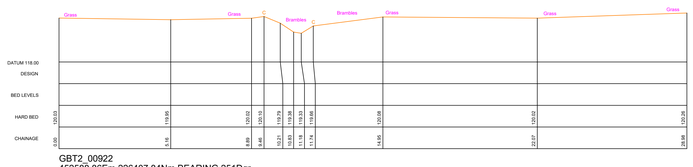

GBT2_00922
452588.86Em 226407.84Nm BEARING 251Dgr
921.710 M
Open Channel

Notes

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Key Plan

Legend

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Surveyed Buildings
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Wall
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Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client

OXFORDSHIRE RAILFRIEGHT LTD

Project Title

OXFORDSHIRE RFI

Drawing Title

WATERCOURSE SURVEY
GAGGLE BROOK
TRIBUTARY 2
SHEET 7 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status

INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-07-ZZ-M2-G-0060	S2	P1

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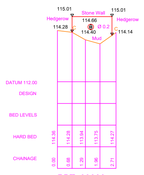

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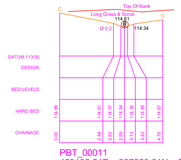
Culvert



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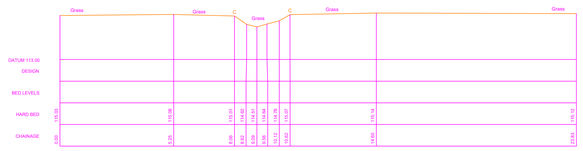
Open Channel



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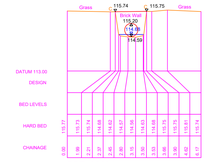

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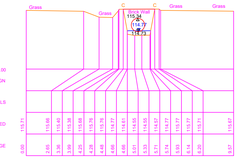

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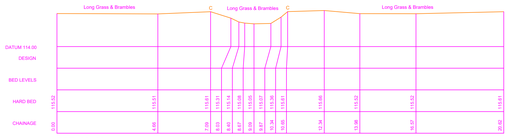

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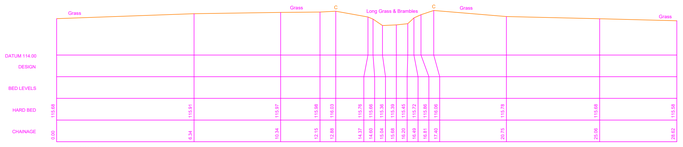

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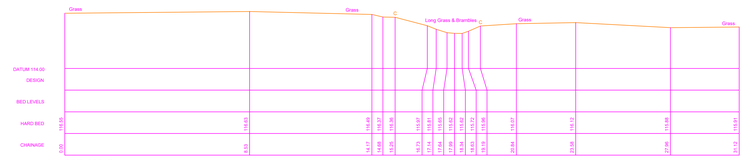

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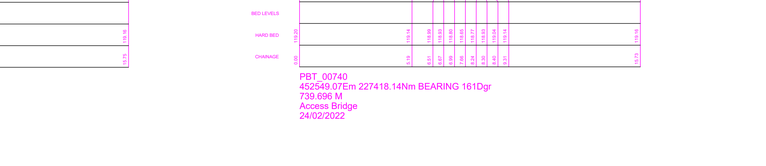

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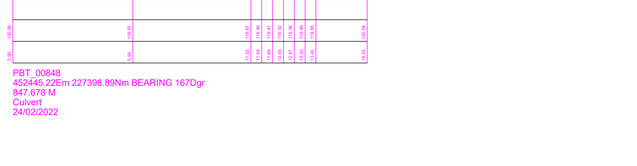

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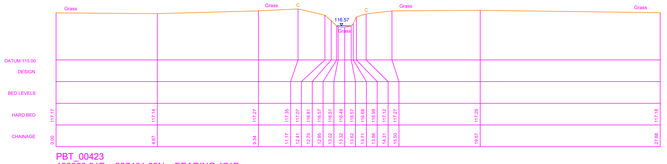

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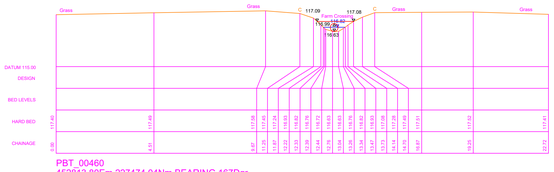

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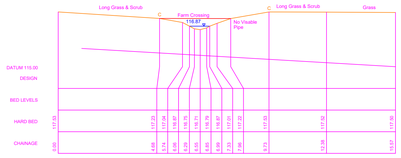

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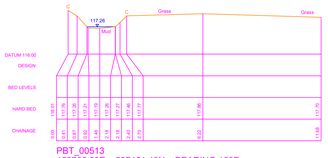

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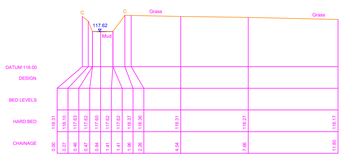

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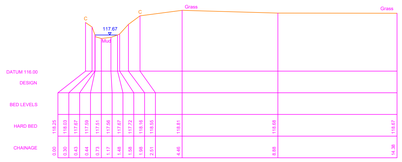

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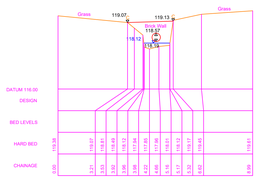

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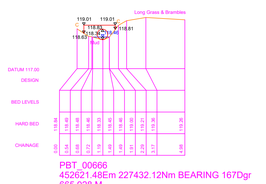
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119.07
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Long Grass & Brambles
114.61
DATUM 117.00
DESIGN
BED LEVELS
HARD BED
CHAINAGE
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118.48
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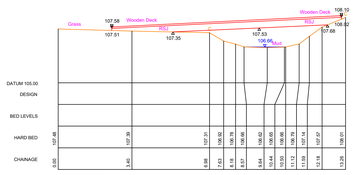

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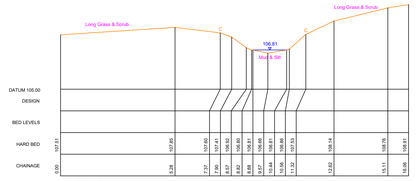
Footbridge



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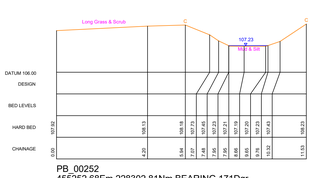
Open Channel



PB_00252
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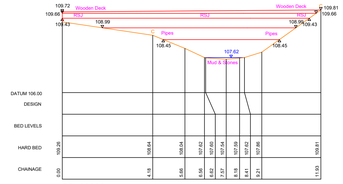

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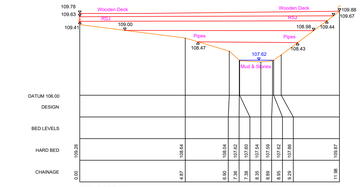

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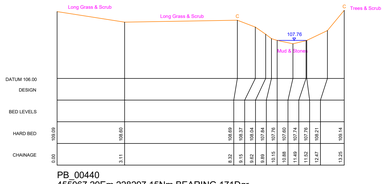

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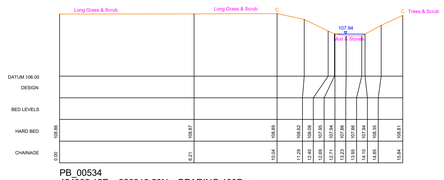

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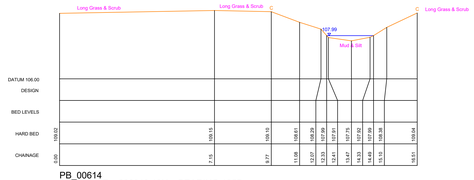

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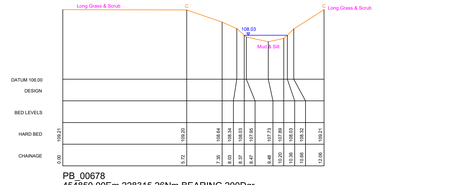

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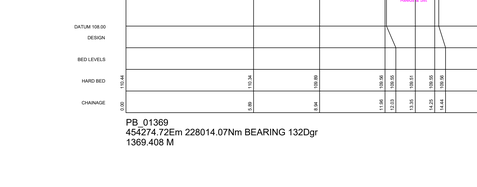

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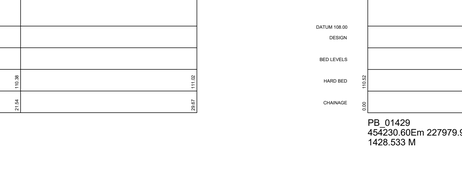

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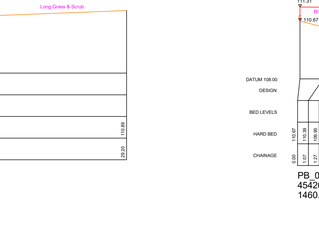

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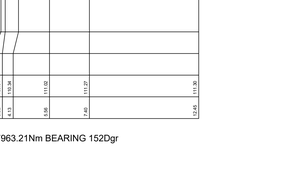

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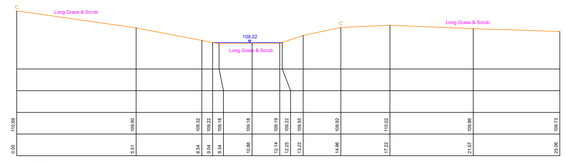

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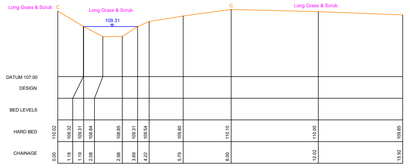

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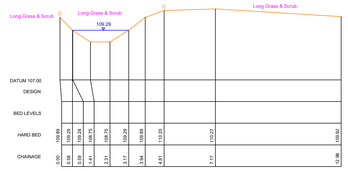

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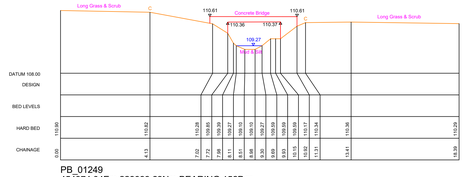

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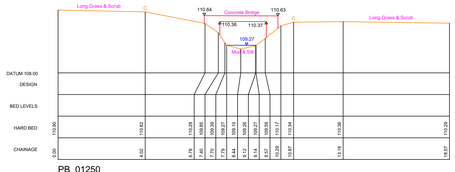

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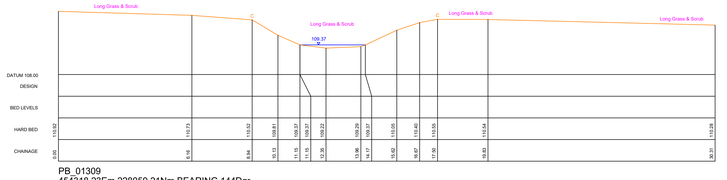

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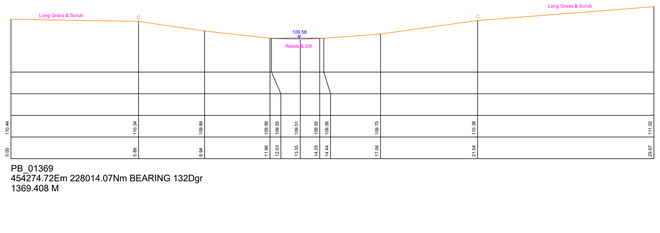

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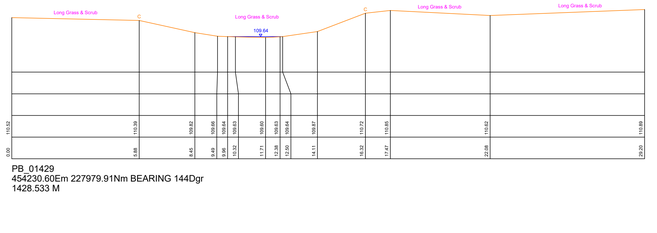

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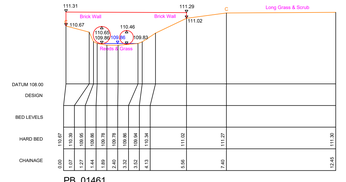

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Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are constructed by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Call Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY PADBURY BROOK TRIBUTARY SHEET 9 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-09-ZZ-M2-G-0060	**S2**	**P1**

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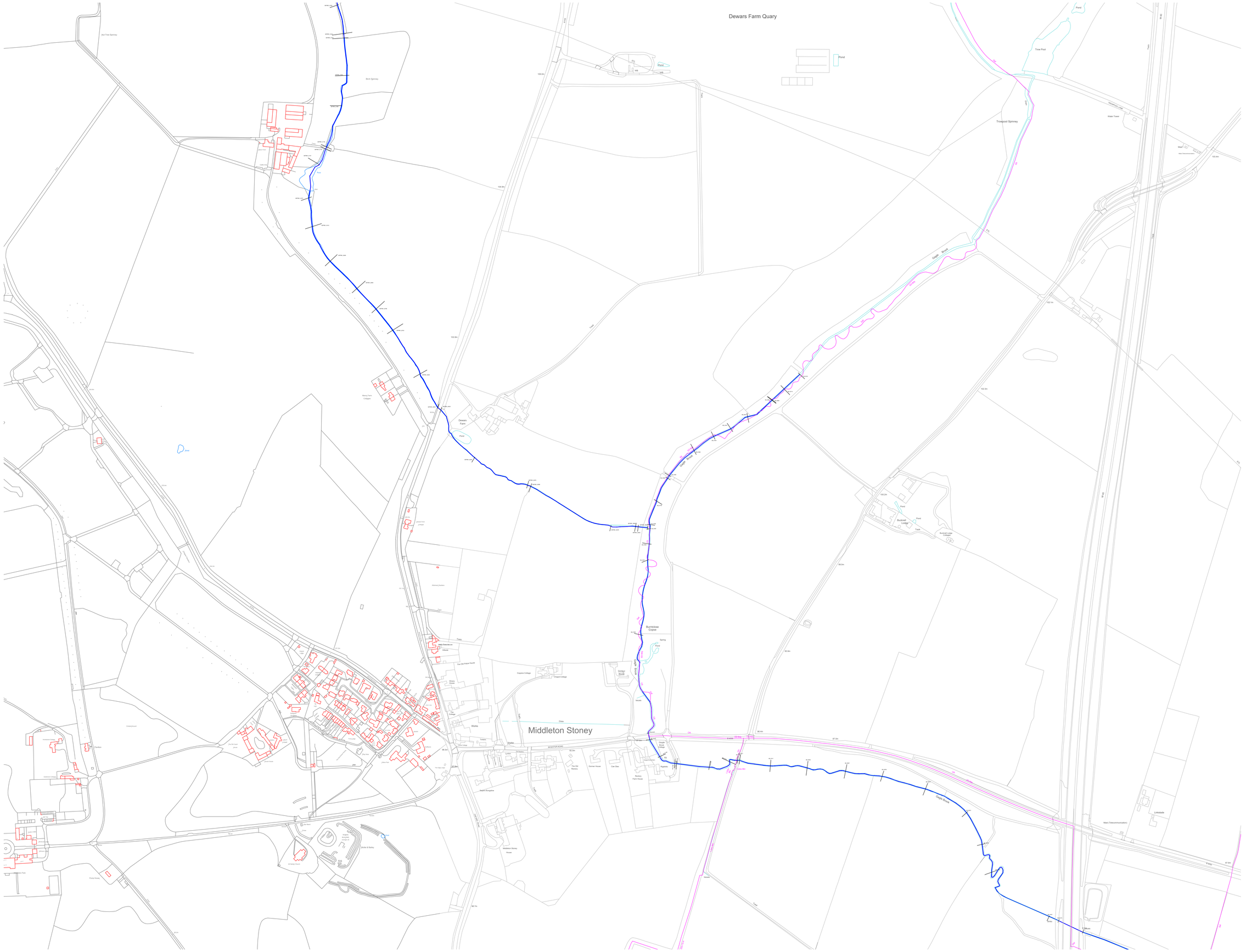
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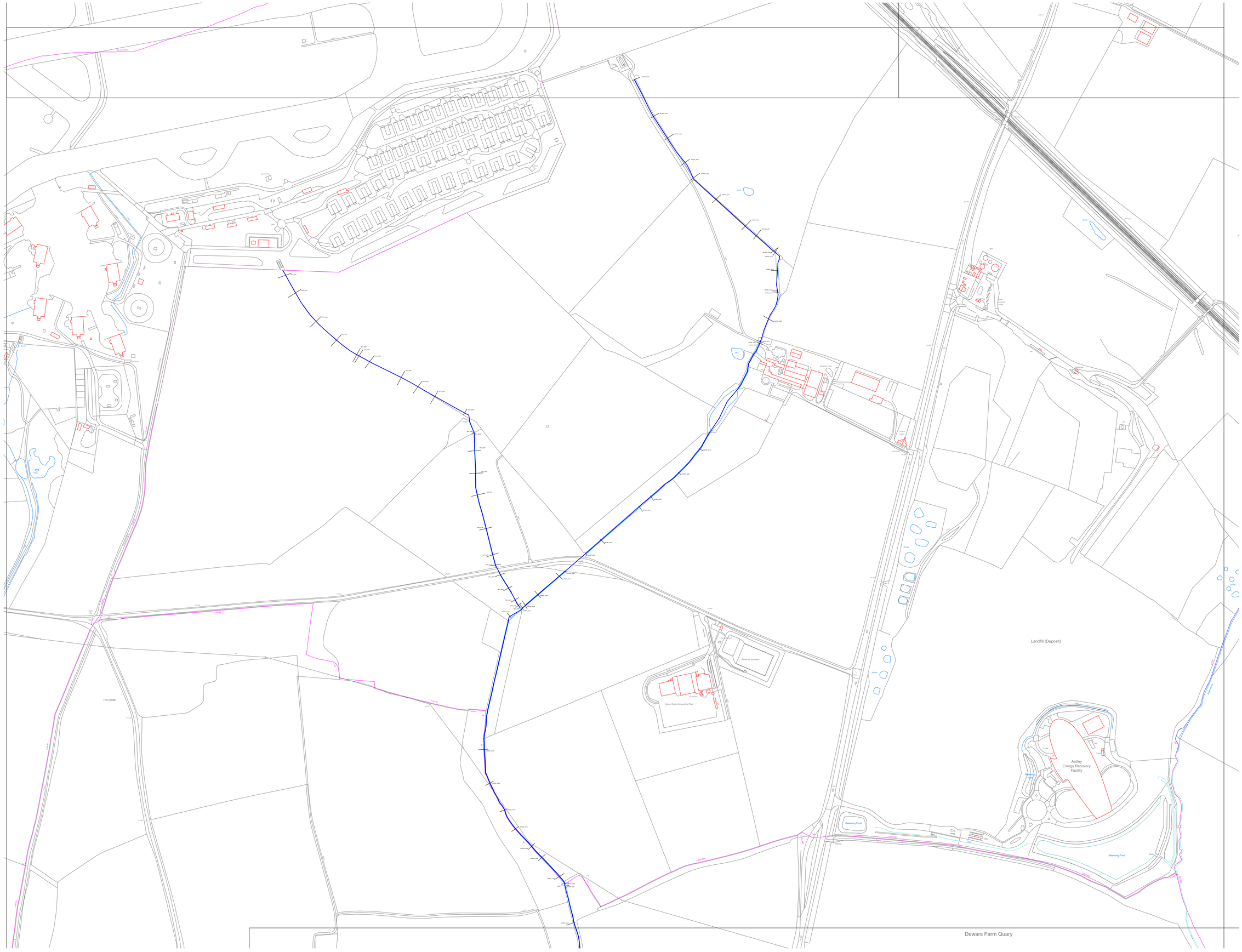
Middleton Stoney
Burntclose Copse
Gaggle Brook
Trow Pool
Trowpool Spinney
Birch Spinney
Jack Tree Spinney
Dewars Farm
Pond
Water Tower
Bucknell Lodge
Bucknell Lodge Cottages
Middleton Stoney House
Middleton Park
Cricket Ground
Bowling Green
Tennis Courts
Football Pitch
Skittle & Bocley
Village Hall
Chapel
Rectory Farm House
Manor House
Oak Dale
The Old Rectory
Lyndon
Jasmin Bungalow
Middleton Stoney Primary School
Middleton Stoney Methodist Church
Chapel Cottage
Coppice Cottage
Manor Farm Cottages
Mixing Farm Cottages
Bicester Road
Chilton
Ardley
Fritwell
Somerton
Ardley Road
Ardley Cutting
Ardley Tunnel
Ardley Embankment
Ardley Tunnel Cutting
Ardley Tunnel Embankment
Ardley Tunnel Cutting
Ardley Tunnel Embankment
Ardley Tunnel Cutting
Ardley Tunnel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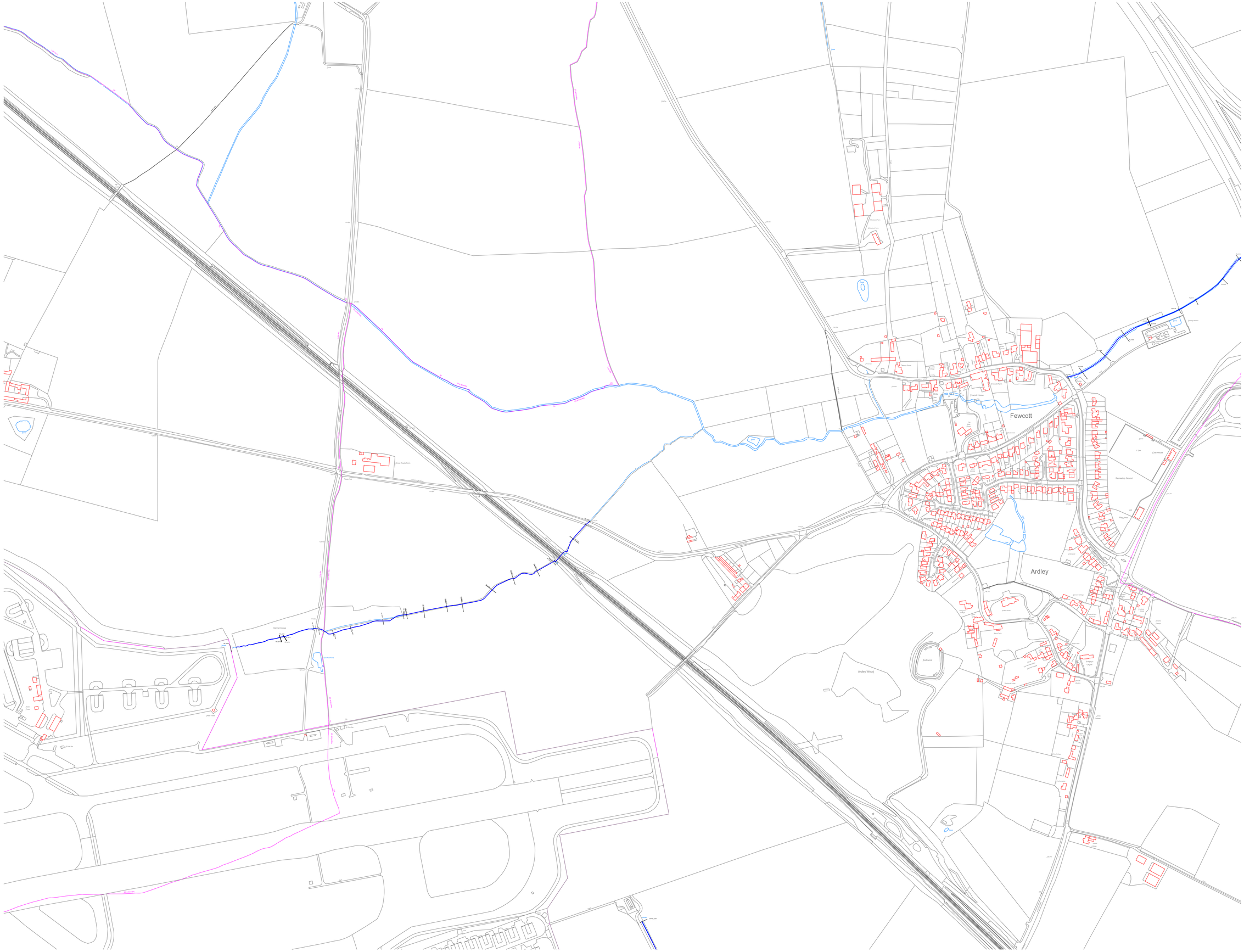
The Heath
Reservoir (covered)
Green Waste Composting Plant
Ardley Energy Recovery Facility
Balancing Pond
Pond
Pond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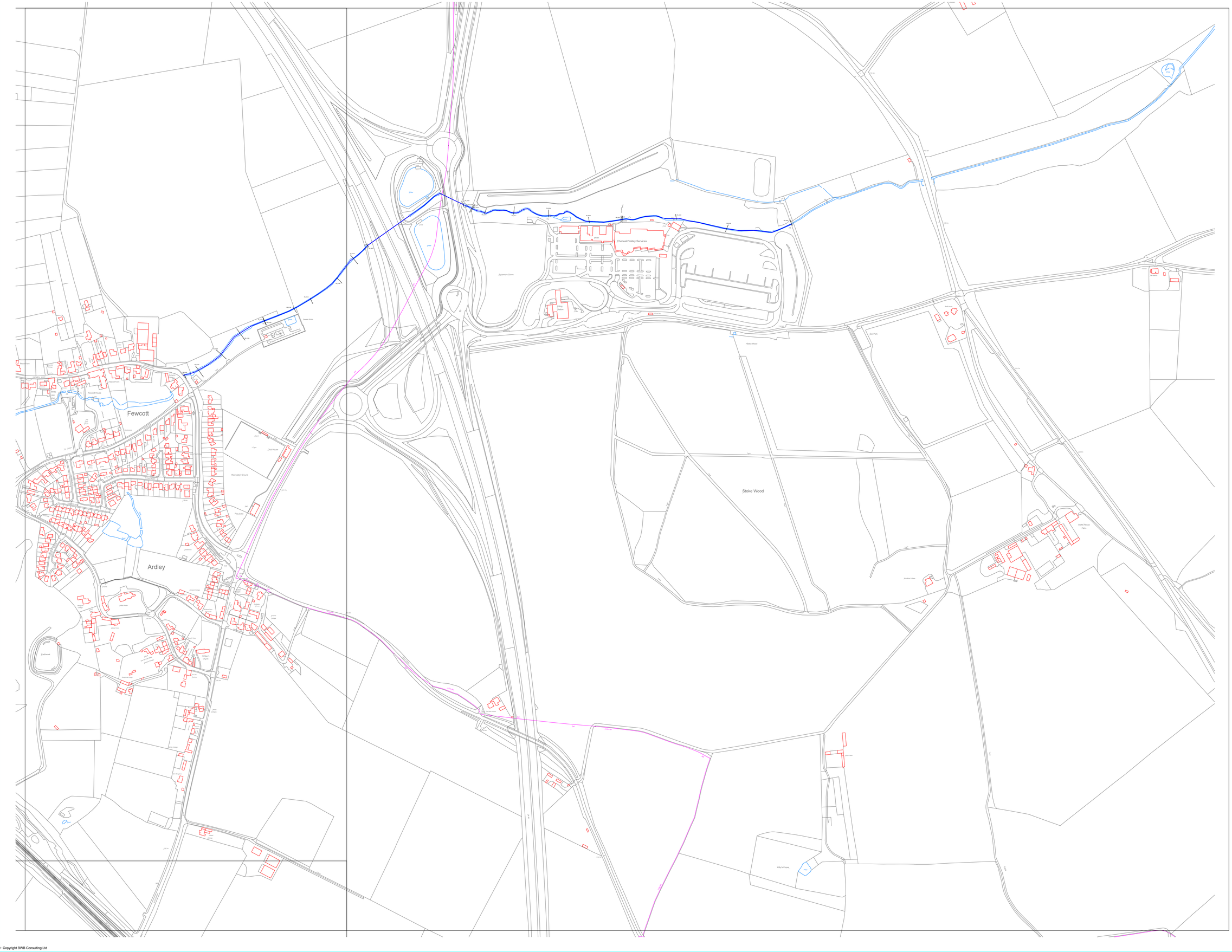
Ardley
Ardley Wood
Fewcott House
Fewcott Farm
Cross Roads Farm
Kennel Copse
Ardley Hill
Ardley House
Ardley Manor
Ardley Manor Farm
Ardley Manor Cottage
Ardley Manor Barn
Ardley Manor Stables
Ardley Manor Lodge
Ardley Manor Bungalow
Ardley Manor Cottages
Ardley Manor Farm Cottages
Ardley Manor Farm Barn
Ardley Manor Farm Bungalow
Ardley Manor Farm Stables
Ardley Manor Farm Lodge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Ardley
Stoke Wood
Cherwell Valley Services
Hotel
Filling Station
Fewcott House
French Farm
Club House
Recreation Ground
Play Area
Ardley House
Earthwork
Old Park
Stoke Wood
Killey's Copse
Stoke Wood Farm
Stoke Wood Cottages
Stoke Wood Villa
Stoke Wood Lodge
Stoke Wood Poultry Farm
Stoke Wood Cottage
Stoke Wood Farm Cottages
Stoke Wood Farm
Stoke Wood Farm Barn
Stoke Wood Farm Bungalow
Stoke Wood Farm Buildings
Stoke Wood Farm Cottage
Stoke Wood Farm Cottages

Appendix 2: Hydrological Assessment

A CAF GROUP COMPANY

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August 2025

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Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	22/08/25	S2	Preliminary Issue	LR	CG	MD

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All Environment Agency mapping data used under special license. Data is current as of August 2025 is subject to change.

The information presented, and conclusions drawn, are based on statistical data and are for guidance purposes only. The study provides no guarantee against flooding of the study site or elsewhere, nor of the absolute accuracy of water levels, flow rates and associated probabilities.

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1. METHOD STATEMENT

Overview of Requirements

1.1 Flow estimates are required for input into a hydraulic model of the Gagle Brook and the Ashgrove Brook, a tributary of the Gagle Brook, to support a Development Consent Order (DCO) application for a Strategic Rail Freight Interchange (SFRI) in Oxfordshire.

1.2 The Gagle Brook and the Ashgrove Brook flow through the Order Limits in a southerly and south-easterly direction. The location of the site of interest and the watercourses to be modelled are provided in **Figure 1.1.**

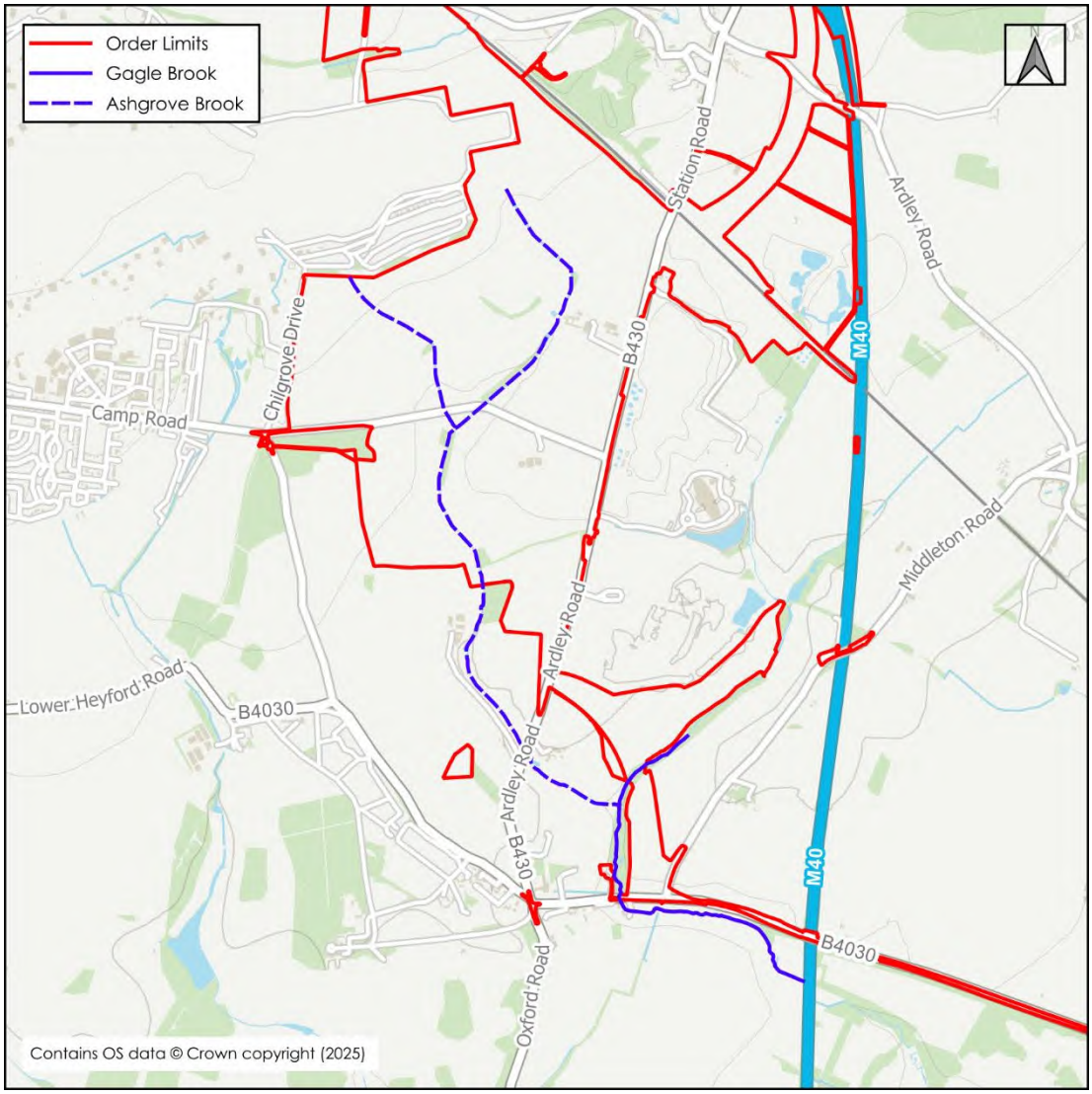


Figure 1.1: Site Location Plan

1.3 Return periods to be assessed include: 2, 5, 10, 30, 50, 75, 100, 200 and 1000-years. To inform the design event and potential future floodplain, the 1 in 100-year event with a range of climate change allowances applied will also be simulated. Hydrographs are required as well as peak flows.

1.4 The Client's agreed project scope does not include for detailed gauging station data quality review, rating reviews or updates, detailed flood history review or ReFH model parameter estimation.

1.5 The hydrological assessment was undertaken in April 2025. The Environment Agency (EA) Flood Estimation Guidelines[1] and River Modelling: Technical Standards and Assessment Guidance (Estimate Flood Flow from rainfall and river flow data)[2] were referred to throughout the hydrological analysis.

Study Complexity

Table 1.1: Study Complexity

Complexity	Category for this Study
Simple	☐
Moderate	✓
Difficult	☐
Very Difficult	☐

Catchment Description

1.6 The Gagle Brook rises to the east of the order limits, upstream of Ardley Road. The Gagle Brook generally flows in a south westerly direction where it is culverted beneath the M40 and the railway and then continues to flow as open channel. The watercourse flows through the south of the Order Limits in a south easterly and southerly direction where it is culverted beneath the B4030. The watercourse then flows in an easterly direction towards the M40.

1.7 The Ashgrove Brook, a tributary of the Gagle Brook, enters the Order Limits from Upper Heyford Airfield via two culverts. The watercourse flows, as two channels, in a southerly direction where they are culverted beneath Camp Road. The watercourses join to the south of Camp Road where it then flows as a single channel in a south easterly direction towards Ardley Road (B430). The watercourse is culverted beneath Ardley Road (B430) and then flows as open channel to its confluence with the Gagle Brook.

1.8 The upper catchment of the Gagle Brook and the Ashgrove brook has elevations of approximately 130m Above Ordnance Datum (AOD), with the upper reaches flowing through narrow, defined channels. Within the Order Limits the watercourses flow through a wider valley with elevations dropping to approximately 81m AOD just upstream of the M40. The catchment topography is shown in **Figure 1.2**.

[1] LIT 11832 Flood Estimation Guidelines Version 9, Environment Agency (November 2023)
[2] River Modelling: technical standards and assessment (estimate flood flow from rainfall and ricer flow data, Environment Agency (December 2023)

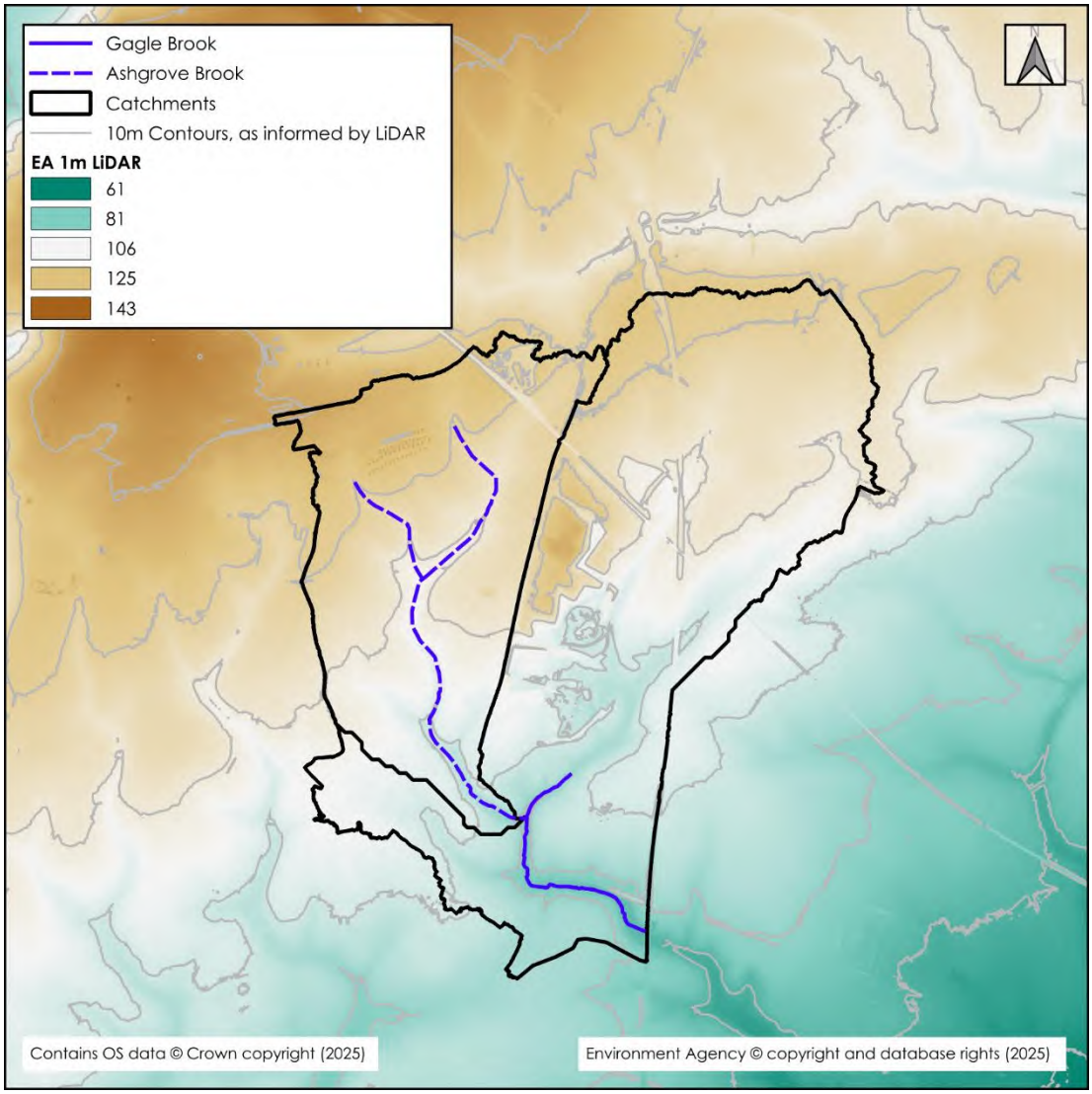


Figure 1.2: Catchment Topography

1.9 British Geological Survey (BGS) mapping indicates that the catchments are predominately underlain by White Limestone Formation (Limestone). The following bedrock is also present within the east of the catchment:

- Cornbrash Formation (Limestone)
- Forest Marble Formation (Limestone)
- Forest Marble Formation (Limestone and Mudstone Interbedded)
- Bladon Member (Mudstone and Limestone Interbedded)

1.10 Soils within the catchment are expected to largely consist of freely draining lime-rich loamy soils.

1.11 Land use within the catchment is predominantly rural, comprising agricultural land. Urban areas consist of Middleton Stoney and Heyford Airfield and a quarry is present within the centre of the catchment.

1.12 OS mapping shows the presence of ponds within the catchment, some of which are online. Given the location of these feature within the context of the catchment and small size, they are not considered to have a significant attenuation effect on the catchment. Any online ponds within the modelled extent will be included within the hydraulic model and flow will be routed through the feature, accounting for any attenuation.

1.13 No further features that may impact hydrology have been identified

Climate Change

1.14 Predicted future change in peak river flows caused by climate change are provided by the EA, with a range of projections applied to regionalised 'River Basin Districts' which are subdivided into Management Catchments.

1.15 The catchment falls within the Cherwell and Ray Management Catchment of the Thames River Basin District. **Table 1.2** identifies the relevant peak river flow allowances from this Management Catchment.

Table 1.2: Peak River Flow Allowance for the Cherwell and Ray Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	27%	49%
Higher Central	11%	10%	25%
Central	6%	4%	15%

Available Hydrometric Data

1.16 The National River Flow Archive (NRFA) Peak Flow Dataset Version 13.0.2 (released August 2024) will be utilised in this assessment for the purposes of identifying any potential donor stations and for the development of pooling groups. This contains data up to water year 2022-23.

1.17 There are no hydrometric gauges within the catchment. Therefore, there are no current hydrometric records of river flows or levels for the watercourse on which a hydrological assessment of flood flows can be made.

Other Data

Table 1.3: Other Data Sources

Type of Data	Data relevant to this study?	Data available?	Source of Data	Details
Check flow gaugings	There are no gauges within the study catchment and the project scope does not include for a review of the gauging stations			
Historical flood data	Yes	See **Section 7**		
Flow or river level data for events	The project scope does not include for a review of gauging stations/data. However, NRFA data will be used, where available and applicable.			
Rainfall data for events	The lack of flow/level gauge data for the study catchments means it is not possible to use rainfall data to define ReFH2 model parameters.			
Potential evaporation data	No	N/A		
Results from previous studies	No	No previous assessments undertaken.		
Other data or information	N/A			

Conceptual Model

Table 1.4: Conceptual Model

Where is the main site(s) of interest?	The main site of interest is the proposed development comprising a SFRI in Oxfordshire. The watercourses to be modelled are shown in **Figure 1.1**. The Gagle Brook and the Ashgrove Brook, a tributary of the Gagle Brook, flow through the Order Limits in a southerly and south-easterly direction.
What is likely to cause flooding at those locations? (e.g. peak flows, flood volumes, combination of peaks, groundwater, snowmelt, tides…)	Peak flows from fluvial sources are likely to be the main cause of flooding at the site. Both watercourses are culverted in several locations, which means there is the potential for backing up of flows if there is insufficient capacity. EA Flood Zone mapping suggests the floodplain associated with the watercourses is relatively confined to the watercourse corridor. However, out of banks flows are illustrated.

Might these locations flood from runoff generated on part of the catchment only e.g. downstream of a reservoir?	There are several small ponds in the catchment and along the watercourses. Due to the small size of these features and their location within the catchment, they are not expected to have a significant attenuation effect. Online ponds, along the watercourses, are to be included within the hydraulic model where flows will be routed through the feature, therefore accounting for this attenuation.
Are there any unusual catchment features? E.g. highly permeable (BFIHOST19>0.66), heavily urbanised, pumped, major reservoir influence (FARL<0.9), FSAs, historical or operational mining?	The catchment is classed as highly permeable with a BFIHOST of 0.848 within the Gagle Brook Catchment and 0.850 in the Ashgrove Brook catchment. Due to the permeable nature of the study catchment, the Statistical method will be the preferred approach for estimating peak flows. This is because floods in groundwater dominated catchments are influenced by hydrogeological factors not adequately represented in rainfall-runoff approaches. The catchments are not classed as heavily urbanised (URBEXT greater than 0.6) and there is no major reservoir influence or attenuation features.

Initial Choice of Approach

Table 1.5: Method Statement

Is FEH appropriate?	Yes, with limitations. Care must be taken with estimation of QMED as the FEH regression equation for QMED is known to over-estimate QMED on some groundwater-dominated catchments. Additionally, the composition of pooling groups needs some consideration as BFIHOST is not used to select the pooling group.
Initial choice of method(s) and reason	Although the Statistical method is preferred, flows will be estimated using both Statistical and ReFH2 methods. Using both will enable comparison between results before choosing the final method.
How will hydrograph shapes be derived?	It is anticipated that ReFH2 will be used to provide hydrograph shapes.
Will different storm durations need to be considered?	Due to the difference in catchment areas, it is expected that there will be some difference in storm duration. Therefore, storm duration testing will be undertaken at the hydraulic modelling stage.
Lumped or Distributed approach for model inputs	Flow estimates will be undertaken for lumped catchments. **Section 6** provides detail on how these will be applied to the model (i.e., distributed via area weighting, intervening hydrographs etc).
Software to be used	WINFAP version 5.1, ReFH2 version 4.1, Wallingford Hydro Solutions Non Flood Years Spreadsheet Beta v2.2

Previous Hydrological Assessments

1.18 There are no previous hydrological assessment with which to compare flows or results.

2. LOCATIONS WHERE FLOOD ESTIMATES ARE REQUIRED

Location of Flow Estimates

Table 2.1: Summary of Subject Sites

Site code	Watercourse	Site	Easting	Northing	Area on FEH Webservice (km^2)	Revised area (if altered) (km^2)
GB_DS	Gagle Brook	M40 at the downstream extent of the hydraulic model	454700	223050	12.5	13.5
AB_DS	Ashgrove Brook	Confluence of the Ashgrove Brook and the Gagle Brook	453800	223950	4.3	4.8
Reasons for choosing locations		GB_DS is based on the downstream extent of the hydraulic model of the Gagle Brook. AB_DS is based on the downstream extent of the Ashgrove Brook, at its confluence with the Gagle Brook. It was decided to undertake an analysis at the downstream extents only as the catchment features don't significantly change between the upstream and downstream extents.				

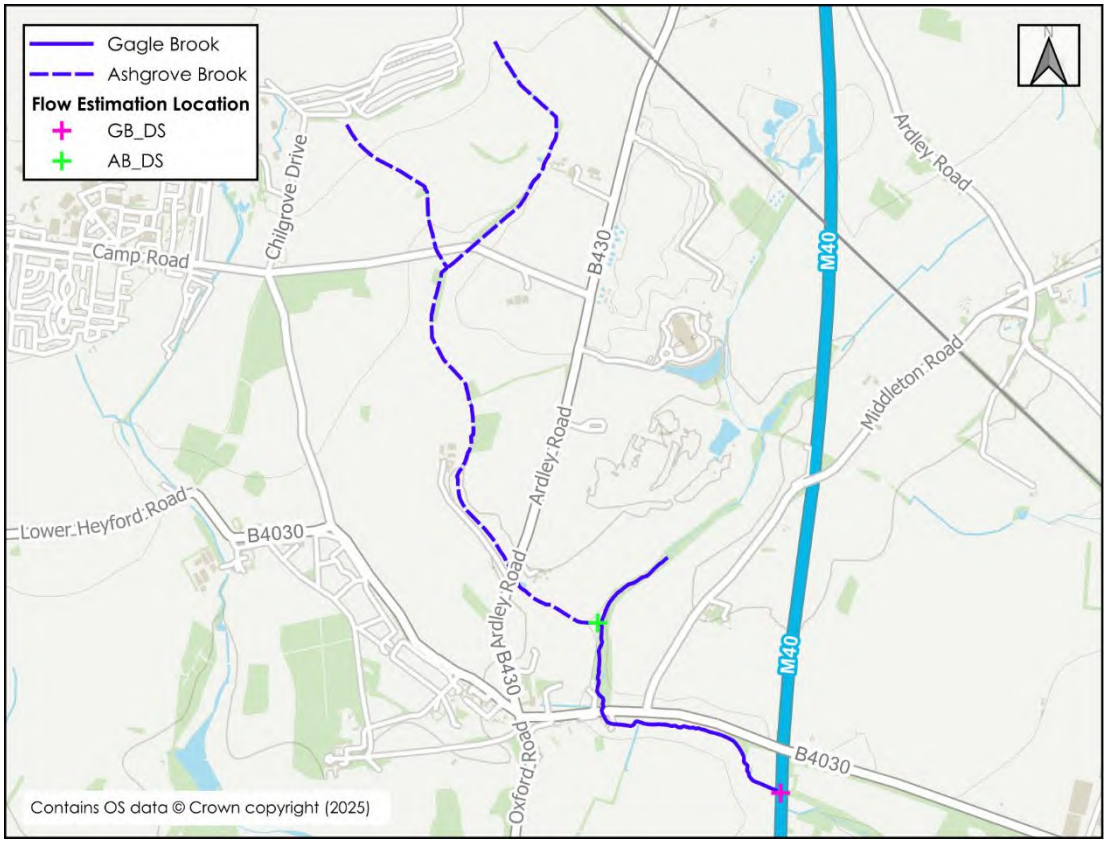


Figure 2.1: Flow Estimation Locations

Checking Catchment Descriptors

Table 2.2: Catchment Descriptor Checks

Record how catchment boundary was checked and describe any changes.	Catchment boundaries were initially identified using the FEH Web Service. The boundaries were reviewed using a combination of OS mapping and EA LiDAR. A watershed analysis was undertaken. Following the watershed analysis, the catchment boundaries were reviewed and updated as demonstrated within **Figure 2.2** and **Figure 2.3**.
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	Following the adjustment of the catchment area for GB_DS, DPLBAR has been updated using the standard equation for DPLBAR, given in the FEH Volume 5. Given the small changes to the topography within the catchment area of AB_DS, and the limitations of the standard DPLBAR equation, the DPLBAR in the original FEH catchment descriptors has been retained. BFIHOST and SPRHOST values are reasonable based on the geology of the catchment. FARL has been checked against OS mapping and is considered appropriate for the catchment.
Source of URBEXT	The URBAN50k method has been used to calculate $URBEXT_{2000}$ for the revised catchment boundary.
Method for updating of URBEXT to present day.	An update to the current year is not required as the URBAN50k method has been used to calculate $URBEXT_{2000}$. As such the current urban extent will be implicitly accounted for in the latest mapping.

Table 2.3: Important Catchment Descriptors (changes made are highlighted in red)

Site Code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR	SPRHOST	URBEXT 2000 *	FPEXT
GB_DS	0.988	0.32	0.848	4.2	20.3	661	6.02	0.0038	0.0547
AB_DS	1	0.32	0.850	2.57	20.3	664	5.5	0.0041	0.0518

* $URBEXT_{2000}$ updated using the URBAN50k method

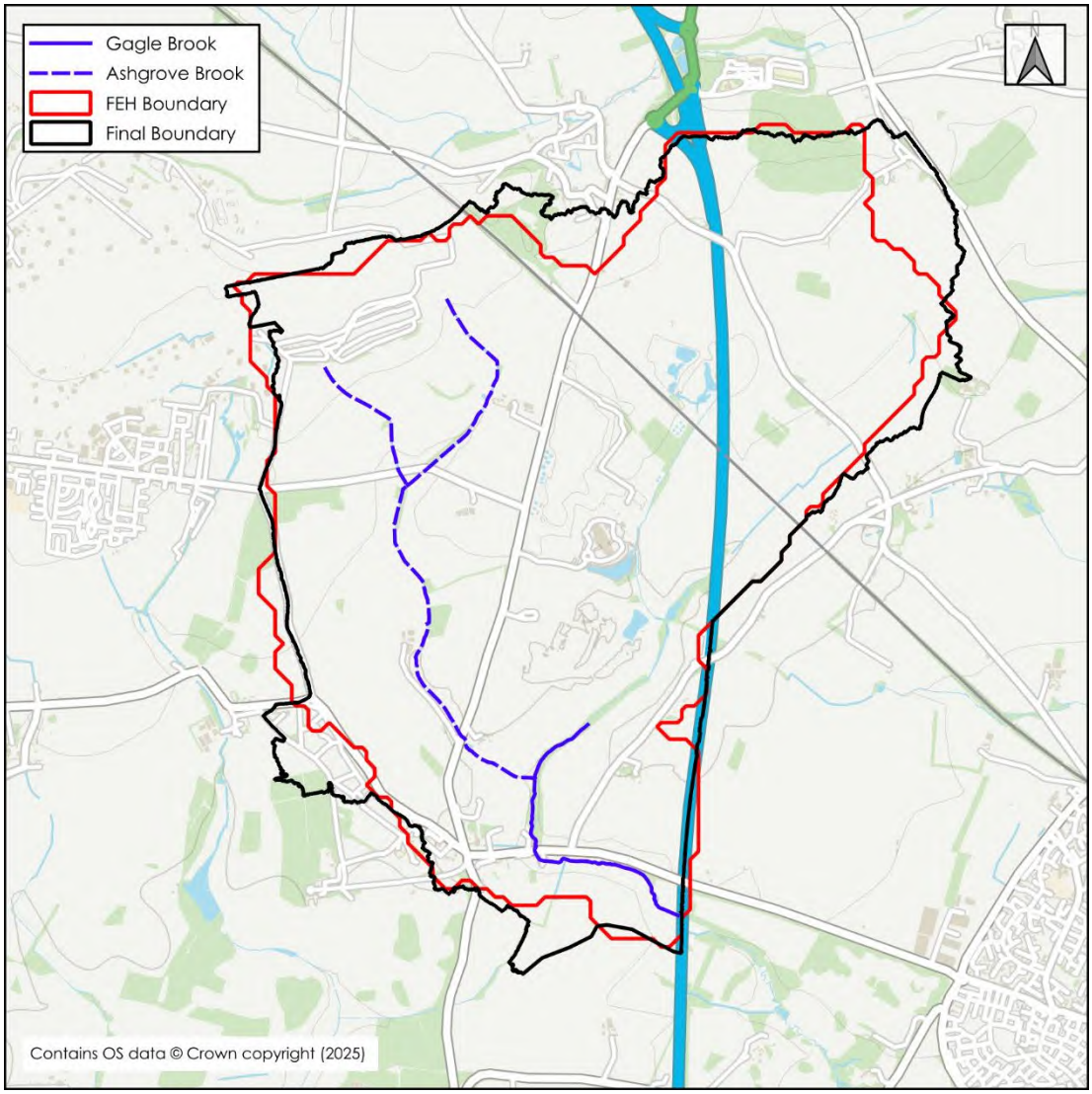


Figure 2.2: Original and Amended Catchment Boundaries – GB_DS

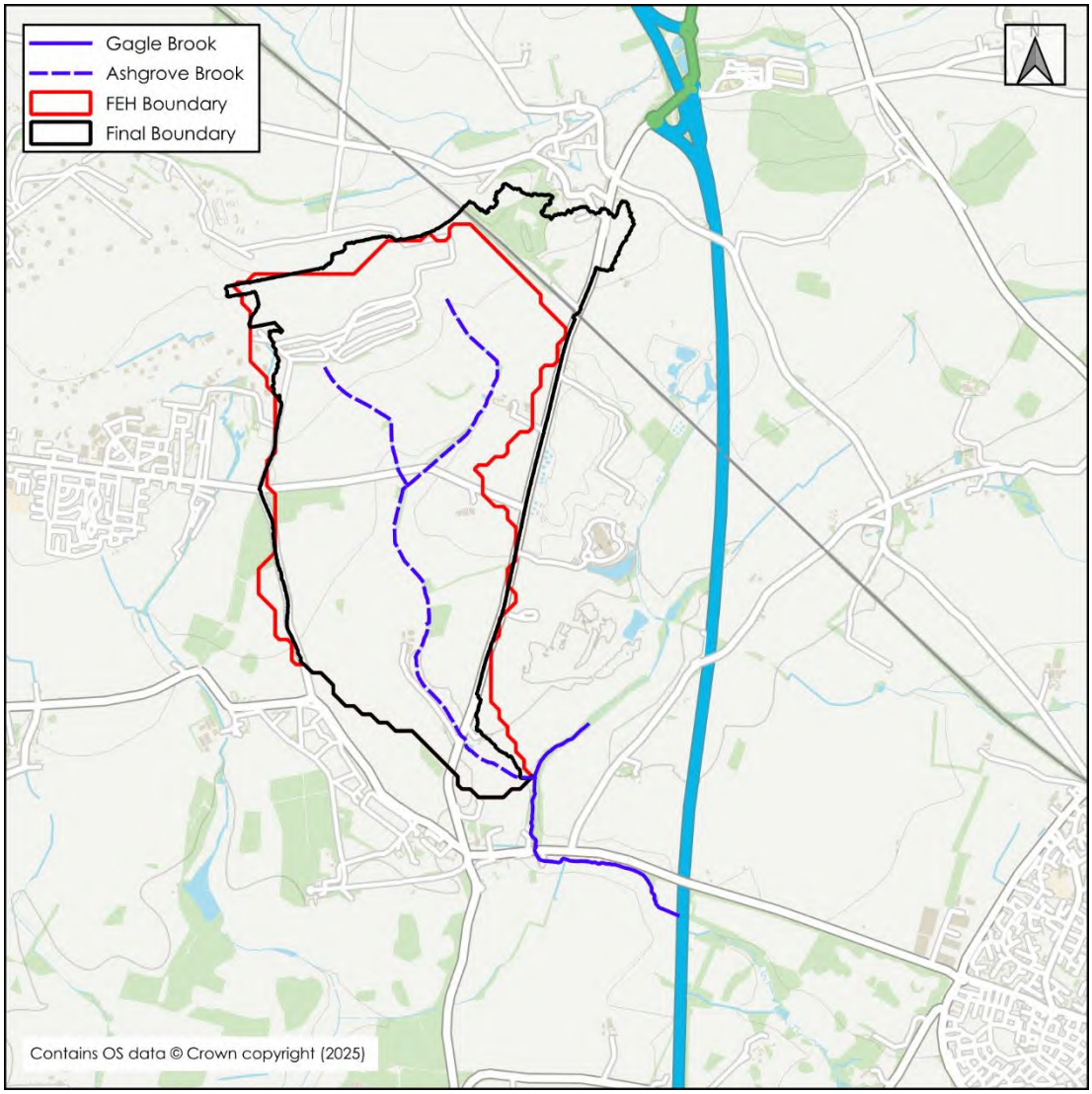


Figure 2.3: Original and Amended Catchment Boundaries – AB_DS

3. STATISTICAL METHOD

3.1 WINFAP was utilised to undertake a statistical analysis of the catchment using a hydrometric record of gauged catchments with similar characteristics.

QMED Development

3.2 Catchment descriptors were originally used to estimate the rural QMED of the study site using the revised equation from Science Report (SC050050). The FEH states that flood frequency is best estimated by gauged data and estimation of key variables from catchment descriptors alone should be a method of last resort. As such, a search was undertaken to identify any potential donor sites that could be used to adjust QMED.

3.3 Phase 2 of Science Report SC090031[3] recommends using a single donor, chosen based on proximity, to adjust QMED for 'small catchments' (defined as catchments with an area of less than 25km^2). This method can also be applied to catchments less than 40km^2 and is implemented in WINFAP5.

3.4 With the guidance in mind, a search was undertaken within WINFAP to identify the closest station to the flow estimation point(s). The data quality of potential donor(s) was also reviewed. Of the recommended donors, the following were rejected:

- 33005 – station closed in 1991; therefore, more recent flood events would not have been captured within the record.
- 39021 – limited utility for flood analysis; level measurement imprecise prior to 1967 and bypassing has varied in magnitude through time.

3.5 Station 39034 was the next closest donor to the subject site and was considered suitable for donor transfer following the review.

3.6 Details for the donor station(s) used to adjust QMED, and which flow estimation point(s) they have been applied to, are provided in **Table 3.1**. Details of the donor adjustment(s) and final QMED estimation are provided in **Table 3.2**.

3.7 Adjustment for climatic variation was not required as the donor station has a record length greater than 14 years.

Table 3.1: Donor Station Details

Station Number	QMED from 'as rural' Observed Data (A)* (m^3/s)	'As rural' QMED from Catchment Descriptors (B)** (m^3/s)	Adjustment Ratio (A/B)	Flow estimation point(s) donor is applied to
39034	20.12	21.14	0.95	GB_DS
				AB_DS

[3] Science Report SC090031/R0: Estimating flood peaks and hydrographs for small catchments (Phase 2), Environment Agency (2019).

Table 3.2: Overview of Estimation of QMED at each Subject Site

Site Code	Method	Initial Estimate of QMED (m^3/s) (Rural)	Data Transfer				Final estimate of QMED (m^3/s) (URBAN)
			Donor site NRFA no	Distance between centroids d_j (km)	Power term, a	Moderated QMED adjustment factor (A/B)[a]	
GB_DS	Donor Transfer	0.47	39034	21.52	0.299	0.99	0.47
AB_DS		0.20		20.52	0.305	0.98	0.20
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?		QMED is consistent with the size and characteristics of the catchment.					
Which version of the urban adjustment was used for QMED?		Urban adjustment was applied using Kjeldsen (2010), as applied in WINFAP.					

Derivation of Pooling Groups

3.8 A pooled group of hydrologically similar gauged sites was generated by the WINFAP software for the subject sites using the 'OK for Pooling' dataset. WINFAP uses the deurbanised pooling group L-moments as default.

3.9 The 'small catchment' pooling procedure implemented within WINFAP has been used. This procedure selects the pooling group using a similarity measure that only considers AREA and SAAR, as recommended by SC090031.

Pooling Group Review

3.10 The pooling group was reviewed to identify sites which may be inappropriate due to being significantly hydrologically dissimilar to the study site, or if they have any inaccuracies, uncertainties, or limitations in their data record.

Adjustment for Non-Flood Years

3.11 For some catchments there are years in which no floods occur (non-flood years), and the annual maximum flow is due to baseflow alone. To avoid a bias in the flood frequency analysis in which growth factors reach an upper limit (the growth curve is bounded above), the L-moments have been adjusted to remove the influence of non-flood years (classed as annual maximum flows smaller than 0.5QMED).

3.12 The adjustment for non-flood years has been undertaken using Wallingford HydroSolutions 'WHS Non-flood Years Spreadsheet Beta v2.2'.

Urban Adjustment

3.13 Growth curves were also adjusted for to reflect the urban influence, using the methods adopted in WINFAP[4] which is based on those published by Kjeldsen 2010[5].

Choice of Distribution

3.14 In accordance with the EA FEH Guidelines, the distribution has been chosen based on which gives the best fit from Generalised Logistic (GL), Generalised Extreme Value (GEV) and Kappa 3.

3.15 The only exception to this is when a pooling group has been adjusted for non-flood years as the procedure for the adjustment uses the GL distribution.

Growth Curve Comparison

3.16 Further detail on pooling group composition is provided in **Section 8.**

Table 3.3: Derivation of Pooling Groups: GB_DS_PG

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
GB_DS_PG	GB_DS	GL	**Stations Removed:** 26016 - non-flood years over 15% of the record. Following a review of the station on the NRFA, the station was removed from the group as the channel is known to run dry and is, therefore, considered dissimilar from the subject site. 26014 – following a review of the station on the NRFA, the station was removed from the group as the watercourse is known to regularly dry up and is, therefore, considered dissimilar from the subject site. 7011 – removed due to an unusually steep growth curve that gives significantly higher than normal growth factors (100 year growth factor >10) which are not considered	L-CV: 0.271 L-Skew: 0.180

4 Wallingford HydroSolutions (2016), WINFAP 4 Urban adjustment procedures, Wallingford HydroSolutions Ltd 2016.
5 Kjeldsen, T.K., 2010. Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrology Research, volume 41, issue 5, pp391-405

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
			representative of the study catchment. **Stations Added:** 53017 – added to get pooling group record above 500 years. **Comments:** Station 36010 was reviewed for its suitability as it was identified as having non-flood years over 15% of the record. The catchment response was not considered to be significantly different to the study catchments and, therefore, this station was retained.	

Table 3.4: Final Choice of Flood Growth Curves at Subject Sites

Site code	Method (SS, P, ESS)	Name of pooling group	Distribution used and reason for choice	Urban adjustment and/or non-flood years adjustment applied?	Growth factor for 1% AEP event
GB_DS	P	GB_DS_PG	GL distribution was chosen because it is the default distribution used for the adjustment for non-flood years.	Urban adjustment and adjustment for non-flood years applied.	3.02
AB_DS					

Table 3.5: Flood Estimates from the Statistical Method

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities								
	2 (50%)	5 (20%)	10 (10%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
GB_DS	0.5	0.7	0.8	1.1	1.2	1.3	1.4	1.7	2.4
AB_DS	0.2	0.3	0.3	0.5	0.5	0.6	0.6	0.7	1.0

4. REVITALISED FLOOD HYDROGRAPH (ReFH) METHOD

4.1 The ReFH2 Revitalised Flood Hydrograph Modelling Tool (Version 4.1) was used to undertake an estimation of the peak flows for the subject sites.

Table 4.1: Overview of Parameters for ReFH2 Method

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
GB_DS	Parameters calculated using catchment descriptors.				
AB_DS					
Description of flood event analysis carried out	Flood event analysis is not possible as the catchments are ungauged.				

Table 4.2: Design Events

Site code	Rainfall DDF model	Season of design event	Storm duration	Selected interval	Initial soil moisture (Cini)	Initial baseflow (BFO)
GB_DS	FEH22	Winter	11.0hr	1.0hr	Default value	Default value
AB_DS	FEH22	Winter	7.5hr	0.5hr	Default value	Default value
Comments	The ReFH2 recommended storm duration at the downstream extent of the model is 11hrs; therefore, a uniform storm duration of 11hrs will be used to derive the model inflow hydrographs. A sensitivity test will be run for the 100-year event for varying storm durations.					

Table 4.3: Flood Estimates from the ReFH Method (based on recommended duration for individual catchments)

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities								
	2 (50%)	5 (20%)	10 (10%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
GB_DS	0.5	0.7	0.8	1.1	1.2	1.4	1.5	1.8	2.7
AB_DS	0.2	0.3	0.3	0.5	0.5	0.6	0.6	0.7	1.1

5. DISCUSSION AND SUMMARY OF RESULTS

Comparison of Method

5.1 A comparison of the peak flow results for the different estimation methods for the 1 in 2-year and 1 in 100-year events is provided in **Table 5.1**. Comparisons of the growth curves for both methods are shown in **Figure 5.1** and **Figure 5.2**.

5.2 The ReFH2 method provides a steeper growth curve when compared to the Statistical method. The ReFH2 method and Statistical method show similar peak flows for lower return periods, however, for return periods approximately 100-year and above ReFH2 provides greater peak flows.

Table 5.1: Comparison of Results

Site code	1 in 2-year peak flows (50% Annual Exceedance Probability)			1 in 100-year peak flows (1% Annual Exceedance Probability)		
	Statistical	ReFH	Ratio	Statistical	ReFH	Ratio
GB_DS	0.5	0.5	1.0	1.4	1.5	1.1
AB_DS	0.2	0.2	1.0	0.6	0.6	1.0

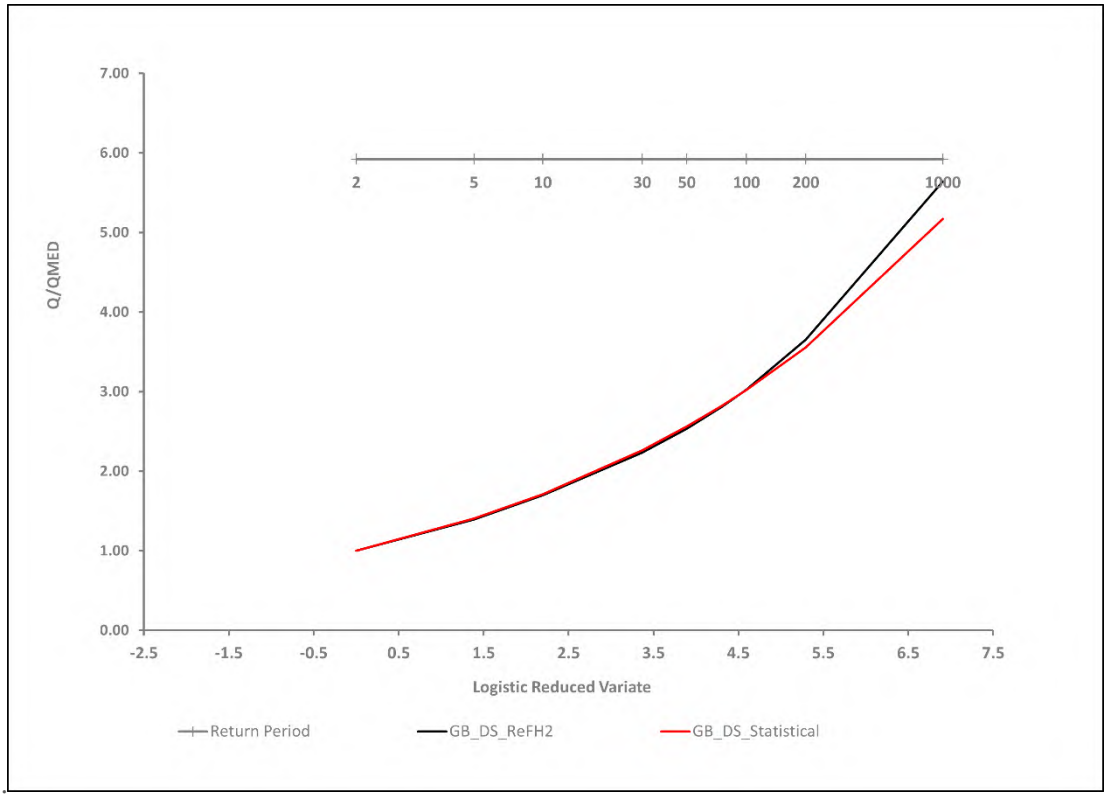


Figure 5.1: Comparison of Statistical method and ReFH Growth Curves – GB_DS

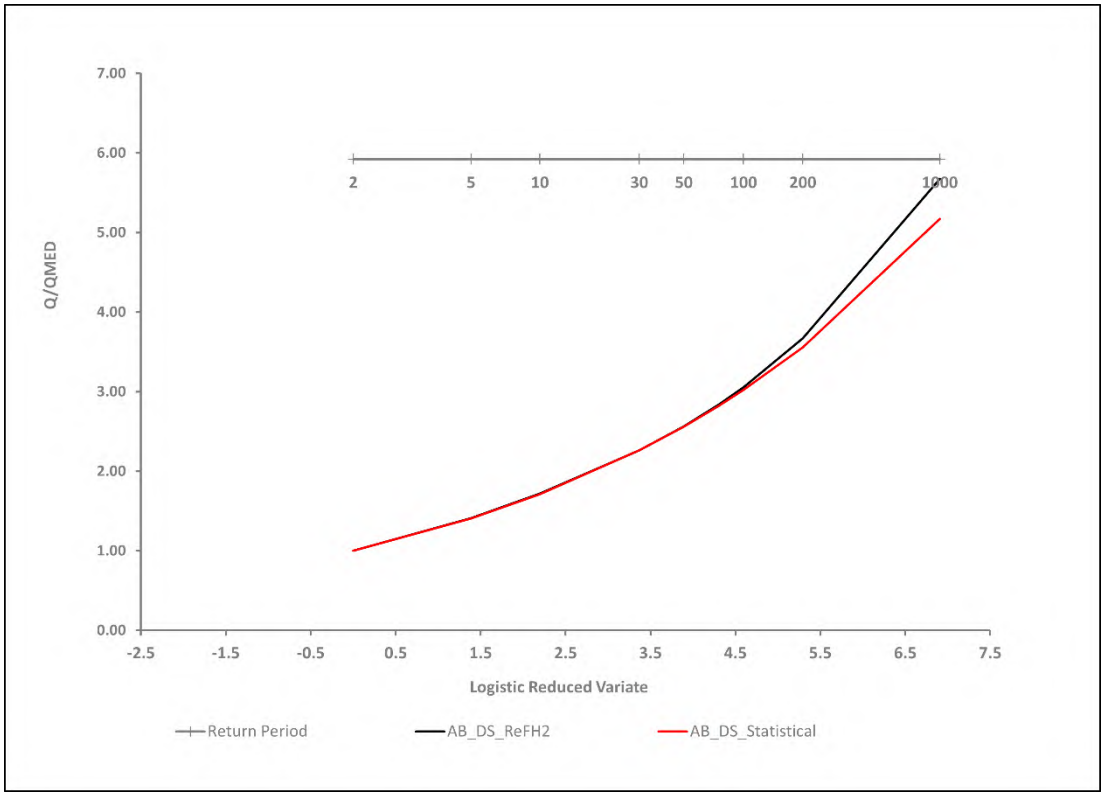


Figure 5.2: Comparison of Statistical method and ReFH Growth Curves – AB_DS

Final Method and Flows

Table 5.2: Final Choice of Method

Choice of method and justification	The final choice of peak flows for input into the model is the Statistical method, in line with EA FEH Guidelines recommendation that it is normally a more appropriate choice for groundwater-dominated catchments. The Statistical method benefits from an up-to-date flood peak dataset, using growth curves from hydrologically similar catchments to derive a growth curve. Flow estimates have been improved by utilising a catchment with similar characteristics from the QMED adjustment. In the absence of any suitable observed data with which to derive a hydrograph shape, ReFH2 will be used to provide a hydrograph shape for the model inflows, scaled to the statistical peak. **Section 6** describes how flows will be applied to the model.

Table 5.3: Final Peak Flows from Chosen Method (Statistical)

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities								
	2 (50%)	5 (20%)	10 (10%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
GB_DS	0.5	0.7	0.8	1.1	1.2	1.3	1.4	1.7	2.4
AB_DS	0.2	0.3	0.3	0.5	0.5	0.6	0.6	0.7	1.0

Table 5.4: Assumptions, Limitations and Uncertainty

List the main assumptions made	• The pooling groups are representative of the catchments. • The ReFH2 hydrograph shape is representative of the catchment response. • Tp and storm duration are representative of the catchment response. • The flow estimate derived at the downstream extents of the Gagle Brook and Ashgrove Brook is applicable to the upstream catchments as there are no significant changes in the catchment characteristics between the upstream and downstream extents. • There are no swallow-holes or springs within the catchment and the groundwater catchment corresponds to the topographical catchment. • The ponds within the catchment are not expected to have a significant attenuative effect on peak flows.
Discuss any limitations e.g. applying methods outside the range of catchment types or return periods for which they were developed	• The FEH Statistical and ReFH2 methods are believed to be suitable up to the 1 in 200-year event. Estimates of flow beyond these events are extrapolations and, therefore, have a higher level of uncertainty. • There are only a small number of gauged sites in the UK. As such the representation in the pooling group is not ideal given the small size of some of the study catchments. • There is no observed flow data within the catchment with which to verify the flow estimates. • The FEH regression equation for QMED can result in overestimates on groundwater-dominated catchments. However, the calculated QMED values have been improved using donor transfer and appear sensible for the size and characteristics of the catchment. • The adjustment for non-flood years methodology uses a GL distribution. However, WINFAP showed Kappa 3 provided the better fit.
Give what information you can on uncertainty in the results	According to Table 4 of the EA FEH Guidelines, confidence intervals for the 1 in 100-year event for a moderately urbanised site when calculated from catchment descriptors are quoted as 0.45-2.23 (for the 95% confidence interval). Confidence is improved when using observed data from a donor site. When one donor is used in the assessment, the confidence intervals changes to 0.47-2.12 (for the 95% confidence interval).

	It is more difficult to quantity uncertainty in design flows estimated from the ReFH rainfall-runoff model. However, evidence[6] suggests the factorial standard errors from ReFH2 are comparable to those observed for the FEH pooled Statistical method when the catchment is treated as ungauged.
Comment on the suitability of the results for future studies	The design flow estimates have been derived for the purpose of providing flow hydrographs into a hydraulic model to support a planning application. Users for different studies, should, as a minimum, review results to assess suitability for the purpose of the study.
Give any other comments on the study	While the installation of temporary flow gauges would provide local data which may better inform the design peak flows and hydrograph shapes, this would not align with the scope and timescales of this project.

Table 5.5: Checks

Are the results consistent?	Peak flows are consistent with the size and characteristics of the catchment.
What do the results imply regarding the return periods of floods during the period of record?	It is not possible to imply return periods of floods due to the lack of gauged data within the study catchment and sufficient information on any historical flooding events.
What is the 1 in 100-year growth factor? (the guidance suggests a typical range or 2.1 to 4.0)	• The 1 in 100-year growth factor for the Statistical Method is 3.02 for GB_DS and AB_DS. • The 1 in 100-year growth factor for the ReFH2 method is 3.02 for GB_DS and 3.05 for AB_DS. These fall within the typical range.
If 1 in 1000-year flows have been derived, what is the range of ratios for 1 in 1000-year flow over 1 in 100-year flow?	• Statistical Method: ratio for GB_DS is 1.71 for GB_DS and AB_DS. • ReFH2 Method: ratio for GB_DS is 1.87 and for AB_DS is 1.86.
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred	There are no previous studies with which to compare results.
Are the results consistent with the longer-term flood history?	There is no long-term flood record for the catchment with which to compare the modelled results to.

[6] Wallingford Hydrosolutions (2019) ReFH2 Science Report: Evaluation of the Rural Design Event Model.

Describe any other checks on the results	Sensibility checks of modelled outlines will be undertaken at the modelling stage.

6. APPLICATION OF FLOWS TO MODEL

6.1 Flows will be applied to the model in the following way.

i. To derive the hydrographs, the ReFH2 hydrographs for GB_DS and AB_DS were scaled to meet the Statistical Method peak flows.

ii. Once the hydrographs were scaled, the hydrographs associated with AB_DS were taken away from the GB_DS hydrographs in order to obtain the flows for GB_DS and ensure flows were not double counted.

iii. The GB_DS catchment was then split into two catchments to provide an inflow at the upstream extent of the Gagle Brook and a lateral inflow along the Gagle Brook downstream of the confluence with the Ashgrove Brook.

iv. The AB_DS catchment was split into three catchments to provide one inflow on each branch of the Ashgrove Brook at the upstream extent. A lateral inflow will be applied along the Ashgrove Brook downstream of the confluence of the two branches of the Ashgrove Brook.

6.2 The proportion of the hydrograph applied at each inflow, as well as the type of inflow, is shown in **Table 6.1. Figure 6.1** demonstrates how the flows will be applied to the model.

Table 6.1: Hydrograph Proportions

Sub Catchment	Type of Inflow	Proportion of Hydrograph
GB_DS		
1	Point	72%
2	Lateral Region	28%
AB_DS		
1	Point	12%
2	Point	40%
3	Lateral Region	48%

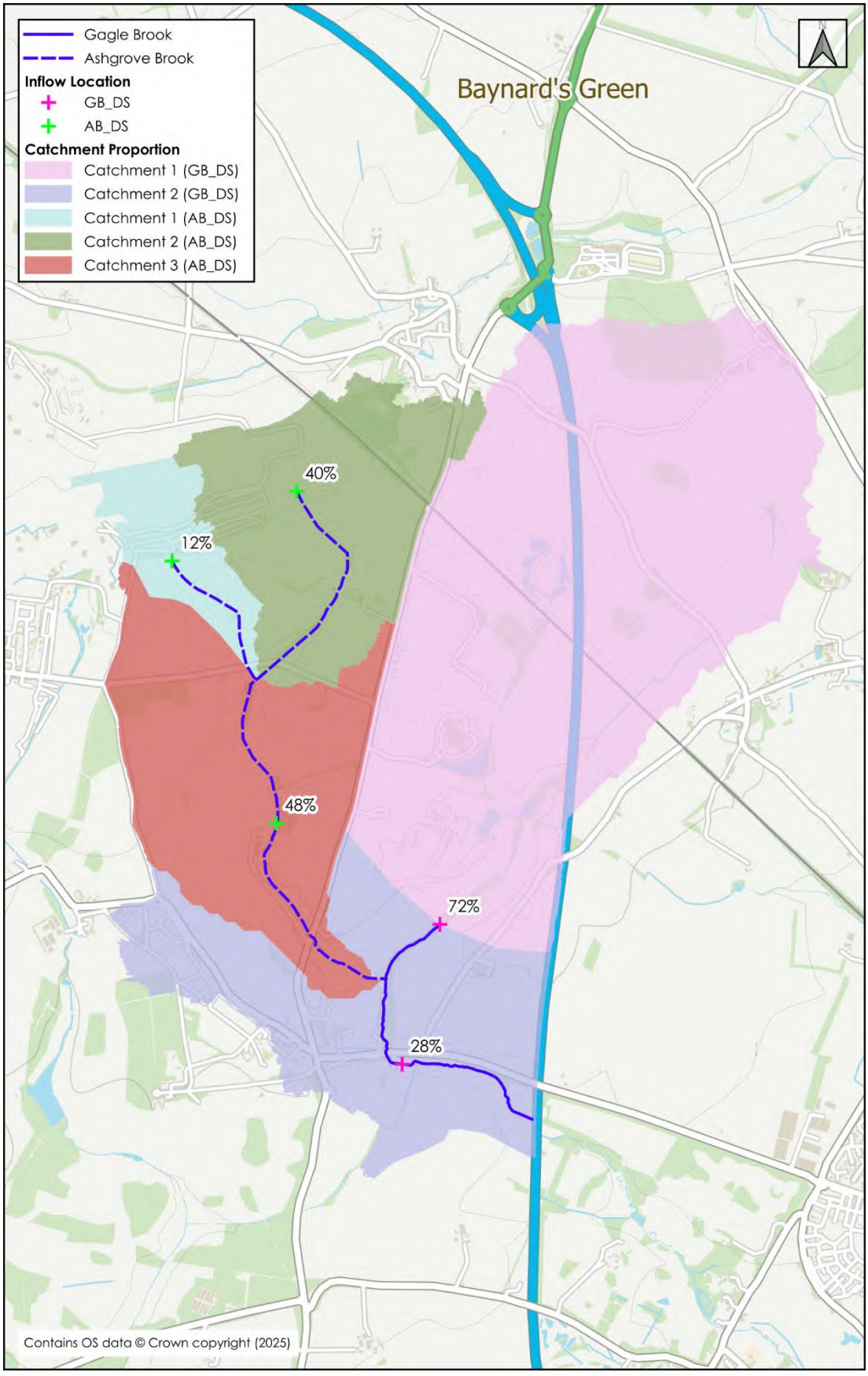


Figure 6.1: Application of Inflows into Model

7. FLOOD HISTORY

Flood History

7.1 A flood history review has been undertaken for the catchment. **Table 7.1** sets out the findings from this review.

Table 7.1: Flood History Review

Data Source	Flood Event Details
Strategic Flood Risk Assessments (SFRA)[7,8]	No flood history relevant to the catchment was found within the Level 1 or Level 2 SFRAs
EA Recorded Flood Outlines	There are no EA recorded flood outlines within the catchment
Section 19 Flood Investigations[9]	Oxfordshire County Council have published several Flood Investigation Reports; however, there are no records of flood investigations with the catchment
British Chronology of Hydrological Events	No flood history relevant to the catchment was found.
Online News Articles	No flood history relevant to the catchment was found.
Other Sources[10]	A blockage of a culvert along the Gagle Brook at the A4095 was reported to Oxfordshire County Council in December 2020 which resulted in flooding to the surrounding area. Further review by the council identified that this was due to a high volume of water rather than blockage. The location of the flooding is located 1.7km downstream of the study catchment and, therefore, has limited use for verifying or improving flows.

[7] Level 1 Strategic Flood Risk Assessment (Wallingford HydroSolutions, March 2025)
[8] Level 2 Strategic Flood Risk Assessment (Wallingford HydroSolutions, October 2024)
[9] https://www.oxfordshirefloodtoolkit.com/risk/investigations/
[10] https://fixmystreet.oxfordshire.gov.uk/report/2446309

8. DETAILED POOLING GROUP INFORMATION

Table 8.1: Default Pooling Group: GB_DS_PG

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
26016 (Gypsey Race @ Kirby Grindalythe)	0.409	25	0.101	0.309	0.249	0.041
27073 (Brompton Beck @ Snainton Ings)	0.478	42	0.816	0.213	0.018	0.843
36010 (Bumpstead Brook @ Broad Green)	0.656	55	7.59	0.354	0.108	1.952
25019 (Leven @ Easby)	0.658	44	5.384	0.341	0.366	0.466
26014 (Water Forlornes @ Driffield)	0.736	24	0.431	0.319	0.184	0.504
27051 (Crimple @ Burn Bridge)	0.838	50	4.641	0.218	0.133	0.378
7011 (Black Burn @ Pluscarden Abbey)	0.973	10	4.752	0.494	0.553	2.642
39033 (Winterbourne Stream @ Bagnor)	0.986	60	0.401	0.34	0.376	1.103
33054 (Babingley @ Castle Rising)	1.018	46	1.132	0.229	0.188	0.803
24007 (Browney @ Lanchester)	1.088	15	10.981	0.222	0.211	1.157
36004 (Chad Brook @ Long Melford)	1.092	55	4.807	0.302	0.175	0.618
26013 (Driffield Trout Stream @ Driffield)	1.094	12	2.778	0.275	0.236	1.941
33032 (Heacham @ Heacham)	1.134	54	0.442	0.297	0.133	0.401
41020 (Bevern Stream @ Clappers Bridge)	1.135	53	13.66	0.202	0.17	1.151
Total		545				
Weighted Means				0.291	0.207	
H2 value	2.0599					
Goodness of Fit	**Generalised Logistic**	**General Extreme Value**		**Kappa 3**		
	0.782	-1.1293		0.0966		

Table 8.2: Final Pooling group (adjusted for non-flood years): GB_DS_PG

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	0.478	42	0.816	0.213	0.018	0.922
36010 (Bumpstead Brook @ Broad Green)	0.656	55	7.59	0.354	0.108	1.931
25019 (Leven @ Easby)	0.658	44	5.384	0.341	0.366	1.192
27051 (Crimple @ Burn Bridge)	0.838	50	4.641	0.218	0.133	0.33
39033 (Winterbourne Stream @ Bagnor)	0.986	60	0.401	0.34	0.376	1.581
33054 (Babingley @ Castle Rising)	1.018	46	1.132	0.229	0.188	0.723
24007 (Browney @ Lanchester)	1.088	15	10.981	0.222	0.211	0.958
36004 (Chad Brook @ Long Melford)	1.092	55	4.807	0.302	0.175	0.506

26013 (Driffield Trout Stream @ Driffield)	1.094	12	2.778	0.275	0.236	2.007
33032 (Heacham @ Heacham)	1.134	54	0.442	0.297	0.133	0.38
41020 (Bevern Stream @ Clappers Bridge)	1.135	53	13.66	0.202	0.17	1.172
53017 (Boyd @ Bitton)	1.149	49	13.87	0.244	0.088	0.296
Total		535				
Weighted Means				0.271	0.180	
H2 value	2.2922					

Goodness of Fit	**Generalised Logistic**	**General Extreme Value**	**Kappa 3**
	0.9062	-1.1809	0.1429

Adjusted L-Moments following Adjustment for Non-Flood Years

Station	Adjusted L-CV	Adjusted L-Skew
27073 (Brompton Beck @ Snainton Ings)	0.199	0.066
36010 (Bumpstead Brook @ Broad Green)	0.287	0.174
25019 (Leven @ Easby)	0.327	0.404
27051 (Crimple @ Burn Bridge)	0.209	0.158
39033 (Winterbourne Stream @ Bagnor)	0.309	0.440
33054 (Babingley @ Castle Rising)	0.214	0.242
24007 (Browney @ Lanchester)	0.222	0.211
36004 (Chad Brook @ Long Melford)	0.255	0.292
26013 (Driffield Trout Stream @ Driffield)	0.275	0.236
33032 (Heacham @ Heacham)	0.275	0.157
41020 (Bevern Stream @ Clappers Bridge)	0.187	0.208
53017 (Boyd @ Bitton)	0.213	0.126

Appendix 3: Table of Hydraulic Structures

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
GB_02082	**Description:** Footbridge **NGR:** 454106, 224205 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 90.08m AOD **Downstream Invert Level:** 90.11 mAOD **Length:** 1m **Manning's N:** 0.035 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GB_01809	**Description:** Access Bridge **NGR:** 453885, 224049 **Domain:** 1D ESTRY **Unit Type:** Irregular Culvert **Upstream Invert Level:** 87.61m AOD **Downstream Invert Level:** 87.77m AOD **Length:** 7m **Manning's N:** 0.035 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
GB_01237	**Description:** Bicester Road Culvert **NGR:** 453839, 223510 **Domain:** 1D ESTRY **Unit Type:** Irregular Culvert **Upstream Invert Level:** 85.23m AOD **Downstream Invert Level:** 84.98m AOD **Length:** 14m **Manning's N:** 0.035 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
GB_01144	**Description:** Access Bridge **NGR:** 453894, 223454 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 84.73m AOD **Downstream Invert Level:** 84.96m AOD **Length:** 4m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GB_01081	**Description:** Farm Track **NGR:** 454026, 223461 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 84.27m AOD **Downstream Invert Level:** 84.37m AOD **Length:** 4m **Manning's N:** 0.02 **Spill/Bypass:** Modelled in 1D domain	
GBT1_03216	**Description:** Culvert **NGR:** 453614, 226461 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.45m (assumed as no pipe visible) **Upstream Invert Level:** 110.90m AOD **Downstream Invert Level:** 110.90m AOD (invert levels assumed) **Length:** 4m **Manning's N:** 0.02 **Spill/Bypass:** Modelled in 1D domain	

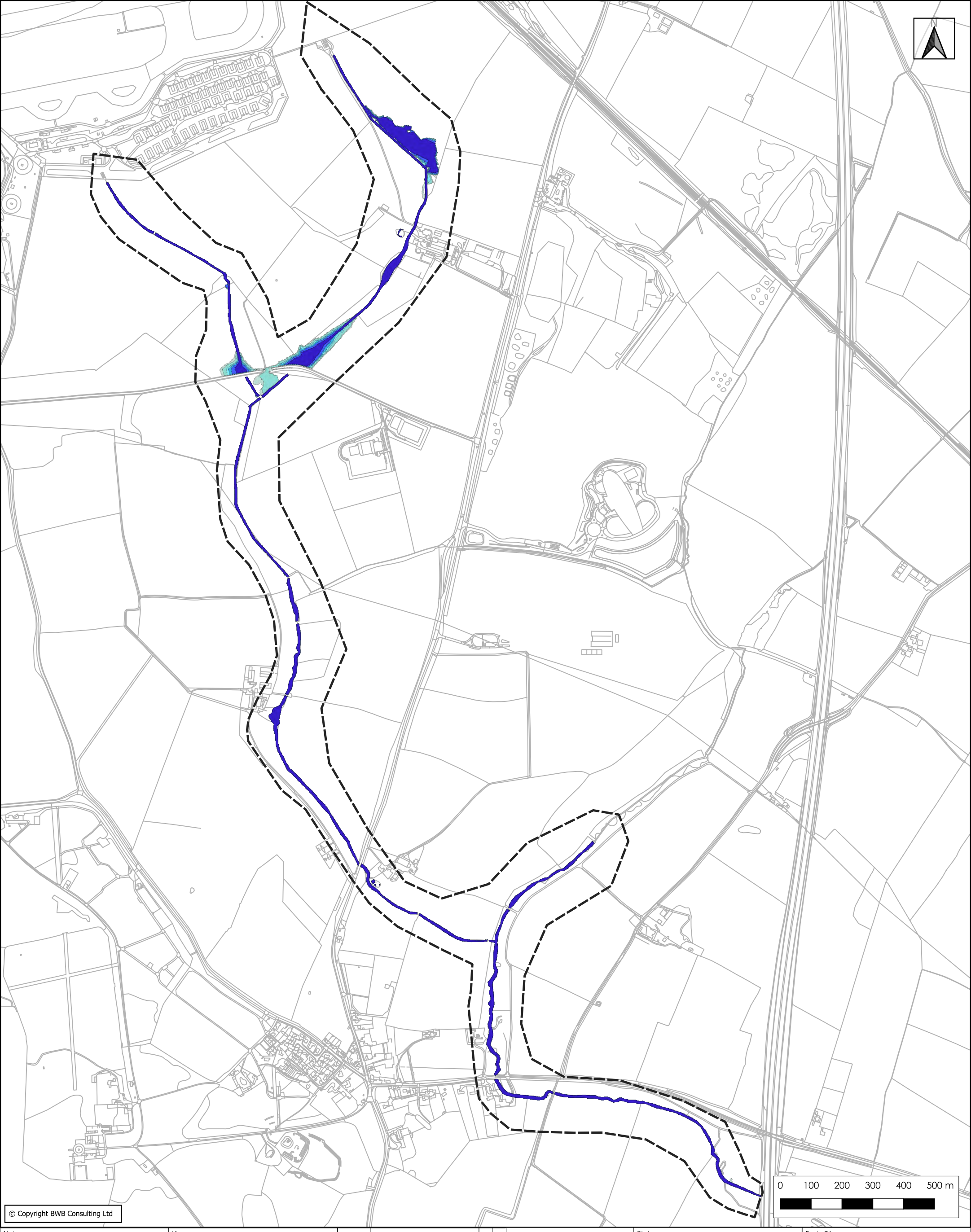
Network ID, Cross Section ID	Model Details	Photograph/Survey Section
GBT1_03125	**Description**: Farm Track Culvert **NGR:** 453614, 226371 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.45m **Upstream Invert Level:** 110.52m AOD **Downstream Invert Level:** 110.44m AOD **Length:** 4m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT1_03011	**Description:** Cattle Grid Culvert **NGR:** 453581, 226262 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.5m **Upstream Invert Level:** 109.57m AOD **Downstream Invert Level:** 109.51m AOD **Length:** 4m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT1_02990	**Description:** Farm Access Culvert **NGR:** 453564, 226241 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert **Dimensions:** 0.5m **Upstream Invert Level:** 109.40m AOD **Downstream Invert Level:** 109.36m AOD **Length:** 10m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	*No image available*
GBT1_02422	**Description:** Camp Road Culvert **NGR:** 453211, 225813 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert **Dimensions:** 0.35m **Upstream Invert Level:** 106.43m AOD **Downstream Invert Level:** 106.07m AOD **Length:** 57m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
GBT1_02254	**Description:** Grass Crossing Culvert **NGR:** 453086, 225701 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert **Dimensions:** 2 x 0.31m **Upstream Invert Level:** 105.55m AOD **Downstream Invert Level:** 105.50m AOD **Length:** 8m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT1_01589	**Description:** Farm Access Culvert **NGR:** 453173, 225124 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.6m **Upstream Invert Level:** 101.52m AOD **Downstream Invert Level:** 101.52m AOD **Length:** 5m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT1_01443	**Description:** Farm Track **NGR:** 453215, 224983 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 100.85m AOD **Downstream Invert Level:** 100.76m AOD **Length:** 10m **Manning's N:** **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT1_01192	**Description:** Farm Crossing Culvert **NGR:** 453172, 224738 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.7m **Upstream Invert Level:** 99.02m AOD **Downstream Invert Level:** 98.97m AOD **Length:** 5m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
GBT1_00543	**Description:** Ardley Road Bridge **NGR:** 453397, 224201 **Domain:** 1D ESTRY **Unit Type:** Irregular Culvert **Upstream Invert Level:** 94.77m AOD **Downstream Invert Level:** 94.89m AOD **Length:** 8m **Manning's N:** 0.035 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
GBT1_00276	**Description:** Wooden Bridge Culvert **NGR:** 453586, 224039 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.45m **Upstream Invert Level:** 92.09m AOD **Downstream Invert Level:** 92.98m AOD **Length:** 8m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT1_00026	**Description:** Culvert **NGR:** 453812, 223951 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.5 **Upstream Invert Level:** 88.06m AOD **Downstream Invert Level:** 87.77m AOD **Length:** 6m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT2_00694	**Description:** Culvert **NGR:** 452734, 226250 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.5m **Upstream Invert Level:** 116.22m AOD **Downstream Invert Level:** 115.98m AOD **Length:** 5.m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
GBT2_00388	**Description:** Culvert **NGR:** 452975, 226074 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions**: 0.15m **Upstream Invert Level:** 111.37m AOD **Downstream Invert Level:** 111.27 mAOD (Updated to reflect partial blockage) **Length:** 3m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	
GBT2_00103	**Description:** Camp Road Culvert **NGR:** 453030, 225795 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert **Dimensions:** 0.21m **Upstream Invert Level:** 107.09m AOD **Downstream Invert Level:** 106.41m AOD **Length:** 23m **Manning's N:** 0.02 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
GBT2_0005	**Description:** Culvert **NGR**: 453073, 225713 **Domain:** 1D ESTRY **Unit Type:** Circular Culvert Weir **Dimensions:** 0.2m **Upstream Invert Level:** 105.70m AOD **Downstream Invert Level:** 105.61m AOD **Length:** 5m **Manning's N:** **Blockage:** 0% **Spill/Bypass:** Modelled in 1D domain	

Appendix 4: Baseline Floodplain Maps



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Key

- Model Domain
- 1 in 30-Year
- 1 in 100-Year
- 1 in 100-Year + 15%CC
- 1 in 100-Year + 25%CC
- 1 in 100-Year + 49%CC
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Baseline Model Floodplain Extents

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1001	S2	P02

0 100 200 300 400 500 m

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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Oxfordshire Railfreight Limited

Drawing Title

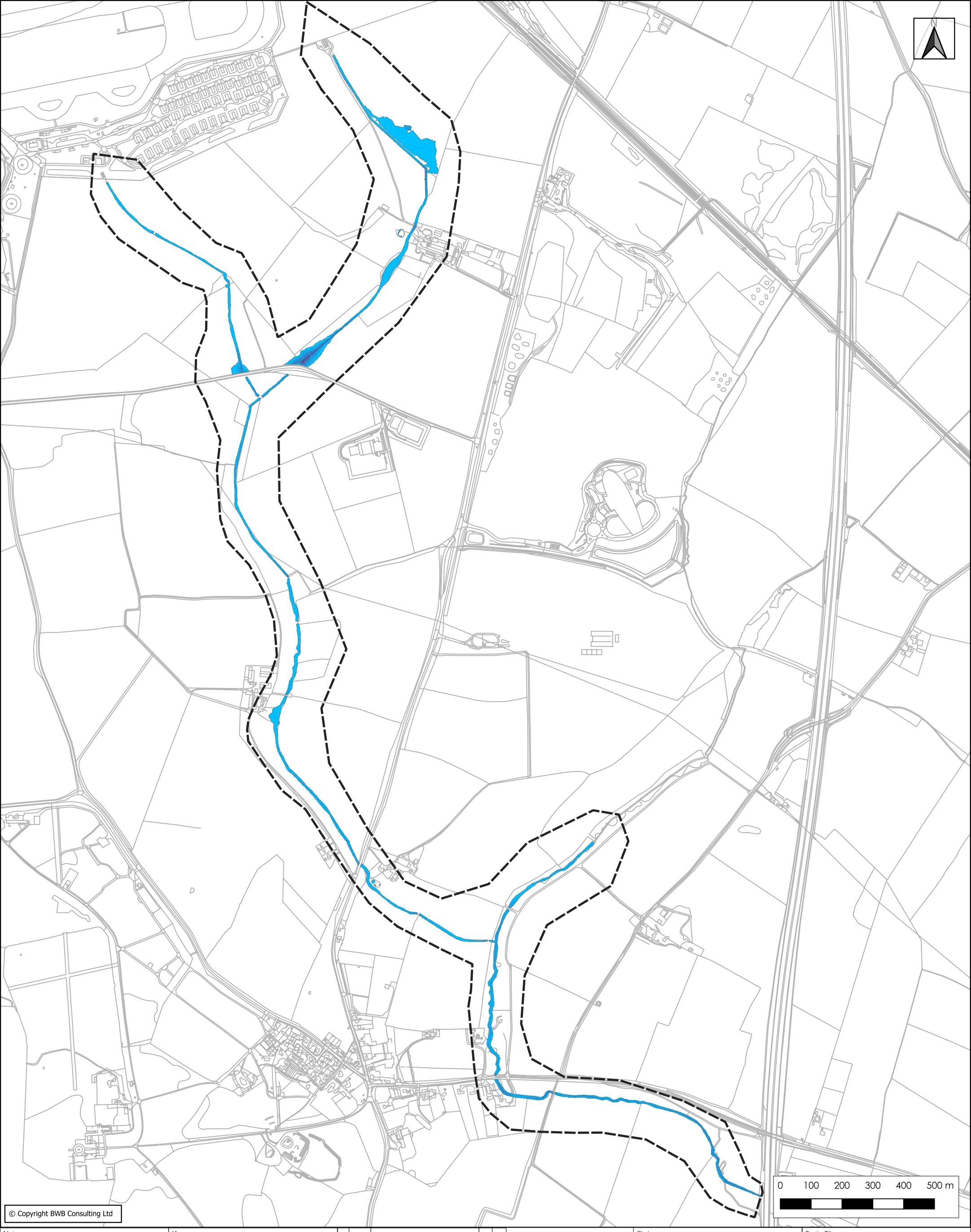
Baseline Modelled Flood Depths: 1 in 30-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1002	S2	P02



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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Oxfordshire Railfreight Limited

Drawing Title

Baseline Modelled Flood Depths: 1 in 100-Year

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BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Baseline Modelled Flood Depths: 1 in 100-Year + 15%CC

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1004	S2	P02

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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Baseline Modelled Flood Depths: 1 in 100-Year + 25%CC

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BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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0 100 200 300 400 500 m

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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Baseline Modelled Flood Depths: 1 in 100-Year + 49%CC

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BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1006	S2	P02

0 100 200 300 400 500 m

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Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	07.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Project Title

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Drawing Title

Baseline Modelled Flood Depths: 1 in 1000-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

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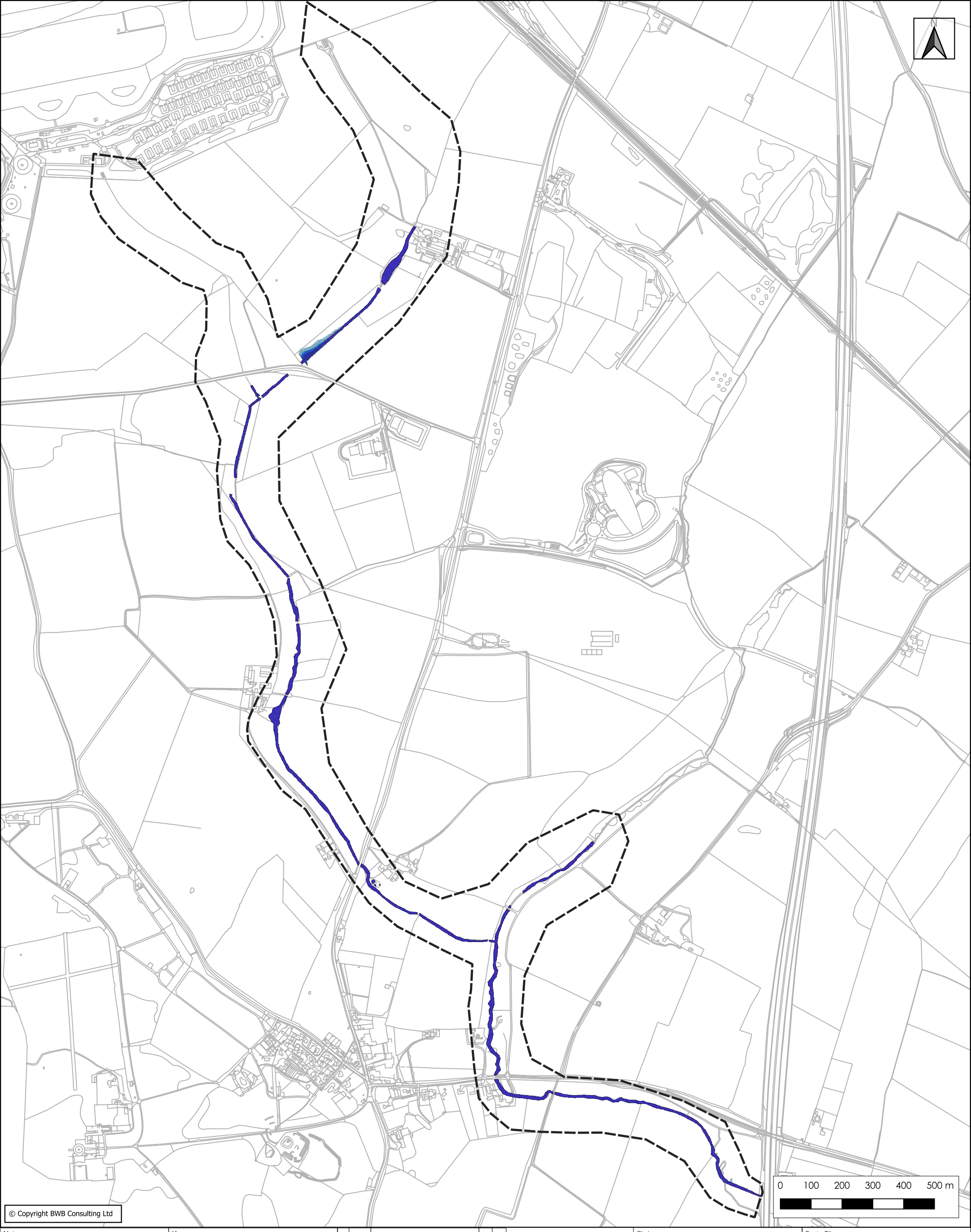
Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1007	S2	P02

Appendix 5: Proposed Floodplain Maps



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Key

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- 1 in 100-Year
- 1 in 100-Year + 15%CC
- 1 in 100-Year + 25%CC
- 1 in 100-Year + 49%CC
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Model Floodplain Extents

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1021	S2	P02

0 100 200 300 400 500 m

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Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Modelled Flood Depths: 1 in 30-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1022	S2	P02

0 100 200 300 400 500 m

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Modelled Flood Depths: 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1023	S2	P02

0 100 200 300 400 500 m

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Modelled Flood Depths: 1 in 100-Year + 15%CC

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23

Scale@A3: 1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1024	S2	P02

0 100 200 300 400 500 m

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

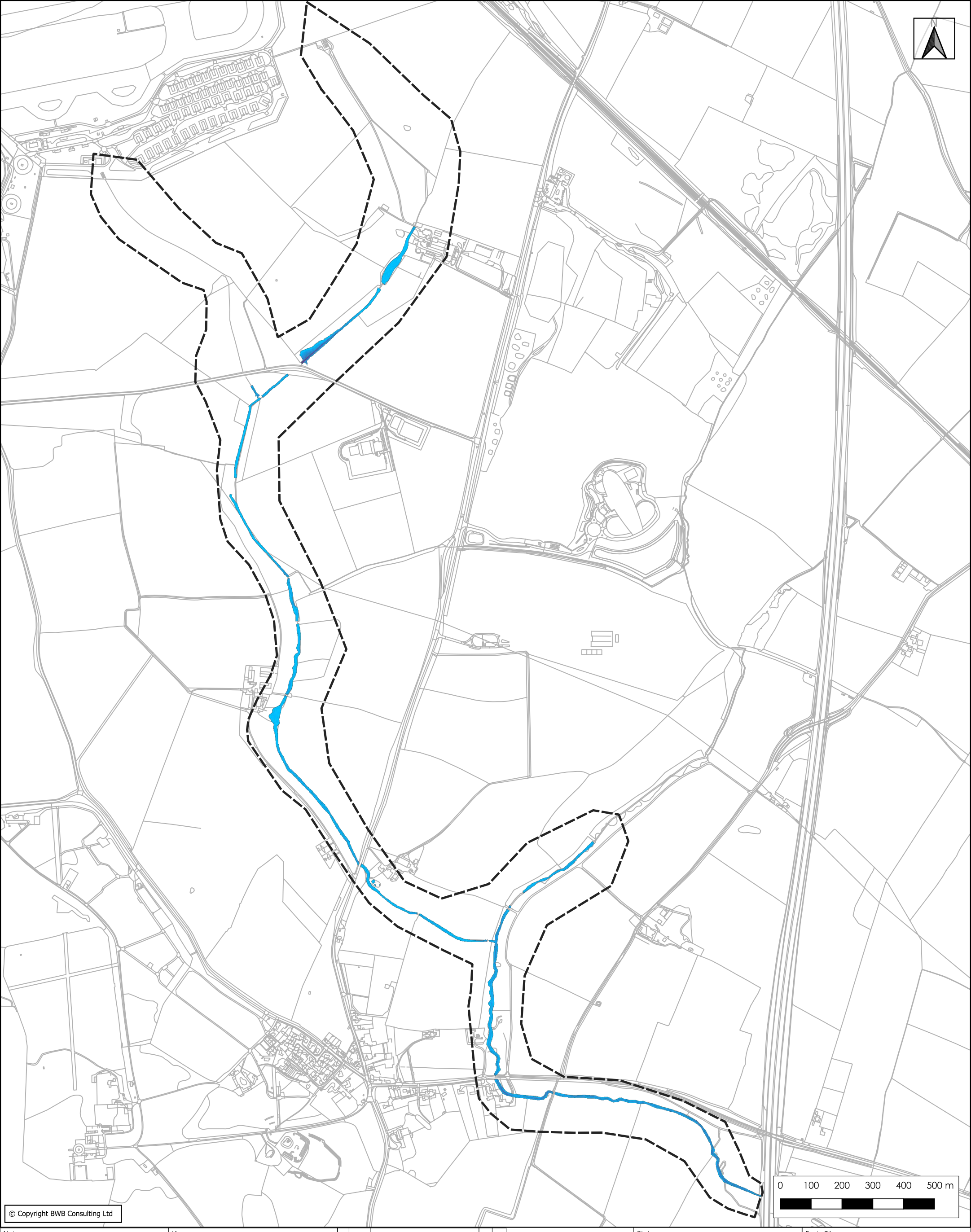
Proposed Modelled Flood Depths: 1 in 100-Year + 25%CC

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1025	S2	P02



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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

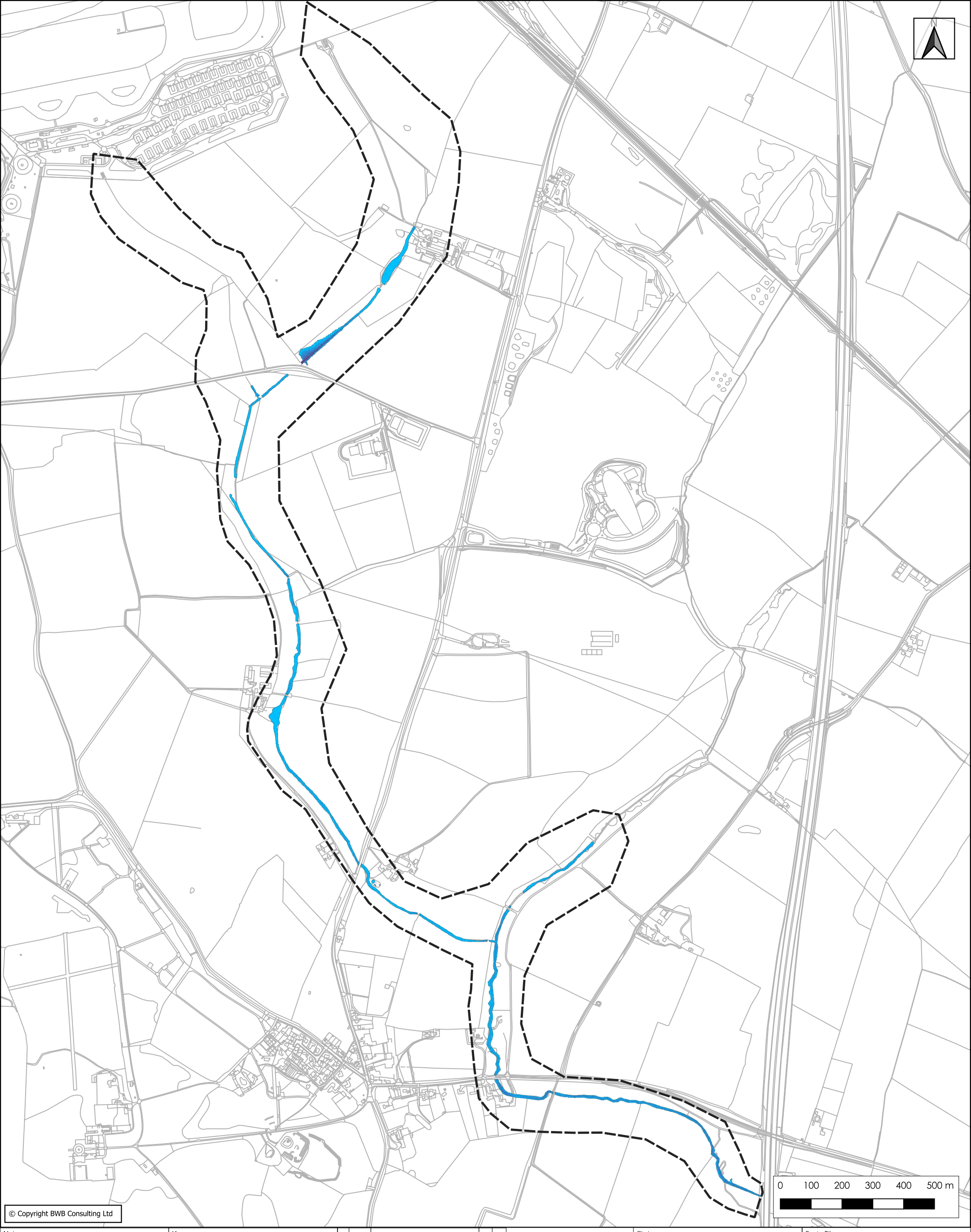
Proposed Modelled Flood Depths: 1 in 100-Year + 49%CC

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1026	S2	P02



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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Modelled Flood Depths: 1 in 1000-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1027	S2	P02

Appendix 6: Comparison Mapping

0 100 200 300 400 500 m

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Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Peak Flood Levels

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet
- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	13.01.26	Minor Amendments	MN	LR
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Impact Analysis: 1 in 30-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1028	S2	P03

0 100 200 300 400 500 m

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Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Peak Flood Levels

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet
- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	13.01.26	Minor Amendments	MN	LR
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Impact Analysis: 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1029	S2	P03

0 100 200 300 400 500 m

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Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Peak Flood Levels

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet
- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	13.01.26	Updated results	MN	LR
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Impact Analysis: 1 in 100-Year + 15%CC

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1030	S2	P03

0 100 200 300 400 500 m

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Peak Flood Levels

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet
- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	13.01.26	Minor Amendments	MN	LR
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Impact Analysis: 1 in 100-Year + 25%CC

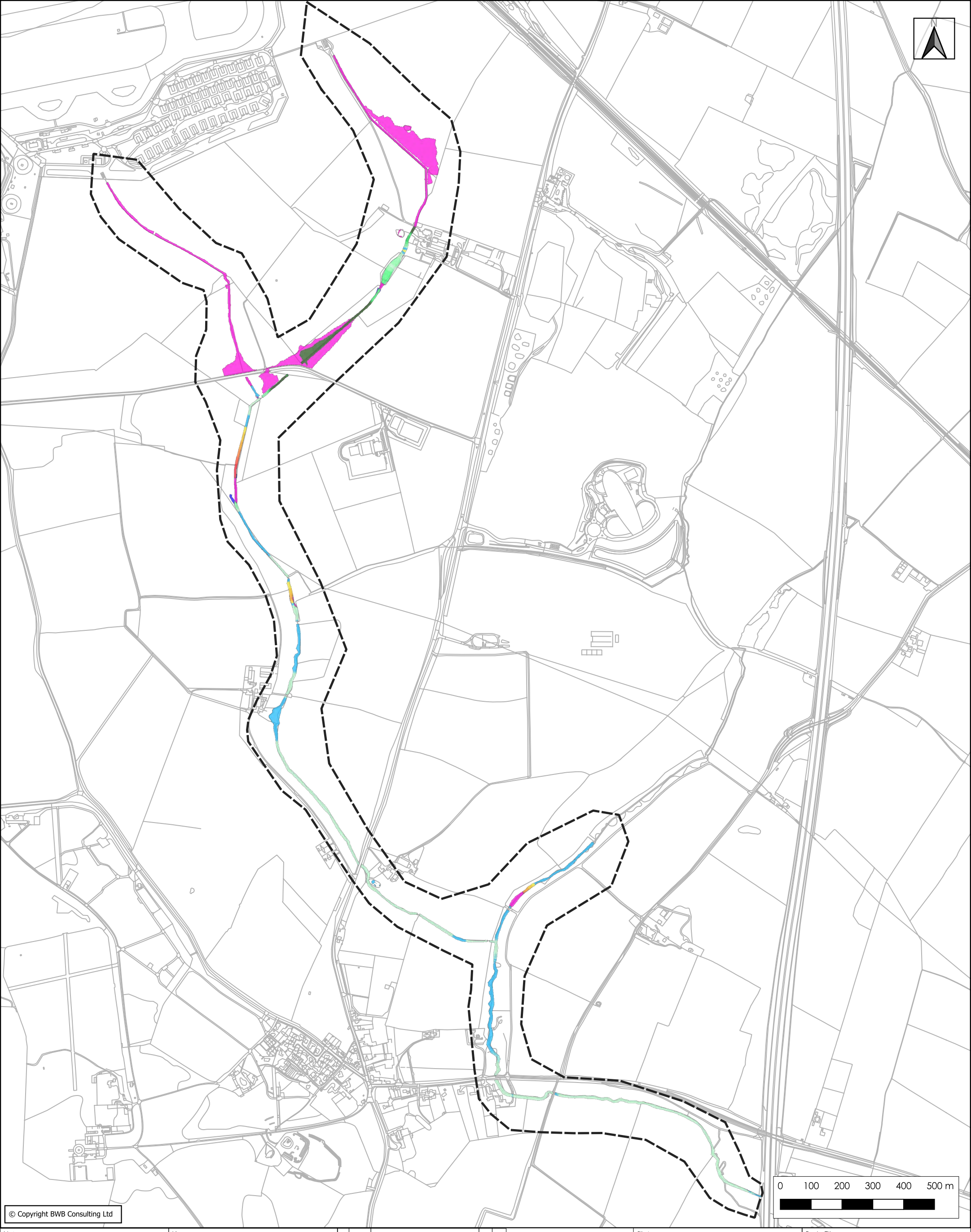
Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23

Scale@A3: 1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1031	S2	P03



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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Peak Flood Levels

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet
- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	13.01.26	Minor Amendments	MN	LR
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Impact Analysis: 1 in 100-Year + 49%CC

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1032	S2	P03

0 100 200 300 400 500 m

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Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Peak Flood Levels

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet
- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	13.01.26	Minor Amendments	MN	LR
P02	30.07.25	Updated to include latest hydrology	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Proposed Impact Analysis: 1 in 1000-Year

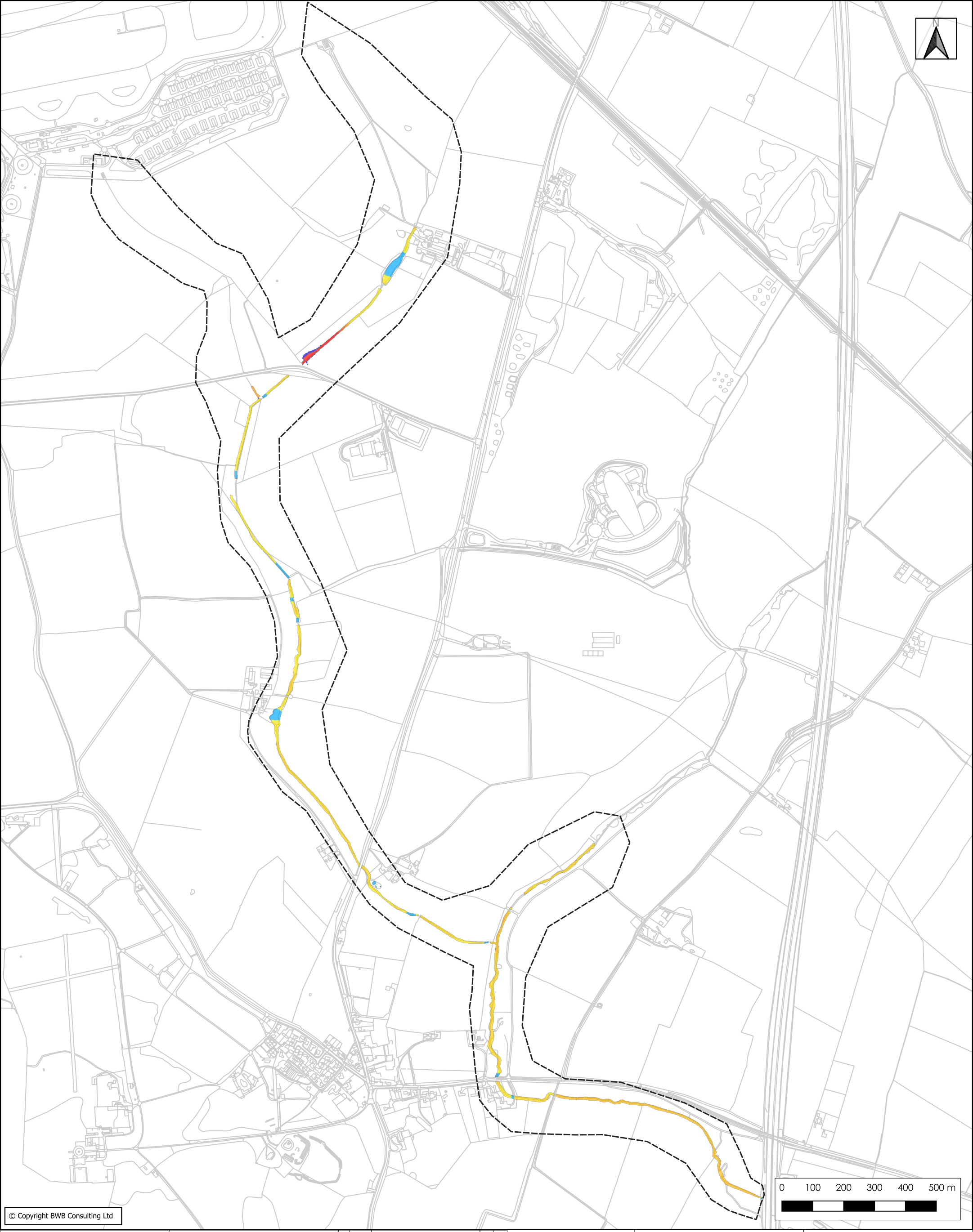
Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1033	S2	P03

Appendix 7: Sensitivity Testing



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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

- Model Domain

Change in Modelled Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	26.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Client

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Gagle Brook - Post-Development Sensitivity: Increased Roughness (20%) 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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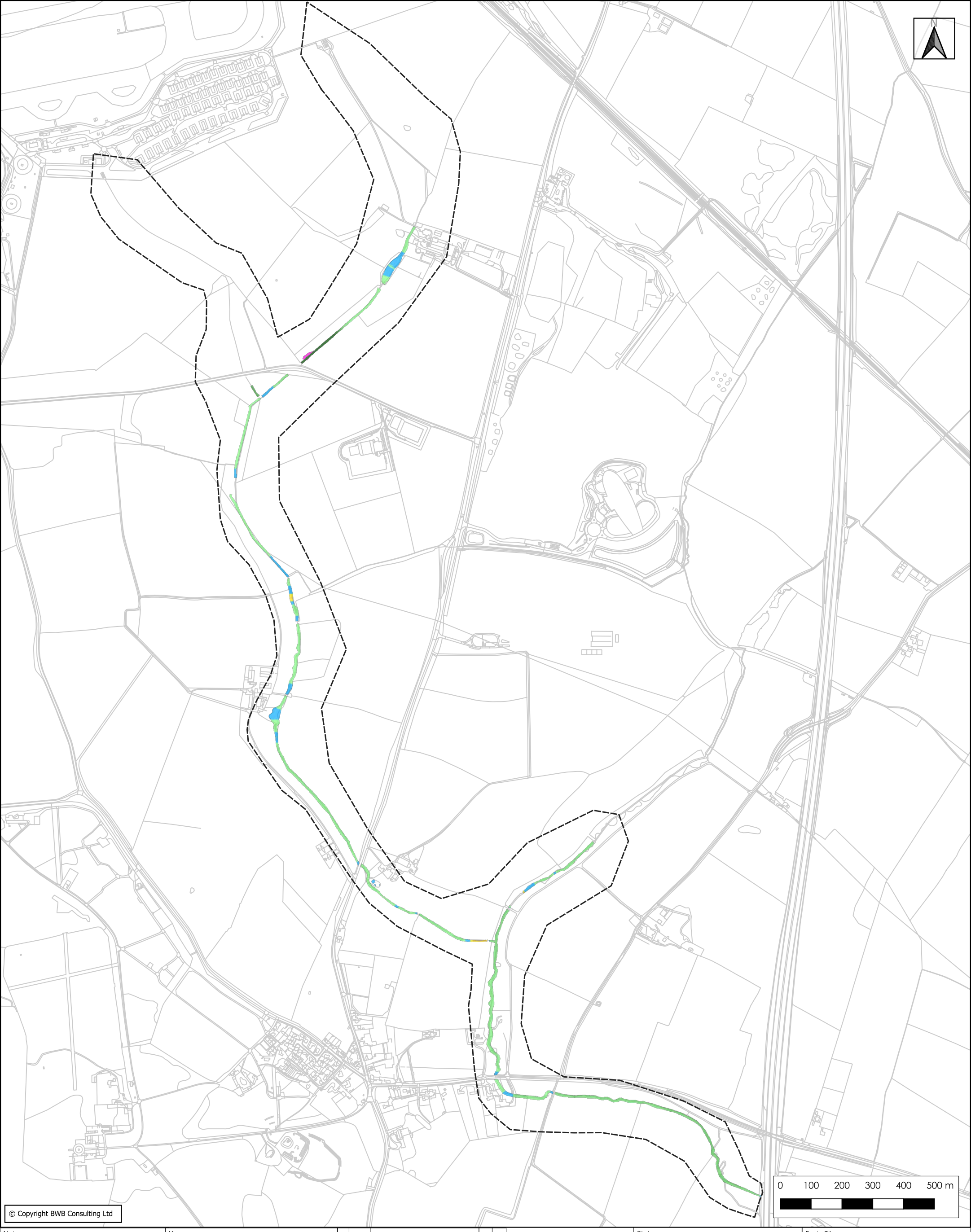

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	26.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Project Title

Oxfordshire Railfreight Limited

Drawing Title

Gagle Brook - Post-Development Sensitivity: Decreased Roughness (20%) 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	NTH2479	Date:	06.04.23	Scale@A3:	1:11,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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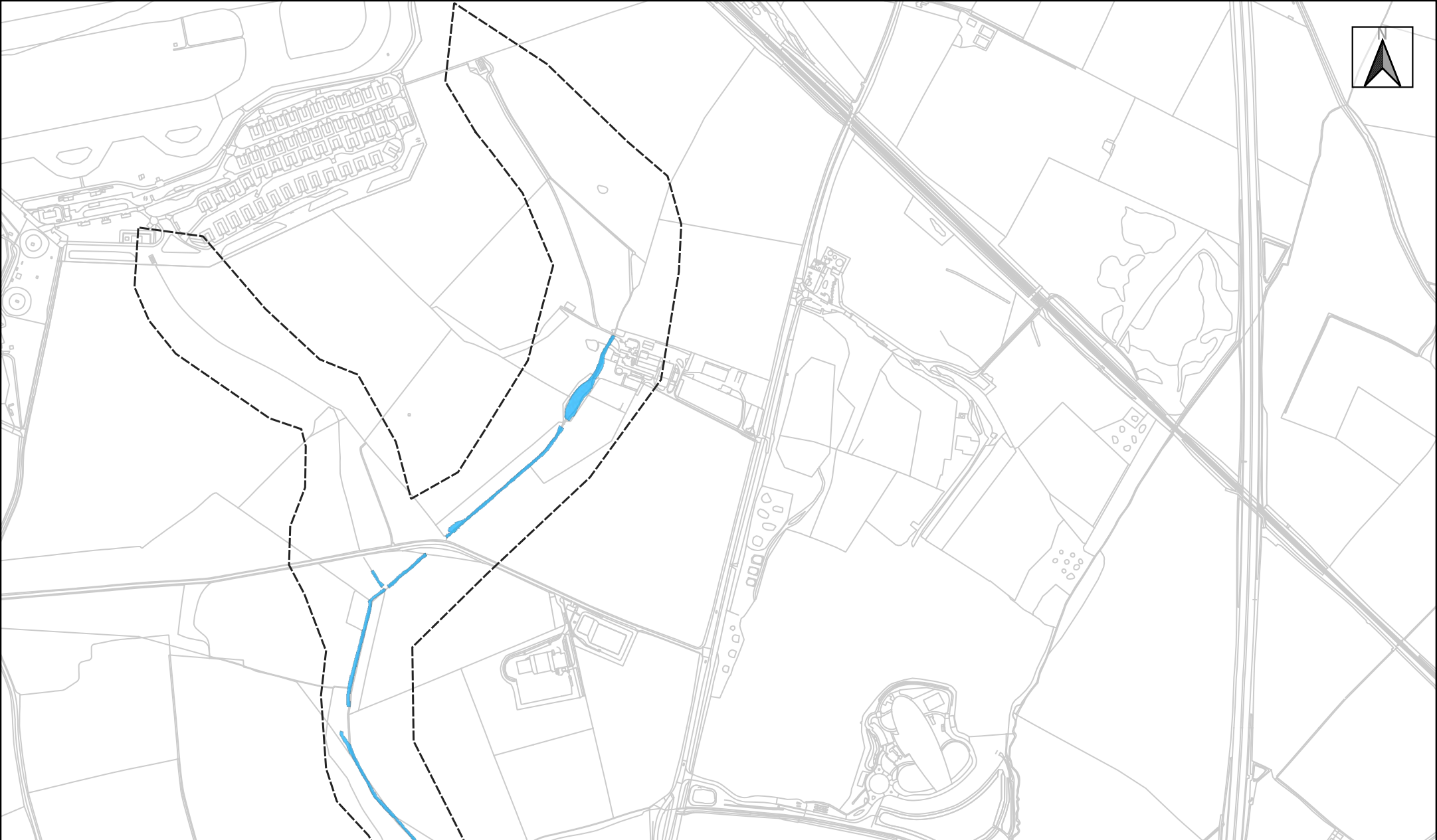

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5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	26.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	LR
P01	06.04.23	PRELIMINARY ISSUE	LR	MB

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Project Title

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Drawing Title

Gagle Brook - Post-Development Sensitivity: Increased Downsteam Boundary (20%) 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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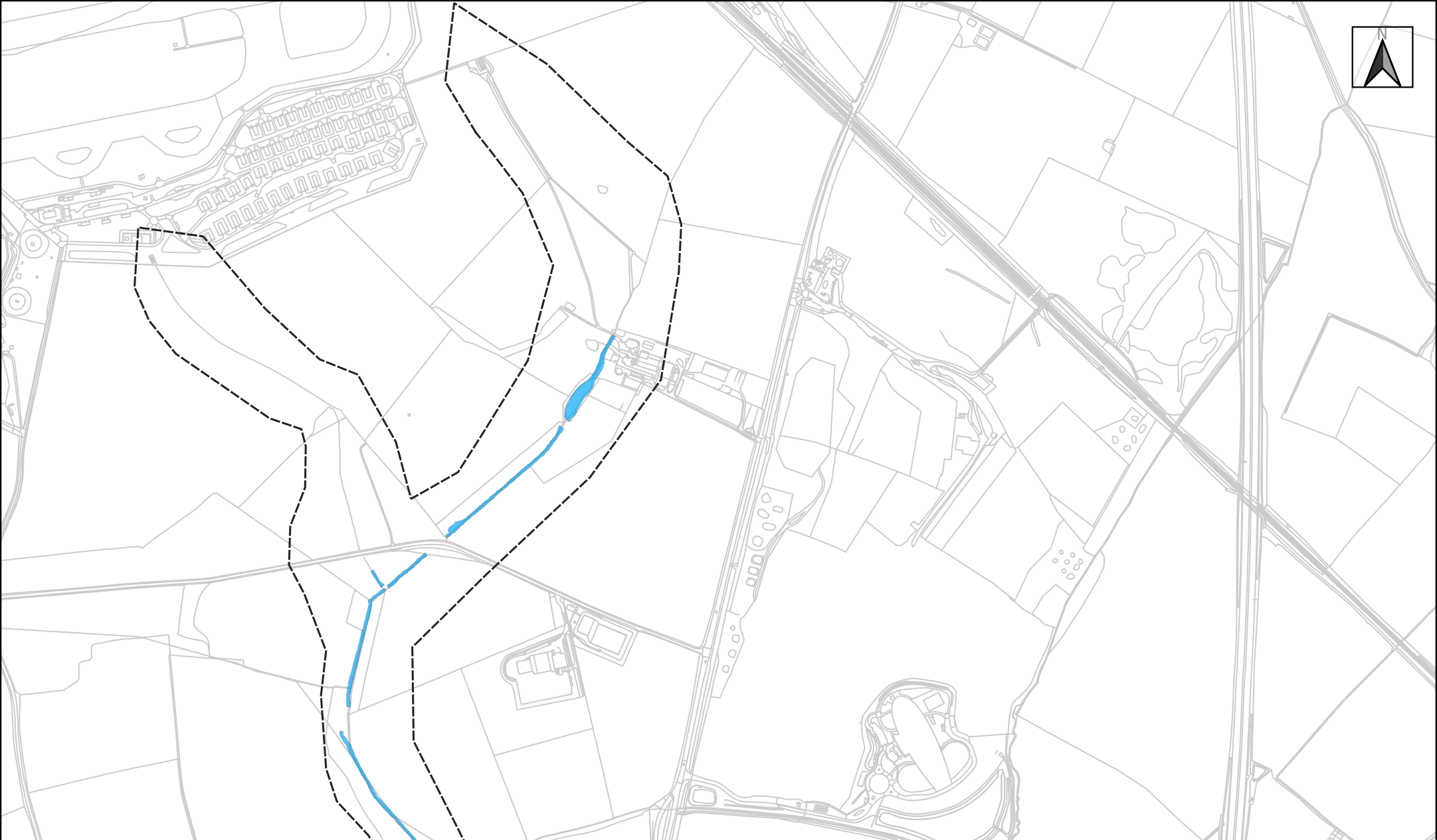

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

- Model Domain

Change in Modelled Floodplain Extents

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	26.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	LR
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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Gagle Brook - Post-Development Sensitivity: Decreased Downsteam Boundary (20%) 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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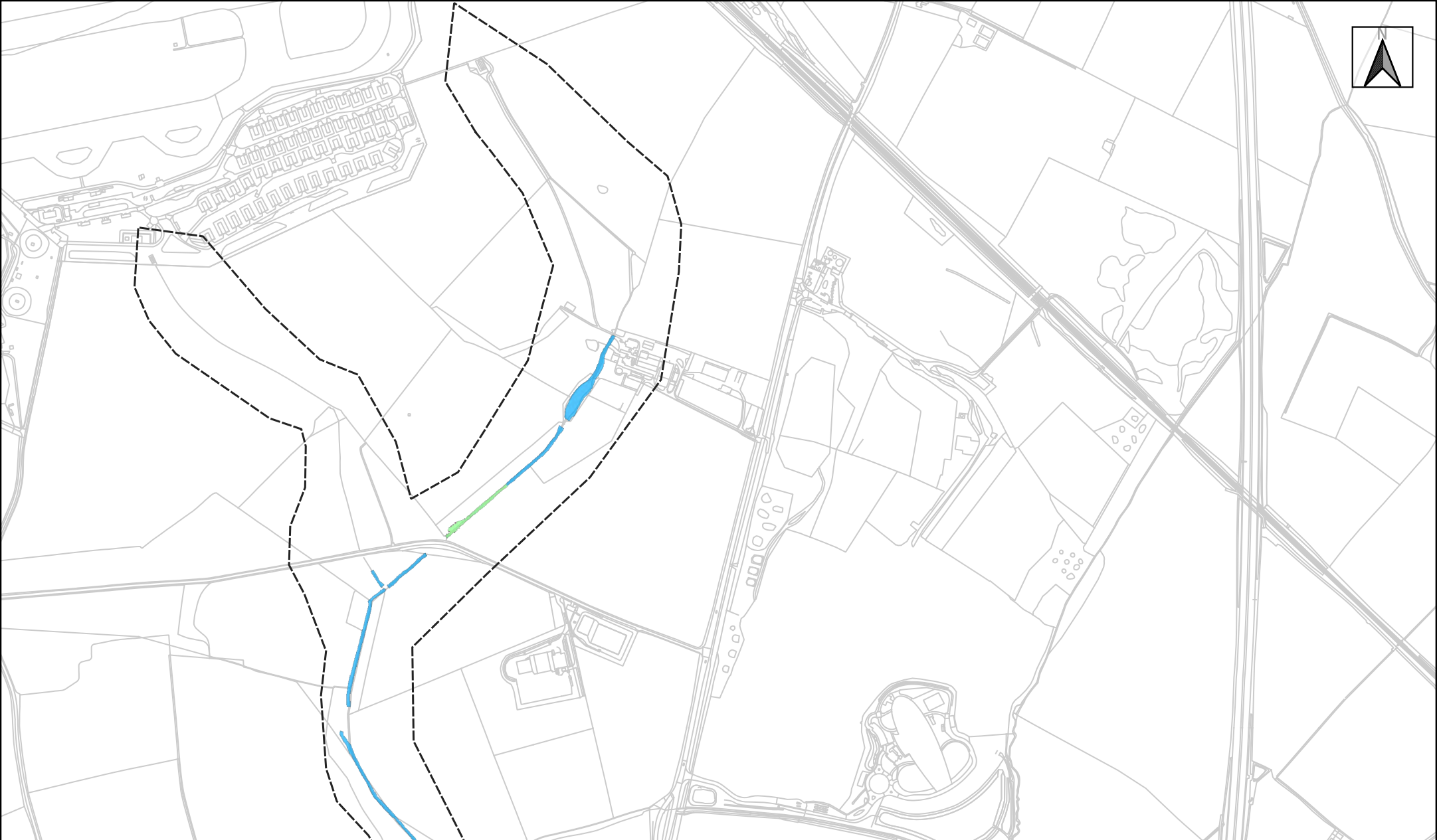

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5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Floodplain Extents

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

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Gagle Brook - Post-Development Sensitivity: Storm Duration (7.5hr) 1 in 100-Year

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BWB Ref:	NTH2479	Date:	06.04.23
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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1044	S2	P02

75% blockage of GBT1_02793_A

0 100 200 300 400 500 m

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5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	26.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	LR
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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Gagle Brook - Post-Development Sensitivity: Blockage 1 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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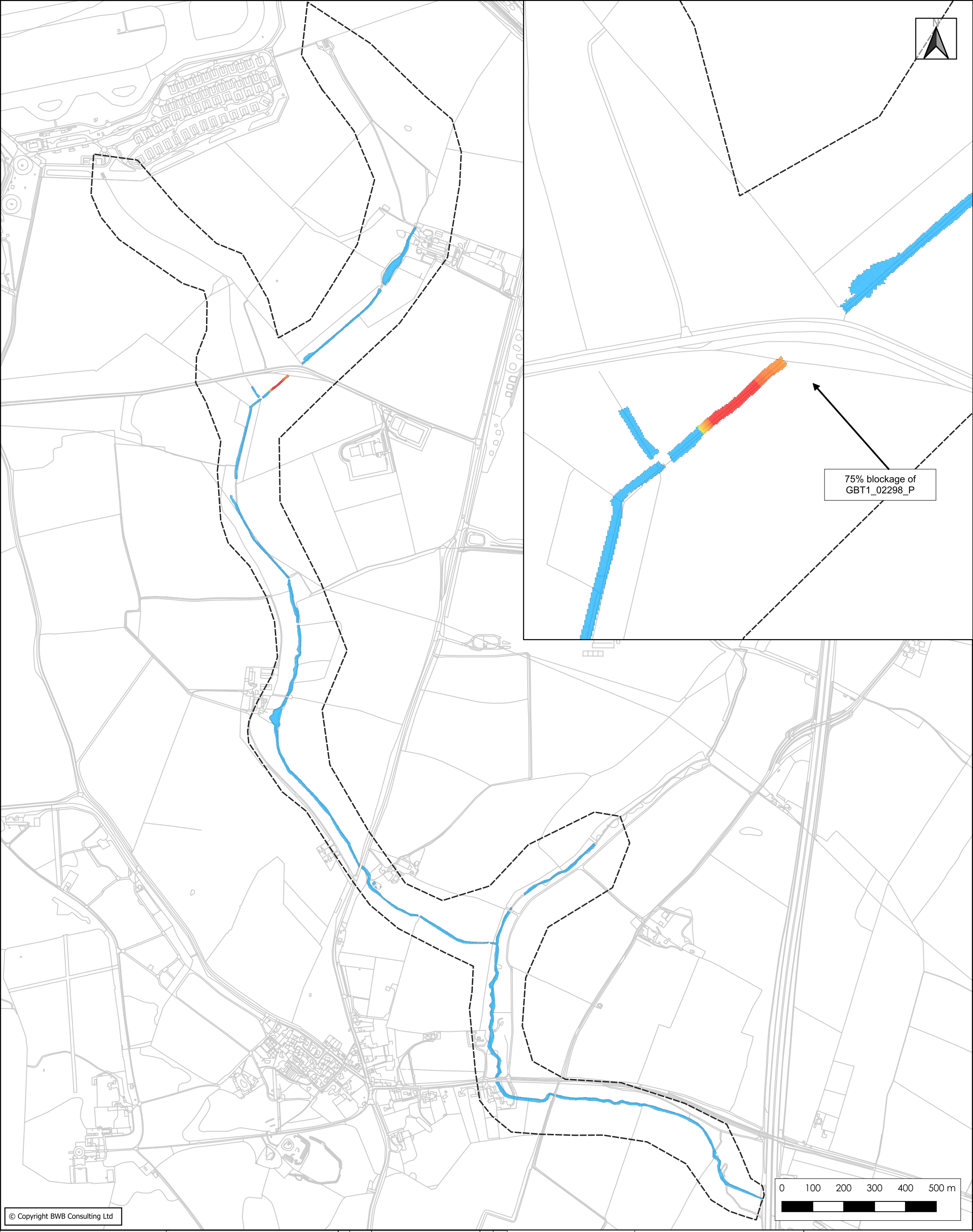

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Floodplain Extents

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

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Project Title

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Drawing Title

Gagle Brook - Post-Development Sensitivity: Blockage 2 1 in 100-Year

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BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1047	S2	P02

50% blockage of GBT1_01968_P

0 100 200 300 400 500 m

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5. Model not yet peer reviewed.

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Key

Model Domain

Change in Modelled Floodplain Extents

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
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Project Title

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Drawing Title

Gagle Brook - Post-Development Sensitivity: Blockage 3 1 in 100-Year

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BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

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PRELIMINARY

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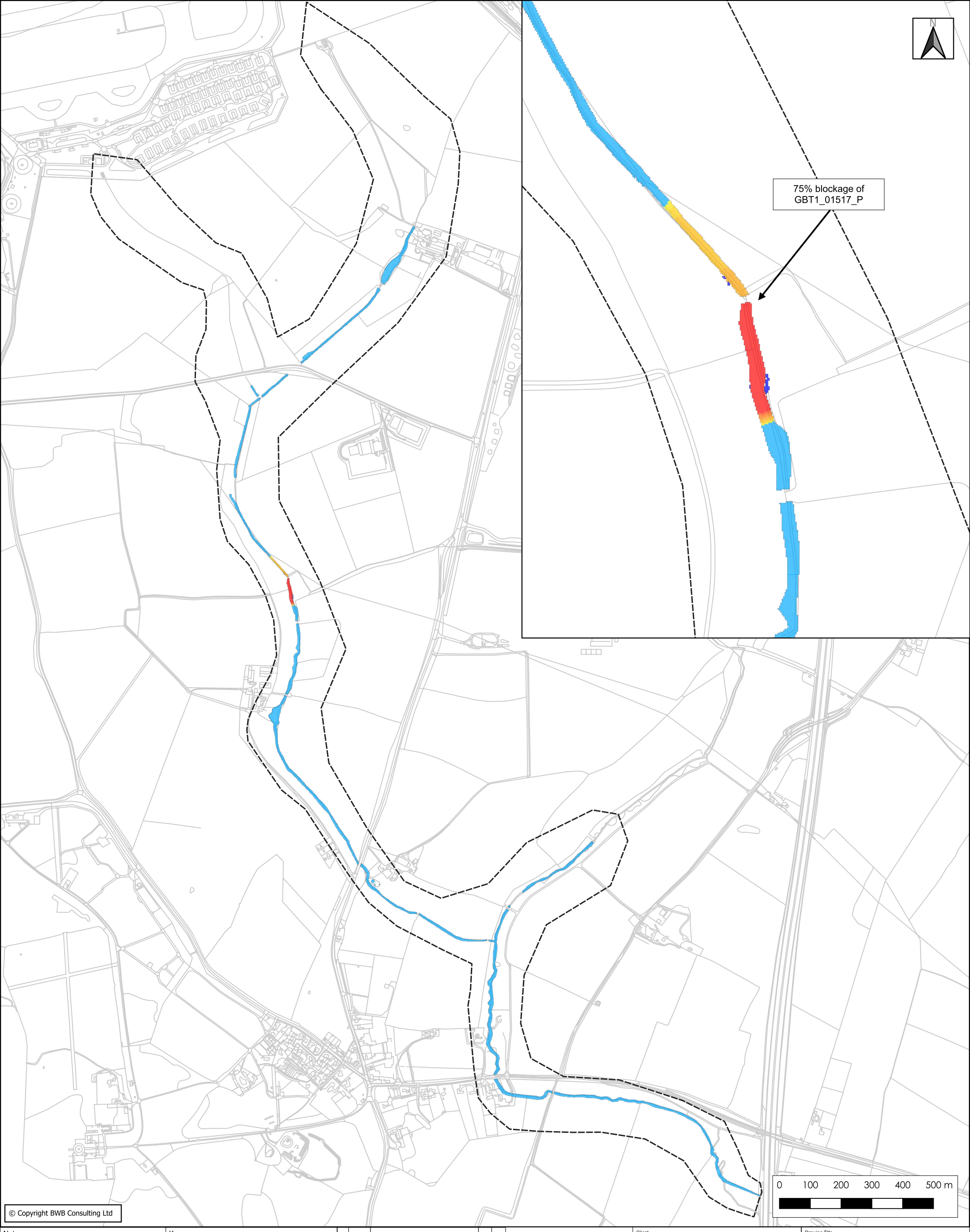

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5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

Key

Model Domain

Change in Modelled Floodplain Extents

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Gagle Brook - Post-Development Sensitivity: Blockage 4 1 in 100 Year

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	06.04.23
Scale@A3:	1:11,000		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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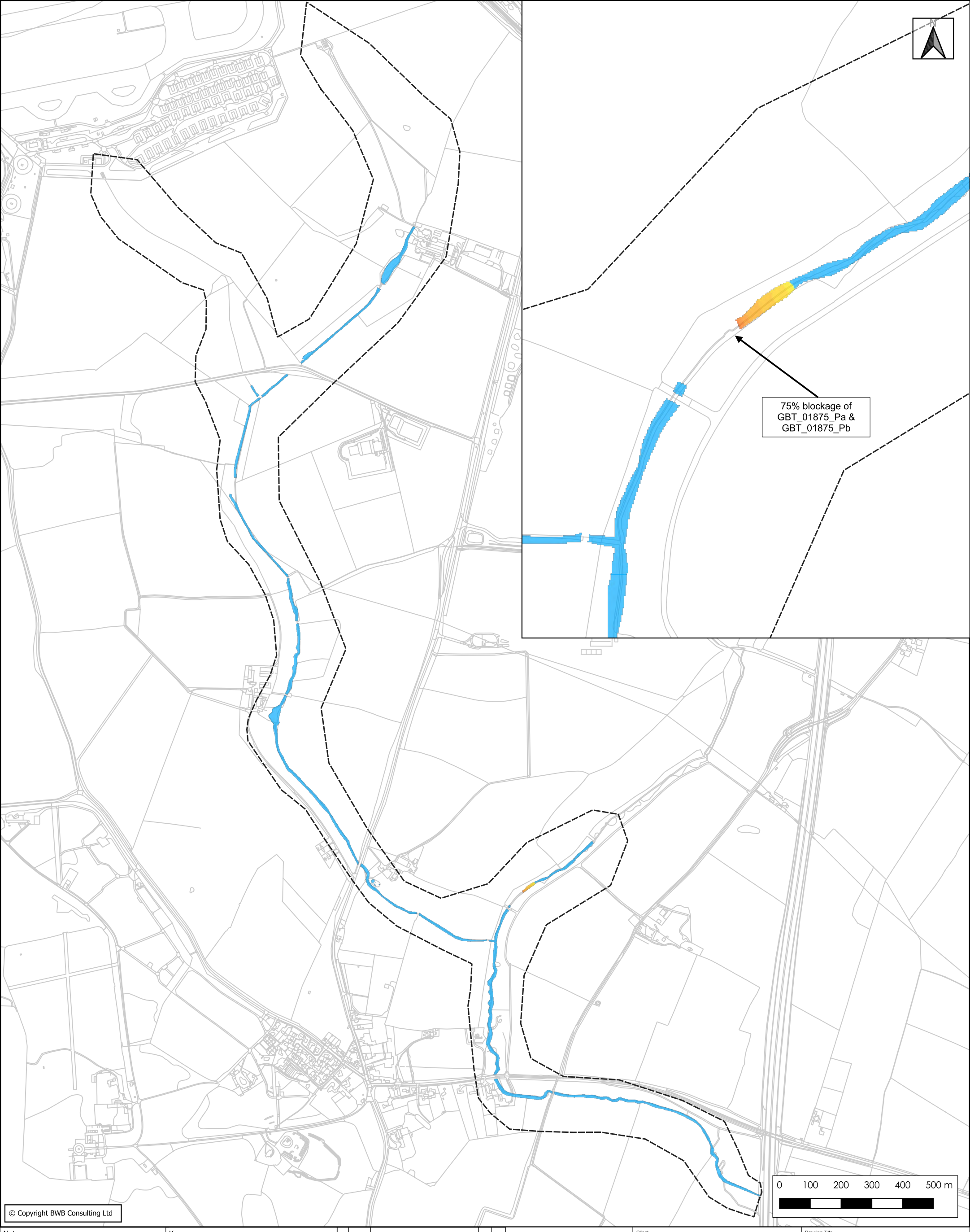

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Key

- Model Domain

Change in Modelled Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

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Project Title

Oxfordshire Railfreight Limited

Drawing Title

Gagle Brook - Post-Development Sensitivity: Blockage 5 1 in 100-Year

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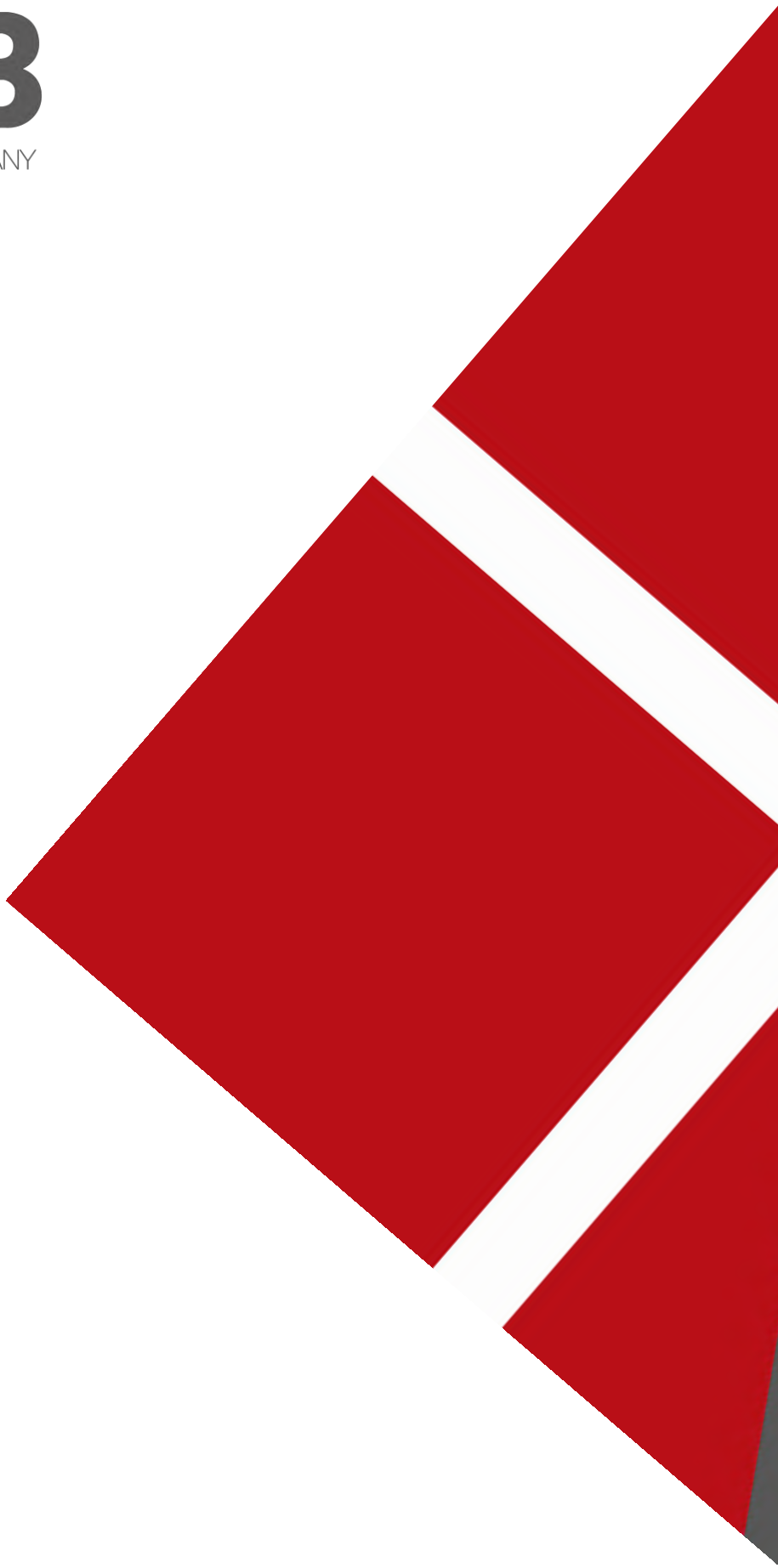

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August 2025

DOCUMENT ISSUE RECORD

Document Number:	OXSRFI-BWB-ZZ-XX-T-W-1005_HMR
BWB Reference:	NTH2479_PBT_HMR

Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	29/08/25	S2	Preliminary Issue	Sian Renwick MSci (Hons)	Lucy Reeves BSc (Hons) MCIWEM	Matthew Day BA (Hons) MSc FRGS MCIWEM C.WEM C.Sci C.Env

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GLOSSARY & NOTATION

1D – one-dimensional hydraulic model, good for representing the hydraulics of a definitive channel or flow pathway and hydraulic structure.

2D – two-dimensional hydraulic model, good for representing complex flow routing present within the floodplain.

Annual Exceedance Probability (AEP) - the probability (%) of a flood event occurring in any year.

Catchment - the land area that drains (normally naturally) to a given point on a river, drainage system or body of water.

CME – Cumulative Mass Error

Design flood event - magnitude of the flood adopted for the design of the whole or part of a development, usually defined in relation to the severity of the flood in terms of its return period. Typically, the 1 in 100-year return period event including an allowance for future climate change for fluvial flood events.

DTM – Digital Terrain Model

EA – Environment Agency

ESTRY - a 1D hydraulic modelling software package published by BMT.

Flood Estimation Handbook (FEH) – industry standard guidance on rainfall and river flood frequency estimation across the UK.

Floodplain - any area of land over which water flows or is stored during a flood event.

FRA – Flood Risk Assessment

Freeboard - the height of the top of a bank, floodwall or other flood defence structure, above the design water level. Freeboard can be seen as a safety margin that makes allowance for uncertainty associated with the potentially damaging effects of flood rise or wave action.

Hydraulic Model - a mathematical (generally computer based) model of a water/sewer/storm system which is used to analyse the system's hydraulic behaviour.

LiDAR – Light Detection and Ranging aerial survey data

LLFA – Lead Local Flood Authority

mAOD – metres above Ordnance Datum

m BGL – metres below ground level

Main River - a statutory type of watercourse in England and Wales, usually larger streams and rivers. The EA can carry out maintenance, improvement or construction work on main rivers to manage flood risk as part of its duties and powers.

NRFA – National River Flow Archive

OS – Ordnance Survey

Preliminary Flood Risk Assessment (PFRA) - an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authority.

ReFH – Revitalised Flood Hydrograph rainfall-runoff hydrological model

Return period - a statistical term defining the probability of occurrence of a flood event. Thus a 1 in 50-year flood is one likely to be equalled or exceeded on average only once in a 50-year period: a flood with a 2.0% annual probability exceedance (AEP).

Strategic Flood Risk Assessment (SFRA) - a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.

TUFLOW – a 2D fixed grid hydraulic modelling software package published by BMT.

UOW – Unnamed Ordinary Watercourse

Watercourse – a natural or man-made open channel for the conveyance of water.

Z-line – a break line layer in TUFLOW which can be used to reinforce linear features in the 2D model domain such as a riverbank, flood defence, or channel bed.

Z-Shape – a layer in TUFLOW which can be used to manipulate the 2D model geometry.

1. INTRODUCTION

1.1 BWB Consulting Ltd (BWB) has been commissioned by Oxfordshire Railfreight Limited (the Client) to undertake a site-specific hydraulic modelling exercise of the Padbury Brook Tributary to support the development of the Oxfordshire Strategic Rail Freight Interchange (SRFI), Oxfordshire (NGR: SP537269).

Site Description

1.2 The Order Limits of the DCO are located approximately 4.3km north-west of Bicester town centre. The M40 motorway and the A43 form the north-eastern boundary and the Ardley Road (B460) forms the south-eastern boundary. Heyford Park is located to the west of the site and the Upper Heyford Airfield (disused) is located to the north-west. The extent of the Order Limits is shown in **Figure 1.1.**

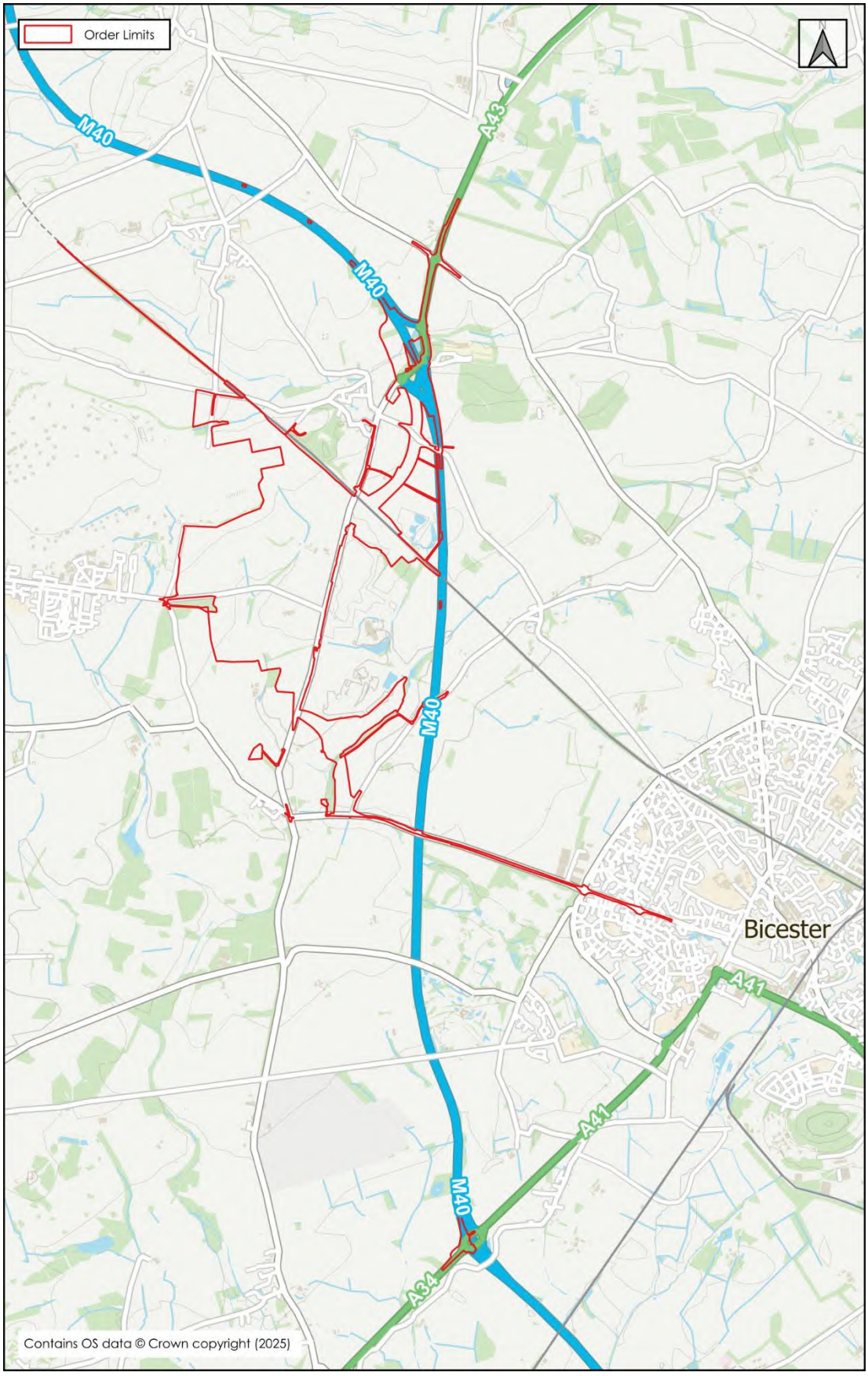


Figure 1.1: Site Location

Padbury Brook Tributary

1.3 **Figure 1.2** shows the extent of the Padbury Brook Tributary to be modelled in this study.

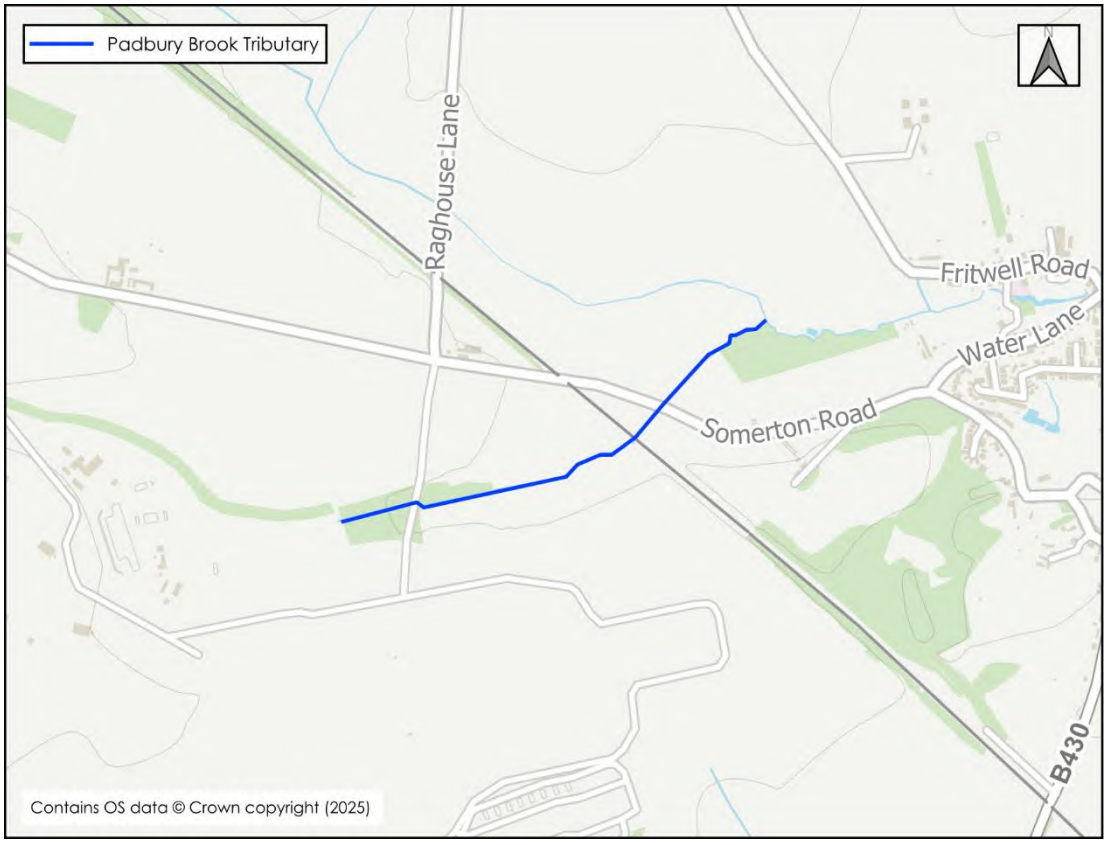


Figure 1.2: Watercourse Network

1.4 The Padbury Brook Tributary rises to the west of the Order Limits, upstream of Raghouse Lane. The watercourse generally flows in an easterly direction and is culverted beneath Raghouse Lane, a farm access track, the railway and Somerton Road, where it then continues to flow in a north-easterly direction as open channel to its confluence with the Padbury Brook.

1.5 The upper catchment of the Padbury Brook Tributary has elevations of approximately 139mAOD. The upper reaches flow through a narrow, defined channel with valley-like topography. Downstream of the railway, the watercourse flows through a wider valley, with levels falling to approximately 112mAOD in the vicinity of the confluence with the Padbury Brook. The catchment topography is shown in **Figure 1.3**.

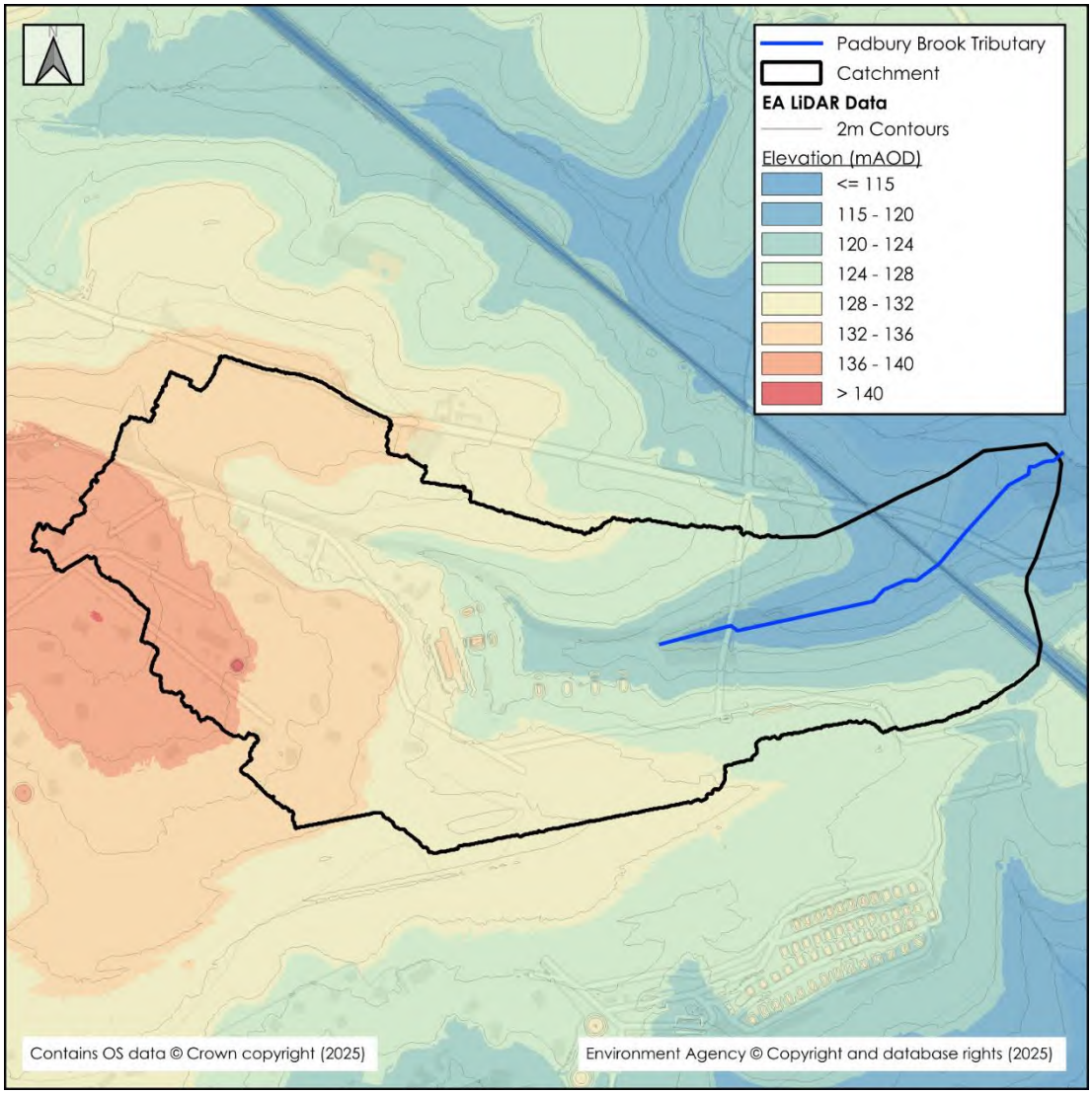


Figure 1.3: Padbury Brook Tributary Catchment Topography

Previous Studies & Available Data

Historical Flooding

1.6 A review of the Cherwell Level 1 Strategic Flood Risk Assessment (SFRA) Update[1], Cherwell Level 2 SRFA[2], Oxfordshire County Council Preliminary Flood Risk Assessment (PFRA)[3] and Addendum[4], EA recorded flood data, and local news outlets did not return any reports of flooding within the vicinity of the site.

[1] Level 1 Strategic Flood Risk Assessment Update (WHS, November 2022)
[2] Level 2 Strategic Flood Risk Assessment (AECOM, May 2017)
[3] Preliminary Flood Risk Assessment (JBA Consulting, June 2011)
[4] Preliminary Flood Risk Assessment Addendum (Oxfordshire County Council, December 2017)

Hydraulic Models

1.7 In 2021, BWB contacted the EA and Oxfordshire County Council, the Lead Local Flood Authority (LLFA), to request any hydraulic model data/files that were held for the area. Both authorities confirmed that they hold no such information at this location.

BWB Site Visit (August 2021)

1.8 A site visit was undertaken by BWB during August 2021 to walk the local watercourse reaches and observe any key features that either needed surveying or needed to be considered during the hydraulic modelling process. The key considerations have been summarised below:

- The Padbury Brook Tributary is understood to flow from the former airfield in an easterly direction.
- The watercourse is culverted underneath the railway by a siphon culvert before flowing as open channel for a short reach, to then be culverted beneath Somerton Road.
- The Padbury Brook Tributary flows in open channel in a north-easterly direction where it outfalls to the Padbury Brook.

1.9 A further site visit was undertaken in March 2025; however, no additional key considerations were noted.

Environment Agency Flood Maps

1.10 The Order Limits in the vicinity of the Padbury Brook Tributary are located in Flood Zone 1. However, the Padbury Brook Tributary is not included within the Flood Map for Planning due to the small catchment associated with the upper reaches of these watercourses (<3km^2).

1.11 In the absence of Flood Zones, the EA Risk of Flooding from Surface Water mapping can be used to identify the potential floodplain associated with small watercourses omitted from the EA strategic fluvial flood risk datasets. The mapping, shown in **Figure 1.4**, shows the probability of surface water flooding based on the Central climate change allowances for the '2050s' epoch and is the most precautionary surface water data projection currently published by the EA.

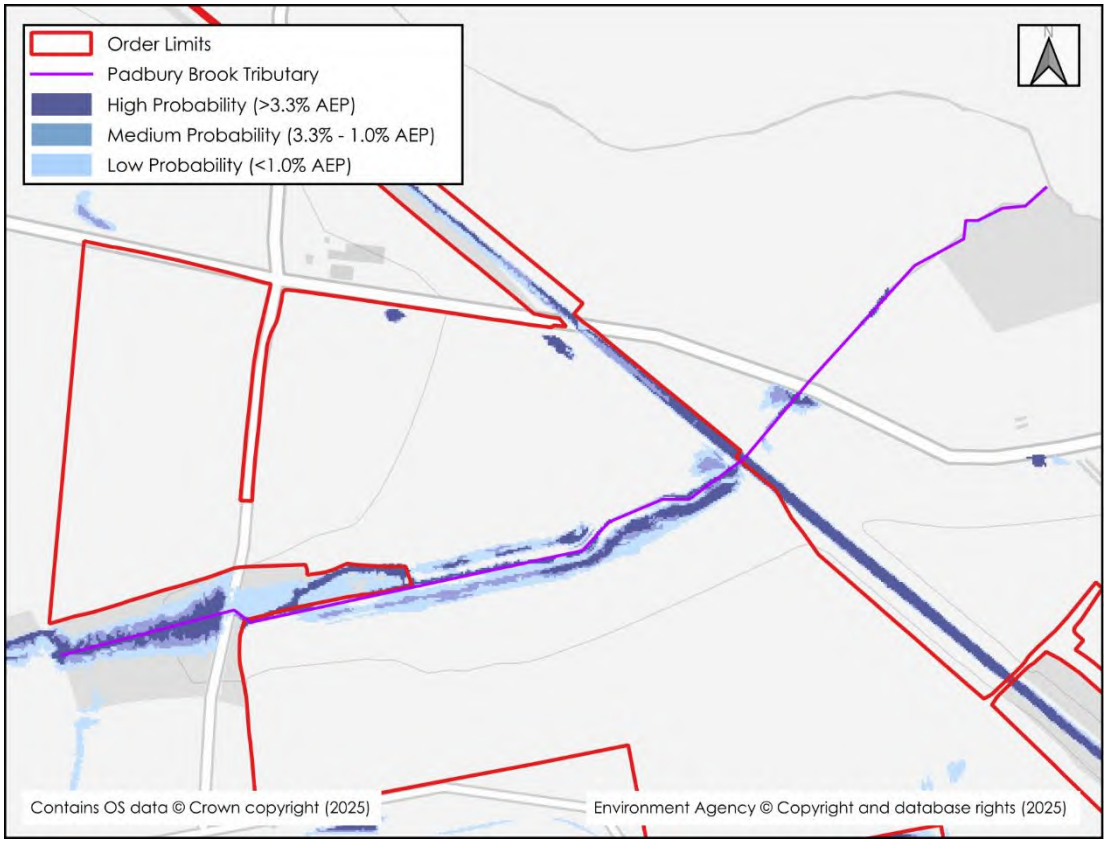


Figure 1.4: EA Risk of Flooding from Surface Water Mapping (Yearly Chance Between 2040 and 2060)

Other Sources of Data

1.12 The following additional datasets were used within the hydraulic modelling exercise:

- EA 2022 LiDAR 1m spatial resolution DTM.
- 3D Topographical Survey by Greenhatch Group in July 2022 (drawing reference: 36646_T_REV4).
- Cross-sectional watercourse survey, undertaken in October 2021 by BWB Consulting (included as **Appendix 1**).
- Photographs and observations from site visit undertaken in August 2021 and March 2025 by BWB Consulting.
- A hydrological assessment of flood flows undertaken in May 2025 by BWB Consulting (included as **Appendix 2**).
- Proposed finished levels surface (model reference: OxSRFI-BWB-HGN-ZZ-M3-CH-0101).

Aims and Objectives

1.13 This modelling exercise will be used to establish a good hydrological and hydraulic representation of the fluvial flooding mechanisms and magnitude within the vicinity of the Order Limits and test development conditions. The following objectives have been identified:

i. Undertake a hydrological review of the Padbury Brook Tributary to estimate peak flows and general flood hydrograph profiles.
ii. Construct a 1D representation of the in-channel environment, including structures using ESTRY software.
iii. Construct a 2D representation of the floodplain using TULOW software.
iv. Combine and link the 1D and 2D model domains.
v. Undertake simulations of key flood return period events to understand the floodplain extents and peak flood levels within and adjacent to the Order Limits.
vi. Undertake simulations to account for climate change flows within the model.
vii. Undertake simulations of post-development conditions for key flood return period events and compare to baseline conditions.
viii. Undertake sensitivity analysis of post-development conditions.

Approach

1.14 In order to achieve the objectives identified above, a new 1D/2D ESTRY-TUFLOW model was constructed, based on a watercourse survey completed by BWB Consulting in October 2021 (reference: OXSRFI-BWB-ZZ-M2-G-0060; see **Appendix 1**).

1.15 The model has been simulated for a series of design storm events. These modelled events include the 1 in 30-year, 1 in 100-year and 1 in 1000-year events that are typically used by the EA to define Flood Zones 3b (Functional Floodplain), 3a and 2 respectively.

1.16 Simulations have been run to account for the impacts of climate change in accordance with the allowances released by the EA[5]. This is necessary so that any future FRA can assess the risk of flooding over the anticipated lifetime of the proposed development.

[5] https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow

Assumptions and Limitations

1.17 Several assumptions were made during the study which may lead to implications on the modelled results. However, the study has been based on the data available at the time of writing. The key assumptions and limitations are as follows:

- The modelling exercise has made use of the available data at the time of construction and simulation. The model represents the floodplain and channel conditions at the time of survey.
- The modelling exercise has made use of the latest hydrological and hydraulic modelling software versions at the time of analysis and completion (the hydrological assessment was completed in May 2025 with the baseline hydraulic modelling completed in May 2025).
- The model contains no formal representation of the conveyance within minor watercourses or ditches other than that captured by the model grid and within the 1D model domain.
- The 2m resolution of the model may negate any small-scale topographic features, although all the significant features are believed to have been captured.
- The floodplain levels are derived from LiDAR, where topographical survey information is unavailable, which has limited accuracy (+/- 0.15m). However, this is considered to be sufficient for the purpose of this study.
- The bare earth DTM does not include for the presence of walls, buildings or other structures. Buildings have been modelled at ground level with an elevated roughness in line with best practice.
- The modelling exercise has been undertaken to produce a good representation of flood risk mechanisms in and around the study site. It has not been designed to accurately map flooding in the wider catchment.
- Cross sections PBT_00265 to PBT_00000 are based on LiDAR due to a lack of surveyed data.
- An invert level (113.2mAOD) for the existing siphon culvert underneath the railway has been assumed.
- It is assumed that the proposed culvert under the new railway will be the same diameter as the existing railway culvert.
- Cross-sections for the upstream and downstream faces of the proposed culvert have been derived from the nearby upstream and downstream faces of the existing culvert (PBT_00427 and PBT_00404). Channel levels have been interpolated based on the channel gradient between the surveyed cross-sections along this reach

2. HYDROLOGY

Flood Flow Estimation

2.1 A hydrological review of the catchment was undertaken using Flood Estimation Handbook (FEH) methodologies to estimate peak flood flows and derive an appropriate hydrograph shape. This was undertaken in relation to the EA's latest guidance[6]. This assessment is included within **Appendix 2**.

2.2 In summary, there was no hydrometric data available in the area to inform the hydrological analysis. Therefore, the industry standard FEH Statistical Method and Revitalised Flood Hydrograph (ReFH2 Version 4.1) rainfall-runoff model were both reviewed, and a comparative analysis undertaken.

2.3 The final choice of peak flows for input into the model was the FEH Statistical Method. This method was chosen as it benefits from an up-to-date peak flood dataset and is the preferred method for groundwater-dominated catchments. ReFH2 was used to provide a hydrograph shape; the hydrographs were subsequently scaled to the statistical peaks.

2.4 Flood flow estimates were derived for a range of return period events; the adopted peak flow estimates are provided within **Table 2.1** and the division of flow is shown in **Figure 2.1**.

Table 2.1: Adopted Peak Flood Flows

Return Period Event (years)	Annual Exceedance Probability	Catchment Peak Flow (m^3/s)
1 in 2	50%	0.08
1 in 5	20%	0.12
1 in 10	10%	0.15
1 in 30	3.3%	0.21
1 in 50	2.0%	0.24
1 in 75	1.3%	0.27
1 in 100	1.0%	0.29
1 in 200	0.5%	0.35
1 in 1000	0.1%	0.55

Note: Flow estimates are quoted to 2 decimal places to demonstrate change in flow estimates; this does not indicate a greater degree of accuracy.

[6] LIT 11832 Flood Estimation Guidelines Version 9, Environment Agency (November 2023)

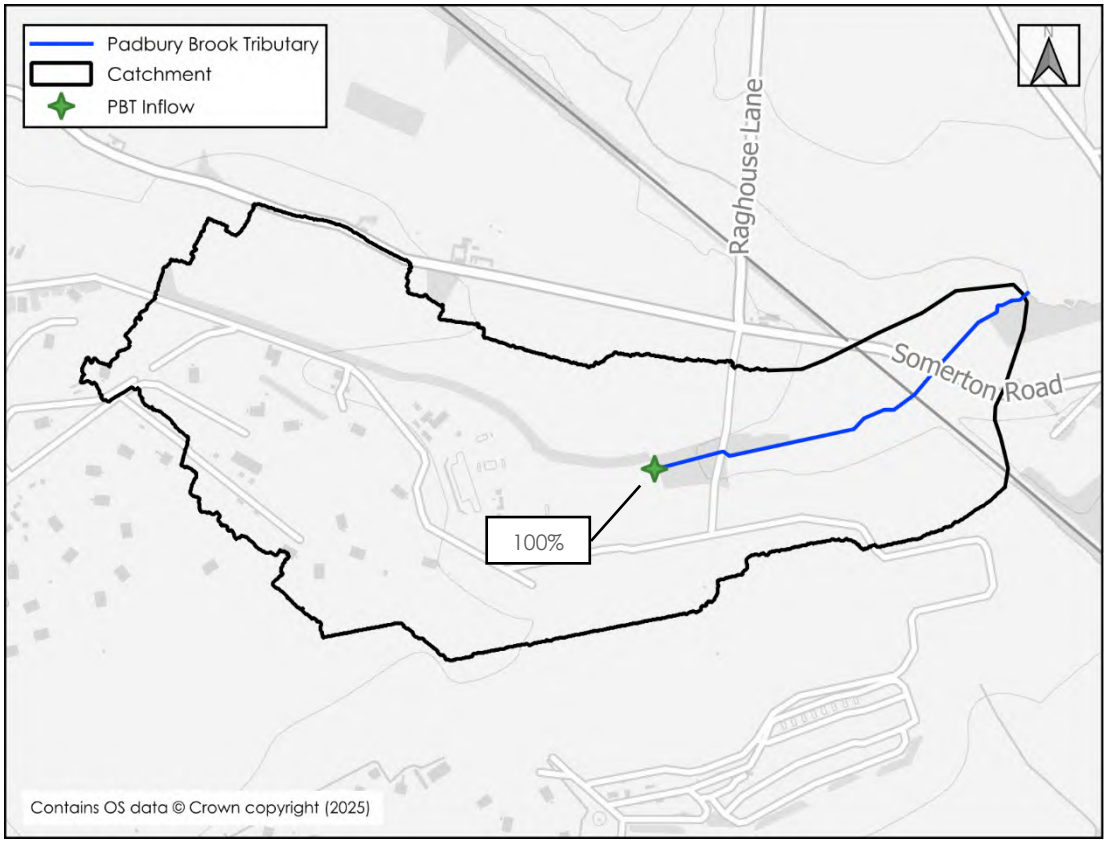


Figure 2.1: Distribution of Model Inflows

Climate Change

2.5 Predicted future change in peak river flows caused by climate change are provided by the EA within their online guidance[7], with a range of projections applied to regionalised 'River Basin Districts'. These districts are further split into 'Management Catchments'. The Padbury Brook Tributary falls within the Upper and Bedford Ouse Management Catchment. **Table 2.2** identifies the relevant peak river flow allowances.

Table 2.2: Peak River Flow Allowance for the Upper and Bedford Ouse Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	58%
Higher Central	10%	11%	30%
Central	5%	4%	19%

2.6 Nationally Significant Infrastructure Projects (NSIPs) may need to assess flood risk from a credible maximum climate change scenario. Or, in other cases, such as new settlements

[7] Environment Agency, Flood risk assessments: climate change allowances: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1

or significant urban extensions, the flood risk may need to be assessed from a high impact climate change scenario. In these circumstances, the Upper End allowance for peak river flow should be used.

2.7 It should be noted that use of the credible maximum should be treated as a sensitivity test to help assess how sensitive the proposals are to changes in the climate and ensure the development can be adapted to large-scale climate change over its lifetime.

2.8 For this study, to estimate the potential future design floodplain under a range of scenarios, the Central, Higher Central and Upper End climate change allowances for the '2080s' will be applied to the 1% AEP flood flows.

3. THE HYDRAULIC MODEL

Software and Solver

3.1 TUFLOW version 2025.0.3-iDP was used for all model runs. The model was simulated using TUFLOW's double precision classic solver. TUFLOW's built in 1D component, ESTRY, was used to model the 1D domain/channel.

The 1D Domain

Extent

3.2 The 1D domain for the Padbury Brook Tributary begins upstream of the Order Limits, adjacent to the former airfield. The Padbury Brook channel is represented within the 1D domain until its confluence with the Padbury Brook, at the downstream boundary. The extent of the 1D domain can be seen in **Figure 3.1**.

Channel Geometry

3.3 The river channel geometry is based on a watercourse survey carried out by BWB Consulting in October 2021. The survey also captured hydraulic structures that were present such as bridges and culverts. A series of cross sections are based on EA LiDAR data where access was unavailable at the time the survey was collected.

3.4 The maximum distance between cross sections is 115m. However, sections are more generally spaced 50m apart. The river channel survey is available as **Appendix 1**.

3.5 The channel sections were truncated at top-of-bank from survey data, at what would be the interface with the 2D domain.

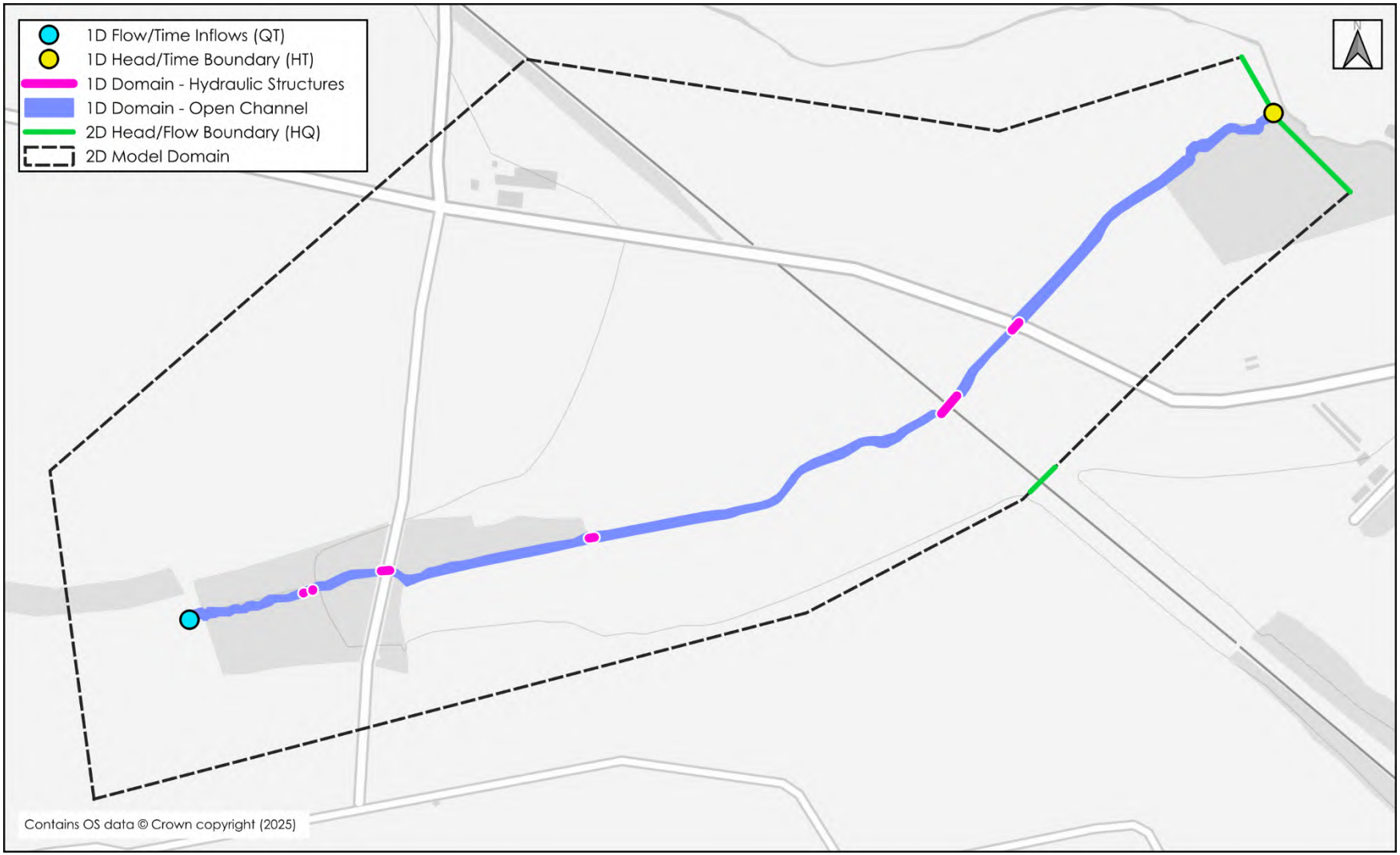


Figure 3.1: Baseline Model Schematic

Hydraulic Roughness

3.6 Hydraulic roughness has been represented using the Manning's n coefficient. The values applied are based on those stipulated in the literature, using Chow (1959)[8]. This study documents appropriate values based on channel bed material, sinuosity and presence of vegetation.

3.7 The guideline values are chosen using engineering judgement, based on photographs of the channel condition taken at the time of survey. Each cross section has a Manning's roughness value applied in the same way as the channel geometry and is read into TUFLOW within a CSV file.

3.8 The Padbury Brook Tributary was observed to be free flowing. The majority of the channel was considered to be clean, but winding with pools and riffles, as well as light bank vegetation with stones/weeds. There were some sections that appeared to be more sluggish. As such, a Manning's n coefficient of between 0.04 and 0.05 was deemed suitable to represent in-channel roughness for the majority of the cross sections.

3.9 The banks and top of banks were in some instances lined with long/short grass and in other instances bordered by light/dense brush and trees. Values of between 0.03 and 0.1 were used to represent the varying conditions.

3.10 Some examples from the watercourse survey are highlighted in **Table 3.1** below.

Table 3.1: Manning's n Examples

Model ID	Values Chosen and Description	Photograph
PBT_00979	**0.045** Main Channels Clean, but winding with pools and riffles, light bank vegetation, stones/weeds	

[8] http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

Model ID	Values Chosen and Description	Photograph
PBT_00530	**0.06** Floodplains Trees – medium density with sprouts	
PBT_00736	**0.03** Floodplains Grass, short	

Hydraulic Structures

3.11 A number of hydraulic structures were represented in the 1D domain, the data for which was collected during the watercourse survey.

3.12 In total, four culverts, two bridges and one weir were included in the model to represent structures. The weir was added to the model due to a difference in levels between sections. The details of the modelled structures are included as **Appendix 3**.

Boundary Conditions

3.13 Boundary conditions were applied to the 1D domain to both allow flow in and out of the model.

3.14 A QT (flow vs time) boundary was used to represent the fluvial inflow (**Section 2**) as hydrographs. This consisted of a point inflow at the upstream extent of the watercourse.

3.15 A HT (water level vs time) boundary was applied at the downstream limit of the 1D domain. This was set to 112.25mAOD which set just below the top of bank at the downstream cross section (PBT_00000).

1D/2D Links

3.16 The 1D channel was linked to the floodplain using 'HX' links. These transfer the calculated water level from the 1D cross sections into the 2D floodplain, providing that the water level is above the level of the cell that the HX link is located in. Therefore, 'HX' links should be digitised along the top of bank of the watercourse visible in the topographical survey, watercourse survey and LiDAR data.

3.17 The average modelled width of the channel was approximately 6-8m along the Padbury Brook Tributary.

The 2D Model Domain

Extent and Active Area

3.18 The main influence on the 2D domain extent is generally the expected width of the floodplain, meaning that it should be large enough to allow for flows to be routed through the floodplain where necessary and so that no "glass walling" occurs within the model domain.

3.19 The river channel was deactivated to ensure that it was modelled in the 1D domain. This deactivated area may appear fragmented in places where the deck of a structure is modelled in the 2D domain. The active area is displayed in **Figure 3.1.**

Grid Size and Orientation

3.20 The grid cell size should be chosen in order to sufficiently represent the average width of the modelled channel and its ability to capture key floodplain topographic features.

3.21 The selected grid size of 2m provides a high enough resolution to capture the capacity of the channel (6-8m width = 3-4 number of 2m cells) as well as provide appropriate representation of key floodplain features.

3.22 The orientation of the grid is important for flow routing as flow cannot pass to the neighbouring cell via its corner, only via the cell sides. Therefore, the location line (2d_loc) was drawn to orientate the grid in the predominant direction of flow.

Floodplain Roughness

3.23 Floodplain roughness is defined by the Manning's n coefficient, as per the 1D domain. However, the method in which it is applied differs.

3.24 Roughness has been applied by polygons using land use types as defined by OS MasterMap data. These are linked to a coefficient listed in a TUFLOW Materials File (TMF).

3.25 The values applied for different land use types are listed in **Table 3.2**.

Table 3.2: Floodplain Roughness Values

Land Use Type	Manning's n Coefficient
Long grass	0.035
Short grass	0.030
Roads	0.025 - 0.030
Rail	0.050
Woodland	0.080
Buildings	0.500

Floodplain Topography and Amendments

3.26 The general floodplain topography is based on the topographical survey (where available) and the latest available LiDAR data, which was downloaded from the DEFRA Open Survey website at a 1m resolution.

3.27 The following amendments to the base topography were made:

- River bank levels were reinforced through the use of a 'THICK' Z-line. Bank elevations were provided at 5m intervals along the Z-line. The levels are informed by surveyed cross-section data, topographical survey and LiDAR data (where survey data is unavailable).
- Road levels and railway levels were reinforced through the use of 2D Z-shapes. Elevations were provided at intervals along the Z-shape, as informed by LiDAR data.
- The inlet structure for the siphon culvert under the railway was reinforced through the use of a 2D Z-shape. This was set at 115.7mAOD, as informed by LiDAR data.

Floodplain Structures

3.28 There were no floodplain structures within the model. All hydraulic structures were in line with the channel and hence modelled in the 1D domain.

Boundary Conditions

3.29 Boundary conditions within the 2D domain are often used to prevent "glass walling" at the downstream end of the model through use of a "HQ" boundary. This is a flow vs stage relationship automatically defined in TUFLOW when the user inputs a slope value, to allow water to flow out of the model.

3.30 A "HQ" boundary was applied to the downstream extent of the model to allow water routing down to flow out of the model. The slope in the "HQ" boundary was calculated by assessing the fall in floodplain levels on both banks. The fall in levels was divided by the distance measured over to determine a slope value (0.011 and 0.021). Error! Reference source not found. shows where these boundaries were applied. Sensitivity testing has been undertaken on these boundaries and is discussed further in **Section 6**.

Calibration/Verification

3.31 A lack of detailed flow or level data for the catchment meant that there was limited opportunity to calibrate the model.

3.32 Due to the lack of documentation on previous historical instances of flooding, the model cannot be verified against historic events. A conservative approach adopted to the model build mitigates this.

Stability, Warnings and Messages

3.33 TUFLOW has a number of indicators available to assess the stability of a model. These differ slightly between the Classic and HPC solver (the Classic solver was used for this model). The following indicators were checked to ensure the model was performing as expected:

- **Stage and flow time series** – A number of spot checks should be completed to ensure that conveyance through the channel is as expected and that both the stage and flow time series are reasonably smooth, particularly around the study area.
- **1D negative depths** – Significant negative depths indicate that instabilities are present.
- **Cumulative Mass Error** – A value of +/-2% is considered acceptable.
- **Velocities** – Unusually high velocities or circulating vectors are usually a sign of instabilities.

3.34 The time series graphs were reviewed along the modelled reaches; no significant issues were identified that could compromise results within the Order Limits. The river channel stages were shown to peak approximately 9 hours into the event.

3.35 No 1D or 2D negative depths were reported during all simulations.

3.36 During all baseline model runs, the cumulative mass error stayed below +/- 0.5% for all simulations, as shown in **Figure 3.2**. This is within the range of acceptable values.

3.37 The remaining indicators highlighted above were considered acceptable.

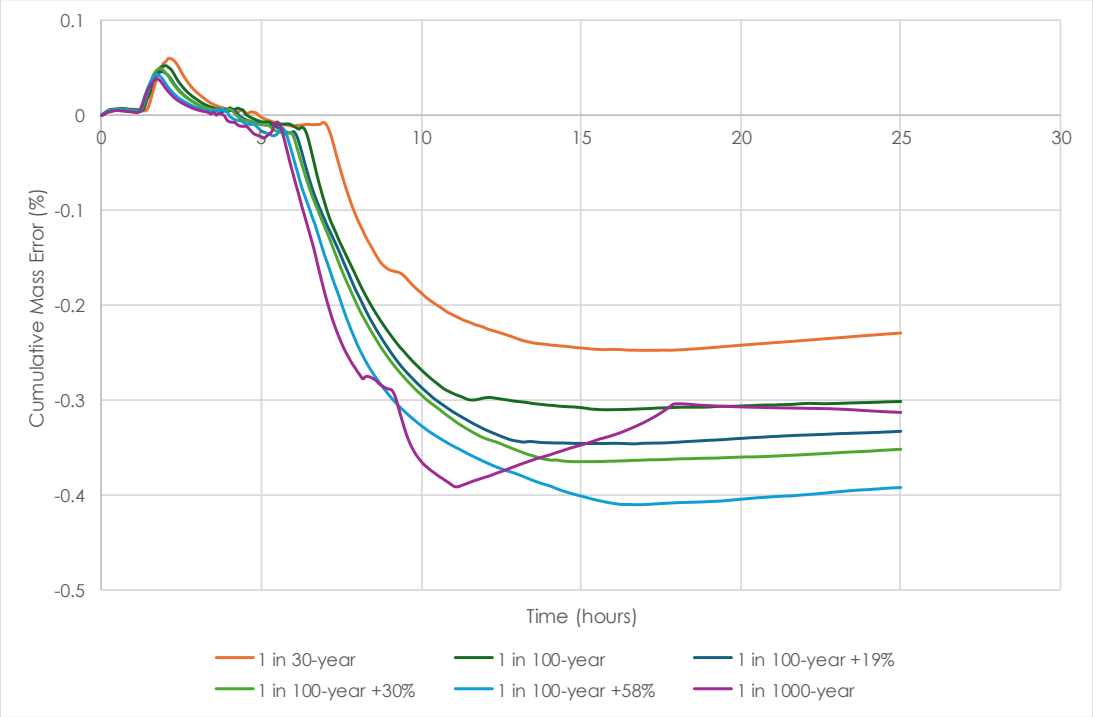


Figure 3.2: Cumulative Mass Error

3.38 There were a maximum of 193 warnings recorded prior to the simulation in all modelled events. The warnings produced by the hydraulic model prior to the simulation, included:

- 'Warning 2073' message relates to null shape objects. These were not expected to have an impact on the model results.
- 'Warning 1100' message relates to structure crest/invert below bed of upstream channel. The model input was reviewed and was found to be in line with the surveyed data.

3.39 No warnings are reported during any of the simulations.

Model Runs

3.40 In order to achieve the study objectives, the simulations summarised in **Table 3.3** were completed.

Table 3.3: Model Runs

Model Geometry	Return Periods	Comments
Baseline	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year+19%CC 1 in 100-Year+30%CC 1 in 100-Year+58%CC	Representative of 'as surveyed' conditions.
Proposed	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year+19%CC 1 in 100-Year+30%CC 1 in 100-Year+58%CC	Representative of 'as-built' conditions
Roughness + 20%	1 in 100-Year	Floodplain, channel and structure roughness increased by 20%
Roughness - 20%	1 in 100-Year	Floodplain, channel and structure roughness decreased by 20%
Downstream Boundary +	1 in 100-Year	20% increase of gradient at downstream boundary and 20% decrease in water depth at downstream boundary
Downstream Boundary -	1 in 100-Year	20% decrease of gradient at downstream boundary and 20% increase in water depth at downstream boundary
Blockage 1 (PBT_00451)	1 in 100-Year	75% blockage of proposed culvert

4. BASELINE RESULTS

4.1 The results from the existing conditions model are mapped within **Appendix 4** and are shown in **Figure 4.1**. The modelled flood levels in the vicinity of the Order Limits included within **Table 4.1**.

4.2 Key flood mechanisms are summarised below, with reference to the points labelled in **Figure 4.1**:

i. At the upstream reaches, in-channel levels exceed the channel capacity upstream of Raghouse Lane during all modelled events. Flood waters spill into the floodplain upstream of the crossing and back up along the floodplain. It is considered that this is due to the restrictive culvert underneath the road.

ii. During the 1 in 100-year + 58%CC and 1 in 1000-year events, flows overtop Raghouse Lane and are conveyed over the floodplain adjacent to the left bank of the Padbury Brook Tributary, prior to re-entering the channel downstream in the vicinity of the farm track crossing. Downstream of Raghouse Lane, the 1 in 30-year flood extents are shown to be contained within the channel. During the remaining modelled events, flows are shown to overtop the farm track crossing.

iii. After the flows from the 1 in 100-year + 58%CC and 1 in 1000-year events have re-entered the channel, flows remain in-channel for all modelled flood events until upstream of the railway.

iv. Upstream of the railway culvert, flows overtop the left bank during the 1 in 100-year + 58%CC and 1 in 1000-year event and the right bank during events greater than and equal to the 1 in 100-year event.

v. During the 1 in 1000-year event, flows overtop onto the railway and flow southwards. All remaining events are shown to either remain in-channel or back up behind the railway.

vi. Downstream of the railway, water overtops both the left and right banks and flows along the floodplain.

vii. The road embankment for the Somerton Road interrupts the flows within the floodplain, resulting in an area of ponding. However, during all modelled events, flow overtop Somerton Road and continue downstream along the left and right floodplain.

viii. Flows along the right bank re-enter the Padbury Brook Tributary channel downstream of Somerton Road. Flows along the left bank continue to flow along the floodplain and outfall to the Padbury Brook.

4.3 The modelled outputs provide a more complete representation of the flood extents in comparison to the EA strategic flood mapping. This is considered to be as a result of improved representation of the channel and structures within the hydraulic model, providing more accurate channel geometry and capacity.

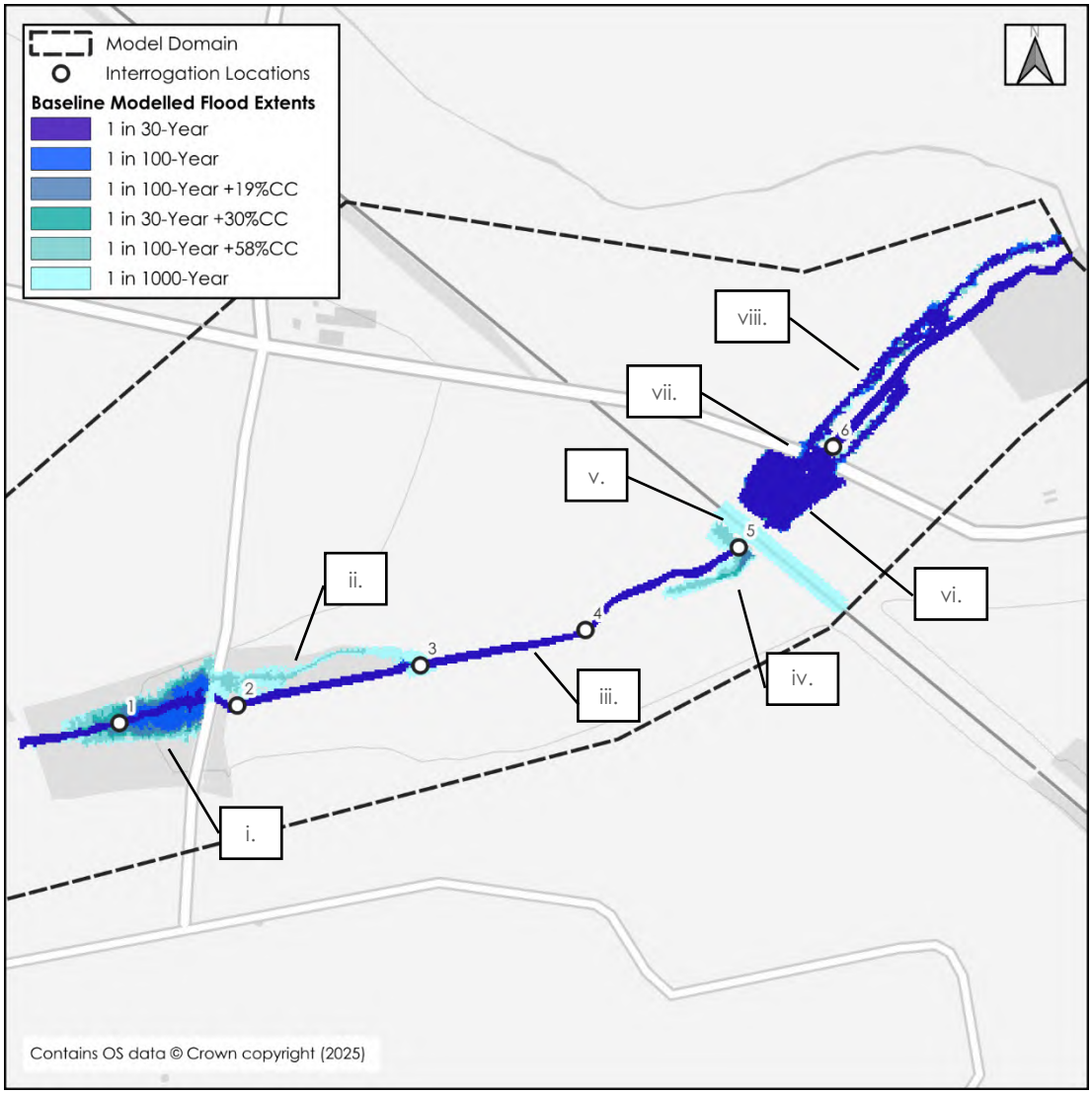


Figure 4.1: Baseline Fluvial Flood Extents

Table 4.1: Baseline Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%CC	1 in 100-Year + 30%CC	1 in 100-Year + 58%CC	1 in 1000-Year
1	119.05	119.21	119.33	119.40	119.58	119.65
2	118.04	118.09	118.11	118.12	118.14	118.16
3	116.98	117.03	117.05	117.06	117.08	117.17
4	116.26	116.30	116.32	116.33	116.34	116.41
5	115.53	115.58	115.61	115.62	115.65	115.73
6	114.11	114.15	114.16	114.17	114.18	114.20

5. PROPOSED DEVELOPMENT MODELLING

Philosophy

5.1 The proposed development comprises a SRFI which includes the construction of several warehouses, a new slip road off the M40 motorway, and an intermodal rail terminal with a new track that connects to the existing railway.

5.2 An earthworks exercise has been undertaken to determine the proposed levels within the development. A new track, associated with the intermodal rail terminal, crosses the Padbury Brook Tributary. A reach of the Padbury Brook Tributary is to be culverted to facilitate the proposed rail track.

Representation in Hydraulic Model

5.3 The baseline hydraulic model was updated to include the proposed development levels. The proposed levels were added to the hydraulic model as a DTM, overlying the topographical survey and LiDAR data.

5.4 The Padbury Brook Tributary is proposed to be culverted beneath the proposed track. As part of the proposals, an additional inverted siphon and culvert is proposed which will be separate to the existing culvert, with approximately 10m of open channel between these structures.

5.5 It is assumed that the proposed culvert will be the same diameter as the existing culvert under the existing railway, with a proposed length of approximately 15m. Cross-sections for the upstream and downstream faces of the proposed culvert have been derived from the nearby upstream and downstream faces of the existing culvert (PBT_00427 and PBT_00404). Channel levels have been interpolated based on the channel gradient between the surveyed cross-sections along this reach.

5.6 The proposed track is to be situated over 3m lower than existing levels in the vicinity of the Padbury Brook Tributary. It is therefore proposed that two bunds, located adjacent to the inlet and outlet of the proposed culvert respectively, and set approximately 1m above surrounding ground levels, are included to prevent flows from overtopping onto the railway and posing a flood risk to the development. A 2D Z-Shape was modelled to represent this feature; this was set at an arbitrary height for the purposes of the modelling exercise and should be confirmed during the detailed design stage.

5.7 To provide additional storage upstream of the proposed culvert, a two-stage channel was proposed within the Order Limits. Amendments were made to surveyed cross-sections (PBT_00581 and PBT_00654) to extend further into the floodplain and to introduce the inset floodplain, with consideration to the existing levels from the watercourse survey data as well as the topographical survey and proposed earthworks levels. The 1D and 2D model domains were amended to reflect these changes.

5.8 A slot weir was proposed upstream of the proposed culvert, with a slot width of 0.5m. This was based on the surveyed cross-section in this location (PBT_00474).

5.9 No further changes were made to the existing model. A model schematic, showing the changes from the baseline model only, is illustrated in **Figure 5.1**.

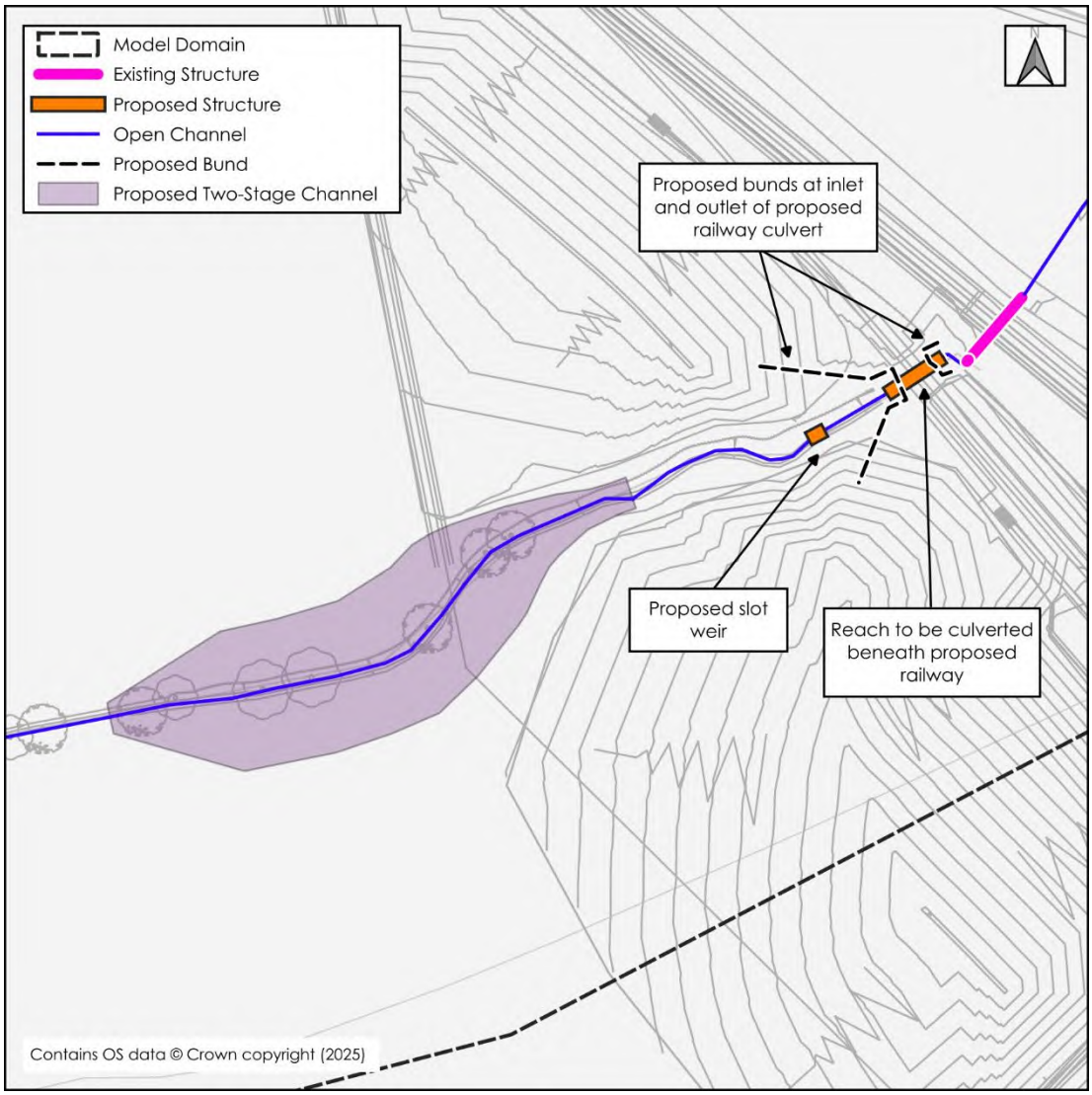


Figure 5.1: Proposed Model Schematic

Stability, Warnings and Messages

5.10 The indicators for assessing stability outlined in **Section 3** have been reviewed for all proposed development simulations. Similar to the baseline scenarios, the peak cumulative mass error was within the acceptable range for all simulations.

5.11 No 1D or 2D negative depths were reported during all simulations.

5.12 No additional warnings were reported prior or during the simulations.

Model Results

5.13 Mapping of the proposed development conditions is included within **Appendix 5** and summarised below. The floodplain extents are shown in **Figure 5.2**, with modelled flood levels outlined within **Table 5.1**.

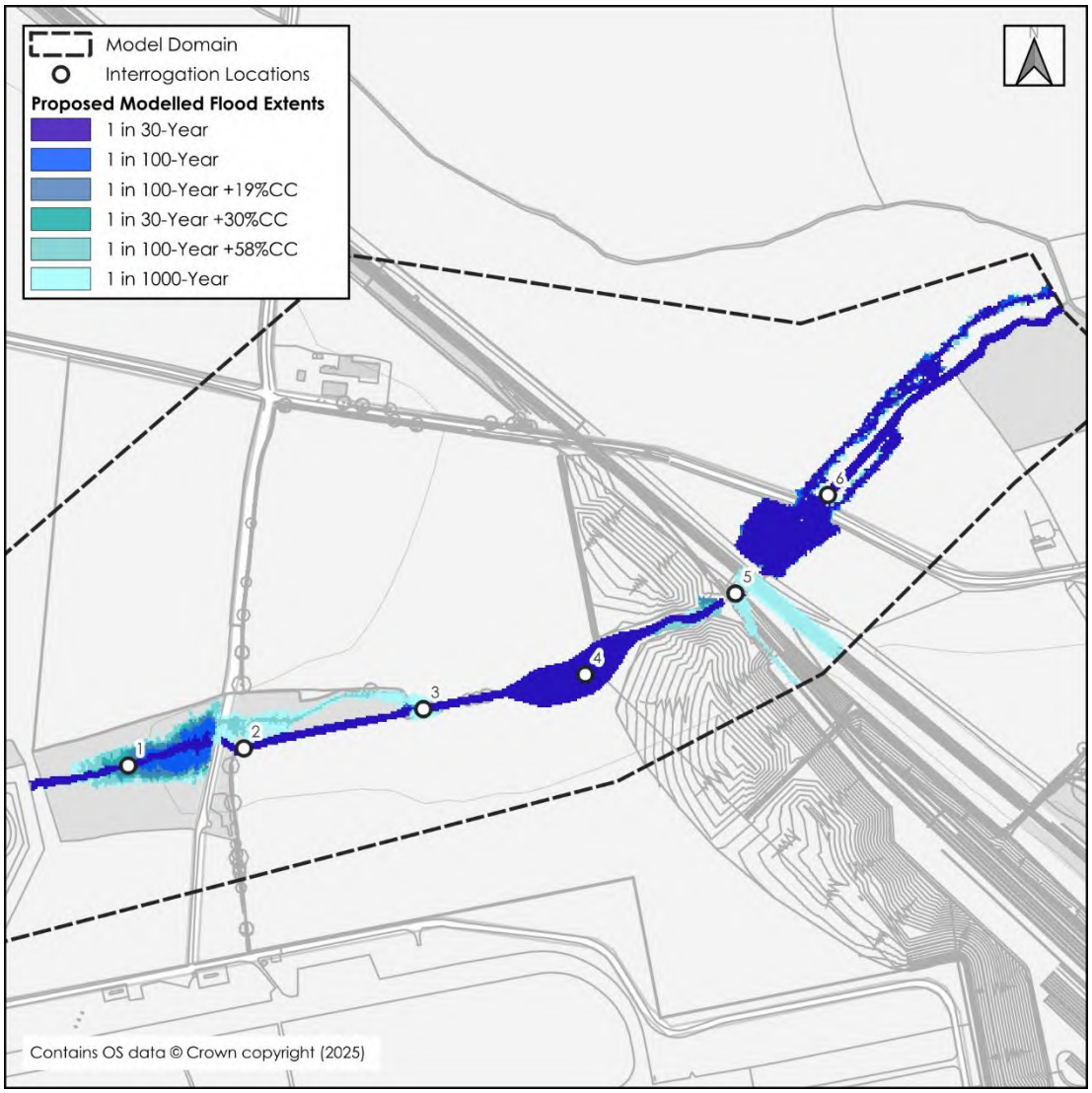


Figure 5.2: Proposed Development Floodplain Extents

Table 5.1: Proposed Development Modelled Flood Levels

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%CC	1 in 100-Year + 30%CC	1 in 100-Year + 58%CC	1 in 1000-Year
1	119.05	119.21	119.33	119.40	119.58	119.65
2	118.04	118.09	118.11	118.12	118.14	118.16
3	116.98	117.03	117.05	117.06	117.08	117.17
4	116.26	116.30	116.32	116.32	116.34	116.40

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 19%CC	1 in 100-Year + 30%CC	1 in 100-Year + 58%CC	1 in 1000-Year
5	115.53	115.58	115.60	115.62	115.65	115.74
6	114.11	114.15	114.16	114.17	114.18	114.21

5.14 The results under the proposed development conditions are broadly similar to those under the baseline conditions, with no change to the flood mechanisms upstream or downstream of the Order Limits.

5.15 Within the Order Limits, the modelled flood extents are increased as a result of the proposed two-stage channel, as intended. Flows are shown to back up behind the proposed railway culvert, in a similar manner to those seen in the baseline conditions, with an increase in modelled flood levels. Flows are also shown to back up behind the proposed bund, which is shown to prevent flows from overtopping onto the proposed railway during all modelled events.

5.16 Following a review of the modelled flood levels, it was established that the proposed bund should be set to a level of 116.3mAOD, with consideration of a 300mm freeboard during the 1 in 100-year +19%CC design event.

5.17 During the 1 in 1000-year event, flows are shown to overtop from the open channel prior to entering the existing railway culvert, to flow onto both the existing and proposed railways. However, both railways are shown to be removed from the flood extents during all modelled events up to and including the 1 in 100-year +58%CC event, inclusive of the design event.

Impact Analysis

5.18 The proposed development modelled peak flood levels have been compared to the equivalent baseline peak flood levels to establish off site impacts. Mapping for all events is included in **Appendix 6**; the comparison mapping for the design event (1 in 100-year +19% climate change event) is illustrated in **Figure 5.3** and discussed below.

5.19 The mapping shows that the proposed siphon culvert, proposed bund and proposed two-stage channel results in no detriment downstream of the Order Limits in all modelled flood events (within the model tolerances of +/-10mm).

5.20 During the 1 in 100-year + 19%CC event, flood levels upstream of the proposed culvert are shown to increase by up to 300mm, as shown in **Figure 5.3**. There is also an increase in flood extent, associated with the widened channel. However, these changes are within the Order Limits and are not anticipated to affect the proposed development.

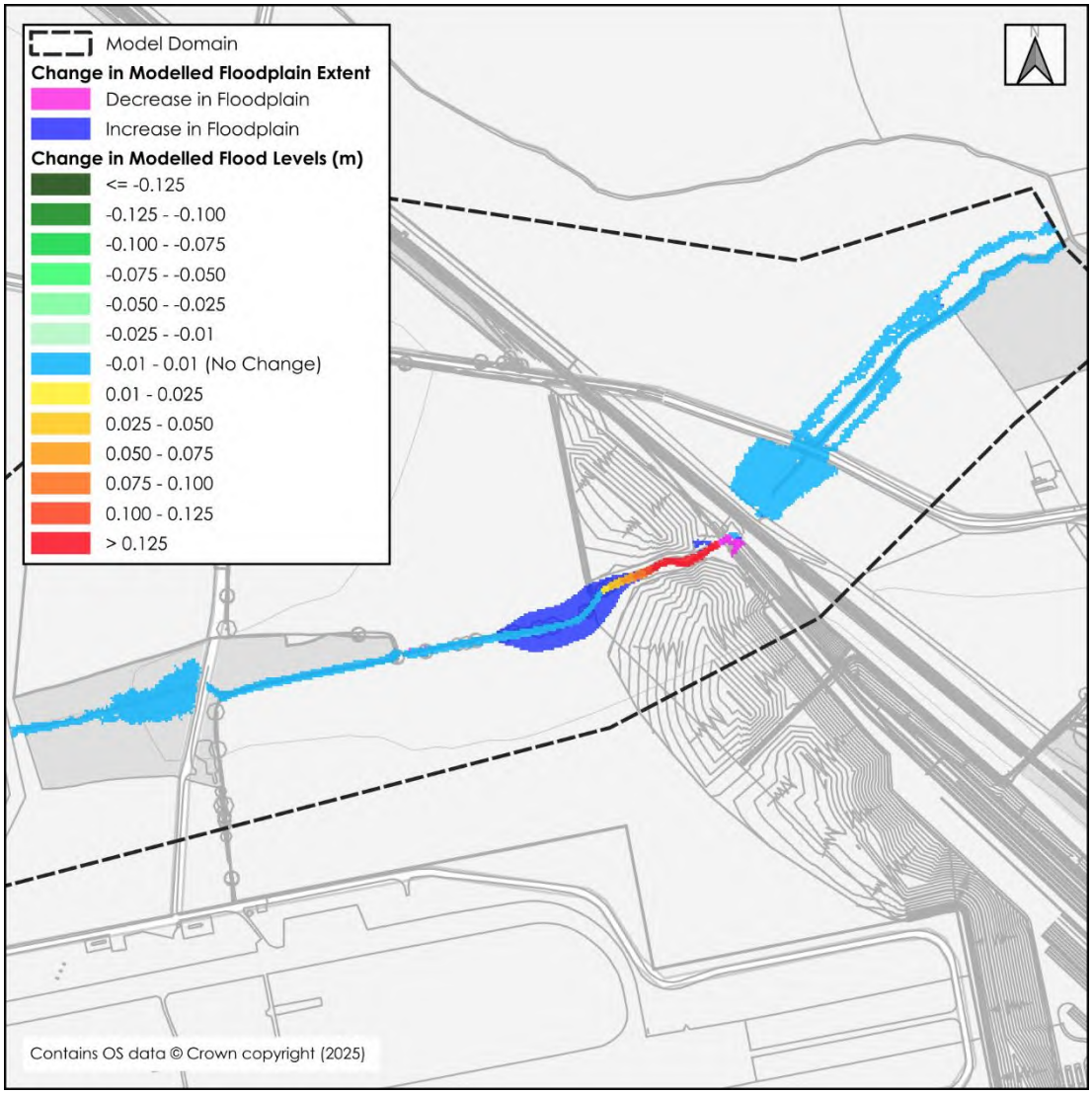


Figure 5.3: Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 19% Climate Change

6. SENSITIVITY TESTING

6.1 To account for seasonal variations in vegetation, test the blockage of proposed structures and to ensure the robustness of boundary conditions, a series of sensitivity tests were conducted using the proposed scenario 1 in 100-year flood return period event. Comparison mappings for the sensitivity tests are included in **Appendix 7**.

6.2 Robust sensitivity analysis also provides improved confidence in the model outputs, particularly in absence of calibration data.

Flow Estimates

6.3 As climate change allowances have been assessed, it was not considered necessary to test further variations on the predicted flood flows.

Roughness

6.4 The modelled roughness coefficients were determined from aerial imagery, site photographs and OS mapping. Increasing and decreasing the roughness values in the channel and at structures as well as in the floodplain tests how seasonal variation and maintenance regimes may affect the flood risk posed to the proposed development.

6.5 A 20% increase in Manning's n roughness coefficient, representative of a period without maintenance, results in an increase in peak flood levels of up to 50mm. Within the Order Limits, there is no increase in floodplain extent and in-channel peak flood levels were shown to increase by up to 30mm. This is to be expected given that an increase in roughness values would be associated with greater frictional forces against the flow of water.

6.6 A 20% decrease in Manning's n roughness coefficient, representative of a period with maintenance, generally leads to reduced peak flood levels within the Padbury Brook Tributary. Within the Order Limits, peak flood levels are expected to decrease by up to 40mm compared to the equivalent proposed development scenario. This is to be expected, as the reduced roughness will increase the conveyance of the floodplain and culverts, allowing water to flow more freely through the system.

6.7 Overall, there is potential for seasonal variations in vegetation and maintenance periods to alter the peak flood levels within the channel, although, there are limited changes to the flood extents. These results therefore show that the model results are not significantly sensitive to changes in Manning's n roughness, which increases confidence in the model outputs.

Downstream Boundary

6.8 To test the implications on variations in the downstream boundary parameters, a sensitivity test has been undertaken. The 2D downstream boundary slope was updated by 20% and the 1D downstream boundary water depth was updated by 20%.

6.9 A 20% increase in slope gradient and a 20% decrease in water depth leads to an increase in peak flood level towards the downstream boundary, which propagates up to approximately 50m upstream. There is no change in peak flood levels or extents (within the model tolerances of +/-10mm) within the Order Limits. This result provides confidence in the location of the downstream boundary, with changes in water level not impacting on results at the Order Limits.

6.10 A 20% decrease in slope gradient and a 20% increase in water depth leads to a decrease in peak flood level towards the downstream boundary. However, a small area is shown to increase in flood level in-channel approximately 50m upstream of the downstream boundary. There is also noted to be a limited area of increased flood levels in-channel within the Order Limits; however, across the majority of the reach within the Order Limits, there is no change in peak flood levels (within the model tolerances of +/-10mm) or floodplain extents.

6.11 Overall, the model results are considered to be robust to changes in the downstream boundary, which increases confidence in the model outputs.

Blockage Scenarios

6.12 Blockage testing was undertaken at one location to understand the impacts of blocking key structures. The location of the blockage is annotated on the respective mapping, included as **Appendix 7**.

6.13 Smaller culverts are more at risk of a significant blockage due to their limited capacity to convey flows and debris, whereas large culverts are less at risk. Therefore, the magnitude of the blockage was determined by the size of the culvert, as shown in **Table 6.1**.

Table 6.1: Sensitivity Test Blockage Percentages

Culvert Diameter (m)	Blockage Applied
< 0.5	100%
0.5 – 1.0	75%
1.0 – 1.5	50%
1.5 >	25%

6.14 A blockage scenario was tested within the hydraulic model on the proposed culvert, underneath the proposed track and embankment. The culvert is 600mm in diameter and was therefore blocked 75%.

6.15 In the blockage scenario, flood levels and extents around the culvert, and on the floodplain adjacent to and upstream of the culvert, were predicted to increase. Flood levels within the Order Limits were predicted to increase by up to 0.74m.

6.16 Whilst it is noted that flows back-up behind the proposed culvert during the equivalent proposed development scenario, the blockage scenario shows that the model results

are sensitive to blockages of this structure. It is recommended that the proposed culvert should be regularly maintained to ensure it remains free of blockages.

7. SUMMARY & RECOMMENDATIONS

7.1 Please note that this conclusion should be read in conjunction with the study limitations and assumptions in **Section 1**.

7.2 BWB Consulting Ltd has been commissioned by Oxfordshire Railfreight Limited to undertake a site-specific hydraulic modelling exercise of the Padbury Brook Tributary to support the development of the Oxfordshire SRFI.

7.3 The modelled flood flows have been informed by a hydrological review of the catchment associated with the Padbury Brook Tributary. The latest climate change allowances have been incorporated into the hydrological assessment.

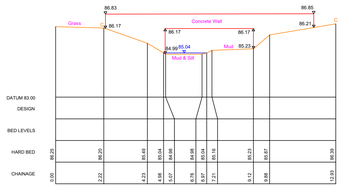
7.4 The baseline results show flows to overtop into the floodplain in the vicinity of existing culverts under Raghouse Lane, the farm access track, the railway and Somerton Road. Within the Order Limits, flows largely remain in-channel , with the exception of an area in the vicinity of the existing railway culvert.

7.5 The proposed development modelling includes consideration of the development of a SRFI. A new track, associated with the intermodal rail terminal, crosses the Padbury Brook Tributary. The proposed built development is located outside of the flood extents during the 1 in 100-year +19%CC design event.

7.6 Sensitivity testing has shown the model to be robust with respect to changes in seasonal variations in vegetation, blockage of the proposed structure and robustness of boundary conditions.

APPENDICES

Appendix 1: River Channel Survey



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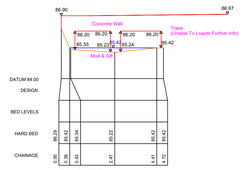

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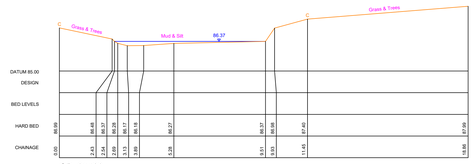
Culvert



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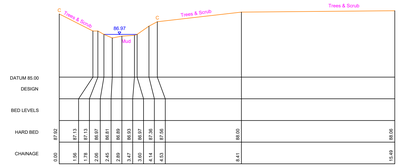

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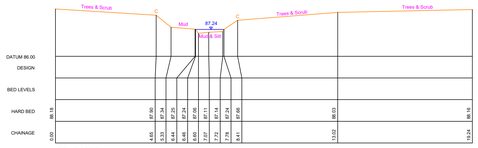
Open Channel



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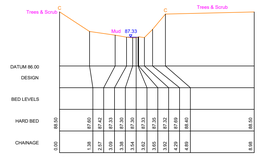

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Open Channel

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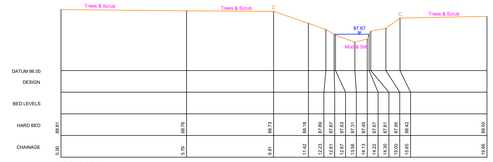
Open Channel



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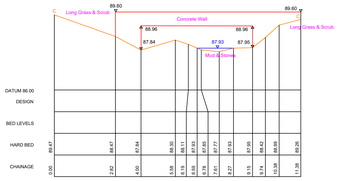

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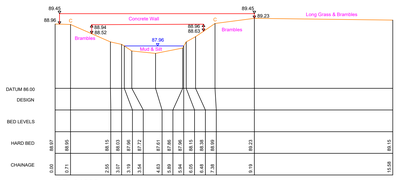

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1808.645 M
Access Bridge

GB_01883
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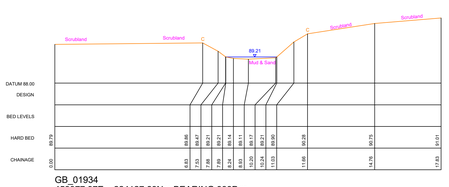
Open Channel



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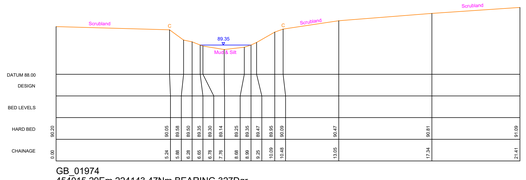
Open Channel



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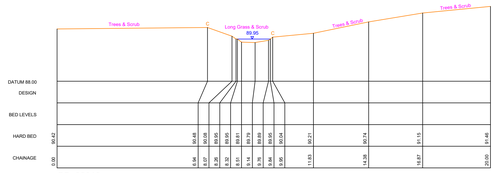
Open Channel



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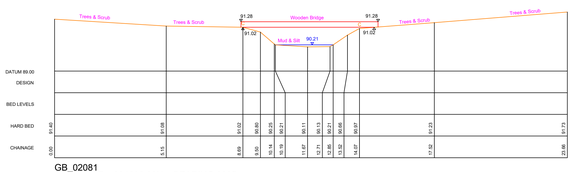

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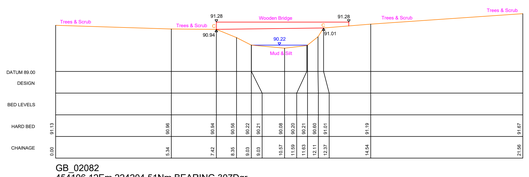
Footbridge



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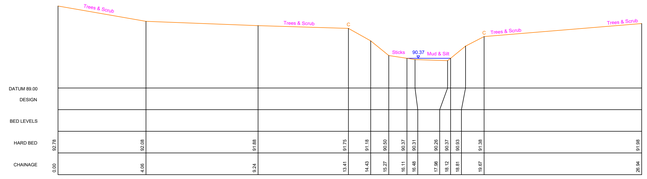
Footbridge



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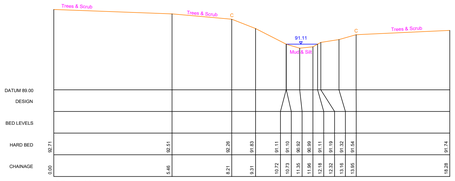

GB_02161
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2161.075 M

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1 Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00 Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Me	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole		
		Gas	Gas	THL	Threshold Level
DK	Drop Kerb	GV	Gas Valve	TL	Traffic Light
DP	Down Pipe	GY	Gully	TP	Telegraph Post
Elec	Electric	Ht	Height	TS	Traffic Signal
EP	Electricity Post	IC	Inspection Chamber	UTS	Unable to Survey
ER	Earth Rod	IFL	Internal Floor Level	WL	Water Level
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WM	Water Meter
FL	Floodlight			WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Leeds | 0113 233 8000
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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK SHEET 1 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-01-ZZ-M2-G-0060	S2	P1

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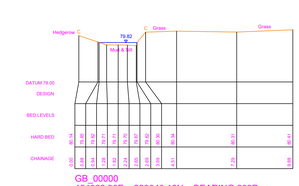
C:\Users\ian.riley\Documents\SS FILES\BUOBS\2021 JOBS\NTH\2479-Oxford Watercourse\OXSRFI-BWB-ZZ-M2-G-0060-S2-P1.dwg



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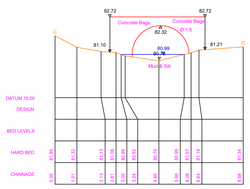

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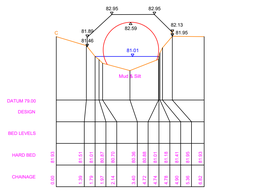

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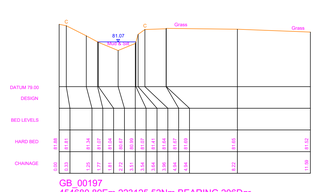

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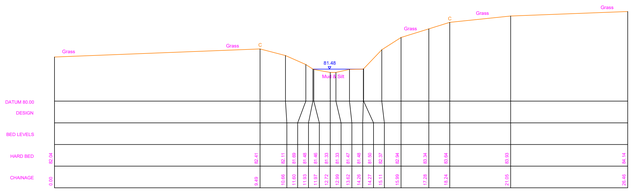

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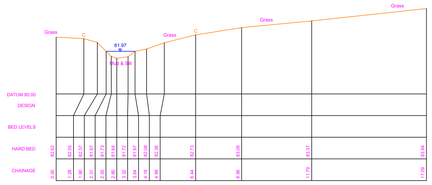

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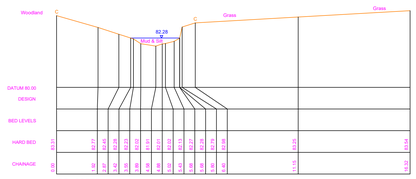

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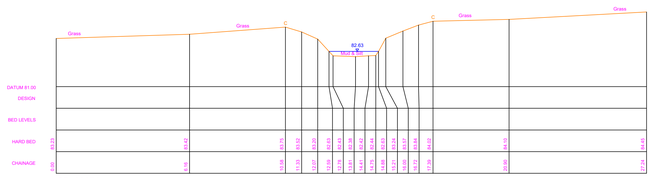

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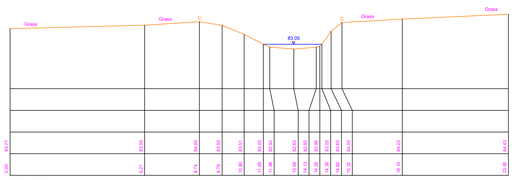

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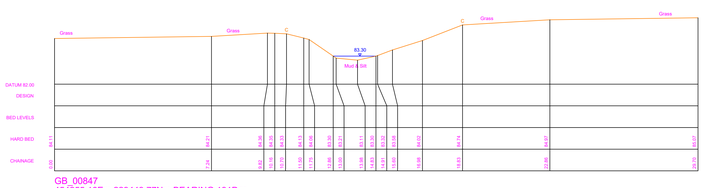

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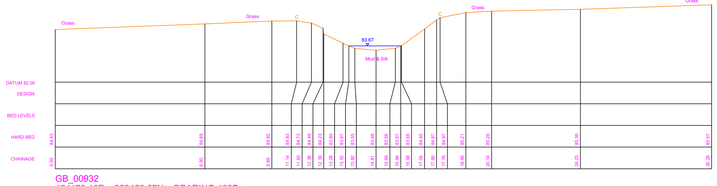

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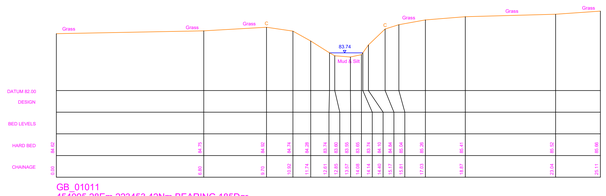

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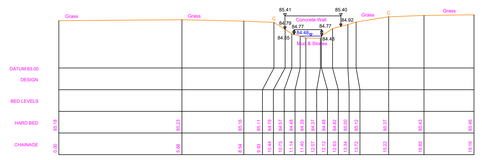

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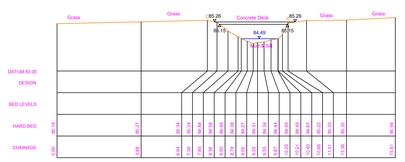

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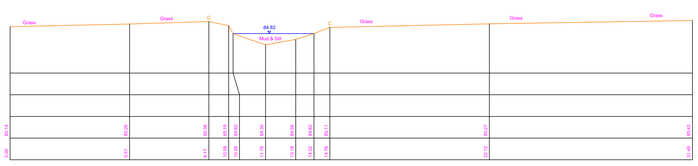

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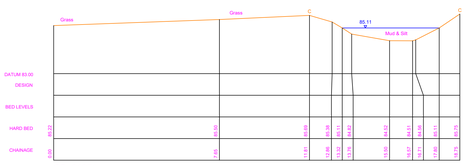
01/03/2022



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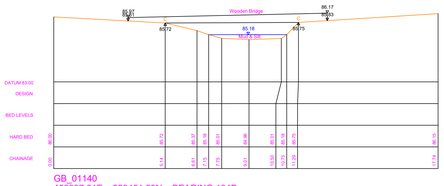

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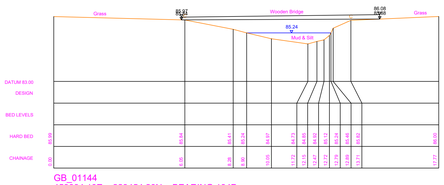

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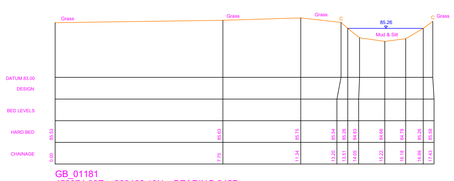
01/03/2022



GB_01181
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1181.275 M
Open Channel
01/03/2022

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings	Contour Lines
Surveyed Buildings	Inspection Chamber
Building	Flow direction and pipe diameter
Wall	Station and Name
Kerb Channel Line	Monitoring Borehole
Top of Kerb	Tree / Bush / Sapling
Edge of Surface	Area of Vegetation/ Extent of Tree Canopy
Top of Bank	Hedge
Bottom of Bank	Body of Water
Canopy / Overhang	Body of Water from OS
Line Marking	Spot Level
Centre Line	Assumed Surface Water Drainage Line
Watercourse	Surface Water Drainage Line
Centre Line Barrier	
Fence	
Gate	
Overhead Powerline	
Overhead Utilities	

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P2	01.03.22	Extra Sections Added	IR	DS
P1	18.10.21	First Issue	IR	DS

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Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK SHEET 1a OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-01-ZZ-M2-G-0060	**S2**	**P2**

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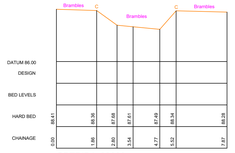

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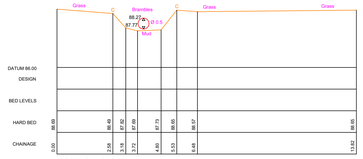

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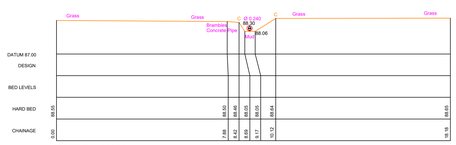

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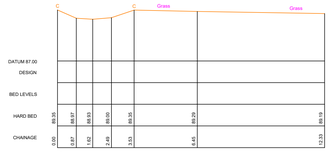
Culvert



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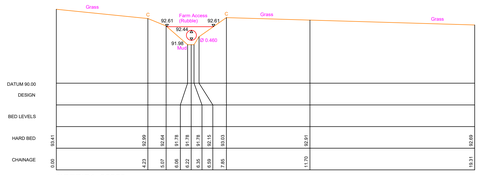

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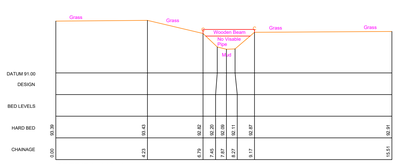
(Farm Access)



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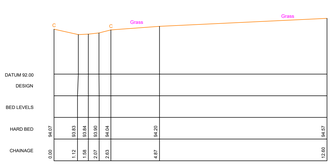

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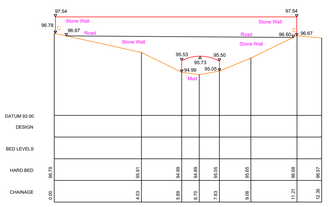

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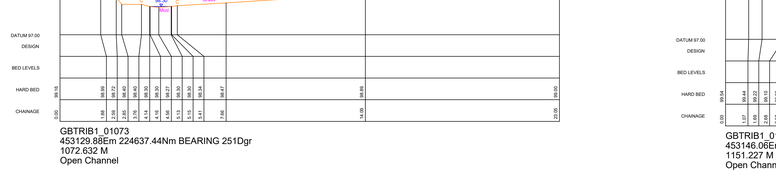
Road Bridge



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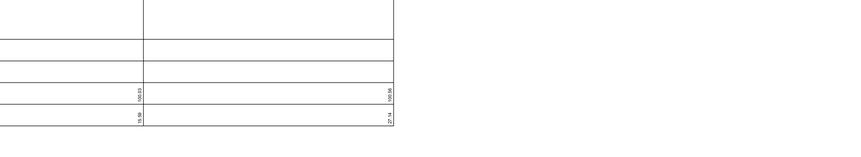

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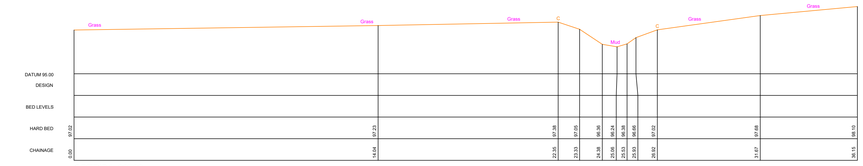

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Open Channel

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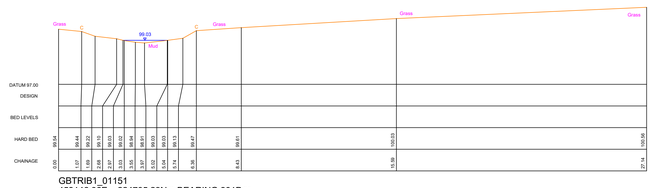

GBTRIB1_01151
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1151.227 M
Open Channel

Notes

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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Me	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Project Title
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WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 2 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-02-ZZ-M2-G-0060	S2	P1

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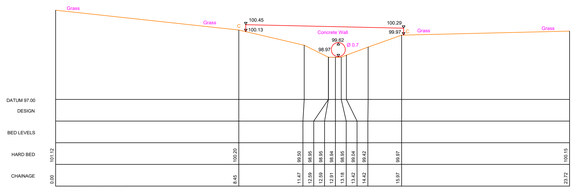

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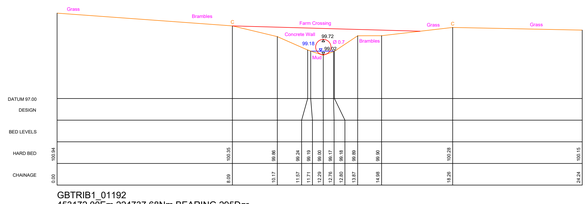

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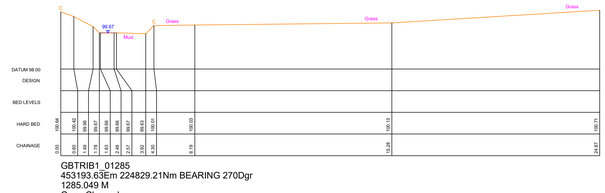

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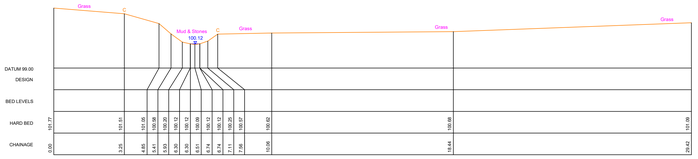

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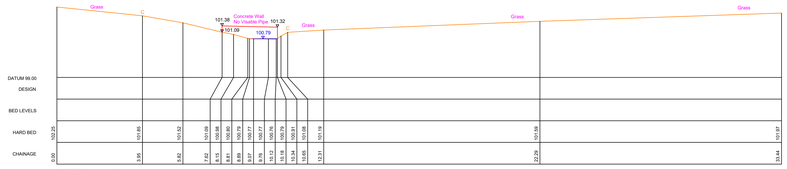
Open Channel



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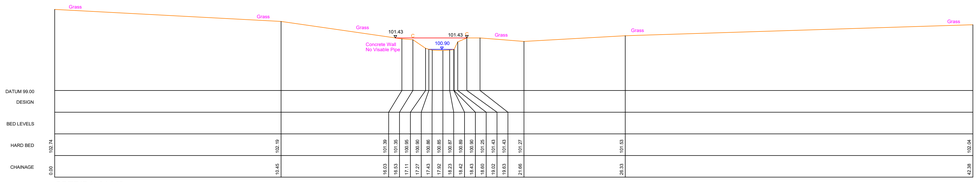

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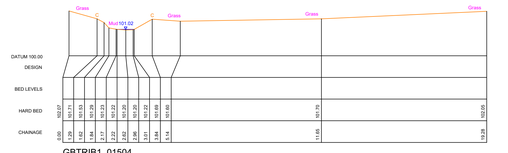

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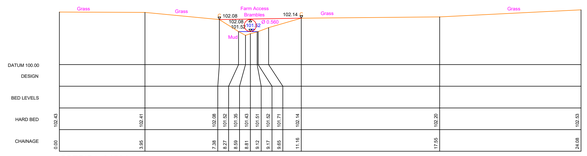
Open Channel



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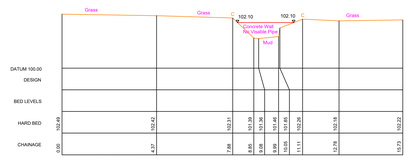

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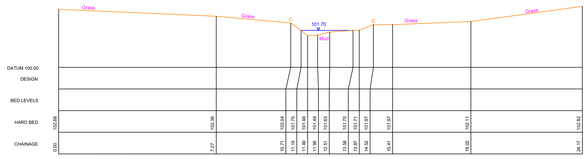

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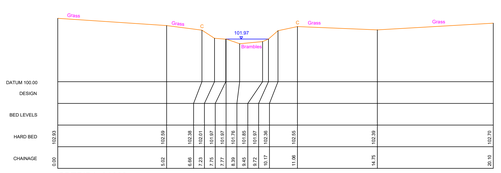

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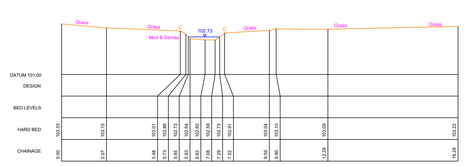

GBTRIB1_01744
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Open Channel

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Notes

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3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Me	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
DC	Drainage Channel	FP	Flagpole		
		Gas	Gas	THL	Threshold Level
DK	Drop Kerb	GV	Gas Valve	TL	Traffic Light
DP	Down Pipe	GY	Gully	TP	Telegraph Post
Elec	Electric	Ht	Height	TS	Traffic Signal
EP	Electricity Post	IC	Inspection Chamber	UTS	Unable to Survey
ER	Earth Rod	IFL	Internal Floor Level	WL	Water Level
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WM	Water Meter
FL	Floodlight			WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Client
OXFORDSHIRE RAILFRIEGHT LTD

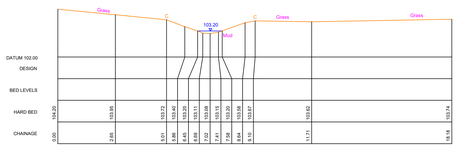
Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 3 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A2:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-03-ZZ-M2-G-0060	**S2**	**P1**



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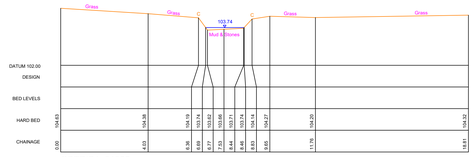

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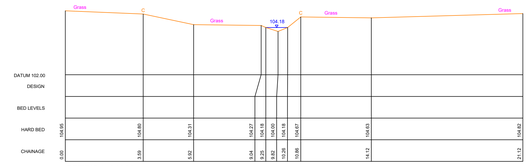

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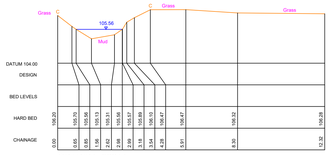

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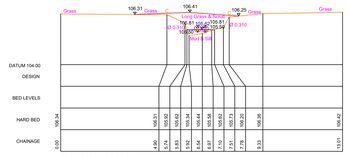

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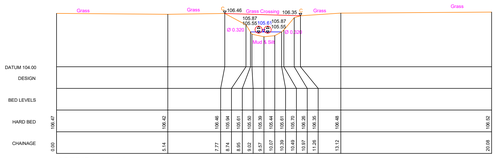

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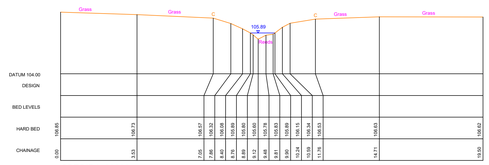

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Open Channel

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Open Channel

GBTRIB1_02365
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Culvert

GBTRIB1_02422
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Culvert

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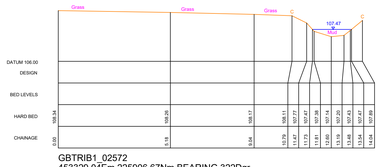

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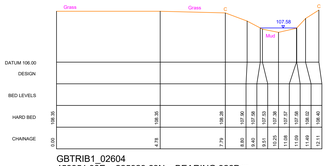

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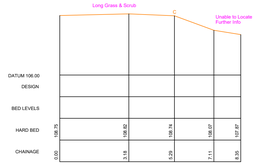

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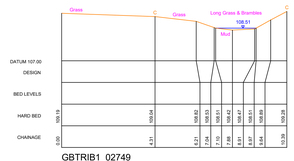

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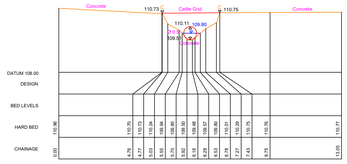
Open Channel



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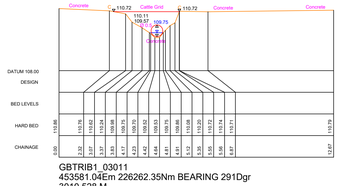

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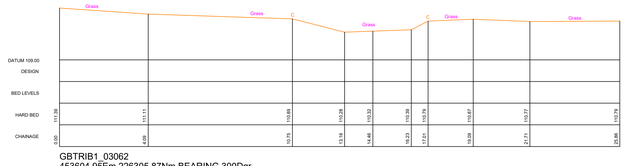

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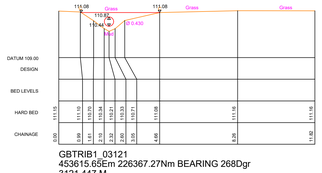

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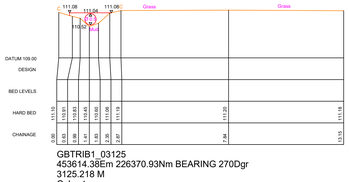

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Culvert

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OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
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Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
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Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
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Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
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DK	Drop Kerb	GV	Gas Valve	TP	Telegraph Post
DP	Down Pipe	GY	Gully	TS	Traffic Signal
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EP	Electricity Post	IC	Inspection Chamber	WL	Water Level
ER	Earth Rod	IFL	Internal Floor Level	WM	Water Meter
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WO	Wash Out
FL	Floodlight				

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 4 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-04-ZZ-M2-G-0060	S2	P1

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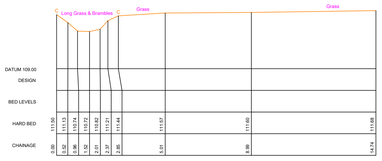

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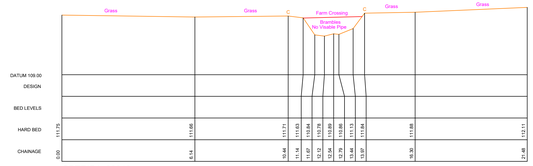
Open Channel



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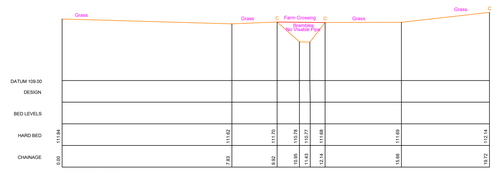

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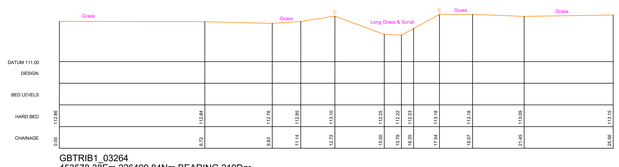

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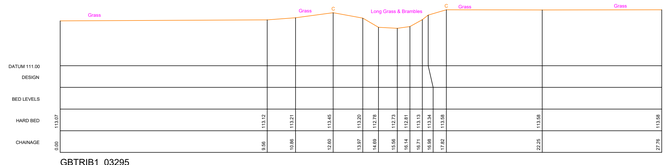
Open Channel



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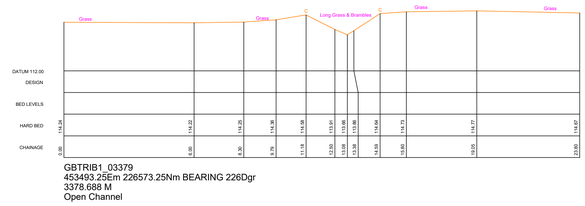

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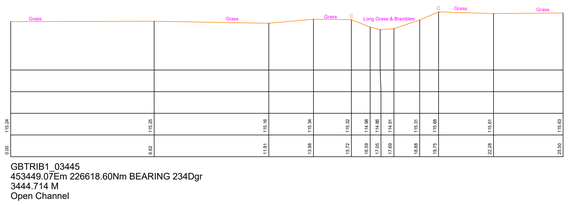
Open Channel



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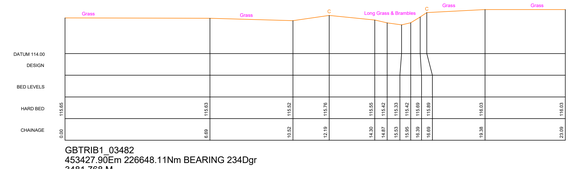
Open Channel



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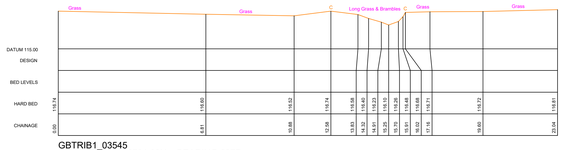
Open Channel



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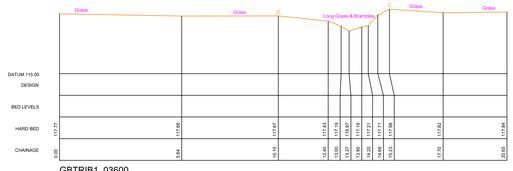
Open Channel



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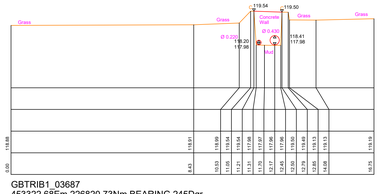
Open Channel



GBTRIB1_03687
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3686.762 M
Culvert

Notes

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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
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C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Cell Box
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DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
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FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
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Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 5 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-05-ZZ-M2-G-0060	**S2**	**P1**

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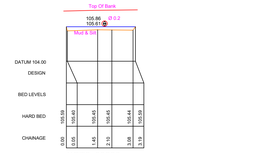

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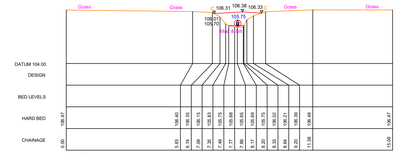
Culvert



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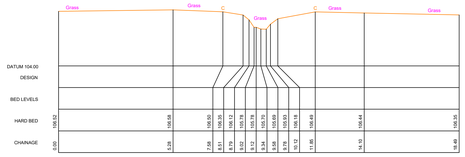
Culvert



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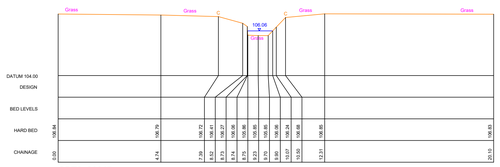
Open Channel



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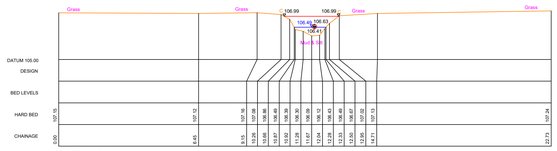
Open Channel



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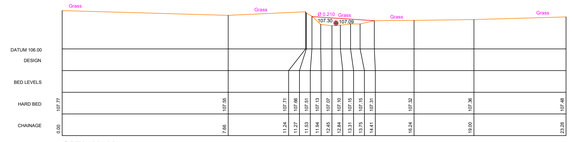

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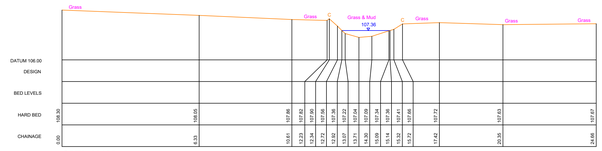

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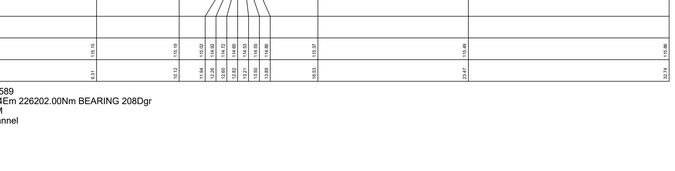
Open Channel



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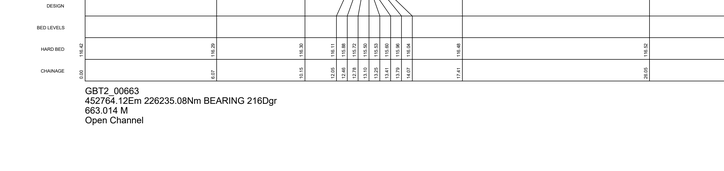
Open Channel



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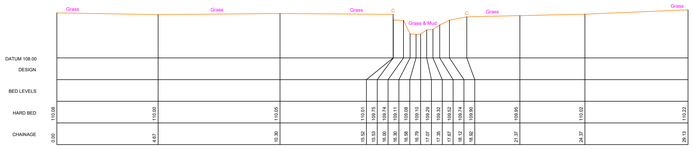
Open Channel



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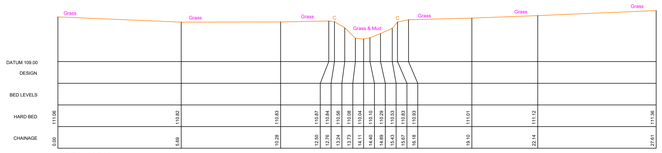
Open Channel



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Open Channel

GBT2_00385
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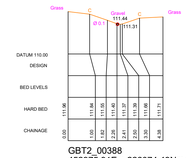
Culvert



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Culvert

GBT2_00436
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435.782 M
Open Channel

GBT2_00508
452898.28Em 226160.15Nm BEARING 211Dgr
507.627 M
Open Channel

GBT2_00549
452864.03Em 226180.22Nm BEARING 216Dgr
548.540 M
Open Channel

GBT2_00589
452827.84Em 226202.00Nm BEARING 208Dgr
588.705 M
Open Channel

GBT2_00663
452764.12Em 226235.08Nm BEARING 216Dgr
663.014 M
Open Channel

Notes

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8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse
Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities

Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
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Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

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Client
OXFORDSHIRE RAILFRIEGHT LTD

Project Title
OXFORDSHIRE RFI

Drawing Title
WATERCOURSE SURVEY
GAGGLE BROOK
TRIBUTARY 2
SHEET 6 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-06-ZZ-M2-G-0060	**S2**	**P1**

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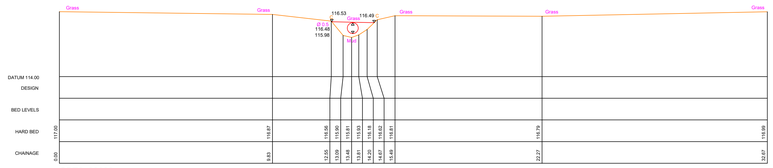

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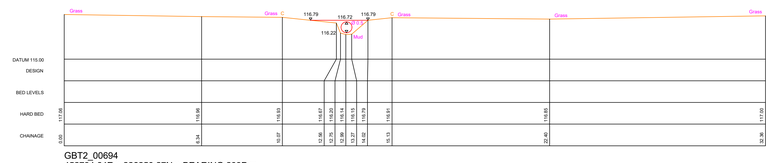
Culvert



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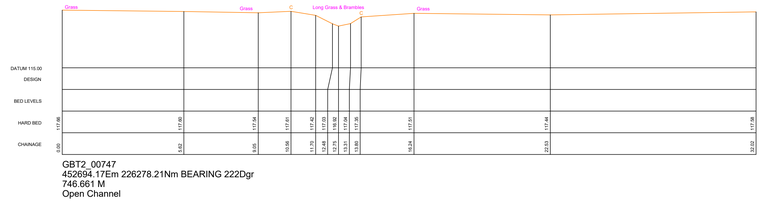
Culvert



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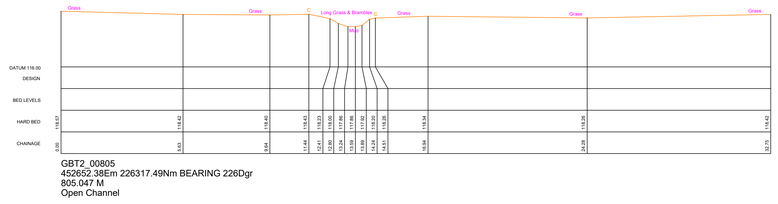
Open Channel



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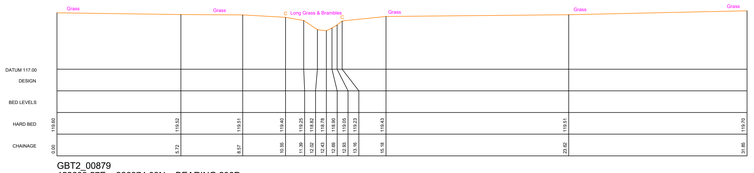

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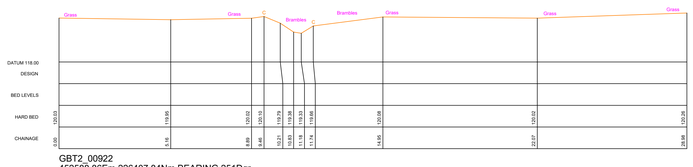

GBT2_00922
452588.86Em 226407.84Nm BEARING 251Dgr
921.710 M
Open Channel

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Flow direction and pipe diameter
Station and Name
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Hedge
Body of Water
Body of Water from OS
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Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

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CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
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DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
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FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

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P1	18.10.21	First Issue	IR	DS

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OXFORDSHIRE RAILFRIEGHT LTD

Project Title

OXFORDSHIRE RFI

Drawing Title

WATERCOURSE SURVEY
GAGGLE BROOK
TRIBUTARY 2
SHEET 7 OF 13

Drawn:	I.Riley		Reviewed:	D.Smith	
BWB Ref:	NTH2479	Date:	18.10.21	Scale@A0:	1:100

Drawing Status

INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-07-ZZ-M2-G-0060	S2	P1

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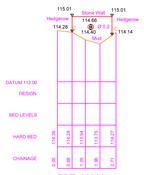

PBT_00000
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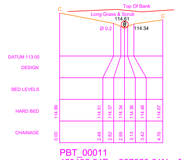
Culvert



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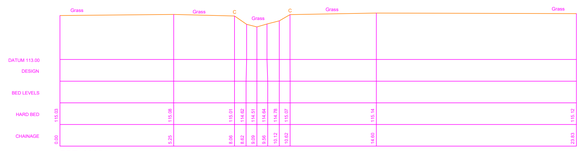
Open Channel



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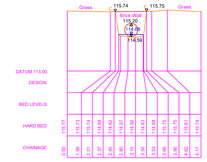

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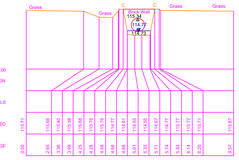
Culvert



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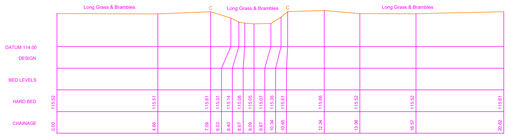
Culvert



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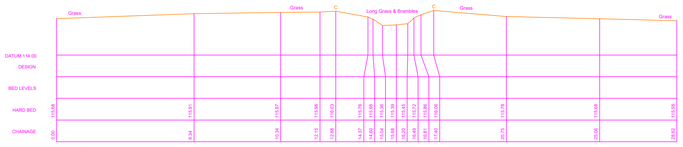

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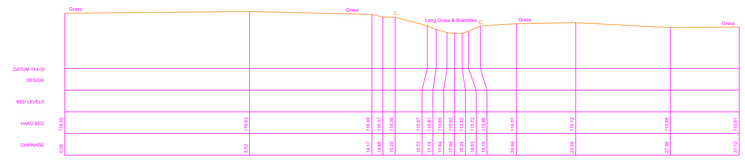

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217.087 M
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PBT_00268
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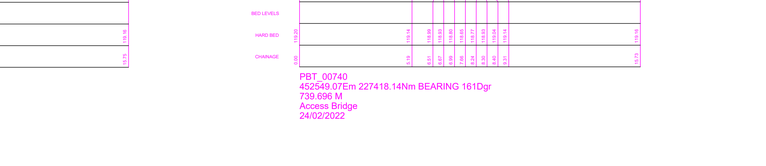
268.325 M
Open Channel



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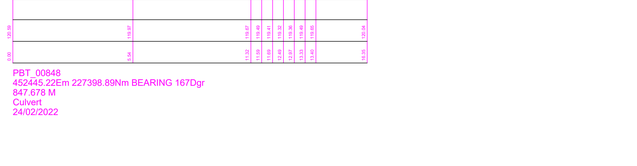

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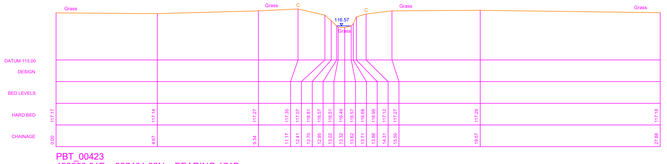

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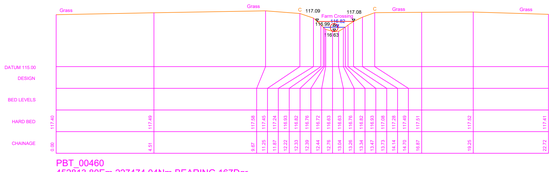

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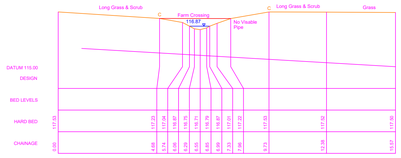
Culvert



PBT_00466
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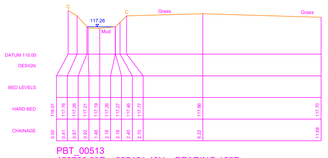
Culvert



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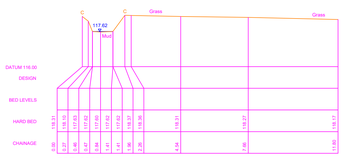

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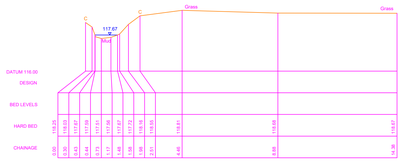
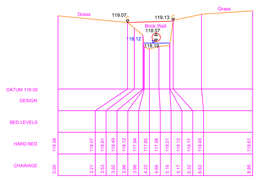
Open Channel



PBT_00622
452661.24Em 227427.83Nm BEARING 166Dgr
621.536 M
Open Channel



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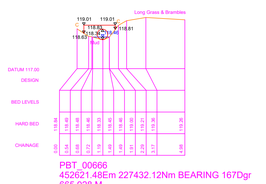
656.717 M
Culvert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118.61
118.61
Long Grass & Brambles
114.61
DATUM 117.00
DESIGN
BED LEVELS
HARD BED
CHAINAGE
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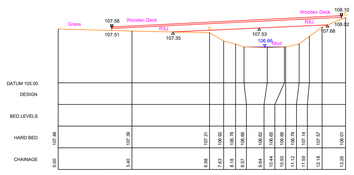

PB_00000
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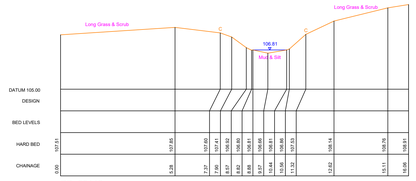
0.014 M
Footbridge



PB_00142
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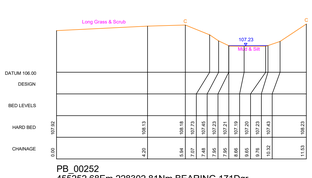
Open Channel



PB_00252
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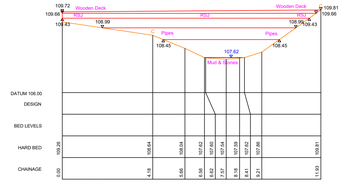
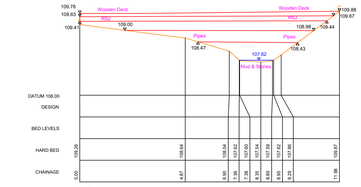
252.063 M
Open Channel



PB_00369
455139.66Em 228299.34Nm BEARING 185Dgr
369.149 M
Footbridge



PB_00371
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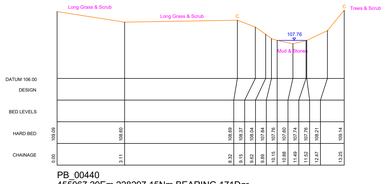
371.476 M
Footbridge



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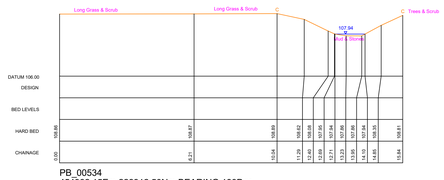
439.847 M
Open Channel



PB_00534
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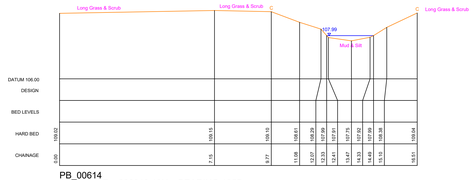
534.386 M
Open Channel



PB_00614
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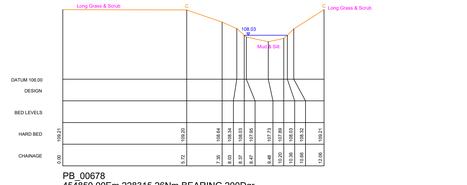
614.274 M
Open Channel



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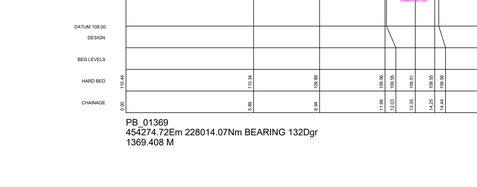
Open Channel



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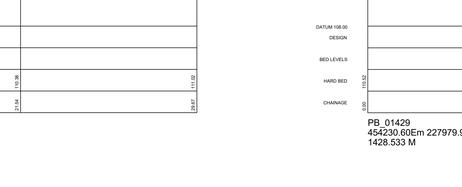
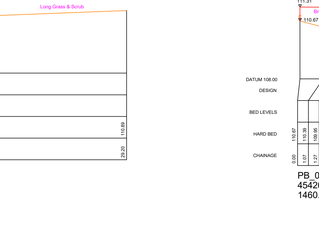
706.220 M
Footbridge



PB_00708
454822.38Em 228322.31Nm BEARING 209Dgr
708.224 M
Footbridge

PB_00728
454799.79Em 228326.97Nm BEARING 163Dgr
727.680 M
Culvert



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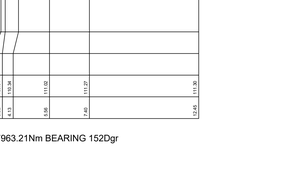
Culvert



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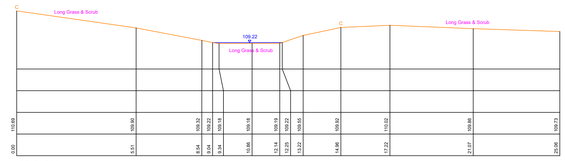
973.585 M
Culvert



PB_01014
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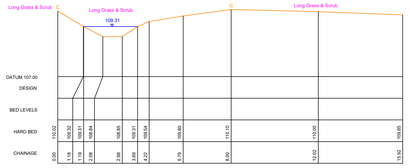
1014.340 M
Open Channel



PB_01069
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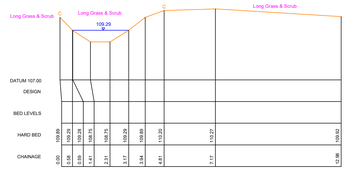
Open Channel



PB_01141
454474.80Em 228124.21Nm BEARING 155Dgr
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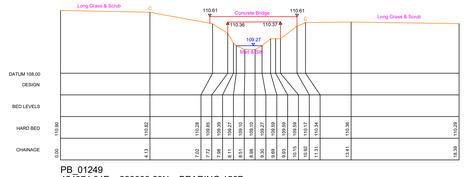
Open Channel

PB_01182
454438.46Em 228104.57Nm BEARING 147Dgr
1181.940 M
Open Channel



PB_01249
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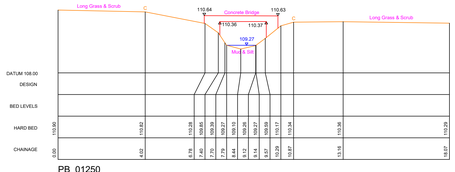
1249.833 M
Footbridge



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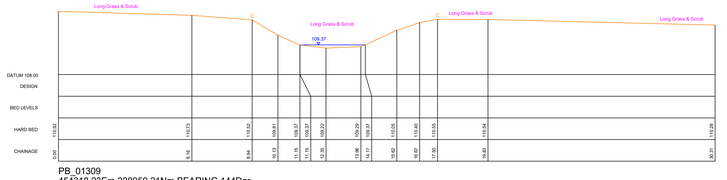
1250.405 M
Footbridge



PB_01309
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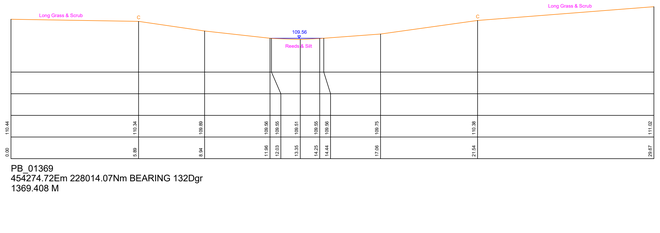
1308.631 M
Open Channel



PB_01369
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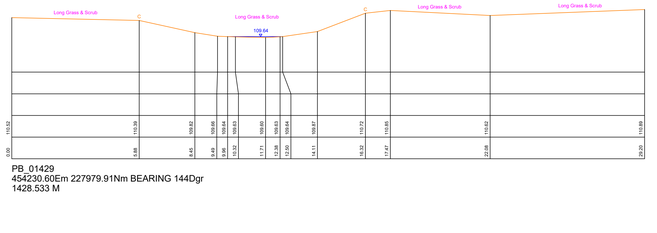
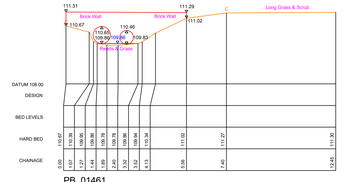


PB_01429
454230.60Em 227979.91Nm BEARING 144Dgr
1428.533 M



PB_01461
454205.59Em 227963.21Nm BEARING 152Dgr
1460.502 M

Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are constructed by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan

Legend

OS Buildings
Surveyed Buildings
Building
Wall
Kerb Channel Line
Top of Kerb
Edge of Surface
Top of Bank
Bottom of Bank
Canopy / Overhang
Line Marking
Centre Line
Watercourse Centre Line
Barrier
Fence
Gate
Overhead Powerline
Overhead Utilities
Contour Lines
Inspection Chamber
Flow direction and pipe diameter
Station and Name
BH 1
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
50.00
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Call Box
DC	Drainage Channel	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	Gas	Gas	TL	Traffic Light
DP	Down Pipe	GV	Gas Valve	TP	Telegraph Post
Elec	Electric	GY	Gully	TS	Traffic Signal
EP	Electricity Post	Ht	Height	UTS	Unable to Survey
ER	Earth Rod	IC	Inspection Chamber	WL	Water Level
FH	Fire Hydrant	IFL	Internal Floor Level	WM	Water Meter
FL	Floodlight	IL	Invert Level (as a reduced level)	WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P1	18.10.21	First Issue	IR	DS

Issues & Revisions

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Client
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Project Title
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Drawing Title
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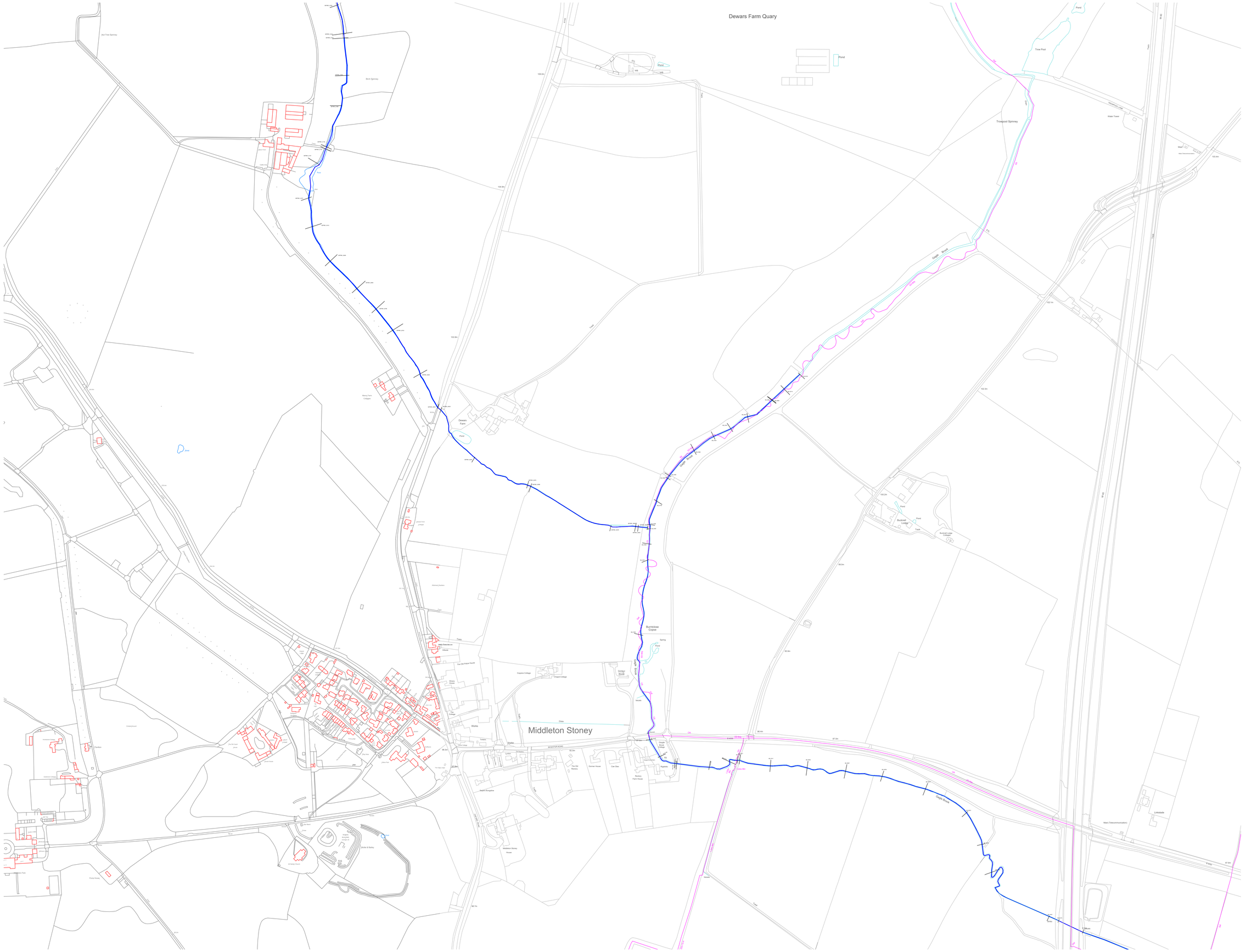
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Trow Pool
Trowpool Spinney
Birch Spinney
Jack Tree Spinney
Dewars Farm
Pond
Water Tower
Bucknell Lodge
Bucknell Lodge Cottages
Middleton Stoney House
Middleton Park
Cricket Ground
Bowling Green
Tennis Courts
Football Pitch
Skittle & Bocley
Village Hall
Chapel
Rectory Farm House
Manor House
Oak Dale
The Old Rectory
Lyndon
Jasmin Bungalow
Middleton Stoney Primary School
Middleton Stoney Methodist Church
Chapel Cottage
Coppice Cottage
Manor Farm Cottages
Mixing Farm Cottages
Bicester Road
Chilton
Ardley
Fritwell
Somerton
Ardley Road
Ardley Cutting
Ardley Tunnel
Ardley Embankment
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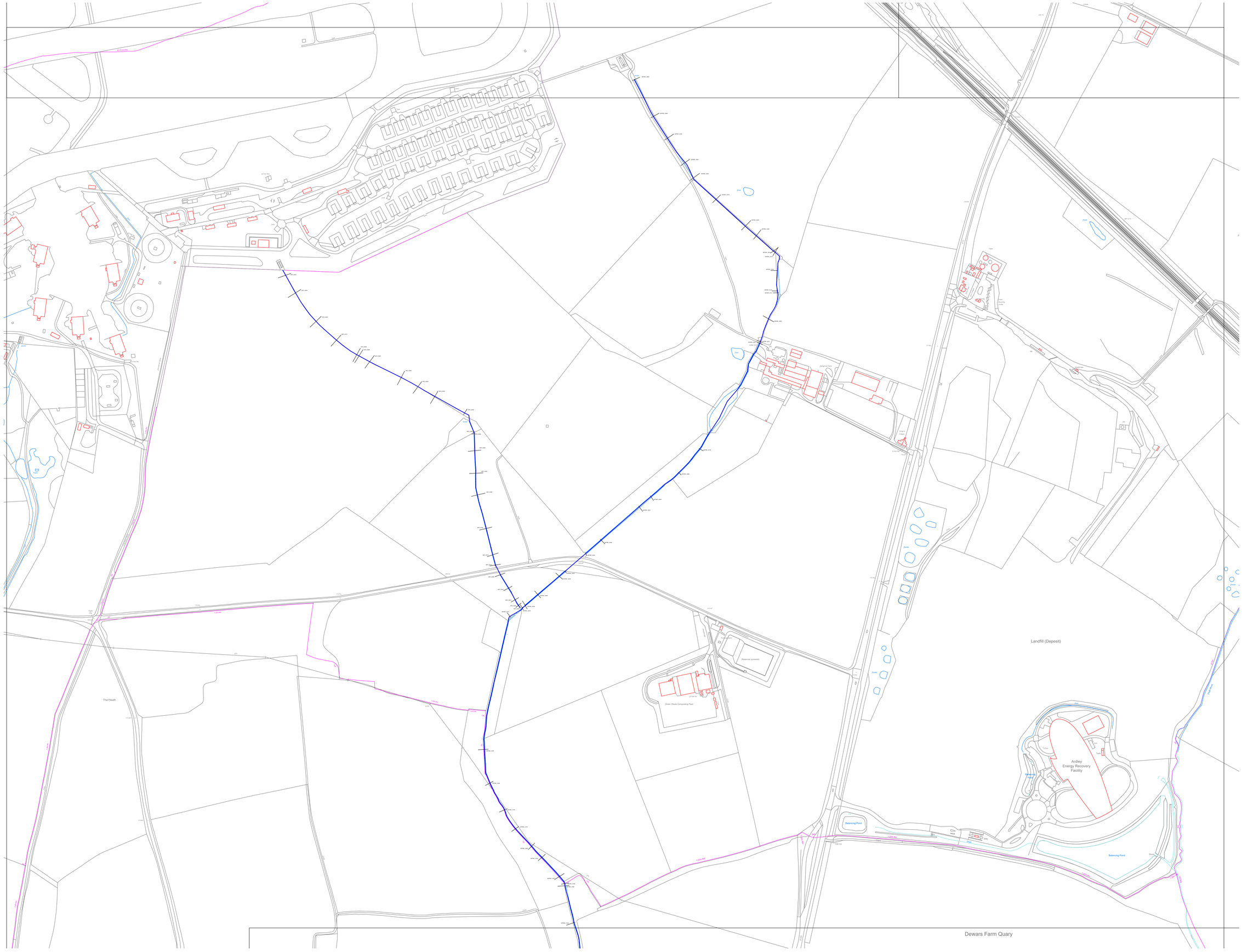
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The Heath
Reservoir (covered)
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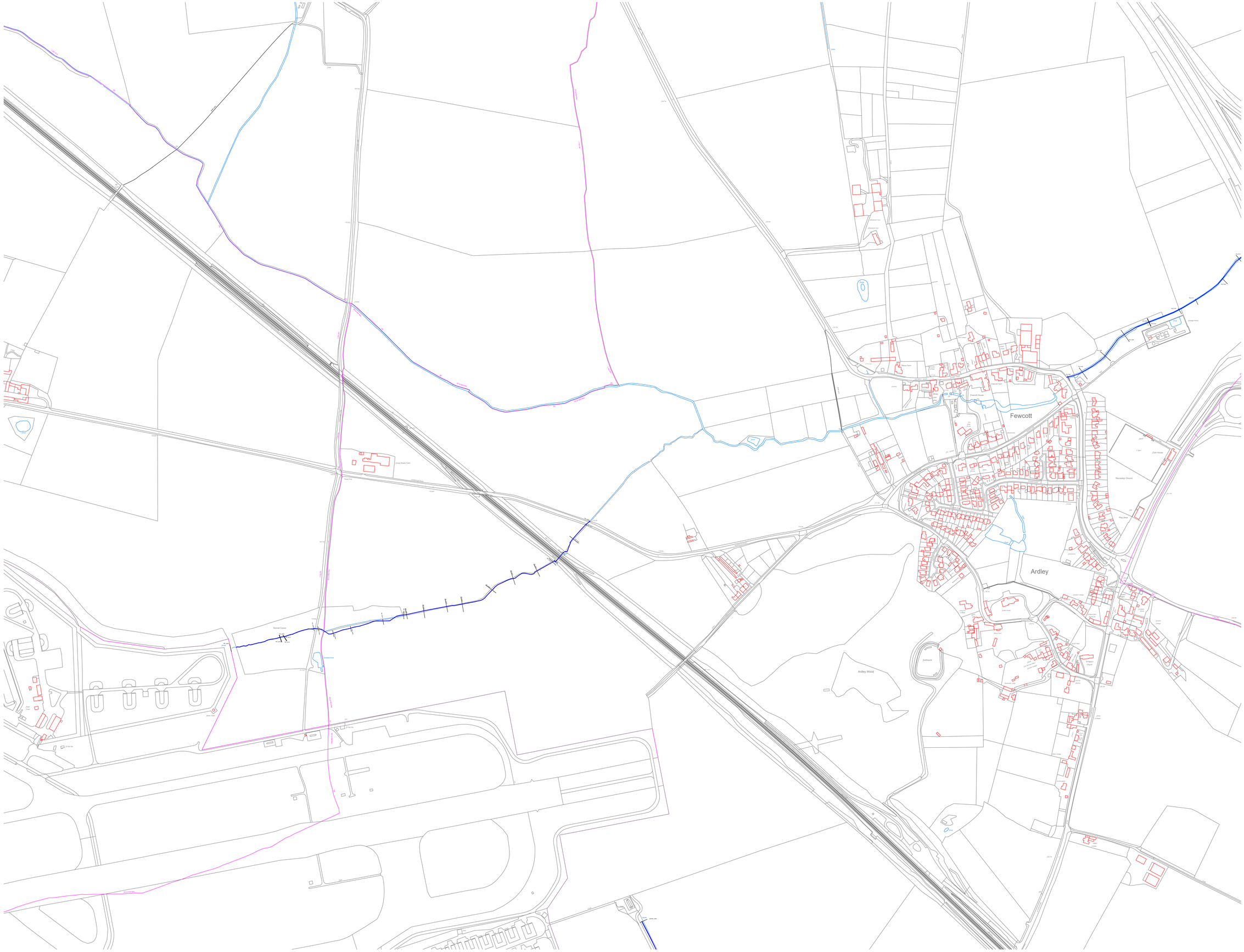
Ardley Energy Recovery Facility
Balancing Pond
Pond
Pond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Fewcott House
Fewcott Farm
Cross Roads Farm
Kennel Copse
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Ardley House
Ardley Manor
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Ardley Manor Barn
Ardley Manor Stables
Ardley Manor Lodge
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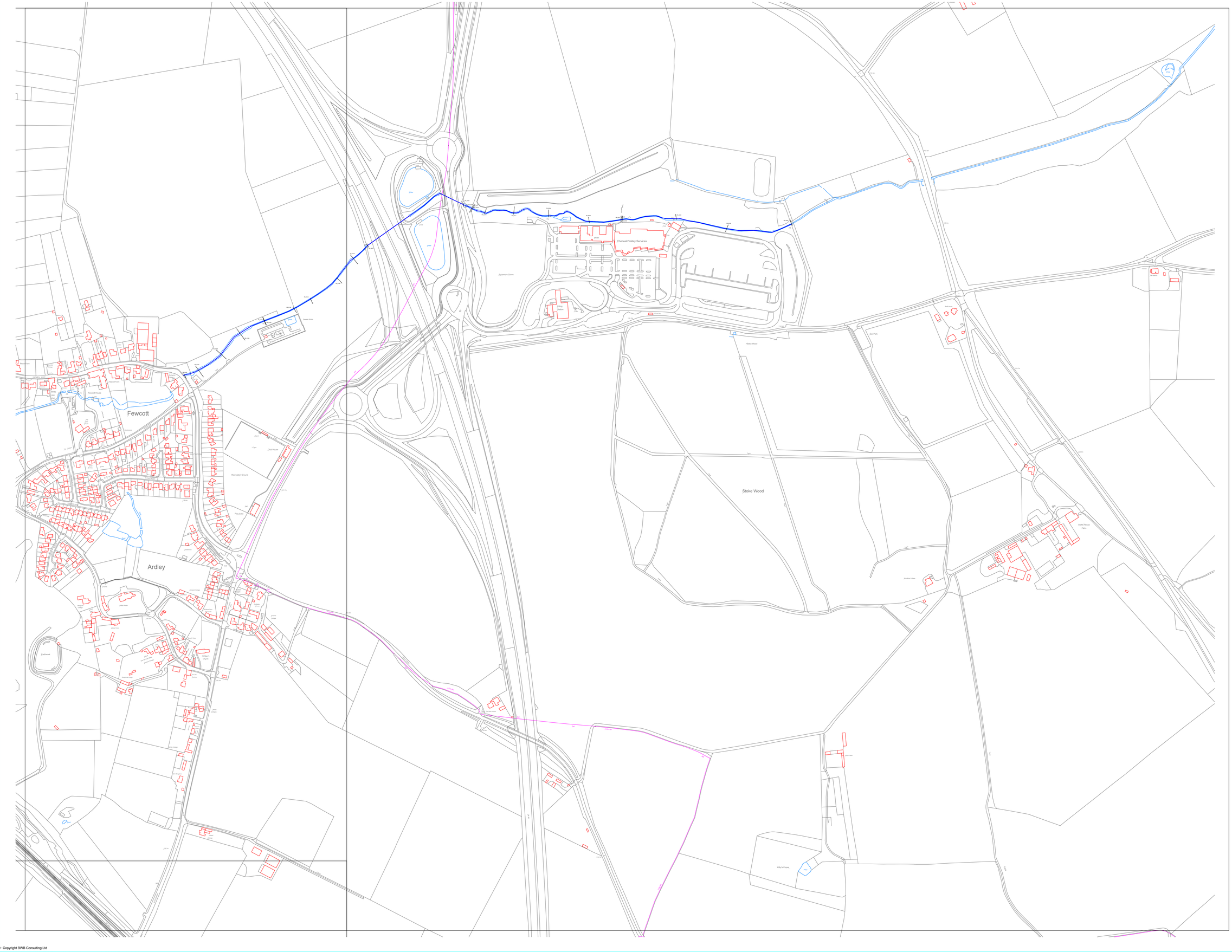
Ardley Manor Farm Stables
Ardley Manor Farm Lodge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Ardley
Stoke Wood
Cherwell Valley Services
Hotel
Filling Station
Fewcott House
French Farm
Club House
Recreation Ground
Play Area
Ardley House
Earthwork
Old Park
Stoke Wood
Killey's Copse
Stoke Wood Farm
Stoke Wood Cottages
Stoke Wood Villa
Stoke Wood Lodge
Stoke Wood Poultry Farm
Stoke Wood Cottage
Stoke Wood Farm Cottages
Stoke Wood Farm
Stoke Wood Farm Barn
Stoke Wood Farm Bungalow
Stoke Wood Farm Buildings
Stoke Wood Farm Cottage
Stoke Wood Farm Cottages

Appendix 2: Hydrological Assessment

A CAF GROUP COMPANY

ADVISORY

Oxfordshire Railfreight Limited
Oxfordshire RFI
Oxfordshire
Flow Estimation Record

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1. METHOD STATEMENT

Overview of Requirements

1.1 Flow estimates are required for input into a hydraulic model of the Padbury Brook Tributary, to support a Development Consent Order (DCO) application for a Strategic Rail Freight Interchange (SRFI) in Oxfordshire.

1.2 The Padbury Brook Tributary flows through the Order Limits in an easterly direction. The location of the site of interest and the watercourse to be modelled is provided in **Figure 1.1.**

Figure 1.1: Site Location

1.3 Return periods to be assessed include: 2, 5, 10, 20, 30, 50, 75, 100, 200 and 1000-years. To inform the design event and potential future floodplain, the 1 in 100-year event with a range of climate change allowances applied will also be simulated. Hydrographs are required as well as peak flows.

1.4 The Client's agreed project scope does not include for detailed gauging station data quality review, rating reviews or updates, detailed flood history review or ReFH model parameter estimation.

1.5 The hydrological assessment was undertaken in May 2025. The Environment Agency (EA) Flood Estimation Guidelines[1] and River Modelling: Technical Standards and Assessment

[1] LIT 11832 Flood Estimation Guidelines Version 9, Environment Agency (November 2023)

Guidance (Estimate Flood Flow from rainfall and river flow data)[2] were referred to throughout the hydrological analysis.

Study Complexity

Table 1.1: Study Complexity

Complexity	Category for this Study
Simple	☐
Moderate	✓
Difficult	☐
Very Difficult	☐

Catchment Description

1.6 The Padbury Brook Tributary rises to the west of the Order Limits, upstream of Raghouse Lane. The watercourse generally flows in an easterly direction and is culverted under the railway and Somerton Road, before flowing in a north-easterly direction in open channel to its confluence with the Padbury Brook.

1.7 The upper catchment of the Padbury Brook Tributary has elevations of approximately 139metres Above Ordnance Datum (mAOD). The upper reaches flow through a narrow, defined channel with valley-like topography. Downstream of the railway, the watercourse flows through a wider valley, with levels falling to approximately 112mAOD in the vicinity of the confluence with the Padbury Brook. The catchment topography is shown in **Figure 1.2**.

[2] River Modelling: technical standards and assessment (estimate flood flow from rainfall and ricer flow data, Environment Agency (December 2023)

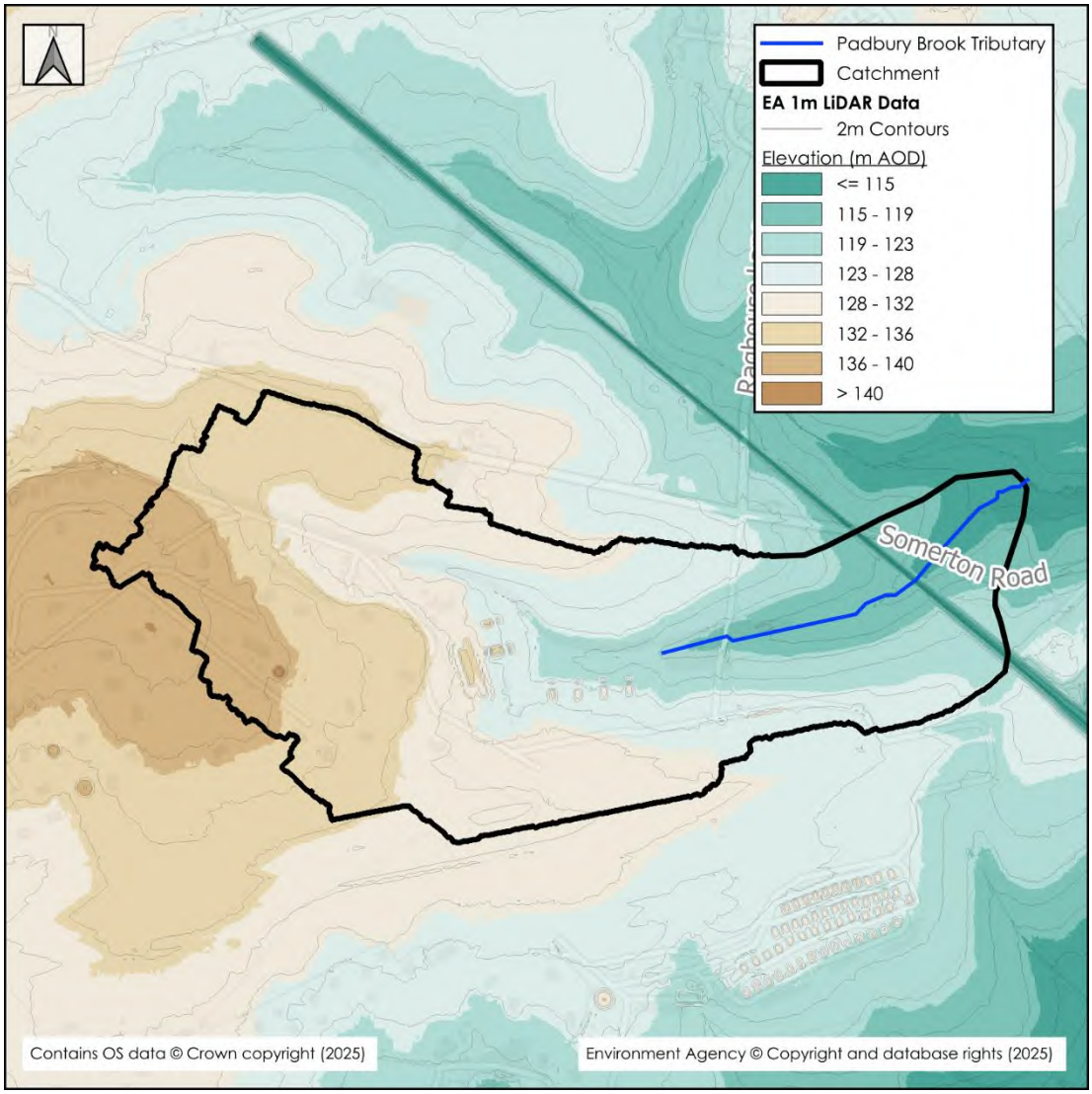

Figure 1.2: Catchment Topography

1.8 British Geological Survey (BGS) mapping indicates that the catchment is predominately underlain by White Limestone Formation (Limestone). The following bedrock is also present within the east of the catchment:

- Rutland Formation (Mudstone);
- Forest Marble Formation (Limestone); and
- Bladon Member (Mudstone and Limestone, Interbedded).

1.9 Superficial deposits of Head (Clay, Silt, Sand and Gravel) and Alluvium (Clay, Silt, Sand and Gravel) are mapped within the catchment, aligned with the watercourse corridor.

1.10 Soils in the catchment are expected to comprise 'freely draining lime-rich loamy soils'.

1.11 Land use in the catchment is predominantly rural, comprising agricultural land. Heyford Park, a former RAF airfield, is located in the upper catchment.

1.12 No features that may impact the flood hydrology, such as ponds, have been identified.

Climate Change

1.13 Predicted future change in peak river flows caused by climate change are provided by the EA, with a range of projections applied to regionalised 'River Basin Districts' which are subdivided into Management Catchments.

1.14 The catchment falls within the Upper and Bedford Ouse Management Catchment of the Anglian River Basin District. **Table 1.2** identifies the relevant peak river flow allowances from this River Basin District.

Table 1.2: Peak River Flow Allowance for the Upper and Bedford Ouse Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	58%
Higher Central	10%	11%	30%
Central	5%	4%	19%

Available Hydrometric Data

1.15 The National River Flow Archive (NRFA) Peak Flow Dataset Version 13.0.2 (released August 2024) will be utilised in this assessment for the purposes of identifying any potential donor stations and for the development of pooling groups. This contains data up to water year 2022-23.

1.16 There are no hydrometric gauges within the catchment. Therefore, there are no current hydrometric records of river flows or levels for the watercourse on which a hydrological assessment of flood flows can be made.

Other Data

Table 1.3: Other Data Sources

Type of Data	Data relevant to this study?	Data available?	Source of Data	Details
Check flow gaugings	There are no gauges within the study catchment and the project scope does not include for a review of gauging stations.			
Historical flood data	Yes	See **Section 7**		
Flow or river level data for events	The project scope does not include for a review of gauging stations/data. However, NRFA data will be used where available and applicable.			

Type of Data	Data relevant to this study?	Data available?	Source of Data	Details
Rainfall data for events	The lack of flow or level gauge data for the study catchment means it is not possible to use rainfall data to refine ReFH2 model parameters.			
Potential evaporation data	No	No		
Results from previous studies	No	No		
Other data or information	N/A			

Conceptual Model

Table 1.4: Conceptual Model

Where is the main site(s) of interest?	The main site of interest is the proposed development, comprising an SRFI in Oxfordshire. The watercourse to be modelled is shown in **Figure 1.1**. The Padbury Brook Tributary flows through the Order Limits in an easterly direction.
What is likely to cause flooding at those locations? (e.g. peak flows, flood volumes, combination of peaks, groundwater, snowmelt, tides…)	Peak flows from fluvial sources are likely to be the main cause of flooding at the site. The watercourse is culverted in several locations, and as such there is potential for backing up of flows if these structures have insufficient capacity. EA strategic flood risk mapping suggests that the floodplain associated with the watercourse is relatively confined to the watercourse corridor, although out of bank flows are depicted.
Might these locations flood from runoff generated on part of the catchment only e.g. downstream of a reservoir?	There are no significant attenuation features within the catchment.
Are there any unusual catchment features? E.g. highly permeable (BFIHOST19>0.66), heavily urbanised, pumped, major reservoir influence (FARL<0.9), FSAs, historical or operational mining?	The catchment is classed as highly permeable, with a BFIHOST19 value of 0.85. Due to the permeable nature of the study catchment, the Statistical method will be the preferred approach for estimating peak flows. This is because floods in groundwater dominated catchments are influenced by hydrogeological factors not adequately represented in rainfall-runoff approaches. The catchment is not classed as heavily urbanised (URBEXT greater than 0.6) and there is no major reservoir influence or attenuation features.

Initial Choice of Approach

Table 1.5: Method Statement

Is FEH appropriate?	Yes
Initial choice of method(s) and reason	Flows will be estimated using both Statistical and ReFH2 methods. Both methods are suitable for the catchment and using both will enable comparison between results before choosing the final method.
How will hydrograph shapes be derived?	It is anticipated that ReFH2 will be used to provide hydrograph shapes.
Will different storm durations need to be considered?	A uniform storm duration will be applied to the modelling.
Lumped or Distributed approach for model inputs	Flow estimates will be undertaken for lumped catchments. **Section 6** provides detail on how these will be applied to the model (i.e., distributed via area weighting, intervening hydrographs etc).
Software to be used	WINFAP version 5.1, ReFH2 version 4.1, Wallingford Hydro Solutions Non Flood Years Spreadsheet Beta v2.2

Previous Hydrological Assessments

1.17 No previous hydrological assessments have been undertaken for this catchment with which to compare results.

2. LOCATIONS WHERE FLOOD ESTIMATES ARE REQUIRED

Location of Flow Estimates

Table 2.1: Summary of Subject Sites

Site code	Watercourse	Site	Easting	Northing	Area on FEH Webservice (km^2)	Revised area (if altered) (km^2)
PBT001	Padbury Brook Tributary	Confluence of Padbury Brook Tributary and Padbury Brook	453400	227850	1.2	1.7
Reasons for choosing locations		The location is based on the downstream extent of the hydraulic model of the Padbury Brook Tributary. One flow estimation point is considered appropriate due to the relatively small difference in catchment area between the upstream and downstream extents of the model.				

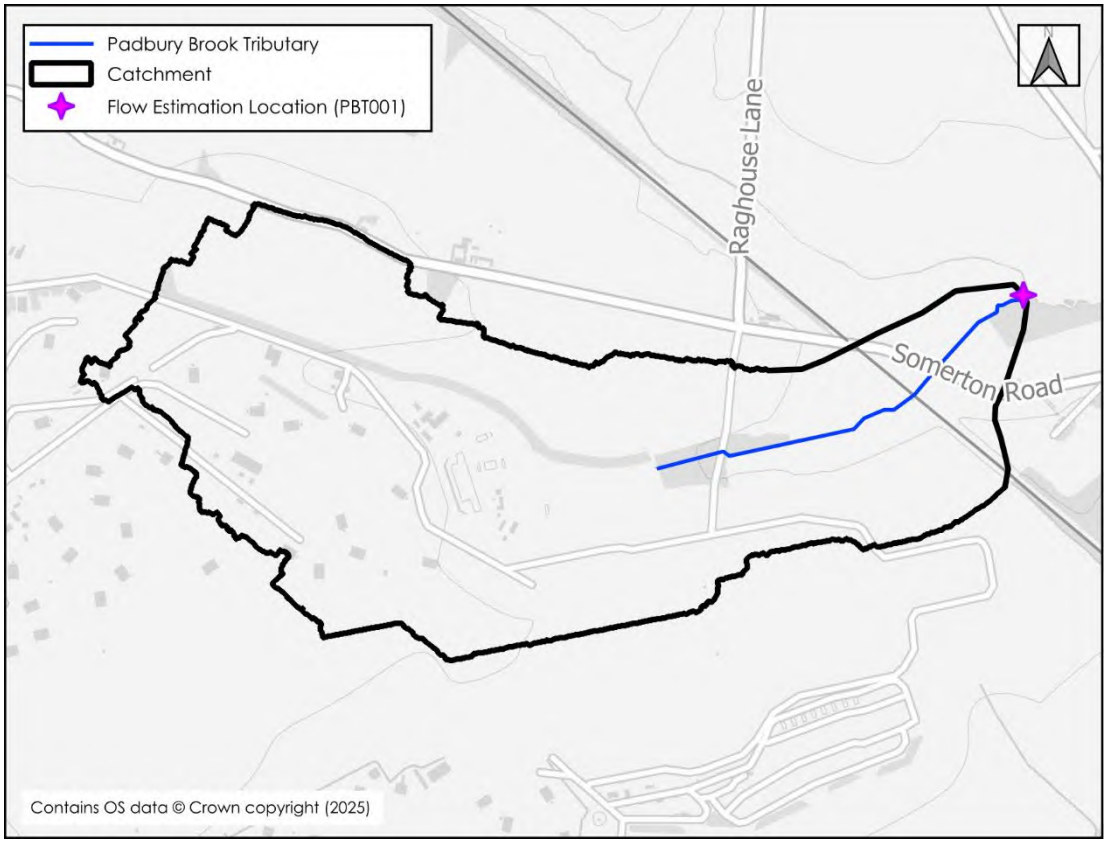

Figure 2.1: Flow Estimation Location

Checking Catchment Descriptors

Table 2.2: Catchment Descriptor Checks

Record how catchment boundary was checked and describe any changes.	The catchment boundary was initially identified using the FEH Web Service. The boundary was reviewed using EA LiDAR data and OS Mapping. A watershed analysis was also undertaken. Following this, adjustments to the catchment boundaries were required and these are illustrated in **Figure 2.2**.
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	As the changes to catchment area are relatively small, with no significant change to the catchment shape, as well as the limitations of the standard DPLBAR equation within FEH Volume 5, the DPLBAR in the original FEH catchment descriptors has been retained. BFIHOST and SPRHOST values are reasonable based on the geology and soils of the catchments. FARL was checked against OS mapping and was considered appropriate for the catchment.
Source of URBEXT	$URBEXT_{2000}$
Method for updating of URBEXT to present day.	$URBEXT_{2000}$ for the catchment is 0. A review of aerial mapping for the catchment showed there has been no urbanisation in the catchment since 2000; therefore, the present day value of $URBEXT_{2000}$ will remain as 0.

Table 2.3: Important Catchment Descriptors

Site Code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR	SPRHOST	URBEXT 2000	FPEXT
PBT001	1.00	0.32	0.85	1.41	17.1	674	5.50	0.00	0.071

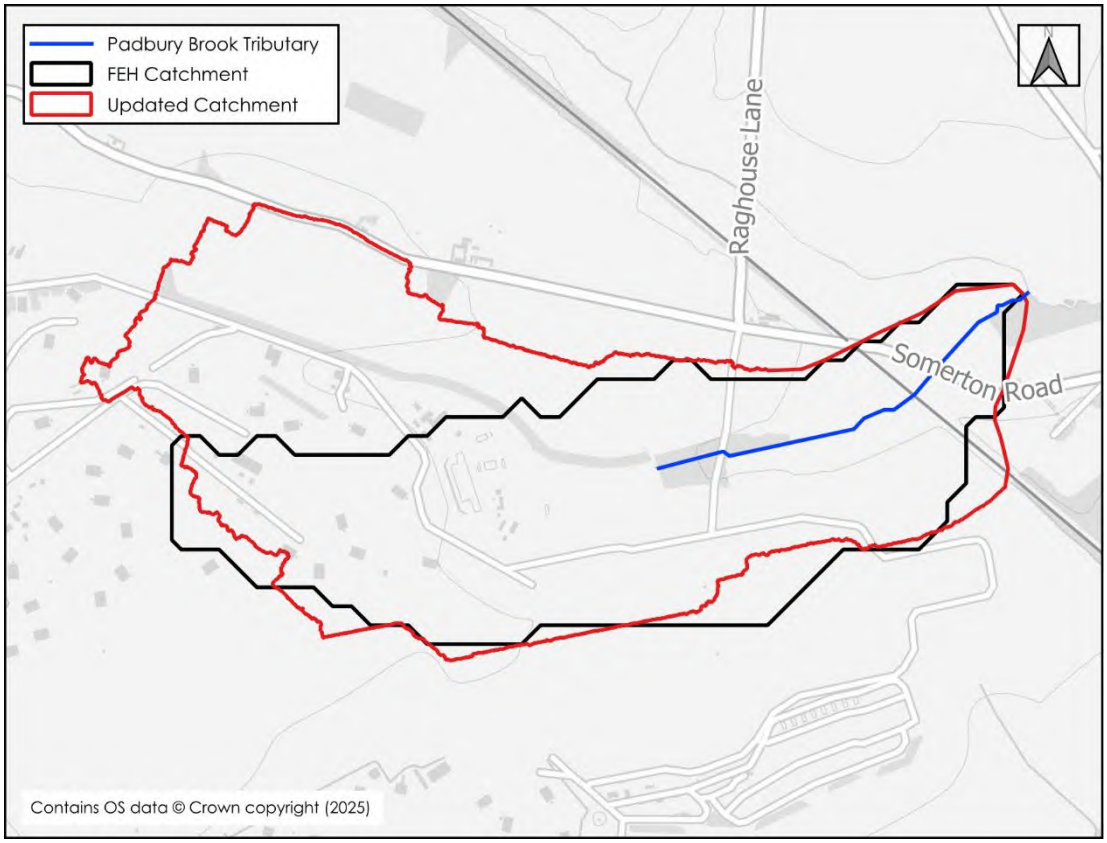

Figure 2.2: Original and Amended Catchment Boundaries

3. STATISTICAL METHOD

3.1 WINFAP was utilised to undertake a statistical analysis of the catchment using a hydrometric record of gauged catchments with similar characteristics.

QMED Development

3.2 Catchment descriptors were originally used to estimate the rural QMED of the study site using the revised equation from Science Report (SC050050). The FEH states that flood frequency is best estimated by gauged data and estimation of key variables from catchment descriptors alone should be a method of last resort. As such, a search was undertaken to identify any potential donor sites that could be used to adjust QMED.

3.3 Phase 2 of Science Report SC090031[3] recommends using a single donor, chosen based on proximity, to adjust QMED for 'small catchments' (defined as catchments with an area of less than 25km^2). This method can also be applied to catchments less than 40km^2 and is implemented in WINFAP5.

3.4 With the guidance in mind, a search was undertaken within WINFAP to identify the closest station to the flow estimation point(s). The data quality of potential donor(s) was also reviewed. Of the recommended donors, the following were rejected:

- *Cherwell at Enslow Mill* (NRFA reference: 39021) - station has limited utility for flood analysis; level measurement imprecise prior to 1967 and bypassing has varied in magnitude through time.
- *Bedford Ouse at Thornborough* (NRFA reference: 33005) - station closed in 1991 and therefore, recent flood events will not be captured within the record.

3.5 The next closest station to the subject site, the *Evenlode at Cassington Mill* (NRFA reference: 39034), was considered suitable for donor transfer following the review.

3.6 Details for the donor station(s) used to adjust QMED, and which flow estimation point(s) they have been applied to, are provided in **Table 3.1**. Details of the donor adjustment(s) and final QMED estimation are provided in **Table 3.2**.

3.7 Adjustment for climatic variation was not required as the donor station has a record length greater than 14 years.

Table 3.1: Donor Station Details

Station Number	QMED from 'as rural' Observed Data (A)* (m^3/s)	'As rural' QMED from Catchment Descriptors (B)** (m^3/s)	Adjustment Ratio (A/B)	Flow estimation point(s) donor is applied to
39034	20.02	21.14	0.95	PBT001

[3] Science Report SC090031/R0: Estimating flood peaks and hydrographs for small catchments (Phase 2), Environment Agency (2019).

Table 3.2: Overview of Estimation of QMED at the Subject Site

Site Code	Method	Initial Estimate of QMED (m^3/s) (Rural)	Data Transfer				Final estimate of QMED (m^3/s) (URBAN)
			Donor site NRFA no	Distance between centroids d_j (km)	Power term, a	Moderated QMED adjustment factor (A/B)[a]	
PBT001	Donor Transfer	0.09	39034	20.14	0.307	0.98	0.08
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?		QMED is consistent with the size and characteristics of the catchment.					
Which version of the urban adjustment was used for QMED?		Urban adjustment was applied using Kjeldsen (2010), as applied in WINFAP.					

Note: Flow estimates are quoted to 2 decimal places to demonstrate change in flow estimates; this does not indicate a greater degree of accuracy.

Derivation of Pooling Groups

3.8 A pooled group of hydrologically similar gauged sites was generated by the WINFAP software for the subject sites using the 'OK for Pooling' dataset. WINFAP uses the deurbanised pooling group L-moments as default.

3.9 The 'small catchment' pooling procedure implemented within WINFAP has been used. This procedure selects the pooling group using a similarity measure that only considers AREA and SAAR, as recommended by SC090031.

Pooling Group Review

3.10 The pooling group was reviewed to identify sites which may be inappropriate due to being significantly hydrologically dissimilar to the study site, or if they have any inaccuracies, uncertainties, or limitations in their data record.

Adjustment for Non-Flood Years

3.11 For some catchments there are years in which no floods occur (non-flood years), and the annual maximum flow is due to baseflow alone. To avoid a bias in the flood frequency analysis in which growth factors reach an upper limit (the growth curve is bounded above), the L-moments have been adjusted to remove the influence of non-flood years (classed as annual maximum flows smaller than 0.5QMED).

3.12 The adjustment for non-flood years has been undertaken using Wallingford HydroSolutions 'WHS Non-flood Years Spreadsheet Beta v2.2'.

Urban Adjustment

3.13 Growth curves were also adjusted for to reflect the urban influence, using the methods adopted in WINFAP[4] which is based on those published by Kjeldsen 2010[5].

Choice of Distribution

3.14 In accordance with the EA FEH Guidelines, the distribution has been chosen based on which gives the best fit from Generalised Logistic (GL), Generalised Extreme Value (GEV) and Kappa 3.

3.15 The only exception to this is when a pooling group has been adjusted for non-flood years as the procedure for the adjustment uses the GL distribution.

3.16 Further detail on pooling group composition is provided in **Section 8.**

Table 3.3: Derivation of Pooling Groups: PBT001

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
PBT001_DS	No	GL	**Stations Removed:** 26016 – non-flood years over 15% of the record. Following a review of the station on the NRFA, the station was removed from the group as the watercourse is known to run dry for the part of the year and is, therefore, considered dissimilar from the subject site. 26014 - following a review of the station on the NRFA, the station was removed from the group as the watercourse is known to regularly dry up and is, therefore, considered dissimilar from the subject site. 7011 and 7012 – removed due to unusually steep growth curves which give very high 1 in 100-year growth factors (>10), which are not considered to be	L-CV: 0.275 L-Skew: 0.260

4 Wallingford HydroSolutions (2016), WINFAP 4 Urban adjustment procedures, Wallingford HydroSolutions Ltd 2016.
5 Kjeldsen, T.K., 2010. Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrology Research, volume 41, issue 5, pp391-405

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
			representative of the study catchment. 28058 – the station was noted to have a negative L-Skew value and shows the growth curve has reached a natural bound. **Stations Added:** 41020 and 39033 - added in to provide 500+ years of data. **Comments:** 49005 – station reviewed for high discordancy. No obvious explanation for this was found; the station was therefore retained. 36010 and 44008 - were flagged for non-flood years comprising over 15% of record. The catchment responses were reviewed and were not considered significantly different to that expected for the study catchment, and so the stations were retained and the adjustment for non-flood years applied. The pooling group is heterogeneous and a review of the pooling group is desirable. It is not considered possible to improve the pooling group any further.	

Table 3.4: Final Choice of Flood Growth Curves at the Subject Site

Site code	Method (SS, P, ESS)	Name of pooling group	Distribution used and reason for choice	Urban adjustment and/or non-flood years adjustment applied?	Growth factor for 1% AEP event
PBT001	P	PBT001_DS	GL distribution was chosen because it is the default distribution used	Urban adjustment and non-flood years adjustment applied within the WHS Non	3.45

Site code	Method (SS, P, ESS)	Name of pooling group	Distribution used and reason for choice	Urban adjustment and/or non-flood years adjustment applied?	Growth factor for 1% AEP event
			for the adjustment for non-flood years	Flood Years Spreadsheet Beta v2.2.	

Table 3.5: Flood Estimates from the Statistical Method

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities									
	2 (50%)	5 (20%)	10 (10%)	20 (5%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
PBT001	0.08	0.12	0.15	0.18	0.21	0.24	0.27	0.29	0.35	0.55

Note: Flow estimates are quoted to 2 decimal places to demonstrate change in flow estimates; this does not indicate a greater degree of accuracy.

4. REVITALISED FLOOD HYDROGRAPH (ReFH) METHOD

4.1 The ReFH2 Revitalised Flood Hydrograph Modelling Tool (Version 4.1) was used to undertake an estimation of the peak flows for the subject site.

Table 4.1: Overview of Parameters for ReFH2 Method

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
PBT001	Parameters calculated using catchment descriptors.				
Description of flood event analysis carried out			Flood event analysis is not possible as study catchment is ungauged.		

Table 4.2: Design Events

Site code	Rainfall DDF model	Season of design event	Storm duration	Selected interval	Initial soil moisture (Cini)	Initial baseflow (BFO)
PBT001	FEH22	Winter	5.5hrs	0.5hrs	Default value	Default value
Comments	A uniform 5.5hr winter storm will be applied at the modelling stage.					

Table 4.3: Flood Estimates from the ReFH Method (based on recommended duration for individual catchments)

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities									
	2 (50%)	5 (20%)	10 (10%)	20 (5%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
PBT001	0.08	0.11	0.14	0.16	0.18	0.20	0.23	0.24	0.29	0.45

Note: Flow estimates are quoted to 2 decimal places to demonstrate change in flow estimates; this does not indicate a greater degree of accuracy.

5. DISCUSSION AND SUMMARY OF RESULTS

Comparison of Method

5.1 A comparison of the peak flow results for the different estimation methods for the 1 in 2-year and 1 in 100-year events is provided in **Table 5.1**. Comparisons of the growth curves for both methods are shown in **Figure 5.1**.

5.2 The Statistical method provided a steeper growth curve compared to the ReFH2 method. The Statistical method also provided higher peak flows for all return periods.

Table 5.1: Comparison of Results

Site code	1 in 2-year peak flows (50% Annual Exceedance Probability)			1 in 100-year peak flows (1% Annual Exceedance Probability)		
	Statistical	ReFH	Ratio	Statistical	ReFH	Ratio
PBT001	0.08	0.08	1.06	0.29	0.24	1.20

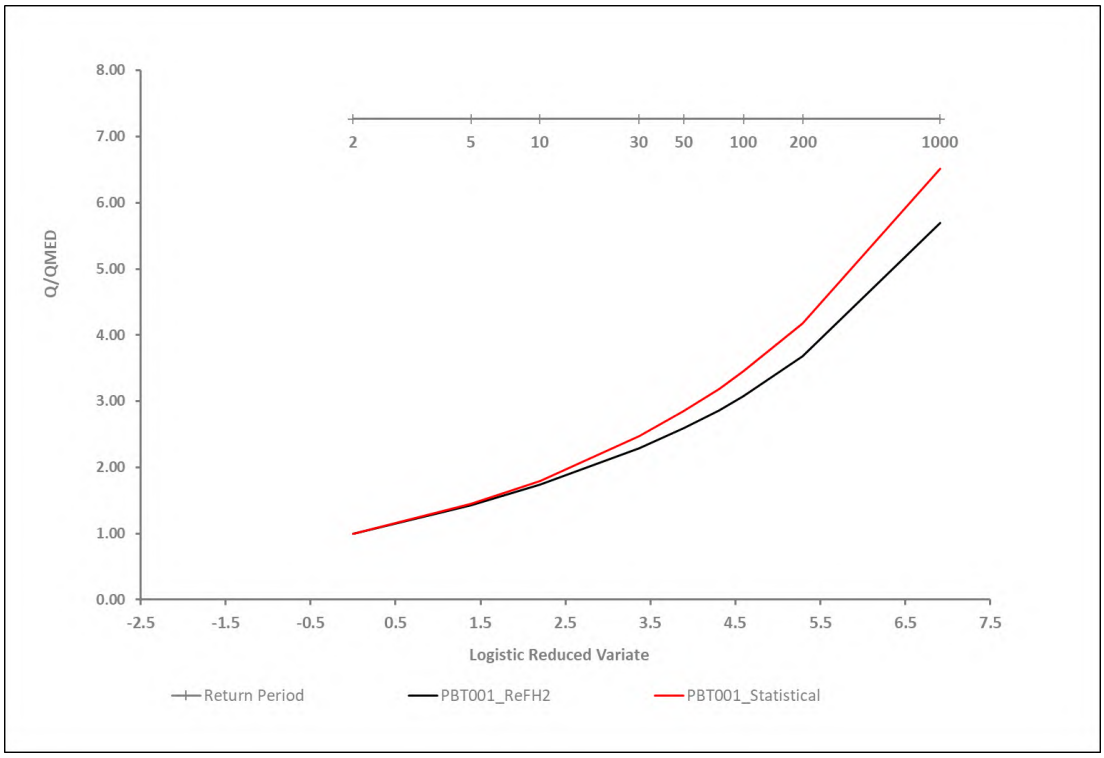

Figure 5.1: Comparison of Statistical method and ReFH Growth Curves

Final Method and Flows

Table 5.2: Final Choice of Method

Choice of method and justification	The final choice of peak flows for input into the model is the Statistical method, in line with EA FEH Guidelines recommendation that it is normally a more appropriate choice for groundwater-dominated catchments. The Statistical method benefits from an up-to-date peak flood dataset, using growth curves from hydrologically similar catchments to derive a growth curve. Flow estimates have been improved by utilising a catchment with similar characteristics for the QMED adjustment. In the absence of any suitable observed data with which to derive a hydrograph shape, ReFH2 will be used to provide a hydrograph shape for the model inflows, scaled to the Statistical peak. **Section 6** describes how flows will be applied to the model.

Table 5.3: Final Peak Flows from Chosen Method (Statistical)

Site Code	Flood peak (m^3/s) for the following return periods / Annual Exceedance Probabilities									
	2 (50%)	5 (20%)	10 (10%)	20 (5%)	30 (3.33%)	50 (2%)	75 (1.33%)	100 (1%)	200 (0.5%)	1000 (0.1%)
PBT001	0.08	0.12	0.15	0.18	0.21	0.24	0.27	0.29	0.35	0.55

Note: Flow estimates are quoted to 2 decimal places to demonstrate change in flow estimates; this does not indicate a greater degree of accuracy.

Table 5.4: Assumptions, Limitations and Uncertainty

List the main assumptions made	• The pooling groups are representative of the catchments. • The ReFH2 hydrograph shape is representative of the catchment response. • Tp and storm duration are representative of the catchment response. • The revised catchment boundary accurately reflects the actual catchment boundary. • The flow estimate derived at the downstream model extent is applicable to the catchment at the upstream model extent. • There are no swallow-holes or springs within the catchment and the groundwater catchment corresponds to the topographical catchment. • DPLBAR is representative of the amended catchment boundary.
Discuss any limitations e.g. applying methods outside the range of catchment types or return periods for which they were developed	• The FEH Statistical and ReFH2 methods are believed to be suitable up to the 1 in 200-year event. Estimates of flow beyond these events are extrapolations and, therefore, have a higher level of uncertainty. • There are only a small number of gauged sites in the UK. As such the representation in the pooling group is not

	ideal given the small size of some of the study catchments. • There is no observed flow data within the catchment with which to verify the flow estimates. • The FEH regression equation for QMED can result in overestimates on groundwater-dominated catchments. However, the calculated QMED value has been improved using donor transfer and appear sensible for the size and characteristics of the catchment. • The adjustment for non-flood years methodology uses a GL distribution. However, WINFAP showed a Kappa 3 distribution provided a better fit.
Give what information you can on uncertainty in the results	According to Table 2 of the EA FEH Guidelines, confidence intervals for the 1 in 100-year event for a rural catchment ($URBEXT_{2000}$ < 0.03) when calculated from catchment descriptors are quoted as 0.45-2.23 (for the 95% confidence interval). Confidence is improved when using observed data from a donor site. When one donor is used in the assessment, the confidence intervals changes to 0.47-2.12 (for the 95% confidence interval). It is more difficult to quantity uncertainty in design flows estimated from the ReFH rainfall-runoff model. However, evidence[6] suggests the factorial standard errors from ReFH2 are comparable to those observed for the FEH pooled Statistical method when the catchment is treated as ungauged.
Comment on the suitability of the results for future studies	The design flow estimates have been derived for the purpose of providing flow hydrographs for a hydraulic model to support a planning application. Prior to use in future different studies, these results should, at minimum, be reviewed to assess their suitability for the purpose of the study.
Give any other comments on the study	While the installation of temporary flow gauges would provide local data which may better inform the design peak flows and hydrograph shapes, this would not align with the scope and timescales of this project.

Table 5.5: Checks

Are the results consistent?	The peak flows are consistent with the size and characteristics of the catchment.
What do the results imply regarding the return periods of floods during the period of record?	It is not possible to imply return periods of floods due to the lack of gauged data within the study catchment and insufficient information on any historical flooding events.
What is the 1 in 100-year growth factor? (the guidance	Statistical Method: 3.45 ReFH2: 3.07

[6] Wallingford Hydrosolutions (2019) ReFH2 Science Report: Evaluation of the Rural Design Event Model.

suggests a typical range or 2.1 to 4.0)	Growth factors are within the typical range.
If 1 in 1000-year flows have been derived, what is the range of ratios for 1 in 1000-year flow over 1 in 100-year flow?	Statistical Method: 1.89 ReFH2: 1.85
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred	There are no previous studies with which to compare results.
Are the results consistent with the longer-term flood history?	There is no long-term flood record for the catchment with which to compare the modelled results to.
Describe any other checks on the results	Sensibility checks of modelled outlines will be undertaken at the modelling stage.

6. APPLICATION OF FLOWS TO MODEL

6.1 Flows will be applied to the model in the following way.

i. To derive the hydrographs, the ReFH2 hydrographs were scaled to meet the Statistical Method peak flows.

ii. Flows will be applied as a point inflow at the upstream extent of the modelled watercourse.

6.2 The proportion of the hydrograph applied at each inflow, as well as the type of inflow, is shown in **Table 6.1. Figure 6.1** demonstrates how the flows will be applied to the model.

Table 6.1: Hydrograph Proportions

Sub Catchment	Type of inflow	Proportion of Hydrograph
PBT001 Inflow	Point	100%

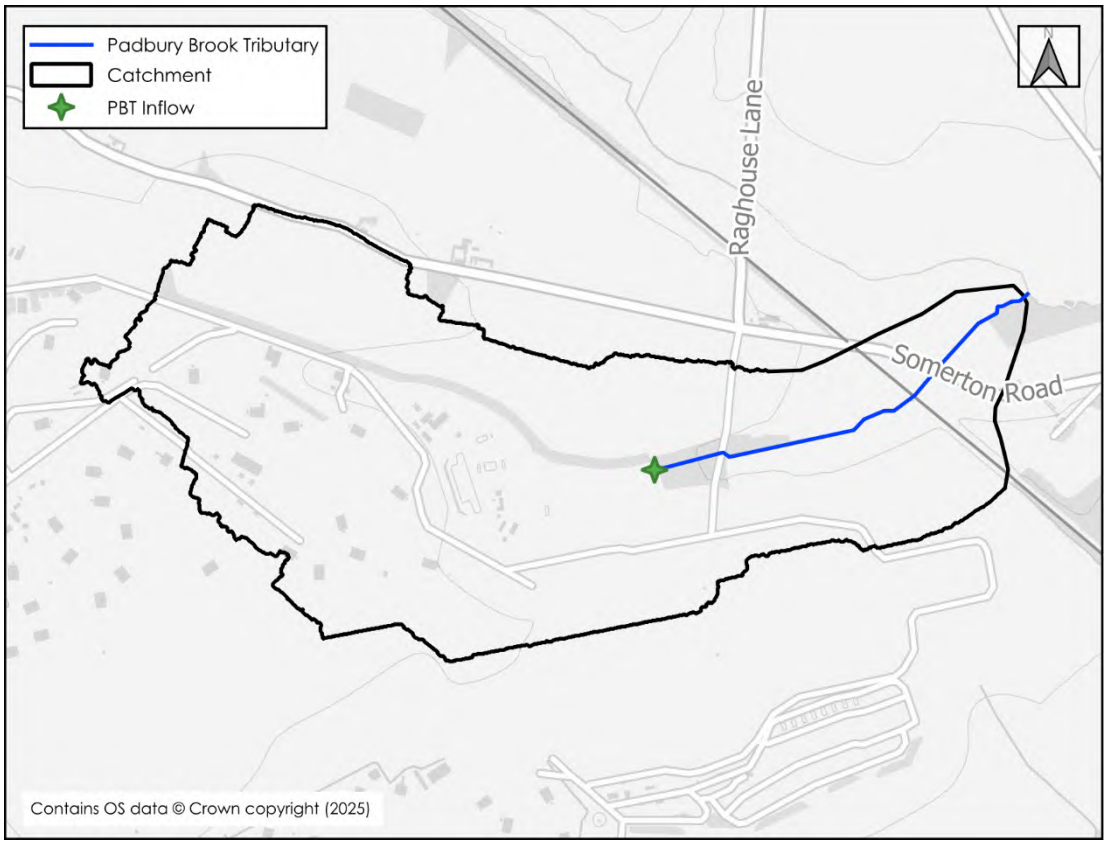

Figure 6.1: Application of Inflows into Model

7. FLOOD HISTORY

Flood History

7.1 A flood history review has been undertaken for the catchment. **Table 7.1** sets out the findings from this review.

Table 7.1: Flood History Review

Data Source	Flood Event Details
Strategic Flood Risk Assessments (SFRA)	No flood history relevant to the catchment was found within the Cherwell District Council Level 1[7] or Level 2[8] SFRAs.
EA Recorded Flood Outlines	There are no EA recorded flood outlines within the catchment.
Section 19 Flood Investigations	Oxfordshire County Council have produced 41 Section 19 Flood Investigation Reports; however, there are no records of flood investigations with the catchment.
British Chronology of Hydrological Events	No flood history relevant to the catchment was found.
Online News Articles	No flood history relevant to the catchment was found.
Other Sources	No additional records of historical flooding has been identified.

[7] Level 1 Strategic Flood Risk Assessment (Wallingford HydroSolutions, March 2025)
[8] Level 2 Strategic Flood Risk Assessment (Wallingford HydroSolutions, October 2024)

8. DETAILED POOLING GROUP INFORMATION

Table 8.1: Default Pooling Group: PBT001_DS

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.268	43	0.812	0.213	0.032	0.995
76011 (Coal Burn @ Coalburn)	1.393	46	1.826	0.170	0.296	1.359
27051 (Crimple @ Burn Bridge)	1.437	51	4.564	0.217	0.141	0.440
26016 (Gypsey Race @ Kirby Grindalythe)	1.819	26	0.100	0.318	0.253	0.168
25019 (Leven @ Easby)	1.849	45	5.090	0.342	0.372	0.098
45816 (Haddeo @ Upton)	2.016	30	3.352	0.289	0.407	0.395
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.194	13	4.072	0.275	0.294	3.548
27010 (Hodge Beck @ Bransdale Weir)	2.213	41	9.420	0.224	0.293	0.542
36010 (Bumpstead Brook @ Broad Green)	2.260	56	7.855	0.350	0.106	1.885
44008 (South Winterbourne @ Winterbourne Steepleton)	2.297	32	0.572	0.406	0.254	0.955
7009 (Mosset Burn @ Wardend Bridge)	2.302	25	7.053	0.365	0.329	0.144
28033 (Dove @ Hollinsclough)	2.337	48	4.138	0.235	0.367	0.892
26014 (Water Forlornes @ Driffield)	2.363	25	0.424	0.319	0.204	0.342
7011 (Black Burn @ Pluscarden Abbey)	2.500	11	4.298	0.495	0.580	1.383
7012 (Lossie @ Ballachraggan)	2.523	9	7.262	0.488	0.670	1.854
27073 (Brompton Beck @ Snainton Ings)	1.268	43	0.812	0.213	0.032	0.995
Total		501				
Weighted Means				0.303	0.282	
H2 value	3.6786					

Goodness of Fit	Generalised Logistic	General Extreme Value	Kappa 3
	1.6679	0.2152	1.1872

Table 8.2: Final Pooling group (adjusted for non-flood years): PBT001_DS

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.268	43	0.812	0.213	0.032	1.461
76011 (Coal Burn @ Coalburn)	1.393	46	1.826	0.170	0.296	0.951
27051 (Crimple @ Burn Bridge)	1.437	51	4.564	0.217	0.141	0.572
25019 (Leven @ Easby)	1.849	45	5.090	0.342	0.372	0.463
45816 (Haddeo @ Upton)	2.016	30	3.352	0.289	0.407	0.574
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.194	13	4.072	0.275	0.294	2.754
27010 (Hodge Beck @ Bransdale Weir)	2.213	41	9.420	0.224	0.293	0.283
36010 (Bumpstead Brook @ Broad Green)	2.260	56	7.855	0.350	0.106	1.623
44008 (South Winterbourne @ Winterbourne Steepleton)	2.297	32	0.572	0.406	0.254	1.27
7009 (Mosset Burn @ Wardend Bridge)	2.302	25	7.053	0.365	0.329	0.524
28033 (Dove @ Hollinsclough)	2.337	48	4.138	0.235	0.367	0.620
41020 (Bevern Stream @ Clappers Bridge)	2.550	54	13.78	0.200	0.162	0.778

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
39033 (Winterbourne Stream @ Bagnor)	2.626	61	0.399	0.337	0.377	1.126
Total		545				
Weighted Means				0.275	0.260	
H2 value	3.4029					

Goodness of Fit	Generalised Logistic	General Extreme Value	Kappa 3
	0.477	-0.8848	0.0216

Adjusted L-Moments following Adjustment for Non-Flood Years

Station	Adjusted L-CV	Adjusted L-Skew
27073 (Brompton Beck @ Snainton Ings)	0.199	0.066
76011 (Coal Burn @ Coalburn)	0.170	0.296
27051 (Crimple @ Burn Bridge)	0.209	0.158
25019 (Leven @ Easby)	0.327	0.404
45816 (Haddeo @ Upton)	0.284	0.421
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	0.275	0.294
27010 (Hodge Beck @ Bransdale Weir)	0.220	0.306
36010 (Bumpstead Brook @ Broad Green)	0.287	0.174
44008 (South Winterbourne @ Winterbourne Steepleton)	0.450	0.134
7009 (Mosset Burn @ Wardend Bridge)	0.353	0.335
28033 (Dove @ Hollinsclough)	0.228	0.397
41020 (Bevern Stream @ Clappers Bridge)	0.187	0.208
39033 (Winterbourne Stream @ Bagnor)	0.309	0.440

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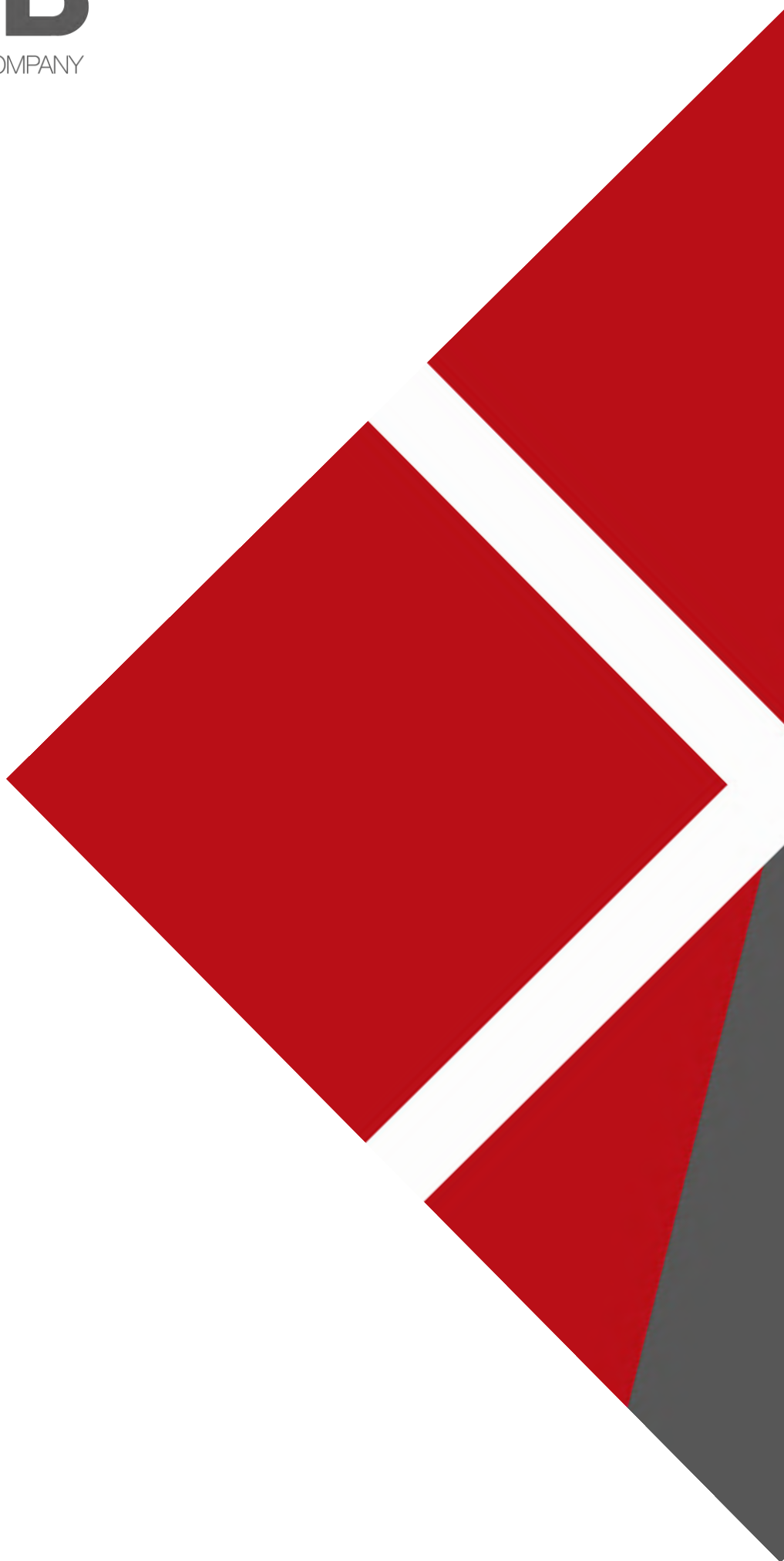

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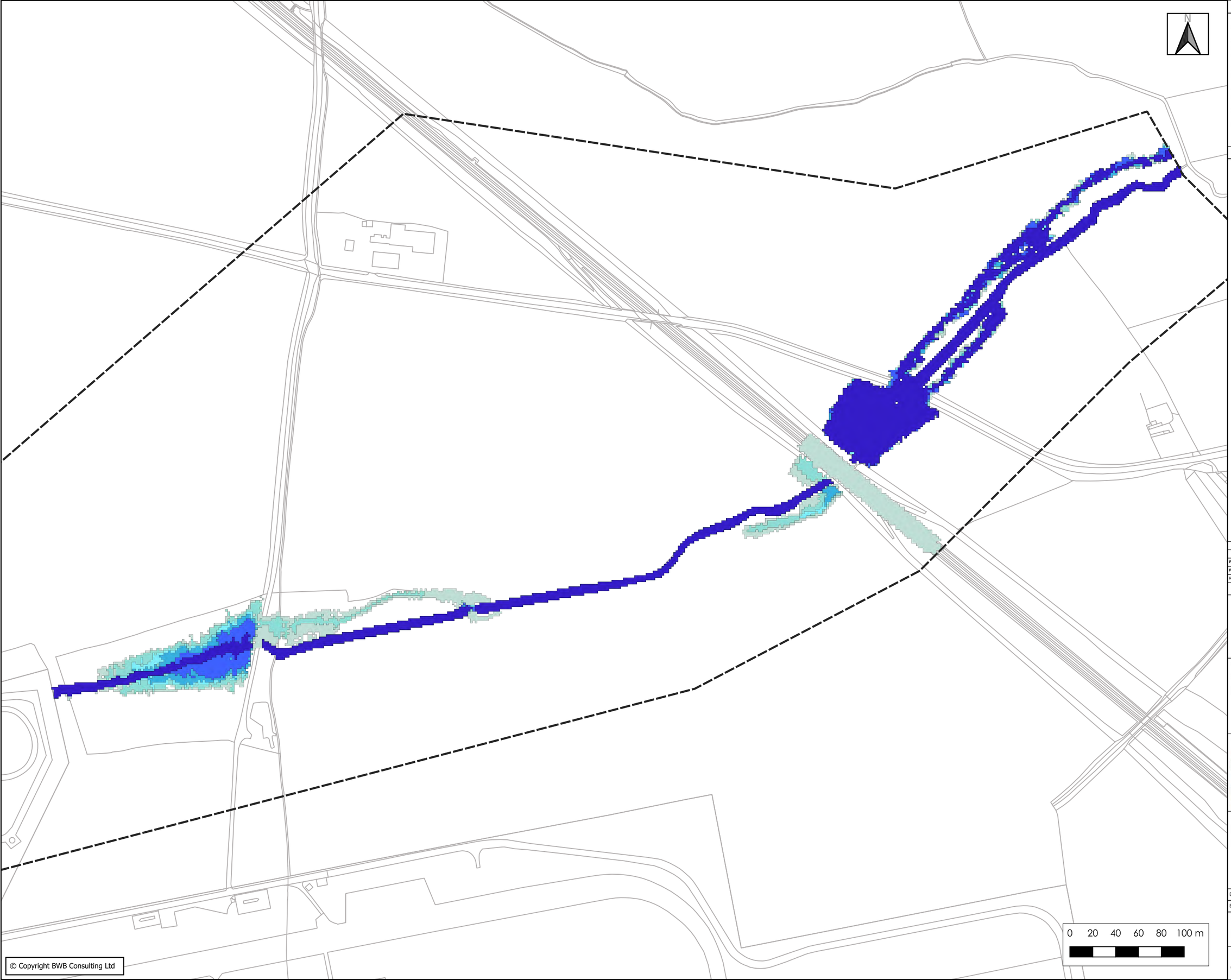
Appendix 3: Table of Hydraulic Structures

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
PBT_01053	**Description:** Wooden Bridge **NGR:** 452549, 227418 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 119.00m AOD **Downstream Invert Level:** 119.02m AOD **Length:** 1m **Manning's N:** 0.04 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PBT_01044	**Description:** Wooden Bridge **NGR:** 452556, 227418 **Domain:** 1D ESTRY **Unit Type:** Bridge Weir **Upstream Invert Level:** 119.05m AOD **Downstream Invert Level:** 119.08m AOD **Length:** 1m **Manning's N:** 0.04 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PBT_00979	**Description:** Unnamed Road Culvert **NGR:** 452627, 227428 **Domain:** 1D ESTRY **Unit Type:** Circular Conduit **Dimensions:** 0.385 **Upstream Invert Level:** 118.34m AOD **Downstream Invert Level:** 118.19m AOD **Length:** 9.2m **Manning's N:** 0.015 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PBT_0779	**Description:** Farm Crossing Culvert **NGR:** 452815, 227461 **Domain:** 1D ESTRY **Unit Type:** Circular Conduit **Dimensions:** 0.361 **Upstream Invert Level:** 116.71m AOD **Downstream Invert Level:** 116.63m AOD **Length:** 6.2m **Manning's N:** 0.015 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	Not Available

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
PBT_00427	**Description:** Railway Culvert **NGR:** 453139, 227584 **Domain:** 1D ESTRY **Unit Type:** Circular Conduit **Dimensions:** 0.607 **Upstream Invert Level (Surveyed):** 114.73m AOD **Upstream Invert of Siphon (Assumed):** 113.20m AOD **Downstream Invert Level:** 114.59m AOD **Length:** 23.7m **Manning's N:** 0.015 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	
PBT_00324	**Description:** Somerton Road Culvert **NGR:** 453190 , 227656 **Domain:** 1D ESTRY **Unit Type:** Circular Conduit **Dimensions:** 0.260 **Upstream Invert Level:** 114.29m AOD **Downstream Invert Level:** 114.40m AOD **Length:** 11.2m **Manning's N:** 0.015 **Blockage:** 0% **Spill/Bypass:** Modelled in 2D domain	

Appendix 4: Baseline Floodplain Maps



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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- 1 in 30-Year
- 1 in 100-Year
- 1 in 100-Year + 19%CC
- 1 in 100-Year + 30%CC
- 1 in 100-Year + 58%CC
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Drawing Title

Baseline Model Floodplain Extents

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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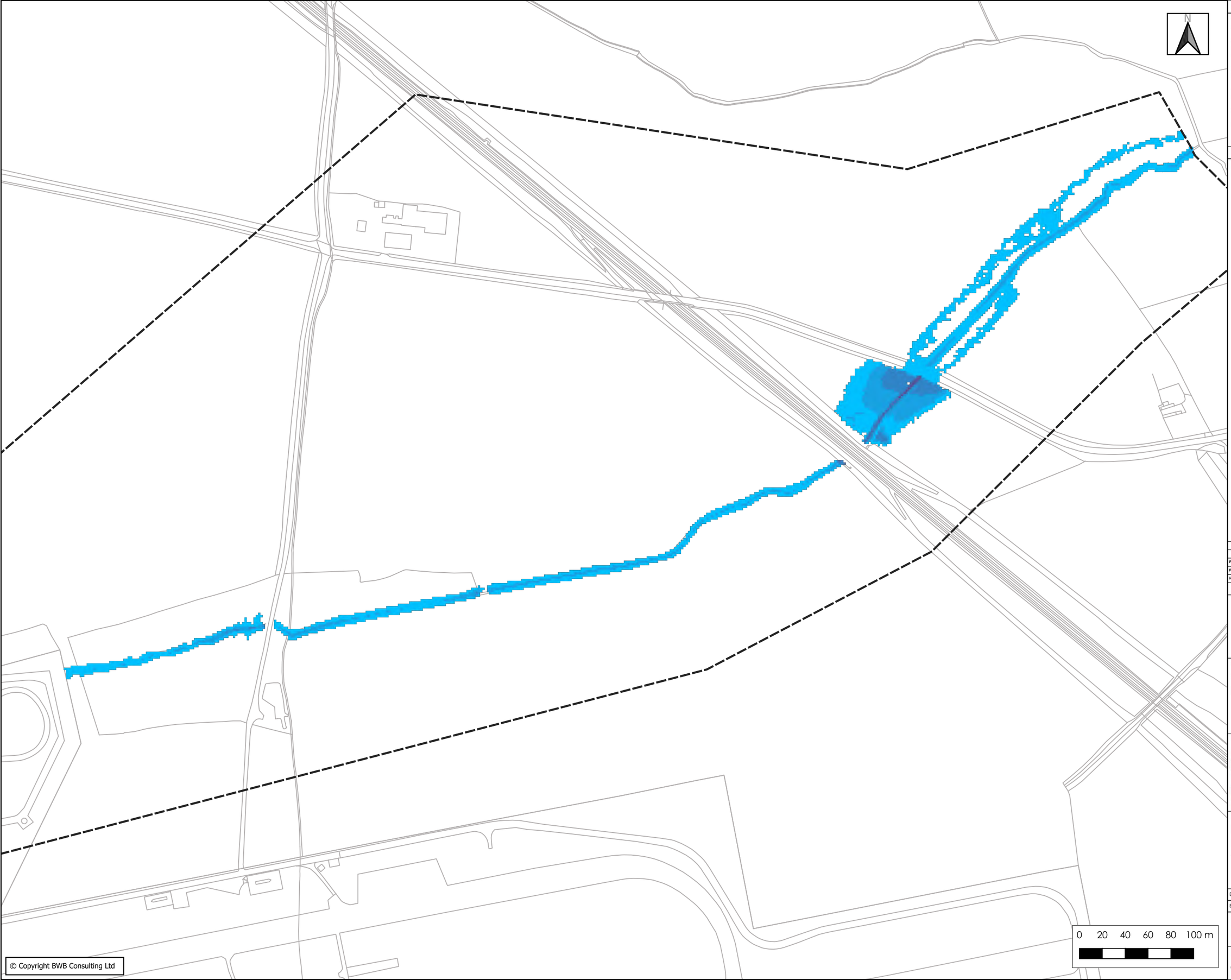

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Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Baseline Modelled Flood Depths 1 in 30-Year

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BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

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N

0 20 40 60 80 100 m

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Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Baseline Modelled Flood Depths 1 in 100-Year

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Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 20 40 60 80 100 m

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Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Drawing Title

Baseline
Modelled Flood Depths
1 in 100-Year + 19%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

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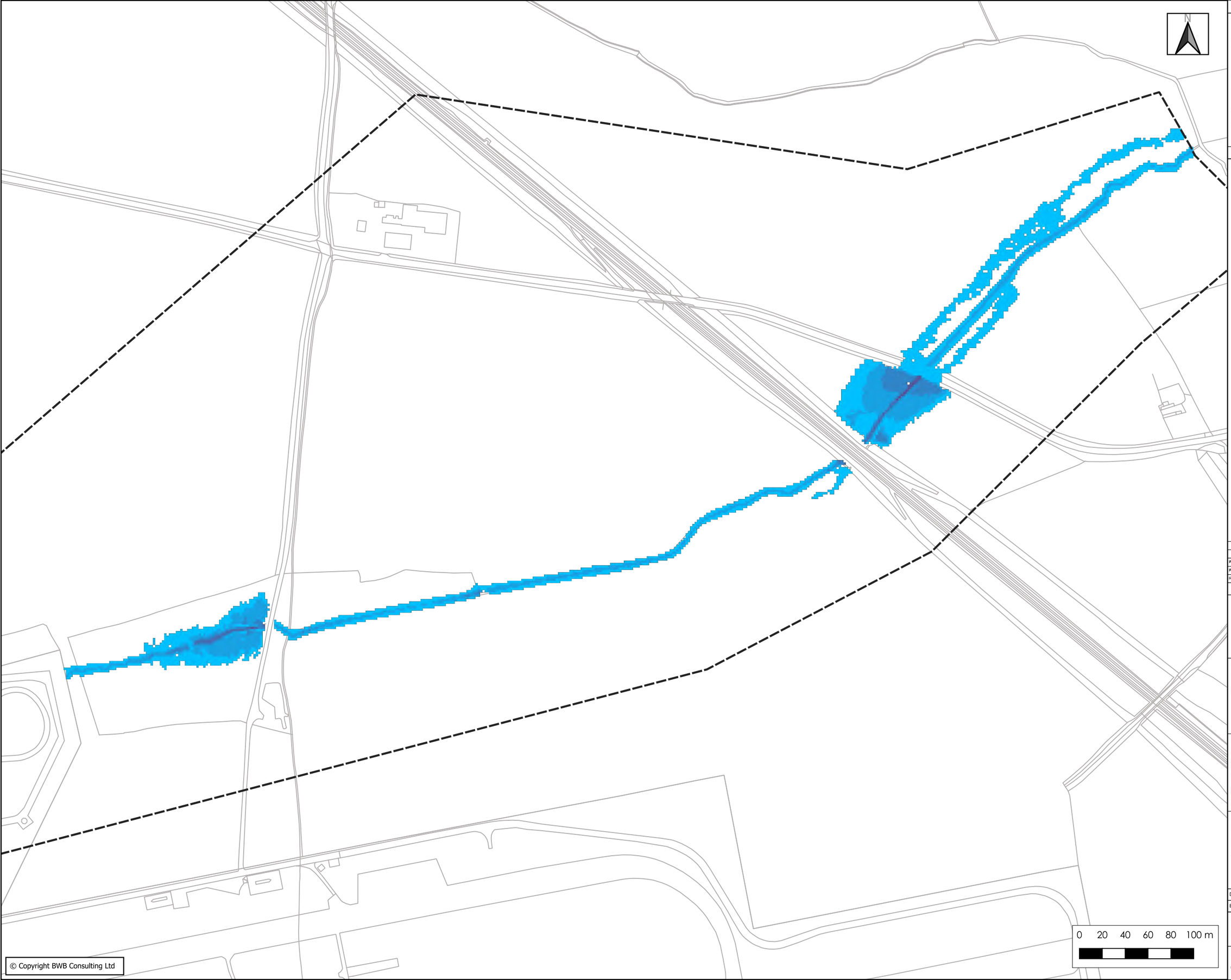

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Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Drawing Title

Baseline Modelled Flood Depths 1 in 100-Year + 30%CC

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Drawing Status

PRELIMINARY

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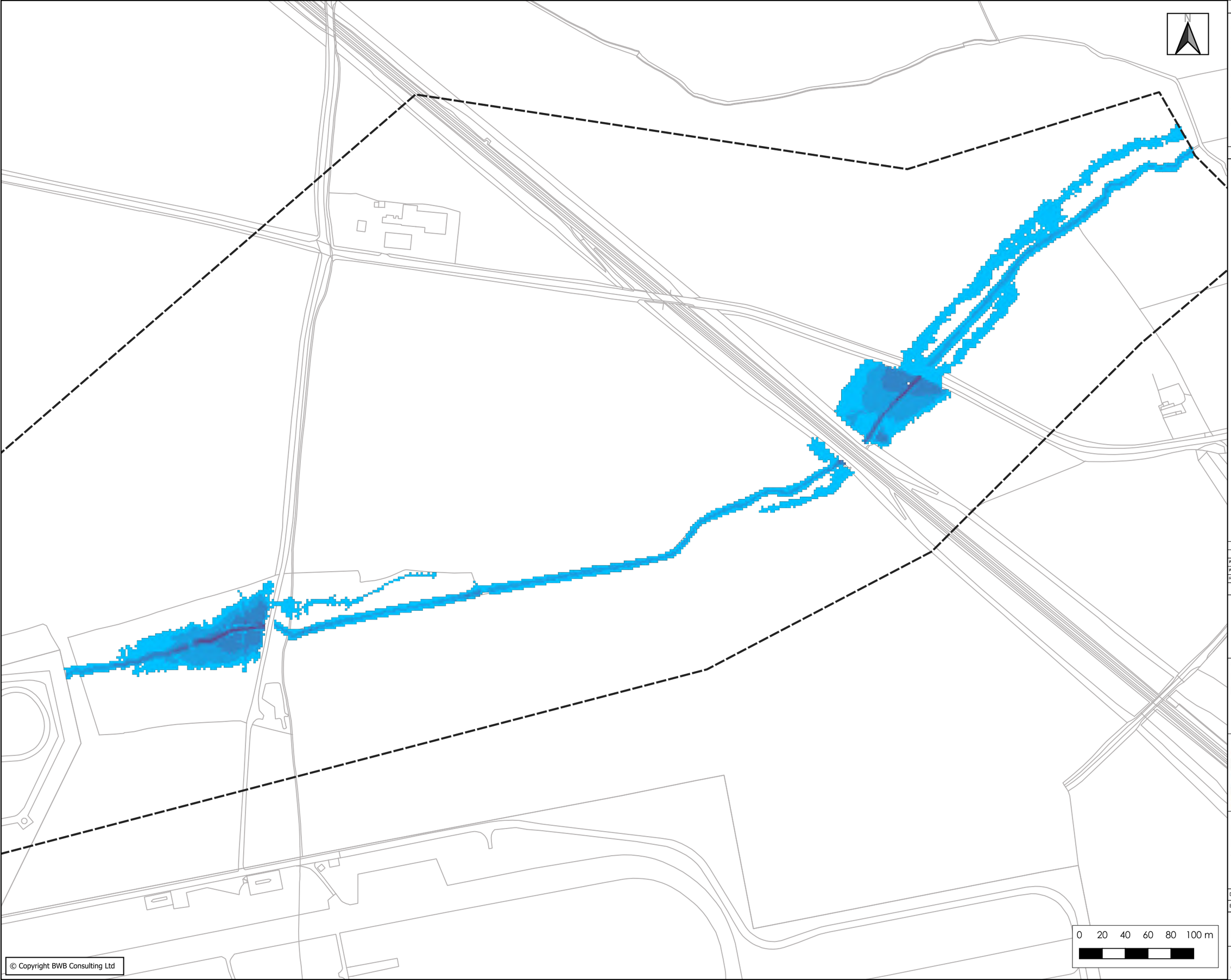

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

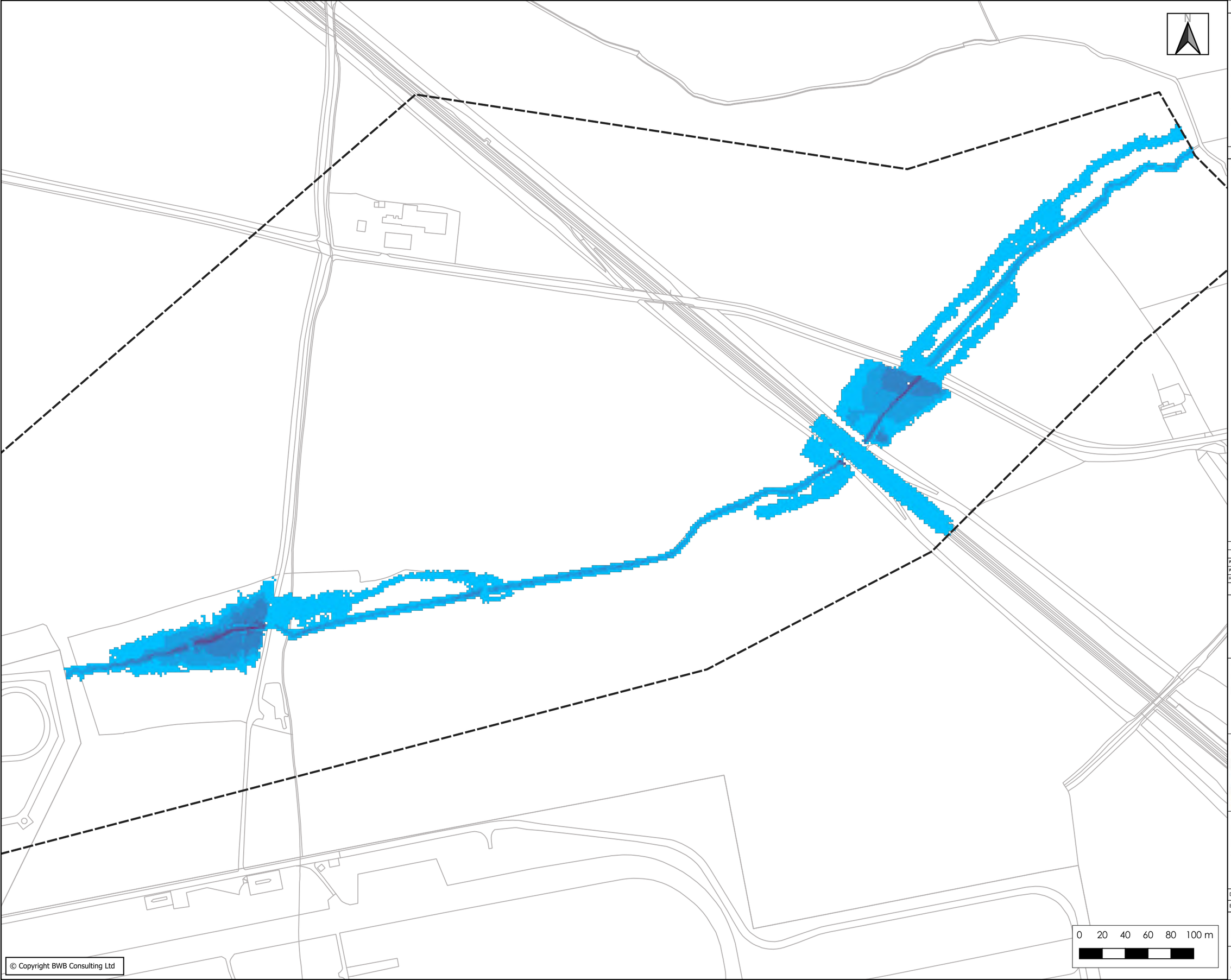
Baseline Modelled Flood Depths 1 in 100-Year + 58%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1206	S2	P02



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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	30.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Baseline Modelled Flood Depths 1 in 1000-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1207	S2	P02

Appendix 5: Proposed Floodplain Maps

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- 1 in 30-Year
- 1 in 100-Year
- 1 in 100-Year + 19%CC
- 1 in 100-Year + 30%CC
- 1 in 100-Year + 58%CC
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Project Title

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OXFORDSHIRE
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Drawing Title

Proposed Model Floodplain Extents

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 20 40 60 80 100 m

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P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 30-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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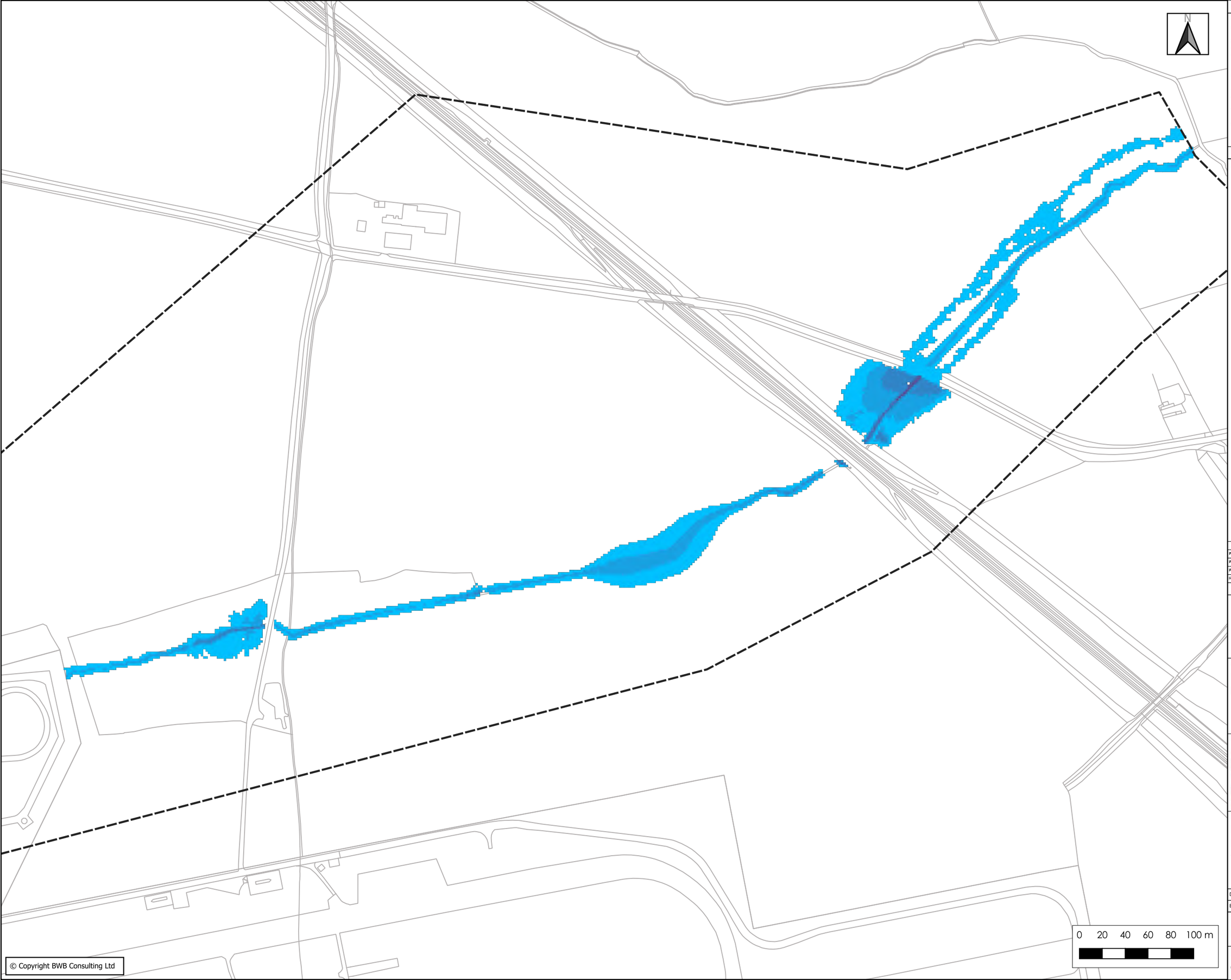

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

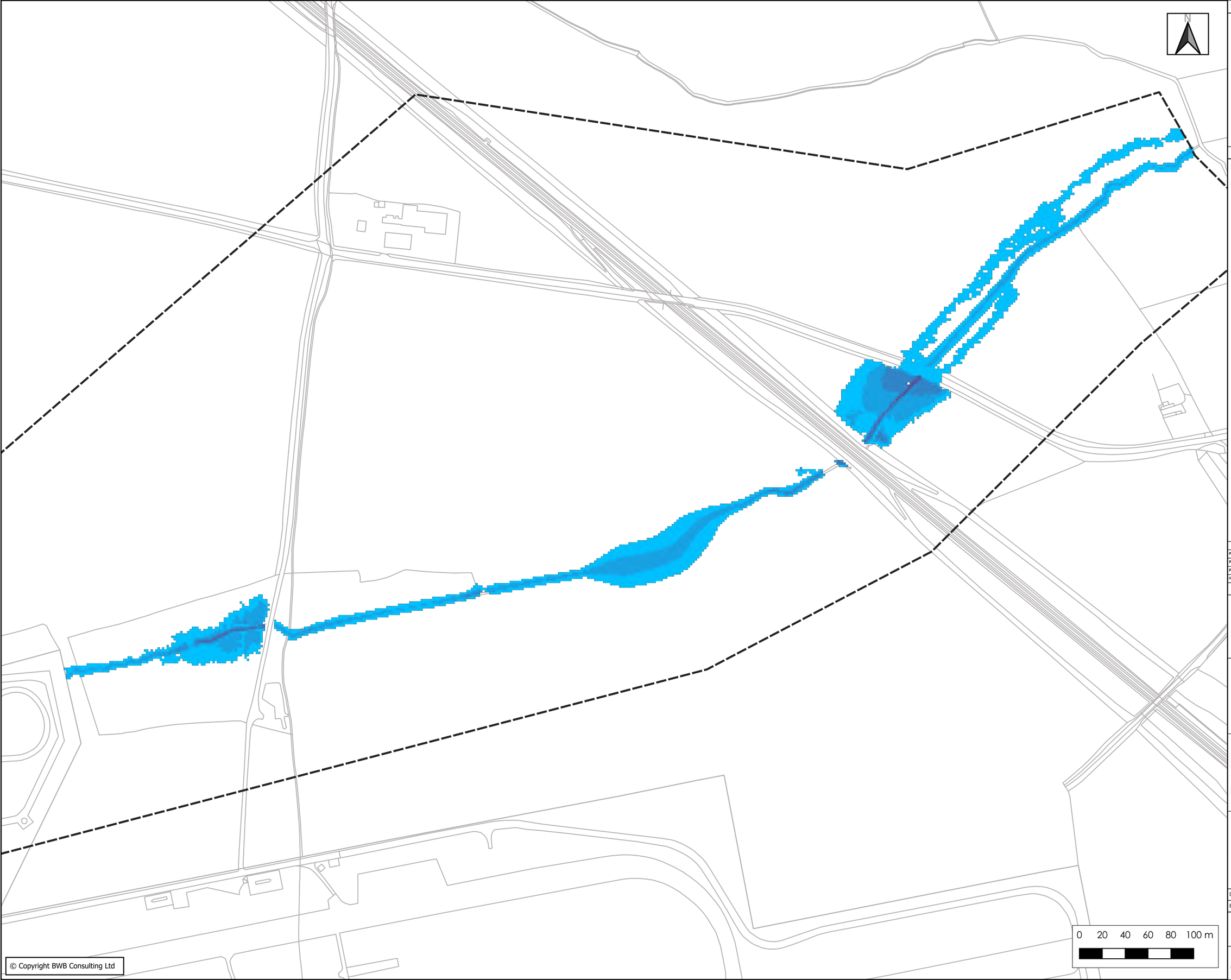
Proposed Modelled Flood Depths 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1223	S2	P03



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Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
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Client

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Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year + 19%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
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Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year + 30%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1225	S2	P03

0 20 40 60 80 100 m

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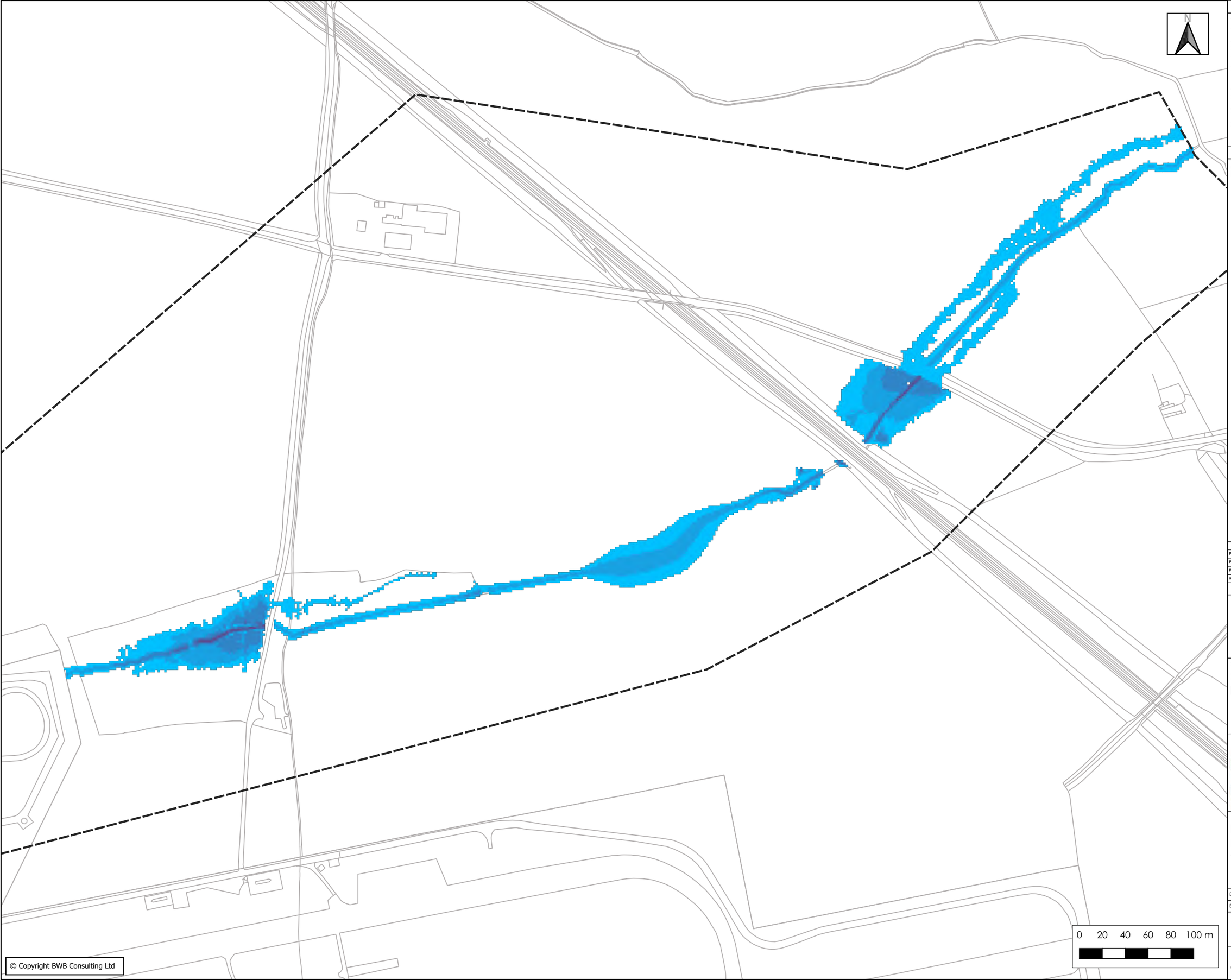

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5. Model not yet peer reviewed.

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Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

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Project Title

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 100-Year + 58%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

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5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

Model Domain

Modelled Flood Depths

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

0 20 40 60 80 100 m

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Modelled Flood Depths 1 in 1000-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

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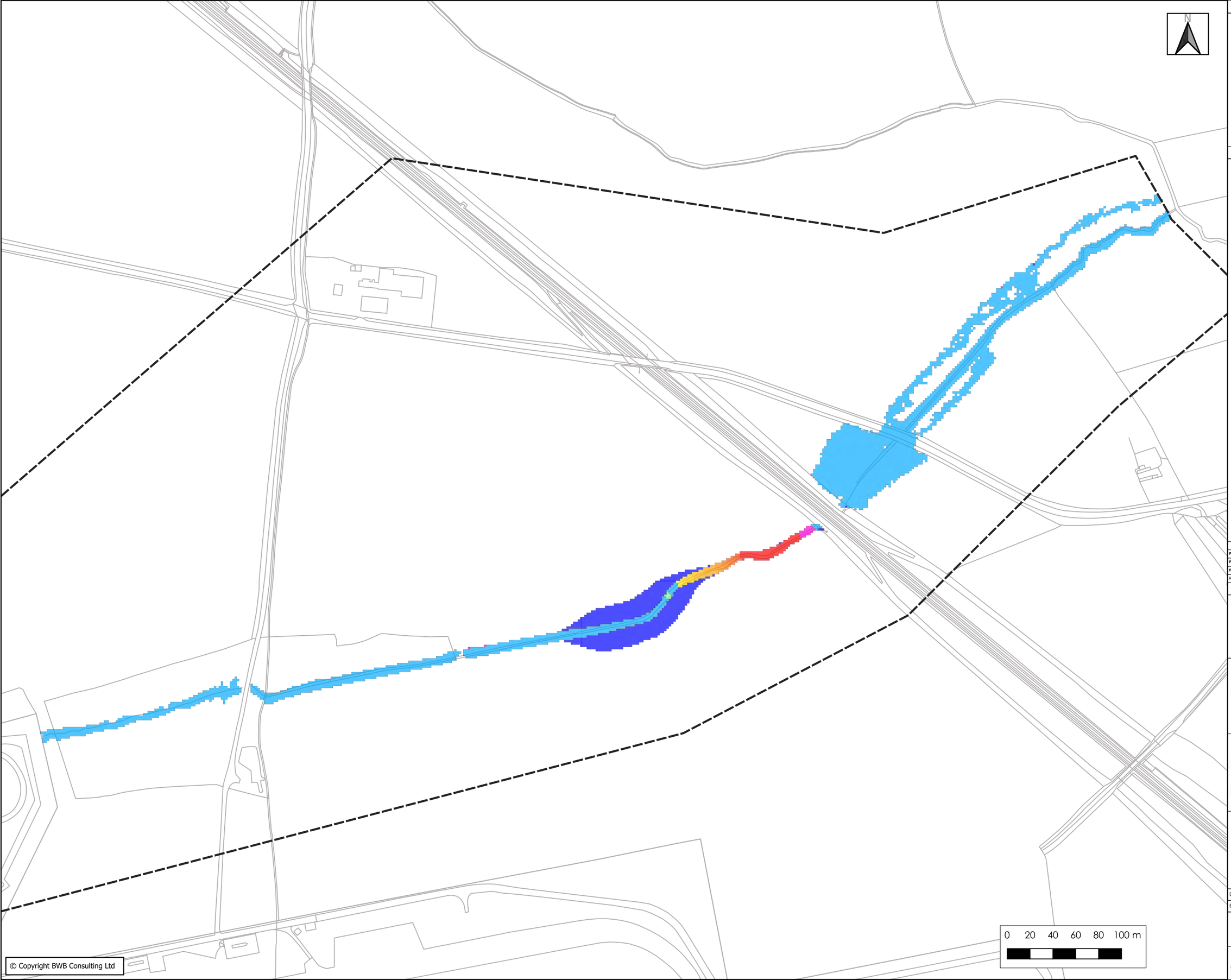
Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1227	S2	P03

Appendix 6: Comparison Mapping



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5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

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P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 30-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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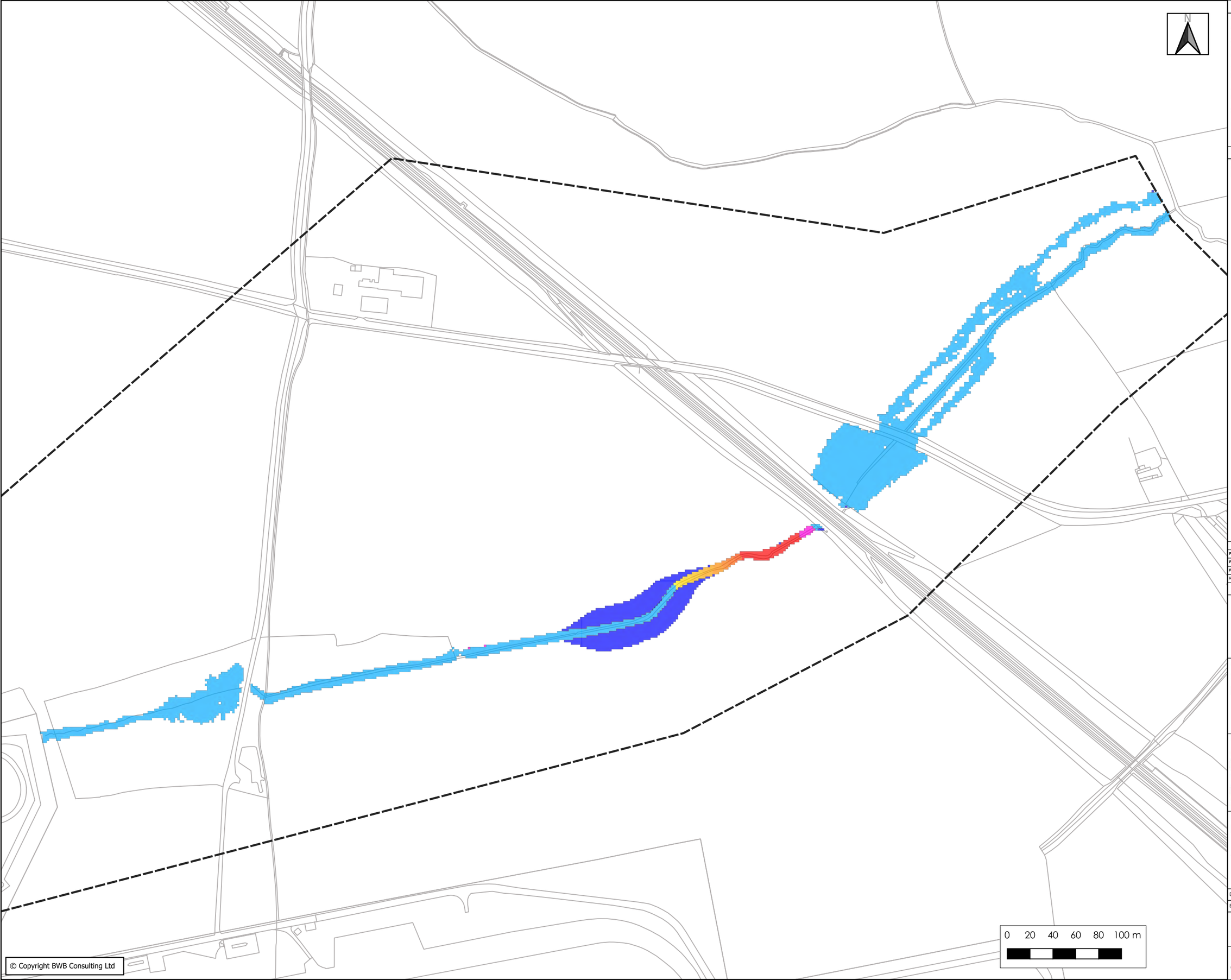

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1229	S2	P03

Notes

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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

0 20 40 60 80 100 m

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P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

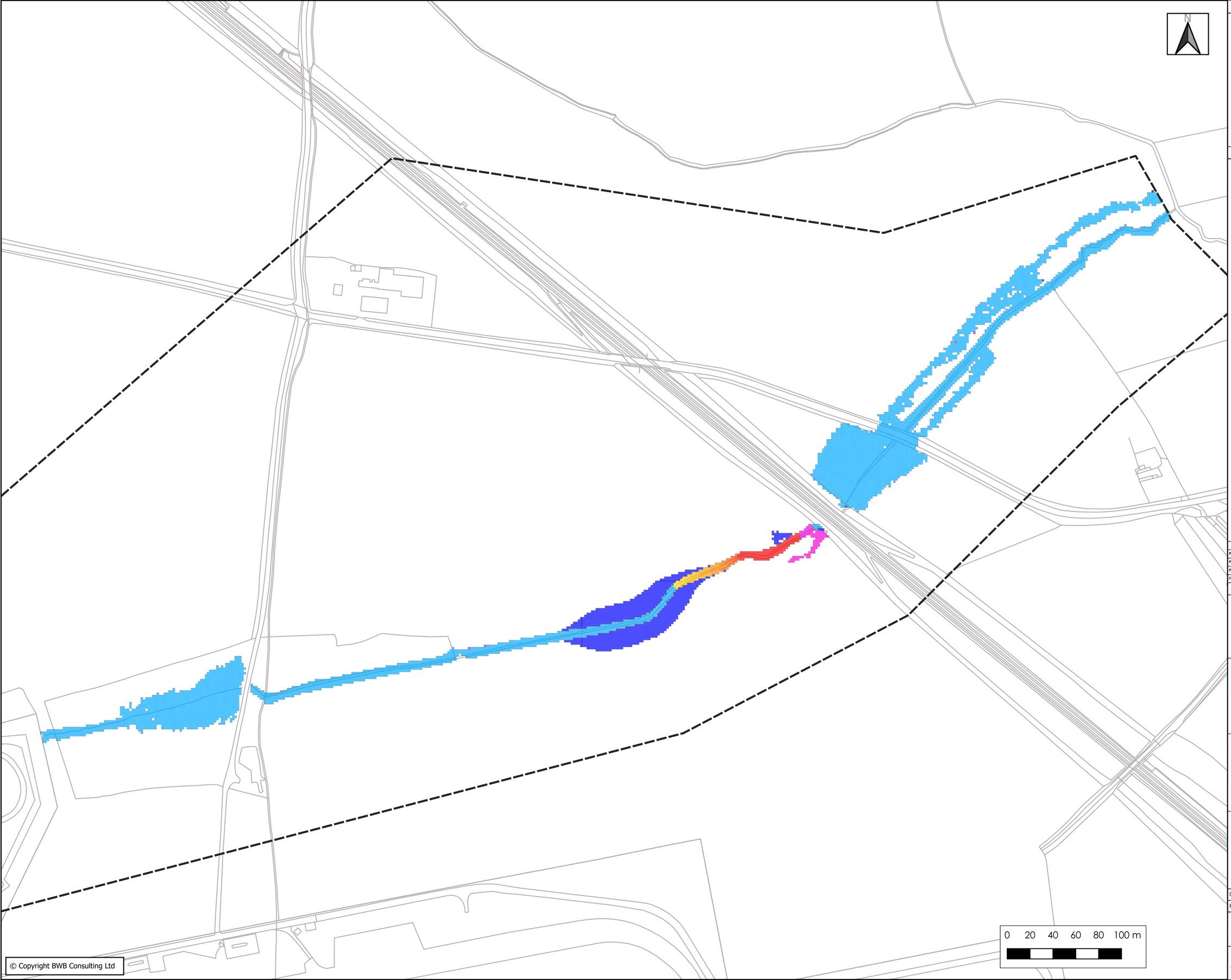
Proposed Impact Analysis 1 in 100-Year + 19%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3: 1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1230	S2	P03



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Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

Issues & Revisions

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

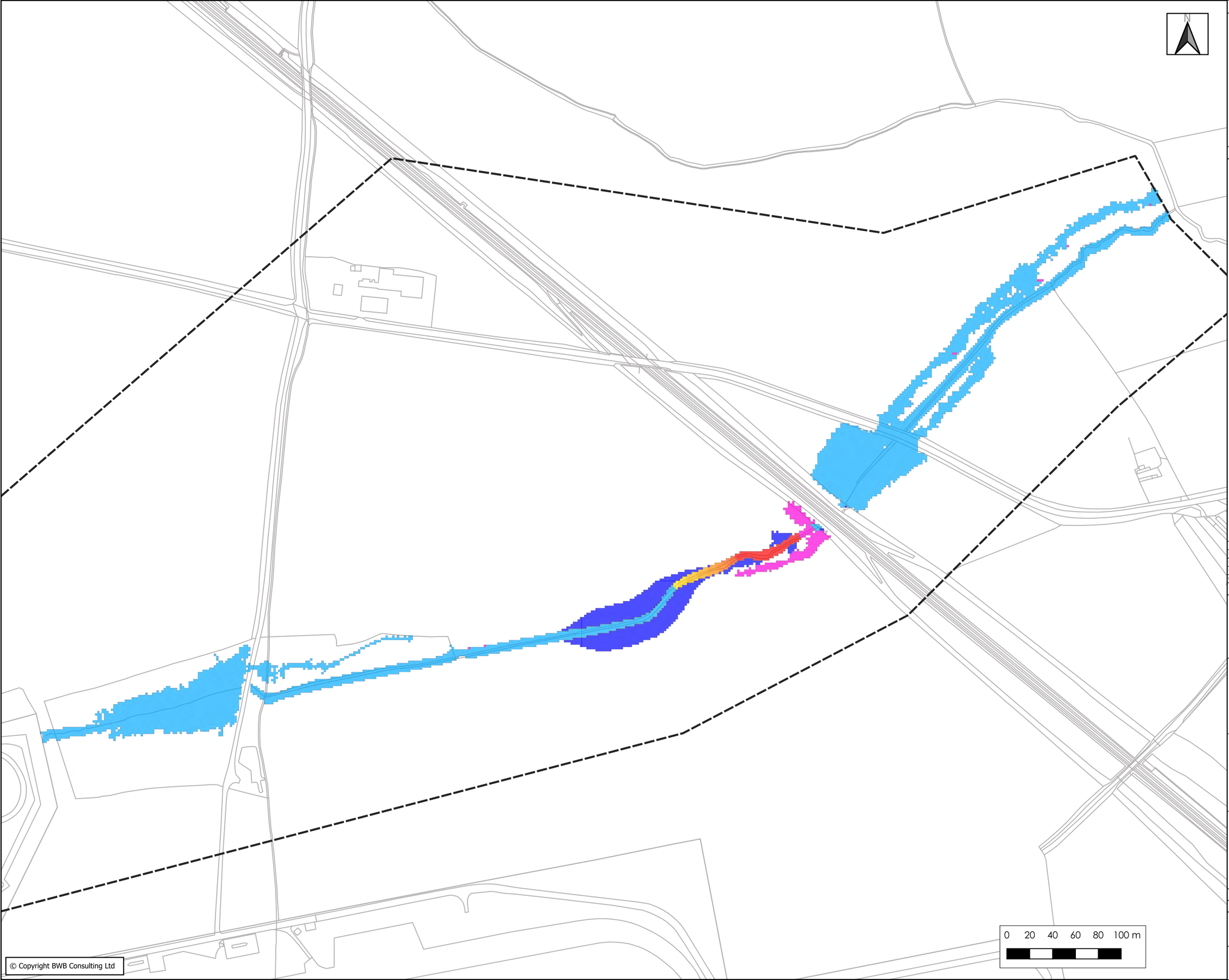
Proposed Impact Analysis 1 in 100-Year + 30%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1231	S2	P03



Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 100-Year + 58%CC

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1232	S2	P03

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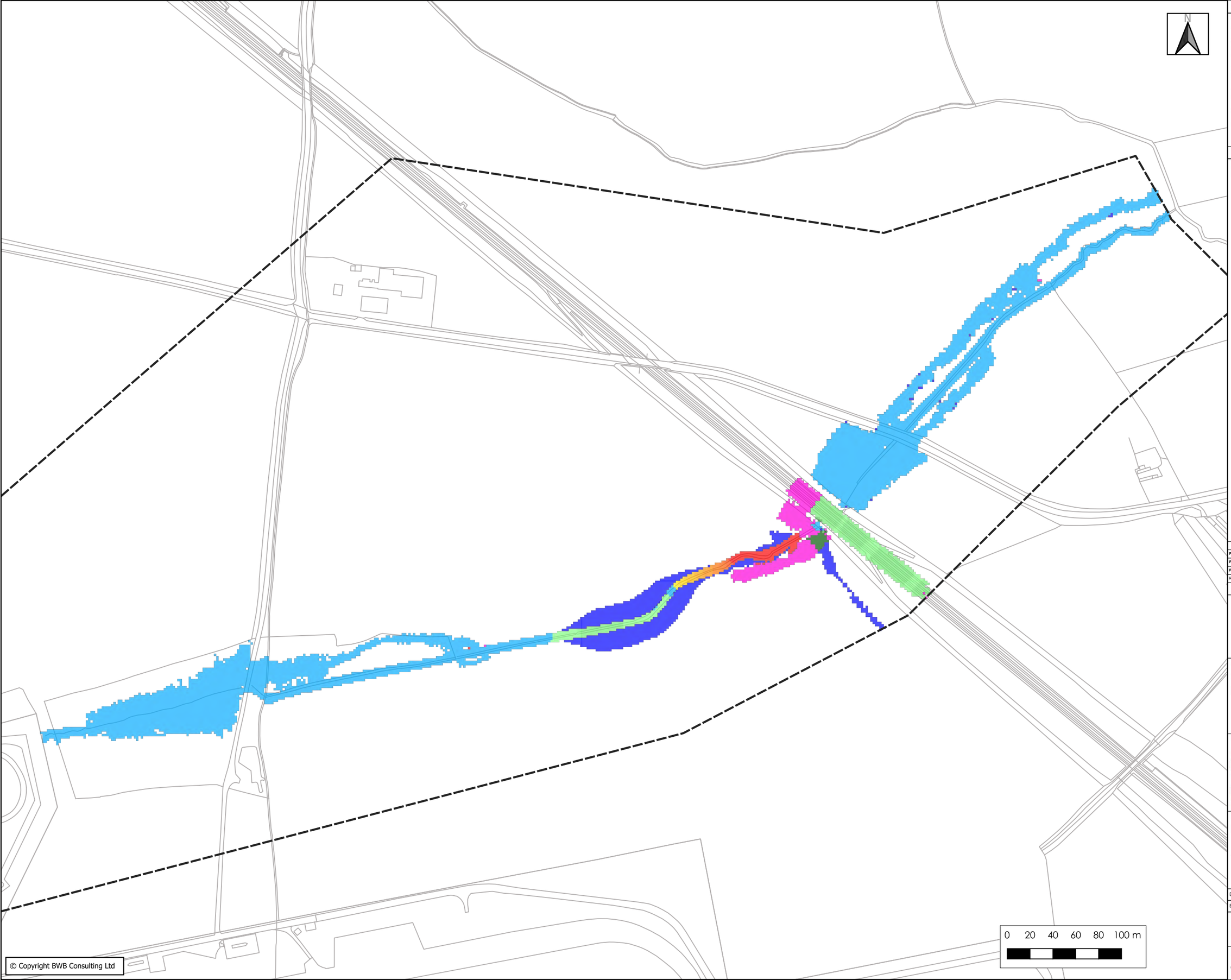

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. Contains OS data © Licence no. 100019980

Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P03	28.08.25	UPDATED MODEL RESULTS	MN	SR
P02	31.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Proposed Impact Analysis 1 in 1000-Year

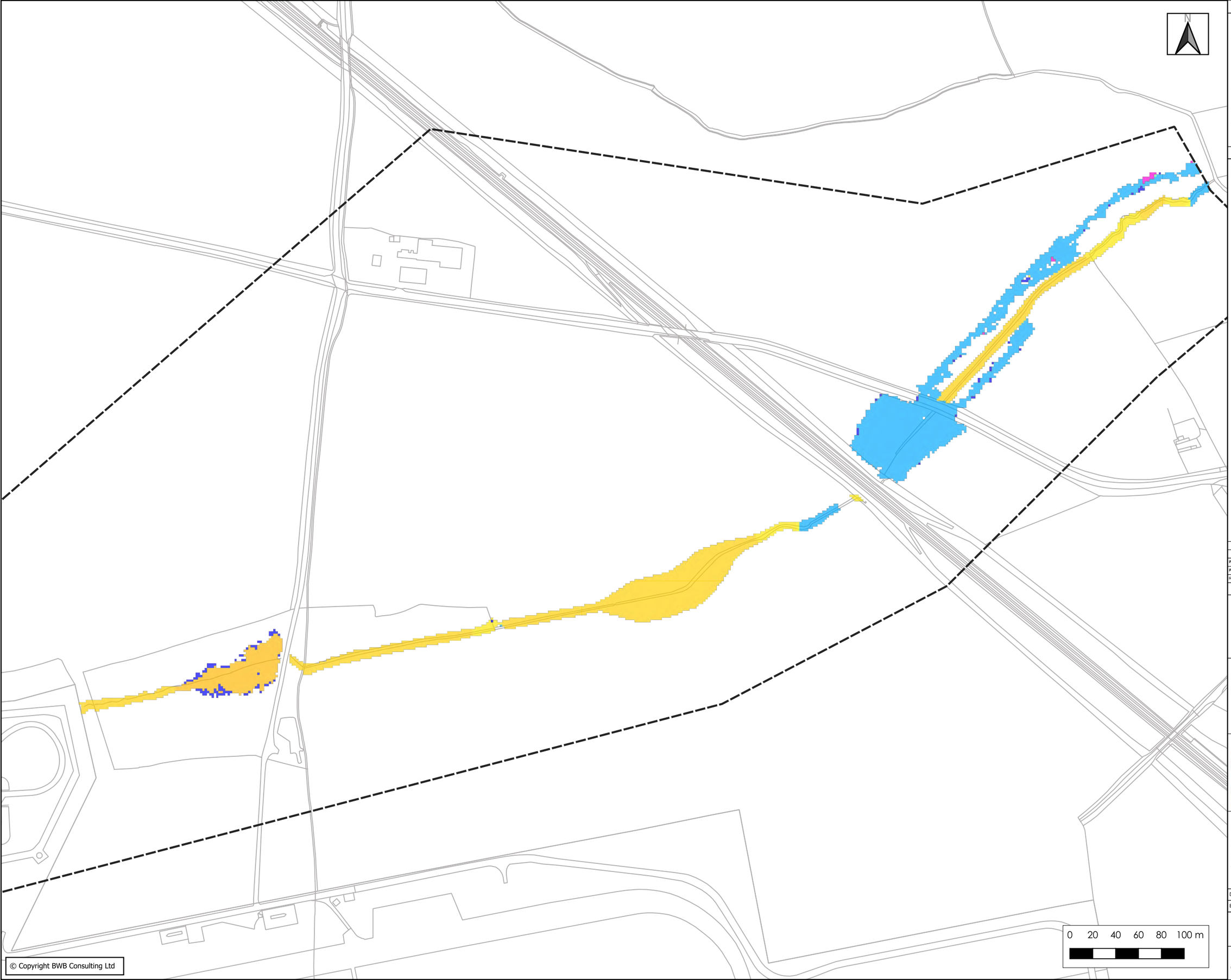
Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1233	S2	P03

Appendix 7: Sensitivity Testing



Notes

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- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Increased Roughness (20%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1240	S2	P02

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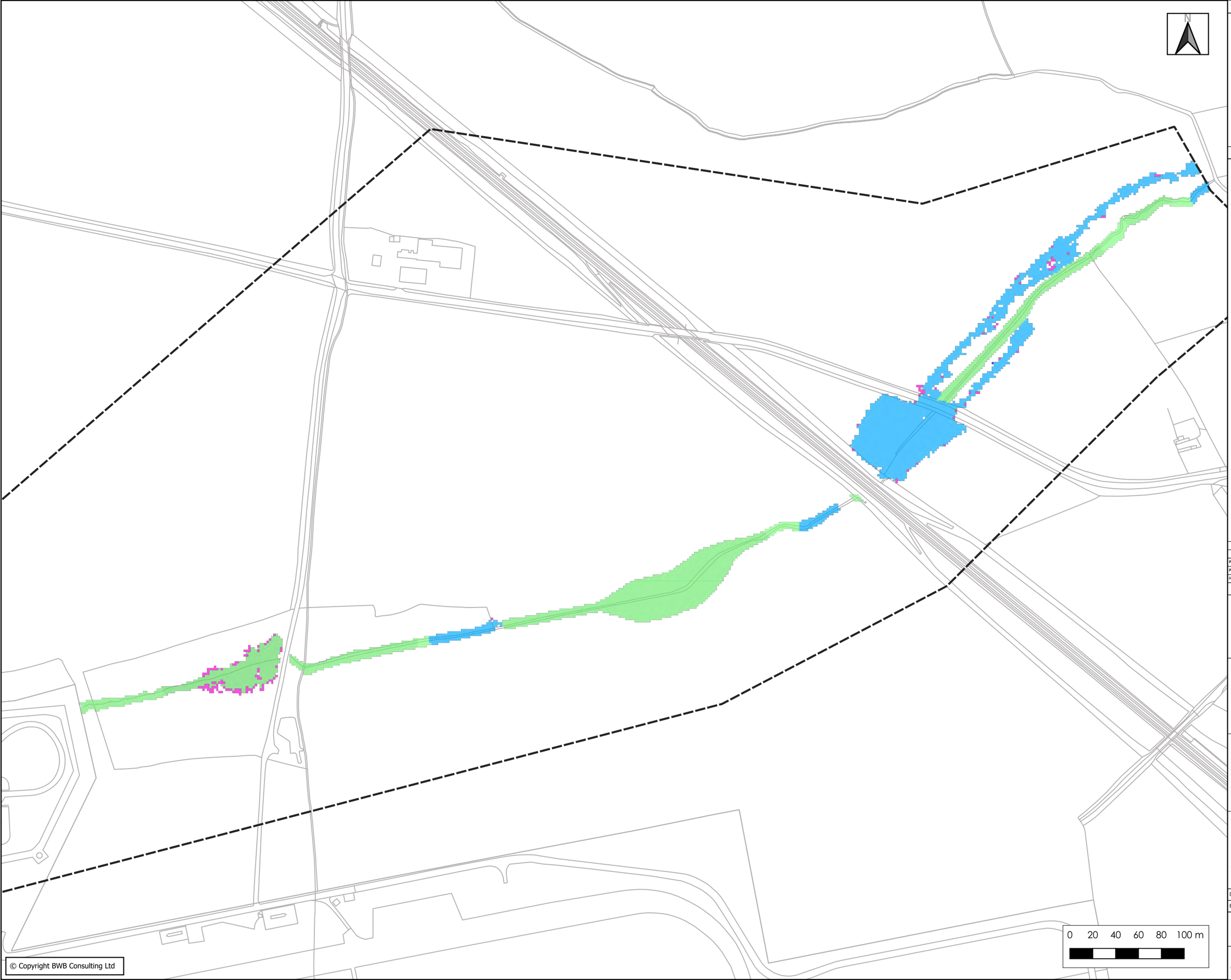

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6. Contains OS data © Licence no. 100019980

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- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Decreased Roughness (20%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3: 1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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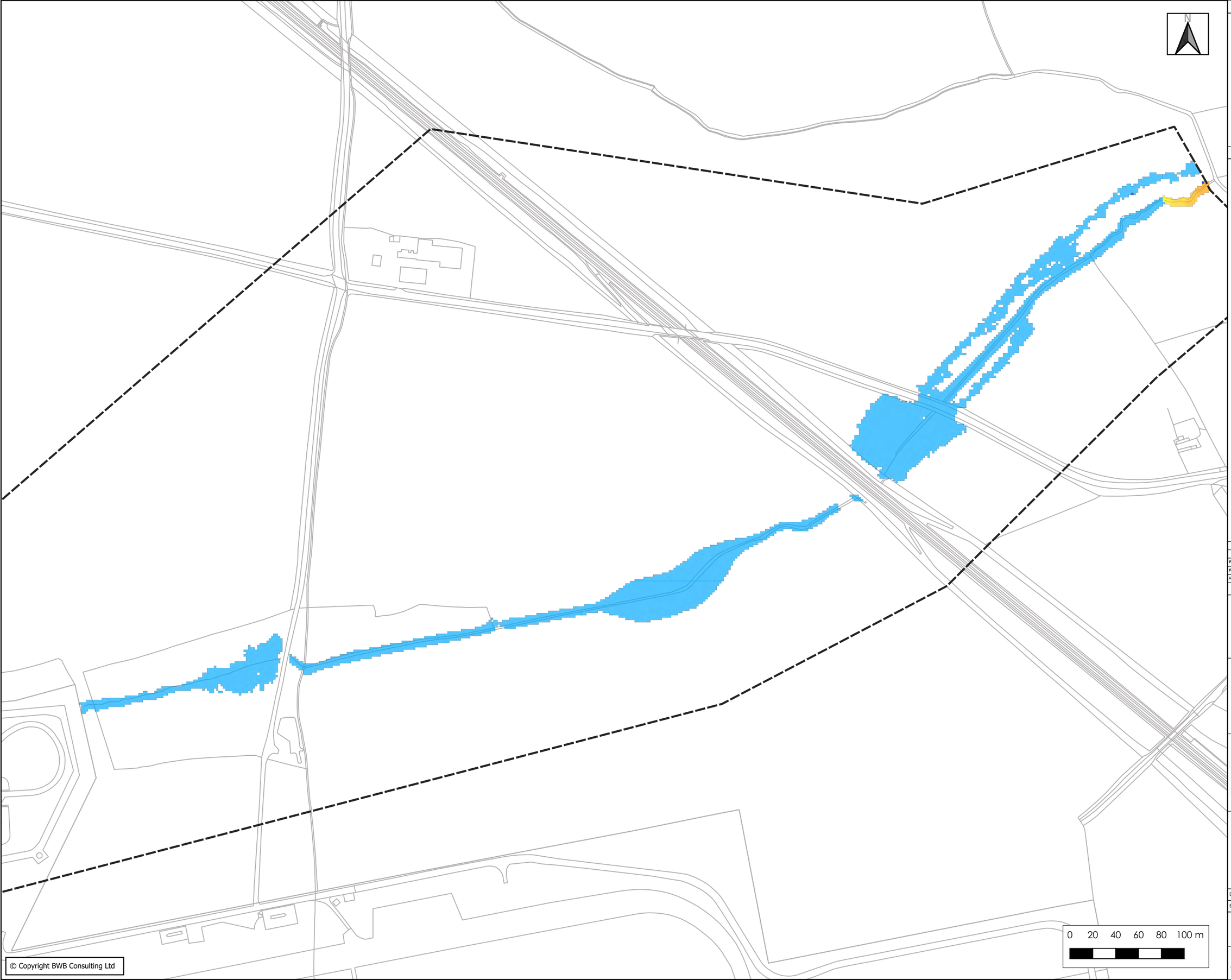

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Key

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- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.06.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI OXFORDSHIRE STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Increased Downstream Boundary (20%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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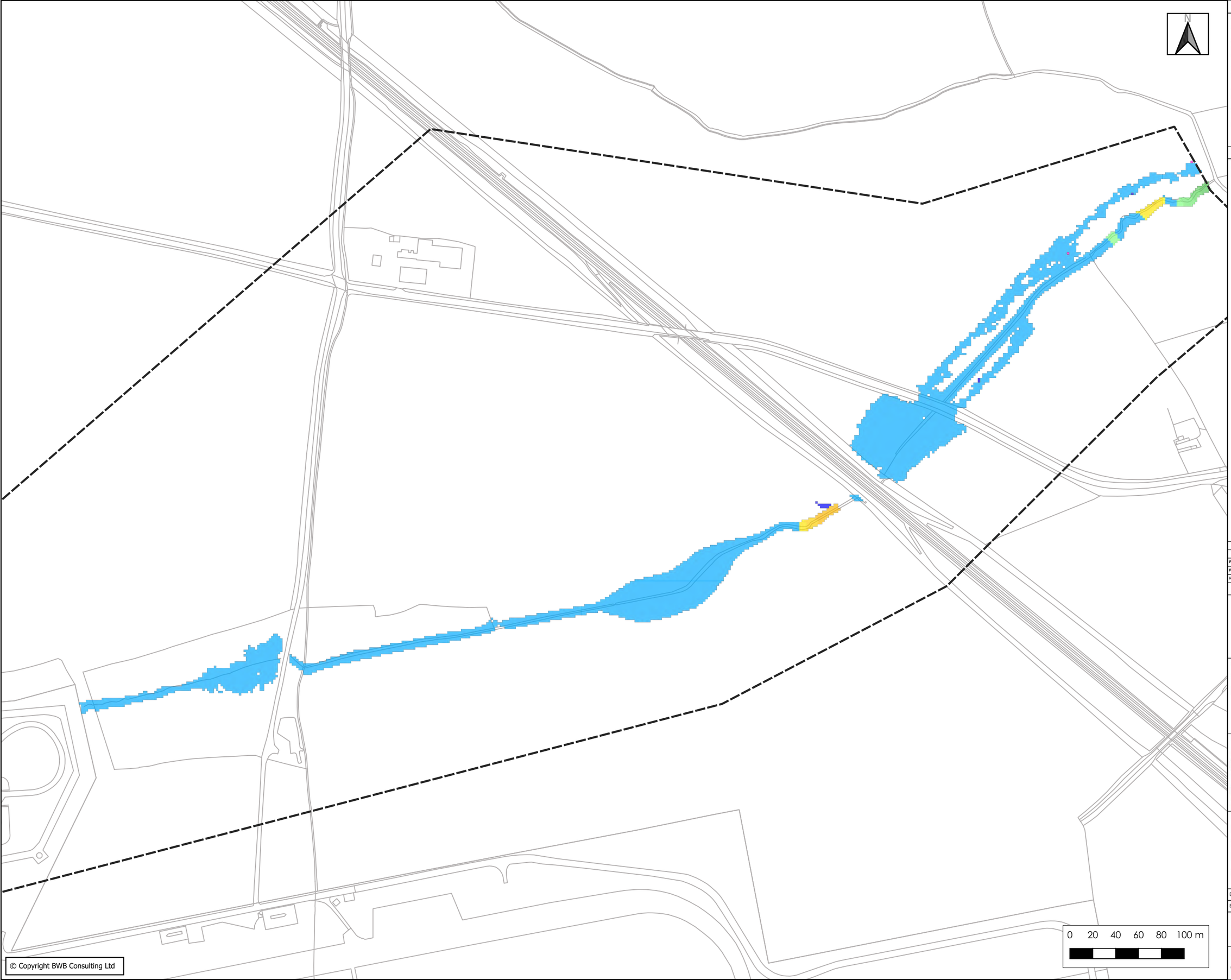

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- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.08.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Decreased Downstream Boundary (20%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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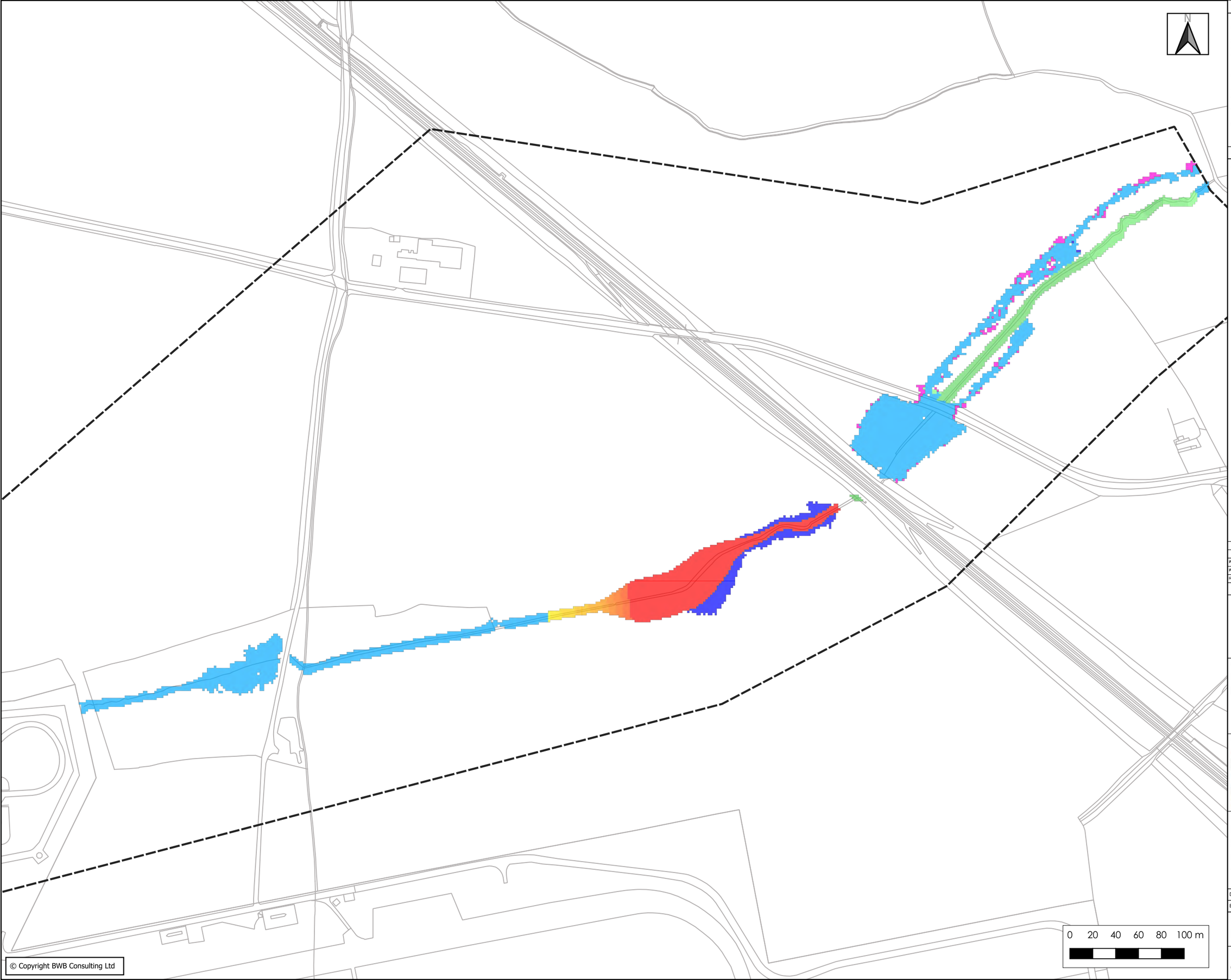

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Key

- Model Domain
- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Modelled Peak Flood Level (m)

- <= -0.125
- -0.125 - -0.100
- -0.100 - -0.075
- -0.075 - -0.050
- -0.050 - -0.025
- -0.025 - -0.01
- -0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	28.07.25	UPDATED HYDROLOGY AND SOFTWARE	MN	SR
P01	27.03.23	PRELIMINARY ISSUE	MPB	MB

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Client

Oxfordshire Railfreight Limited

Project Title

OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

Post-Development Sensitivity: Proposed Culvert Blockage (75%) 1 in 100-Year

Drawn:	M. Bailey		Reviewed:	M. Brambani	
BWB Ref:	NTH2479	Date:	27.03.23	Scale@A3:	1:3,000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
OXSRFI-BWB-ZZ-XX-D-W-1248	S2	P02

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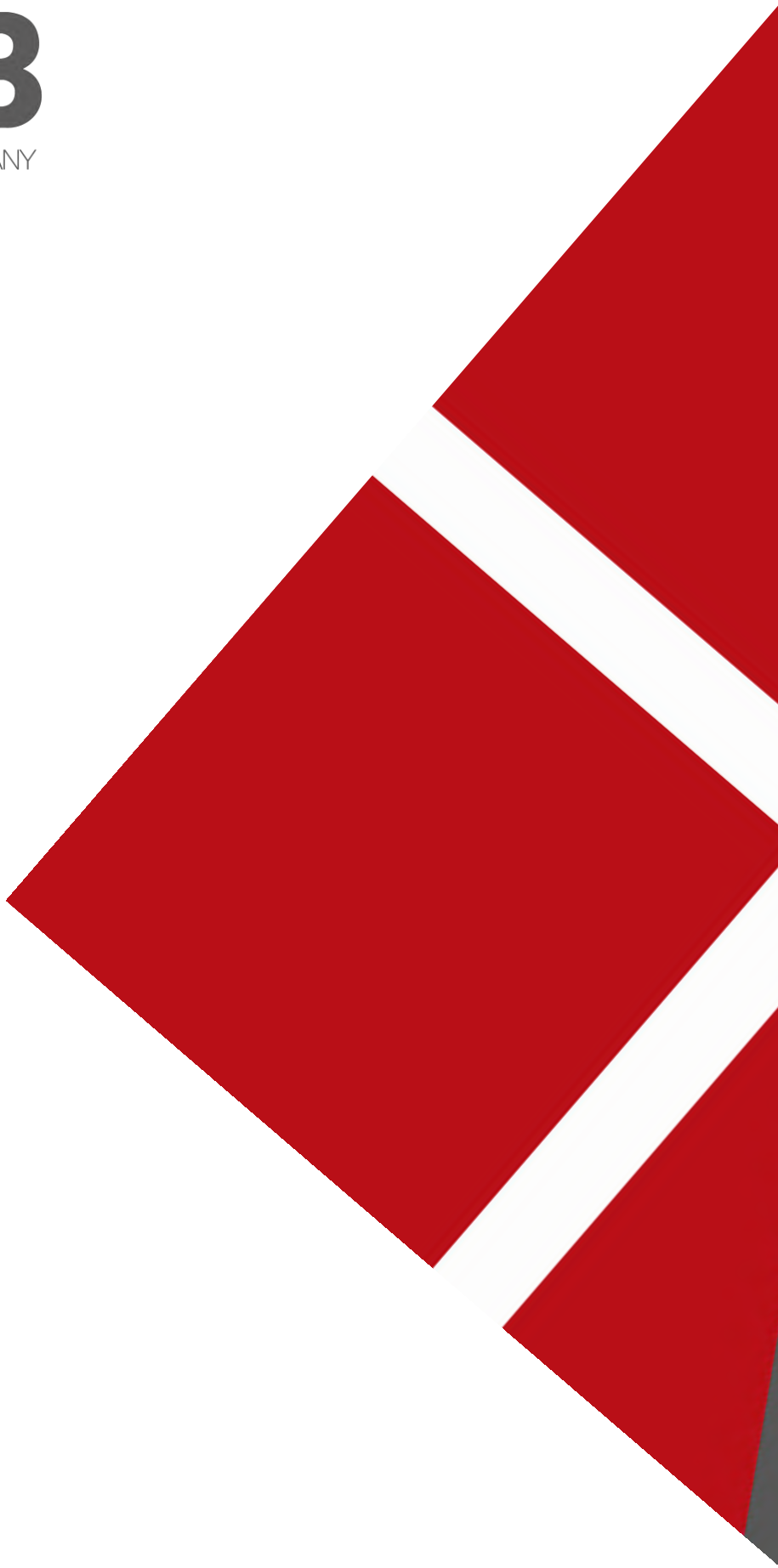

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Appendix 5: Thames Water Sewer Plans

Asset location search

Property Searches

Engineering Services Consultancy Limited
Griffin House
19Ludgate Hill
BIRMINGHAM
B3 1DW

Search address supplied OX27 7PH

Your reference Q-CPC-Ardley

Our reference ALS/ALS Standard/2018_3817907

Search date 19 June 2018

Keeping you up-to-date

Knowledge of features below the surface is essential in every development. The benefits of this not only include ensuring due diligence and avoiding risk, but also being able to ascertain the feasibility for any commercial or residential project.

An asset location search provides information on the location of known Thames Water clean and/or wastewater assets, including details of pipe sizes, direction of flow and depth. Please note that information on cover and invert levels will only be provided where the data is available.

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

searchcode

Asset location search

Property Searches

Search address supplied: OX27 7PH

Dear Sir / Madam

An Asset Location Search is recommended when undertaking a site development. It is essential to obtain information on the size and location of clean water and sewerage assets to safeguard against expensive damage and allow cost-effective service design.

The following records were searched in compiling this report: - the map of public sewers & the map of waterworks. Thames Water Utilities Ltd (TWUL) holds all of these.

This searchprovides maps showing the position, size of Thames Water assets close to the proposed development and also manhole cover and invert levels, where available.

Please note that none of the charges made for this report relate to the provision of Ordnance Survey mapping information. The replies contained in this letter are given following inspection of the public service records available to this company. No responsibility can be accepted for any error or omission in the replies.

You should be aware that the information contained on these plans is current only on the day that the plans are issued. The plans should only be used for the duration of the work that is being carried out at the present time. Under no circumstances should this data be copied or transmitted to parties other than those for whom the current work is being carried out.

Thames Water do update these service plans on a regular basis and failure to observe the above conditions could lead to damage arising to new or diverted services at a later date.

Contact Us

If you have any further queries regarding this enquiry please feel free to contact a member of the team on 0845 070 9148, or use the address below:

Thames Water Utilities Ltd
Property Searches
PO Box 3189
Slough
SL1 4WW

Email: searches@thameswater.co.uk
Web: www.thameswater-propertysearches.co.uk

Waste Water Services

Please provide a copy extract from the public sewer map.

The following quartiles have been printed as they fall within Thames' sewerage area:

SP5226SW
SP5226NW
SP5226SE
SP5226NE
SP5326NW

Enclosed is a map showing the approximate lines of our sewers. Our plans do not show sewer connections from individual properties or any sewers not owned by Thames Water unless specifically annotated otherwise. Records such as "private" pipework are in some cases available from the Building Control Department of the relevant Local Authority.

Where the Local Authority does not hold such plans it might be advisable to consult the property deeds for the site or contact neighbouring landowners.

This report relates only to sewerage apparatus of Thames Water Utilities Ltd, it does not disclose details of cables and or communications equipment that may be running through or around such apparatus.

The sewer level information contained in this response represents all of the level data available in our existing records. Should you require any further Information, please refer to the relevant section within the 'Further Contacts' page found later in this document.

The following quartiles have not been printed as they contain no assets:

SP5225NW
SP5225NE
SP5325NW
SP5326SW

For your guidance:

- The Company is not generally responsible for rivers, watercourses, ponds, culverts or highway drains. If any of these are shown on the copy extract they are shown for information only.
- Any private sewers or lateral drains which are indicated on the extract of the public sewer map as being subject to an agreement under Section 104 of the Water Industry Act 1991 are not an ‘as constructed’ record. It is recommended these details be checked with the developer.

Clean Water Services

Please provide a copy extract from the public water main map.

The following quartiles have been printed as they fall within Thames' water area:

SP5225NW
SP5225NE
SP5325NW

Enclosed is a map showing the approximate positions of our water mains and associated apparatus. Please note that records are not kept of the positions of individual domestic supplies.

For your information, there will be a pressure of at least 10m head at the outside stop valve. If you would like to know the static pressure, please contact our Customer Centre on 0800 316 9800. The Customer Centre can also arrange for a full flow and pressure test to be carried out for a fee.

The following quartiles have not been printed as they contain no assets:

SP5226SW
SP5226NW
SP5226SE
SP5226NE
SP5326SW
SP5326NW

For your guidance:

- Assets other than vested water mains may be shown on the plan, for information only.
- If an extract of the public water main record is enclosed, this will show known public water mains in the vicinity of the property. It should be possible to estimate the likely length and route of any private water supply pipe connecting the property to the public water network.

Payment for this Search

A charge will be added to your suppliers account.

Further contacts:

Waste Water queries

Should you require verification of the invert levels of public sewers, by site measurement, you will need to approach the relevant Thames Water Area Network Office for permission to lift the appropriate covers. This permission will usually involve you completing a TWOSA form. For further information please contact our Customer Centre on Tel: 0845 920 0800. Alternatively, a survey can be arranged, for a fee, through our Customer Centre on the above number.

If you have any questions regarding sewer connections, budget estimates, diversions, building over issues or any other questions regarding operational issues please direct them to our service desk. Which can be contacted by writing to:

Developer Services (Waste Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

Clean Water queries

Should you require any advice concerning clean water operational issues or clean water connections, please contact:

Developer Services (Clean Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

Asset Location Search Sewer Map - ALS/ALS Standard/2018_3817907	SP5226SW

The width of the displayed area is 500m and the centre of the map is located at OS coordinates 452250,226250

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

Based on the Ordnance Survey Map with the Sanction of the controller of H.M. Stationery Office, License no. 100019345 Crown Copyright Reserved.

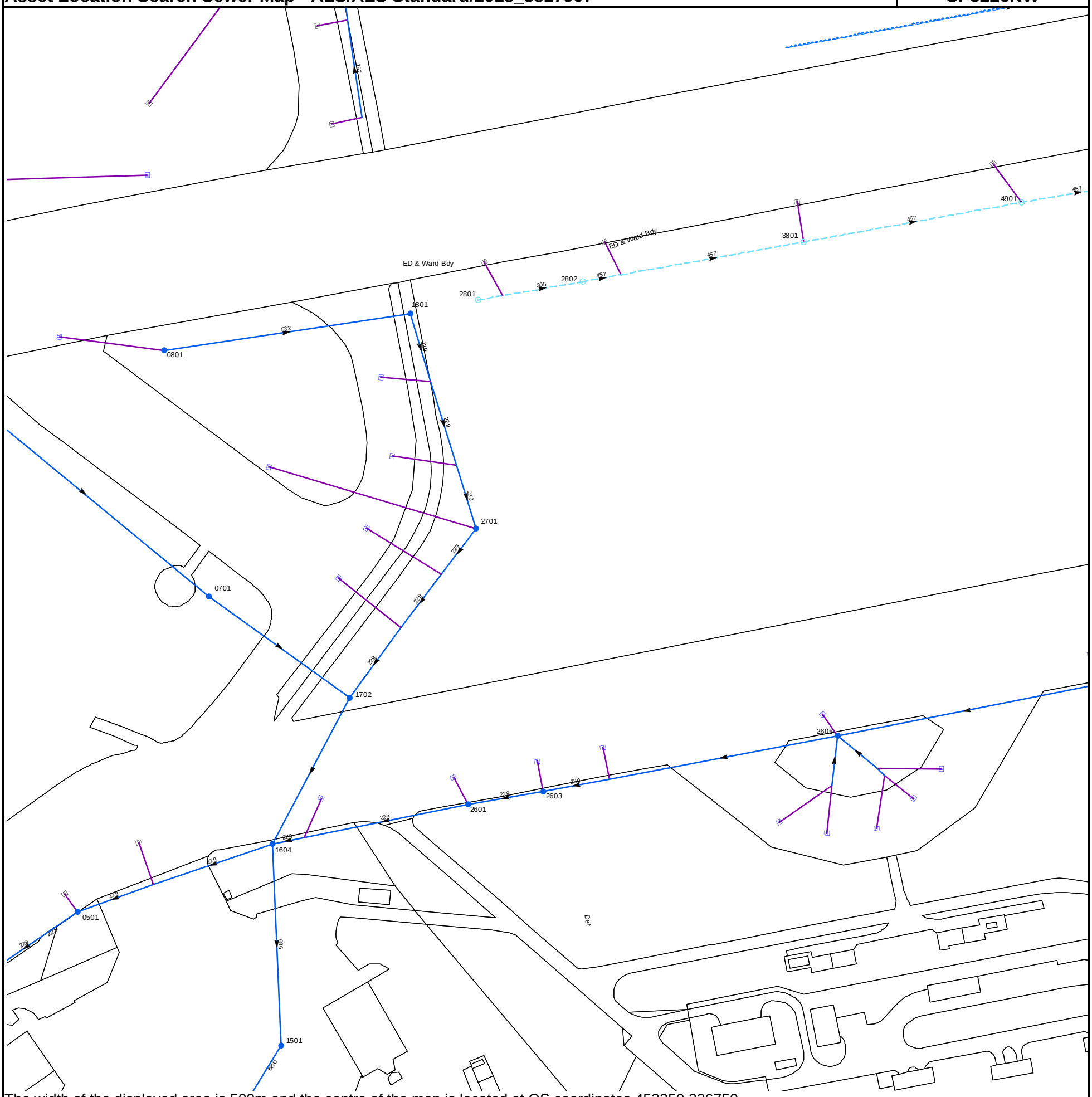
NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
1301	n/a	n/a
1201	n/a	n/a
4401	n/a	n/a
5404	n/a	n/a
0402	n/a	n/a
0401	n/a	n/a

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

Asset Location Search Sewer Map - ALS/ALS Standard/2018_3817907

SP5226NW



The width of the displayed area is 500m and the centre of the map is located at OS coordinates 452250,226750

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

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NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
1702	n/a	n/a
1801	n/a	n/a
2601	n/a	n/a
2701	n/a	n/a
2801	n/a	n/a
2603	n/a	n/a
2802	n/a	n/a
3801	n/a	n/a
2605	n/a	n/a
4901	n/a	n/a
0501	n/a	n/a
0801	n/a	n/a
0701	n/a	n/a
1604	n/a	n/a
1501	n/a	n/a

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Asset Location Search Sewer Map - ALS/ALS Standard/2018_3817907	SP5226SE

The width of the displayed area is 500m and the centre of the map is located at OS coordinates 452750,226250

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NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
5407	n/a	n/a
5403	n/a	n/a
5406	n/a	n/a
5405	n/a	n/a
5409	n/a	n/a

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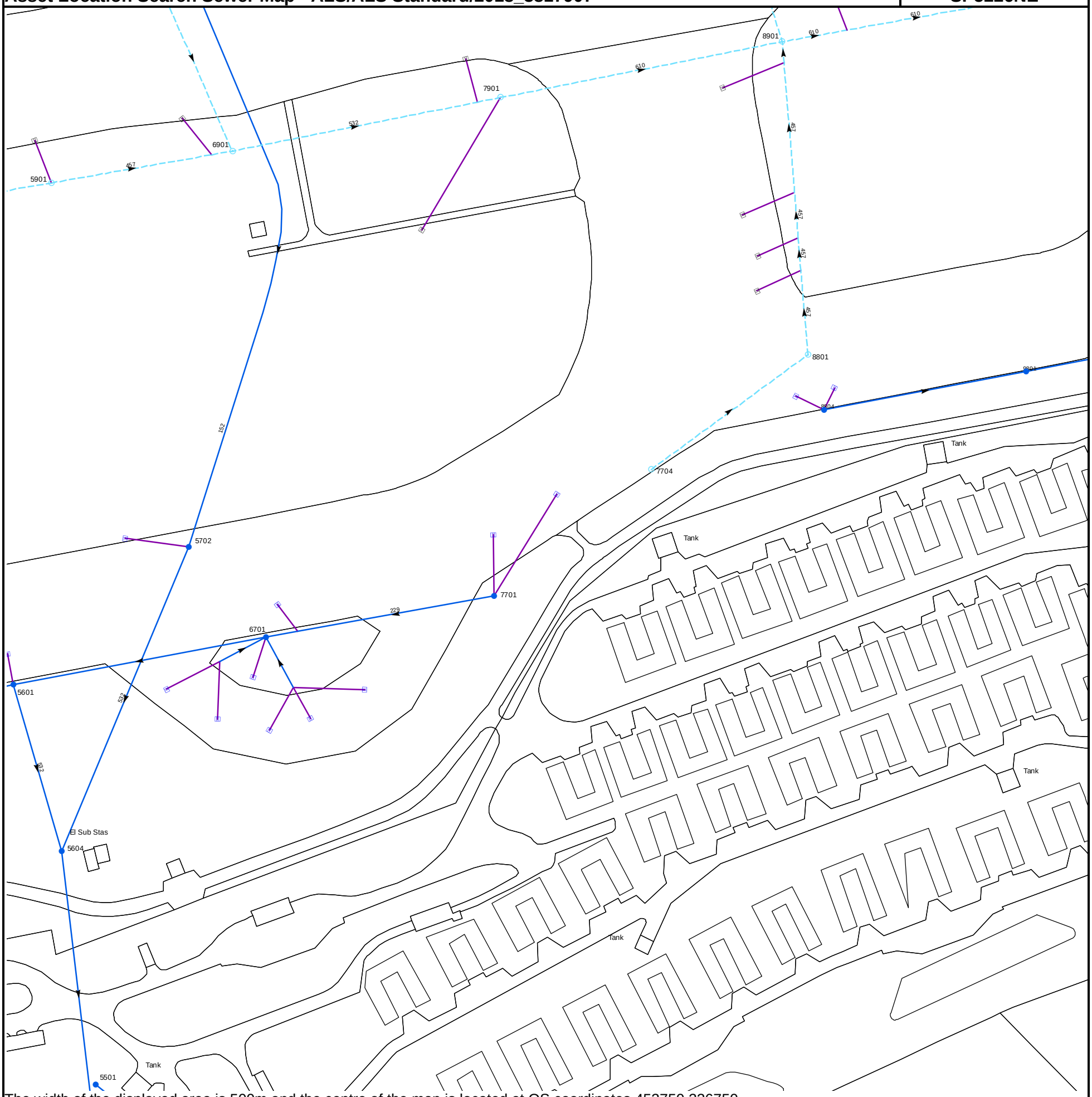
Asset Location Search Sewer Map - ALS/ALS Standard/2018_3817907 | SP5226NE



The width of the displayed area is 500m and the centre of the map is located at OS coordinates 452750,226750

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Manhole Reference	Manhole Cover Level	Manhole Invert Level
7901	n/a	n/a
7704	n/a	n/a
8901	n/a	n/a
8801	n/a	n/a
8804	n/a	n/a
9801	n/a	n/a
5601	n/a	n/a
5901	n/a	n/a
5604	n/a	n/a
5501	n/a	n/a
5702	n/a	n/a
6901	n/a	n/a
6701	n/a	n/a
7701	n/a	n/a

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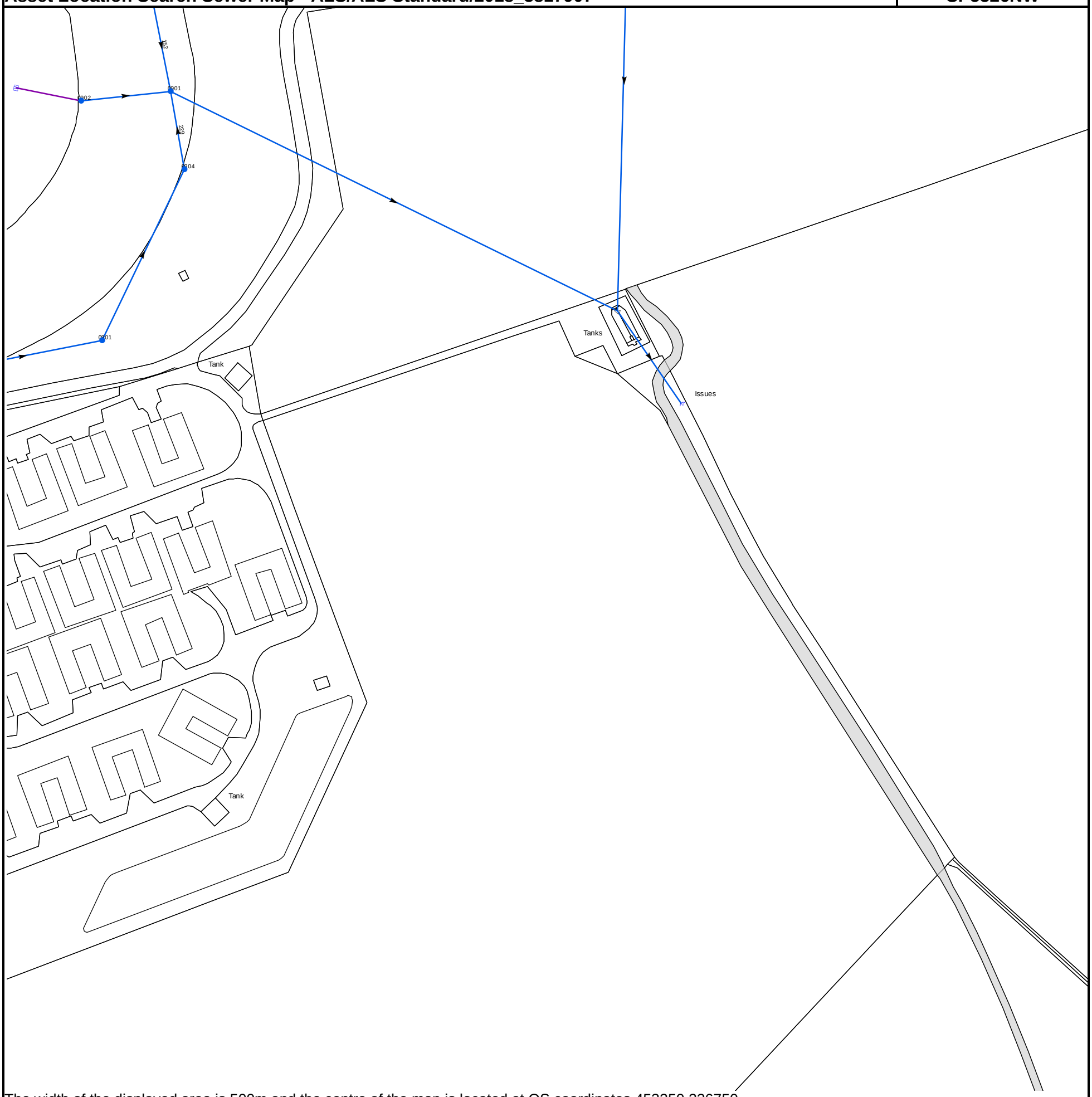
Asset Location Search Sewer Map - ALS/ALS Standard/2018_3817907	SP5326NW



The width of the displayed area is 500m and the centre of the map is located at OS coordinates 453250,226750

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NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
0801	n/a	n/a
0901	n/a	n/a
0904	n/a	n/a
0902	n/a	n/a

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Based on the Ordnance Survey Map with the sanction of the Controller of H.M Stationary Office License Number 10019345

ALS/ALS Standard/2018_3817907

0 45 90 180 270 360
Meters

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Scale:	1:7165
Width:	2001m
Printed By:	dshivaji
Print Date:	19/06/2018
Map Centre:	452819,226164
Grid Reference:	SP5226SE

Comments:

ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.

Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.

- Trunk Surface Water
- Trunk Foul
- Storm Relief
- Trunk Combined
- Vent Pipe
- Bio-solids (Sludge)
- Proposed Thames Surface Water Sewer
- Proposed Thames Water Foul Sewer
- Gallery
- Foul Rising Main
- Surface Water Rising Main
- Combined Rising Main
- Sludge Rising Main
- Proposed Thames Water Rising Main
- Vacuum

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

- Air Valve
- Dam Chase
- Fitting
- Meter
- Vent Column

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

- Control Valve
- Drop Pipe
- Ancillary
- Weir

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

- Outfall
- Undefined End
- Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

- Public/Private Pumping Station
- Change of characteristic indicator (C.O.C.I.)
- Invert Level
- Summit

Areas

Lines denoting areas of underground surveys, etc.

- Agreement
- Operational Site
- Chamber
- Tunnel
- Conduit Bridge

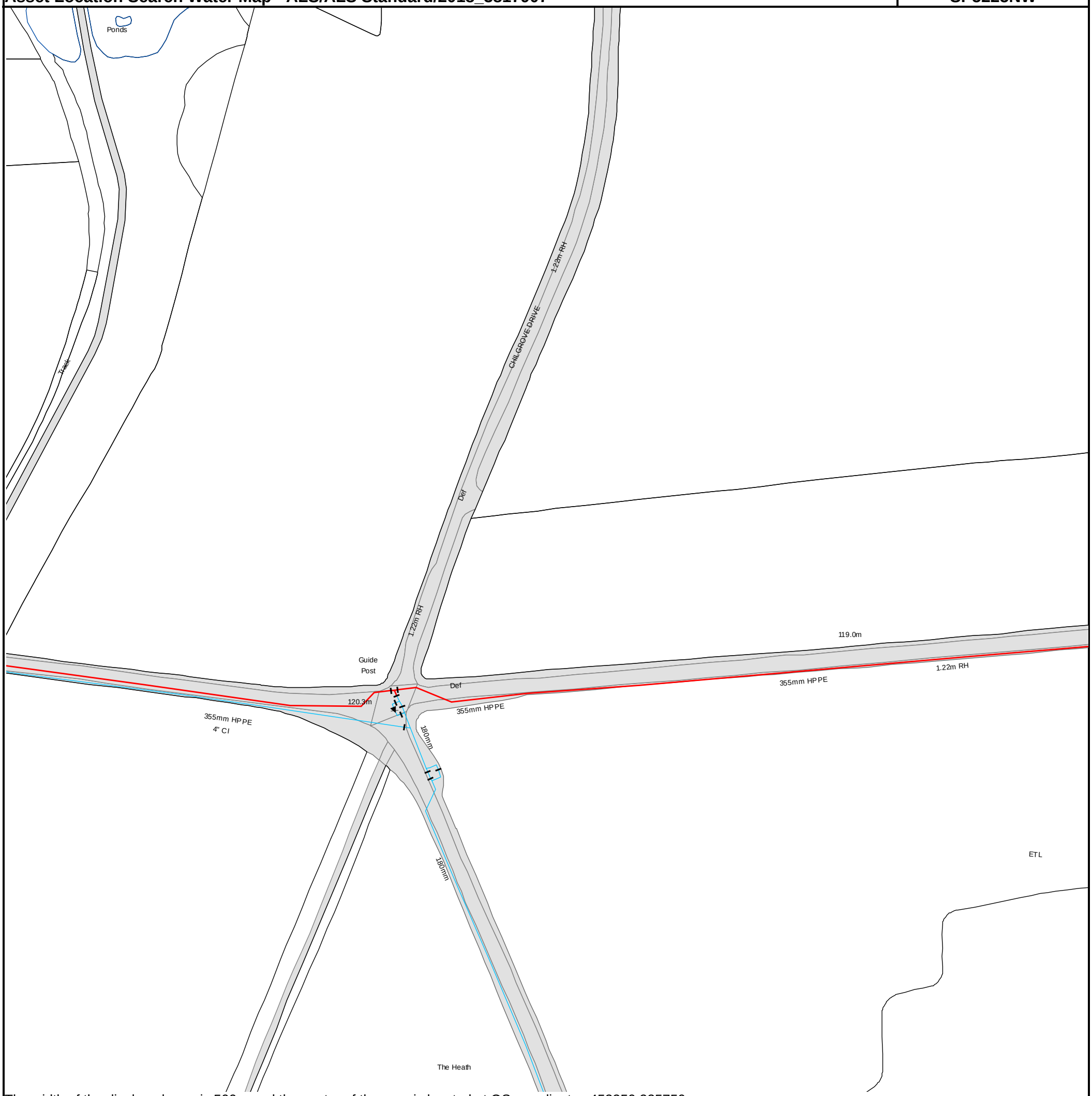
Other Sewer Types (Not Operated or Maintained by Thames Water)

- Foul Sewer
- Surface Water Sewer
- Combined Sewer
- Gulley
- Culverted Watercourse
- Proposed
- Abandoned Sewer

Notes:

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plans are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
5) 'na' or '0' on a manhole level indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in milimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

Asset Location Search Water Map - ALS/ALS Standard/2018_3817907	SP5225NW



The width of the displayed area is 500m and the centre of the map is located at OS coordinates 452250,225750

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Asset Location Search Water Map - ALS/ALS Standard/2018_3817907	SP5225NE

The width of the displayed area is 500m and the centre of the map is located at OS coordinates 452750,225750

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Asset Location Search Water Map - ALS/ALS Standard/2018_3817907	SP5325NW

The width of the displayed area is 500m and the centre of the map is located at OS coordinates 453250,225750

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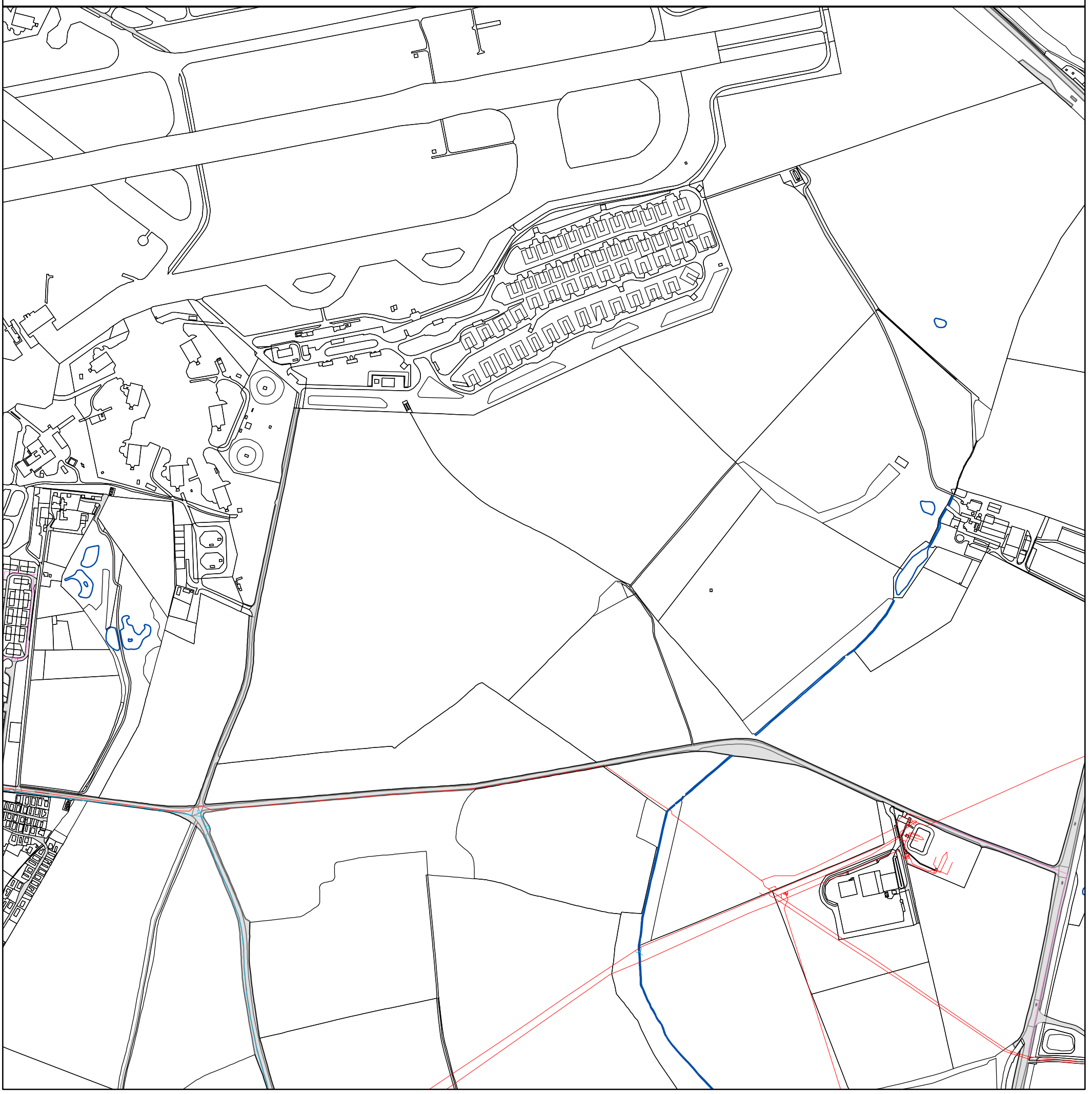
ALS/ALS Standard/2018_3817907



0 45 90 180 270 360
Meters

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Scale:	1:7165
Width:	2001m
Printed By:	dshivaji
Print Date:	19/06/2018
Map Centre:	452819,226164
Grid Reference:	SP5226SE

Comments:

ALS Water Map Key

Water Pipes (Operated & Maintained by Thames Water)

4"

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

16"

Trunk Main: A main carrying water from a source of supply to a treatment plant or reservoir, or from one treatment plant or reservoir to another. Also a main transferring water in bulk to smaller water mains used for supplying individual customers.

3" SUPPLY

Supply Main: A supply main indicates that the water main is used as a supply for a single property or group of properties.

3" FIRE

Fire Main: Where a pipe is used as a fire supply, the word FIRE will be displayed along the pipe.

3" METERED

Metered Pipe: A metered main indicates that the pipe in question supplies water for a single property or group of properties and that quantity of water passing through the pipe is metered even though there may be no meter symbol shown.

Transmission Tunnel: A very large diameter water pipe. Most tunnels are buried very deep underground. These pipes are not expected to affect the structural integrity of buildings shown on the map provided.

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number are generally included near the main.

Valves

- General Purpose Valve
- Air Valve
- Pressure Control Valve
- Customer Valve

Hydrants

- Single Hydrant

Meters

- Meter

End Items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold
- Customer Supply
- Fire Supply

Operational Sites

- Booster Station
- Other
- Other (Proposed)
- Pumping Station
- Service Reservoir
- Shaft Inspection
- Treatment Works
- Unknown
- Water Tower

Other Symbols

- Data Logger

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

Other Water Pipes (Not Operated or Maintained by Thames Water)

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our clean water coverage area. These mains are denoted in purple and in most cases have the owner of the pipe displayed along them.

Private Main: Indiates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.

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2. Provision of service will be in accordance with all legal requirements and published TWUL policies.
3. All invoices are strictly due for payment 14 days from due date of the invoice. Any other terms must be accepted/agreed in writing prior to provision of goods or service, or will be held to be invalid.
4. Thames Water does not accept post-dated cheques-any cheques received will be processed for payment on date of receipt.
5. In case of dispute TWUL`s terms and conditions shall apply.
6. Penalty interest may be invoked by TWUL in the event of unjustifiable payment delay. Interest charges will be in line with UK Statute Law 'The Late Payment of Commercial Debts (Interest) Act 1998'.
7. Interest will be charged in line with current Court Interest Charges, if legal action is taken.
8. A charge may be made at the discretion of the company for increased administration costs.

A copy of Thames Water's standard terms and conditions are available from the Commercial Billing Team (cashoperations@thameswater.co.uk).

We publish several Codes of Practice including a guaranteed standards scheme. You can obtain copies of these leaflets by calling us on 0800 316 9800

If you are unhappy with our service you can speak to your original goods or customer service provider. If you are not satisfied with the response, your complaint will be reviewed by the Customer Services Director. You can write to her at: Thames Water Utilities Ltd. PO Box 492, Swindon, SN38 8TU.

If the Goods or Services covered by this invoice falls under the regulation of the 1991 Water Industry Act, and you remain dissatisfied you can refer your complaint to Consumer Council for Water on 0121 345 1000 or write to them at Consumer Council for Water, 1st Floor, Victoria Square House, Victoria Square, Birmingham, B2 4AJ.

Ways to pay your bill

Credit Card	**BACS Payment**	**Telephone Banking**	**Cheque**
Call **0845 070 9148** quoting your invoice number starting CBA or ADS / OSS	Account number **90478703** Sort code **60-00-01** A remittance advice must be sent to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW.** or email **ps.billing@thameswater.co.uk**	By calling your bank and quoting: Account number **90478703** Sort code **60-00-01** and your invoice number	Made payable to '**Thames Water Utilities Ltd**' Write your Thames Water account number on the back. Send to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW** or by DX to **151280 Slough 13**

Thames Water Utilities Ltd Registered in England & Wales No. 2366661 Registered Office Clearwater Court, Vastern Rd, Reading, Berks, RG1 8DB.

Search Code

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- provides protection for homebuyers, sellers, estate agents, conveyancers and mortgage lenders who rely on the information included in property search reports undertaken by subscribers on residential and commercial property within the United Kingdom
- sets out minimum standards which firms compiling and selling search reports have to meet
- promotes the best practise and quality standards within the industry for the benefit of consumers and property professionals
- enables consumers and property professionals to have confidence in firms which subscribe to the code, their products and services.

By giving you this information, the search firm is confirming that they keep to the principles of the Code. This provides important protection for you.

The Code's core principles

Firms which subscribe to the Search Code will:

- display the Search Code logo prominently on their search reports
- act with integrity and carry out work with due skill, care and diligence
- at all times maintain adequate and appropriate insurance to protect consumers
- conduct business in an honest, fair and professional manner
- handle complaints speedily and fairly
- ensure that products and services comply with industry registration rules and standards and relevant laws
- monitor their compliance with the Code

Complaints

If you have a query or complaint about your search, you should raise it directly with the search firm, and if appropriate ask for any complaint to be considered under their formal internal complaints procedure. If you remain dissatisfied with the firm's final response, after your complaint has been formally considered, or if the firm has exceeded the response timescales, you may refer your complaint for consideration under The Property Ombudsman scheme (TPOs). The Ombudsman can award compensation of up to £5,000 to you if he finds that you have suffered actual loss as a result of your search provider failing to keep to the Code.

Please note that all queries or complaints regarding your search should be directed to your search provider in the first instance, not to TPOs or to the PCCB.

TPOs Contact Details

The Property Ombudsman scheme
Milford House
43-55 Milford Street
Salisbury
Wiltshire SP1 2BP
Tel: 01722 333306
Fax: 01722 332296
Email: admin@tpos.co.uk

You can get more information about the PCCB from www.propertycodes.org.uk

PLEASE ASK YOUR SEARCH PROVIDER IF YOU WOULD LIKE A COPY OF THE SEARCH CODE

BWB

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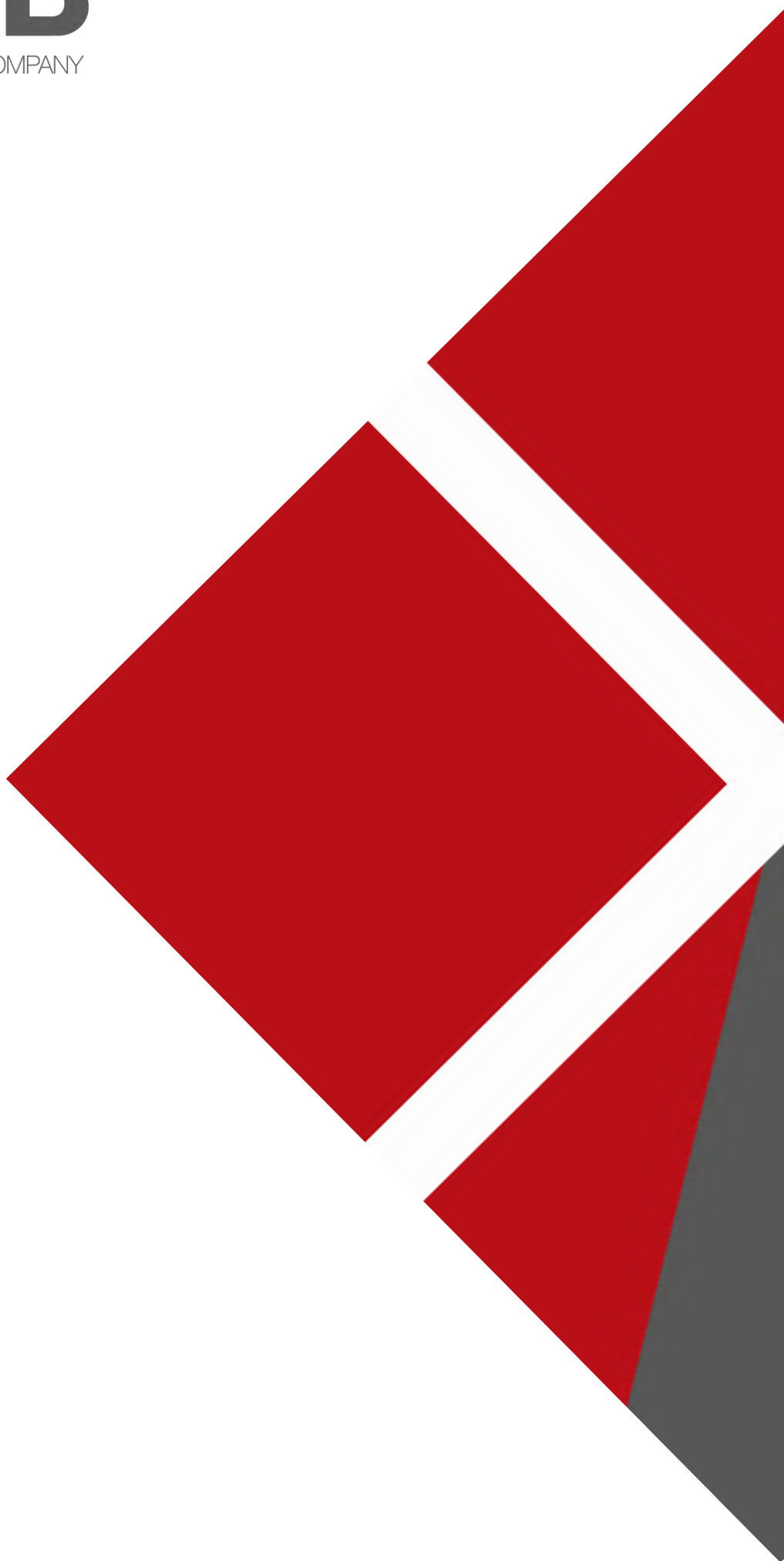

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