OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

**DCO Submission**

Environmental Statement

**Chapter 9:** Water Environment
Appendix 9.2: Flood Risk Assessment – Part 1 of 2

**Document 6.9B.01**
Rev P05

On behalf of
Oxfordshire Railfreight Limited

Prepared by BWB Consulting Ltd
**October 2026**

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**ADVISORY**

# Oxfordshire Railfreight Limited
# Oxfordshire Strategic Rail Freight Interchange
# Oxfordshire
# Flood Risk Assessment – Main Site

www.bwbconsulting.com

**ADVISORY**

# Oxfordshire Railfreight Limited
# Oxfordshire Strategic Rail Freight Interchange
# Oxfordshire
# Flood Risk Assessment – Main Site

Birmingham
Livery Place, 35 Livery Street, Colmore Business District, Birmingham, B3 2PB
T: 0121 233 3322

Leeds
Whitehall Waterfront, 2 Riverside Way, Leeds
LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11 Portland Street, Manchester, M1 3HU
0161 233 4260

**Nottingham**
**Waterfront House, Station Street, Nottingham NG2 3DQ**
**T: 0115 924 1100**

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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<br>(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 B430 Station Road.
- 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**.

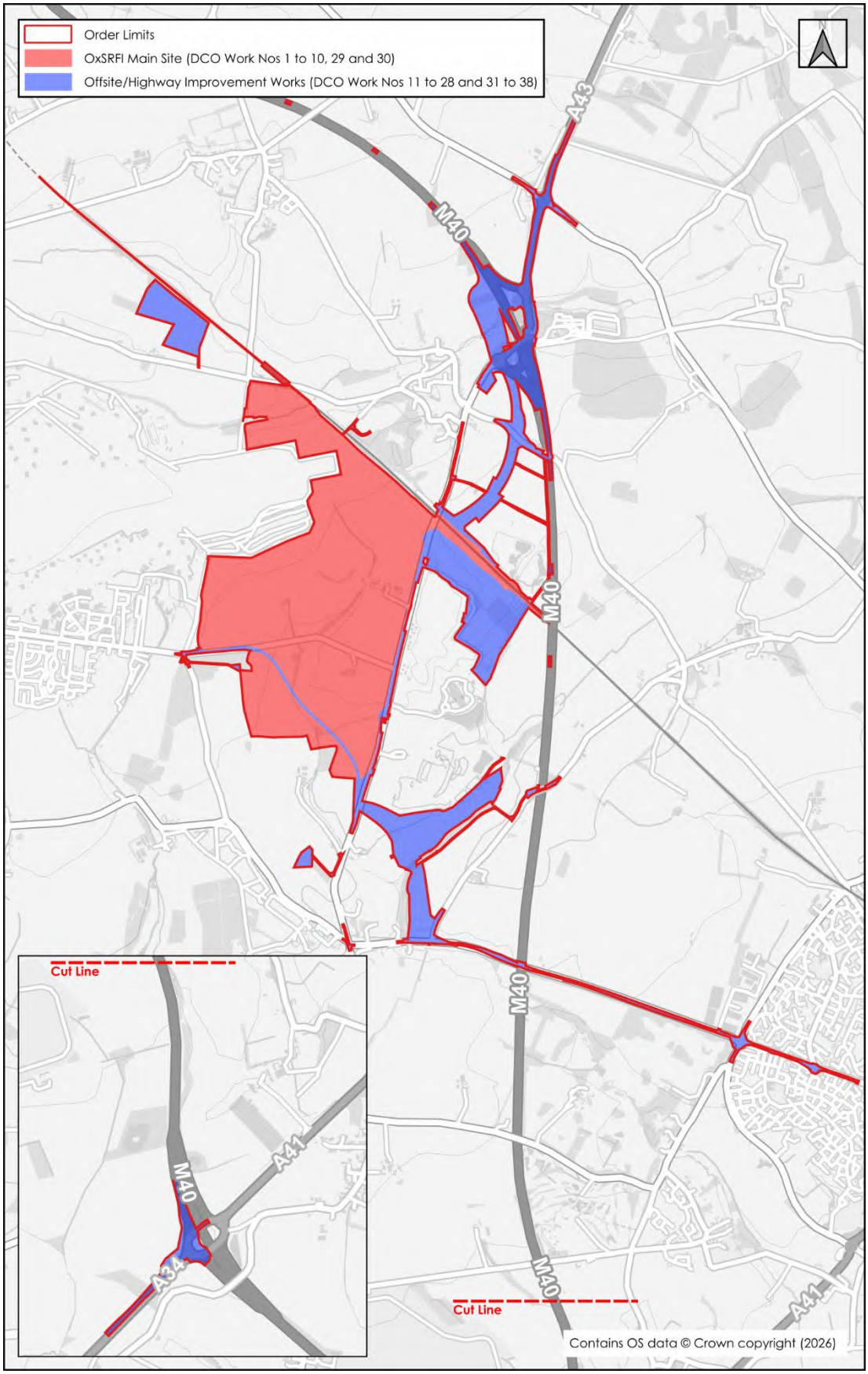


**Figure 1.1: Site Location**

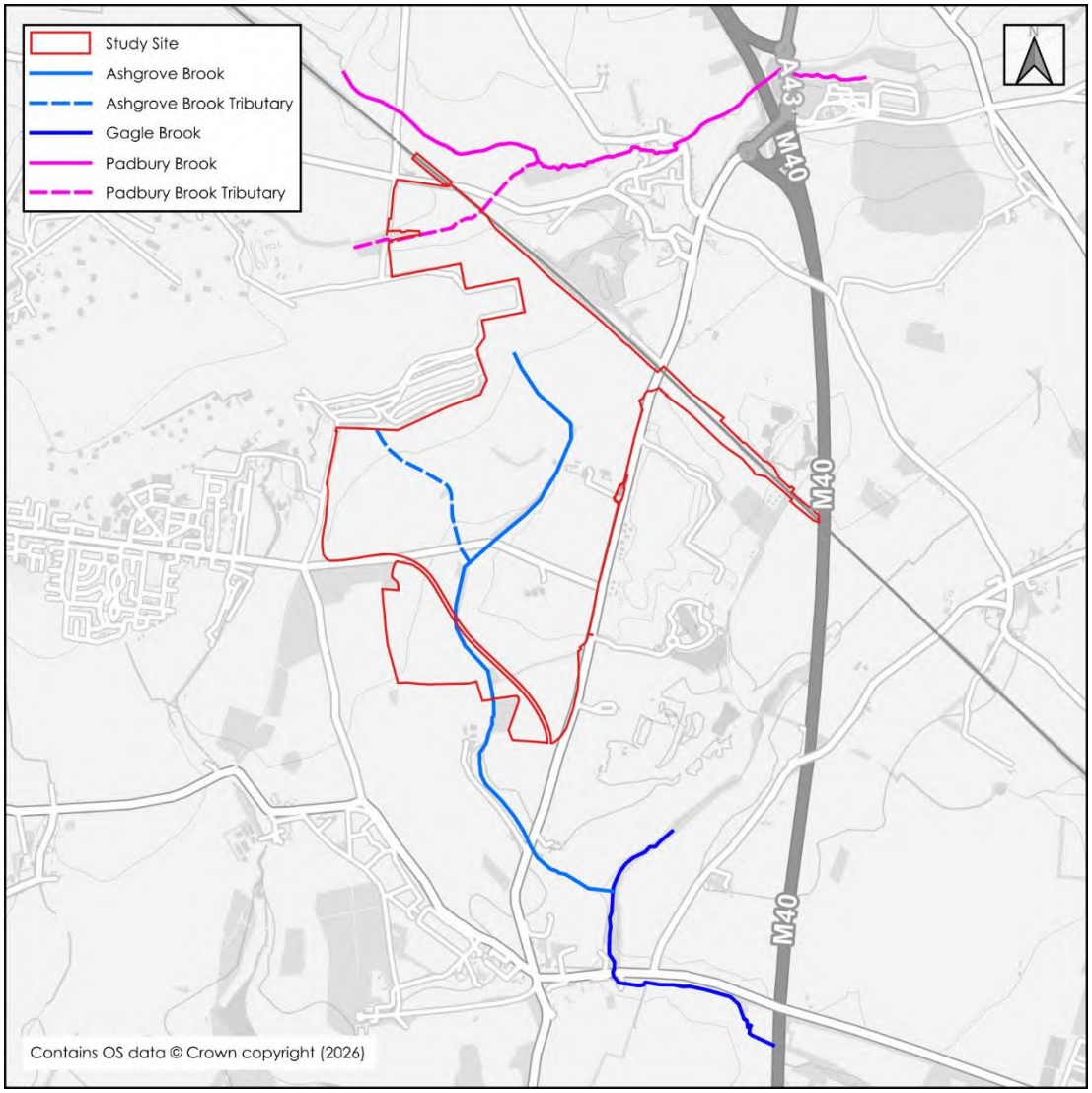


**Figure 1.2: Study Site Location and Watercourse Network**

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.

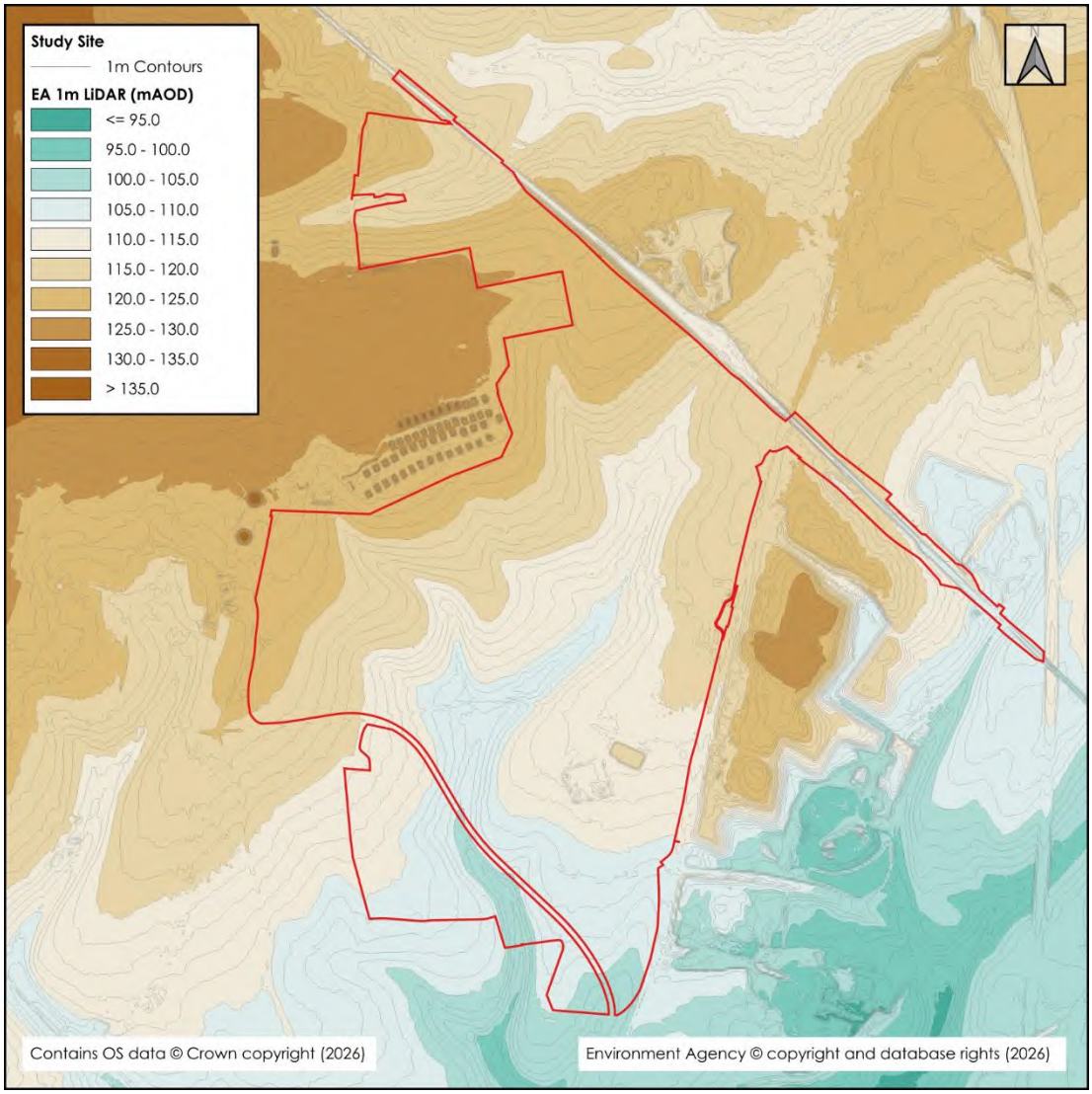


**Figure 1.3: Existing Study Site Topography based on EA 1m LiDAR**

## 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, 2026
[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 the PPG include a series of tables that define Flood Zones (Annex F, Table 1 of the NPPF), the flood risk vulnerability classification of development land uses (Annex F, Table 2 of the NPPF) and 'compatibility' of development within the defined Flood Zones (Annex F, Table 3 of the NPPF).

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 (>0.5% AEP). This is represented by "Flood Zone 3" on the Flood Map for Planning. |

| Flood Zone | Description |
|---|---|
| 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.

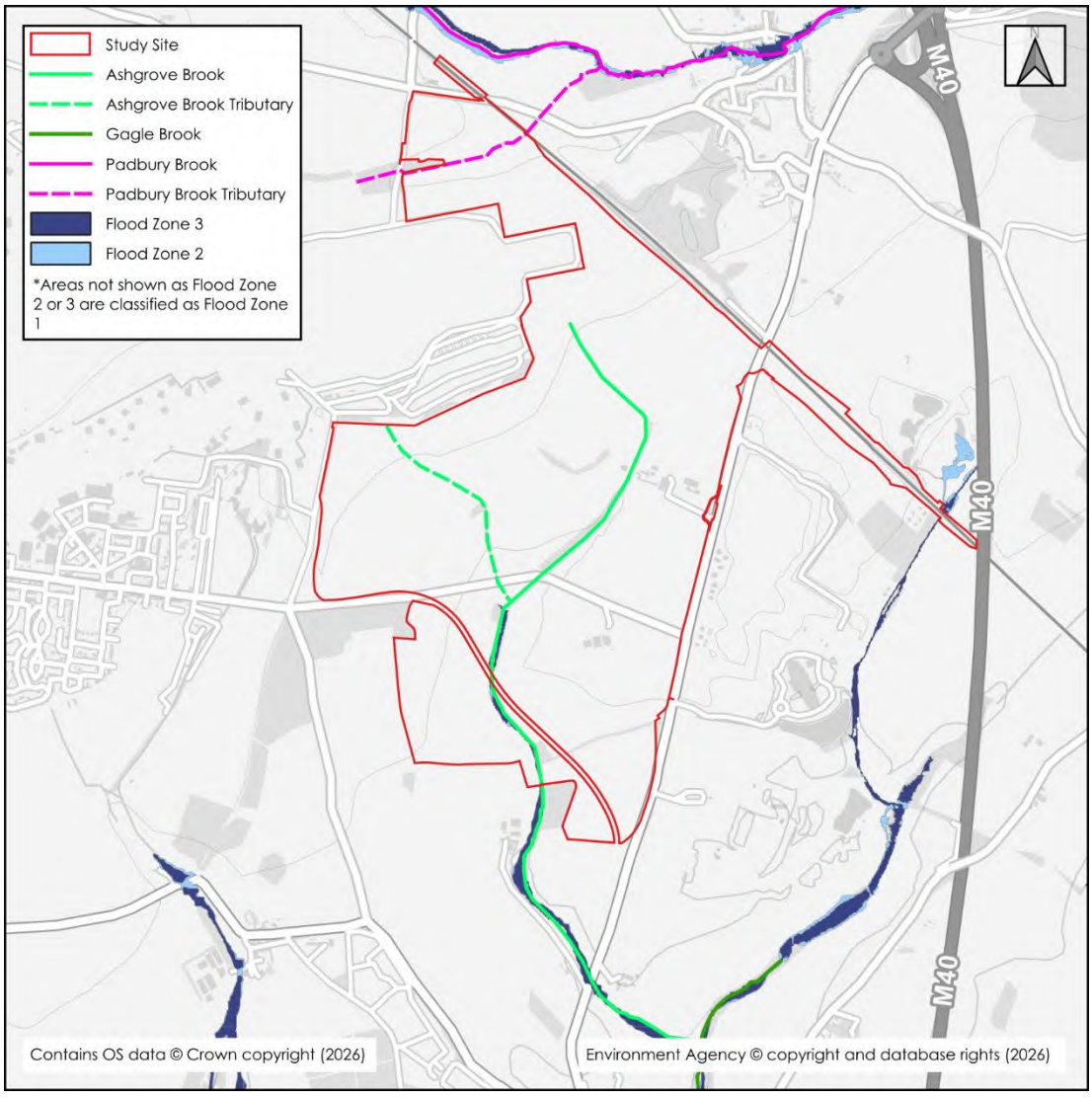


**Figure 2.1: EA Flood Map for Planning**

## 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.<br>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 3** 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**.

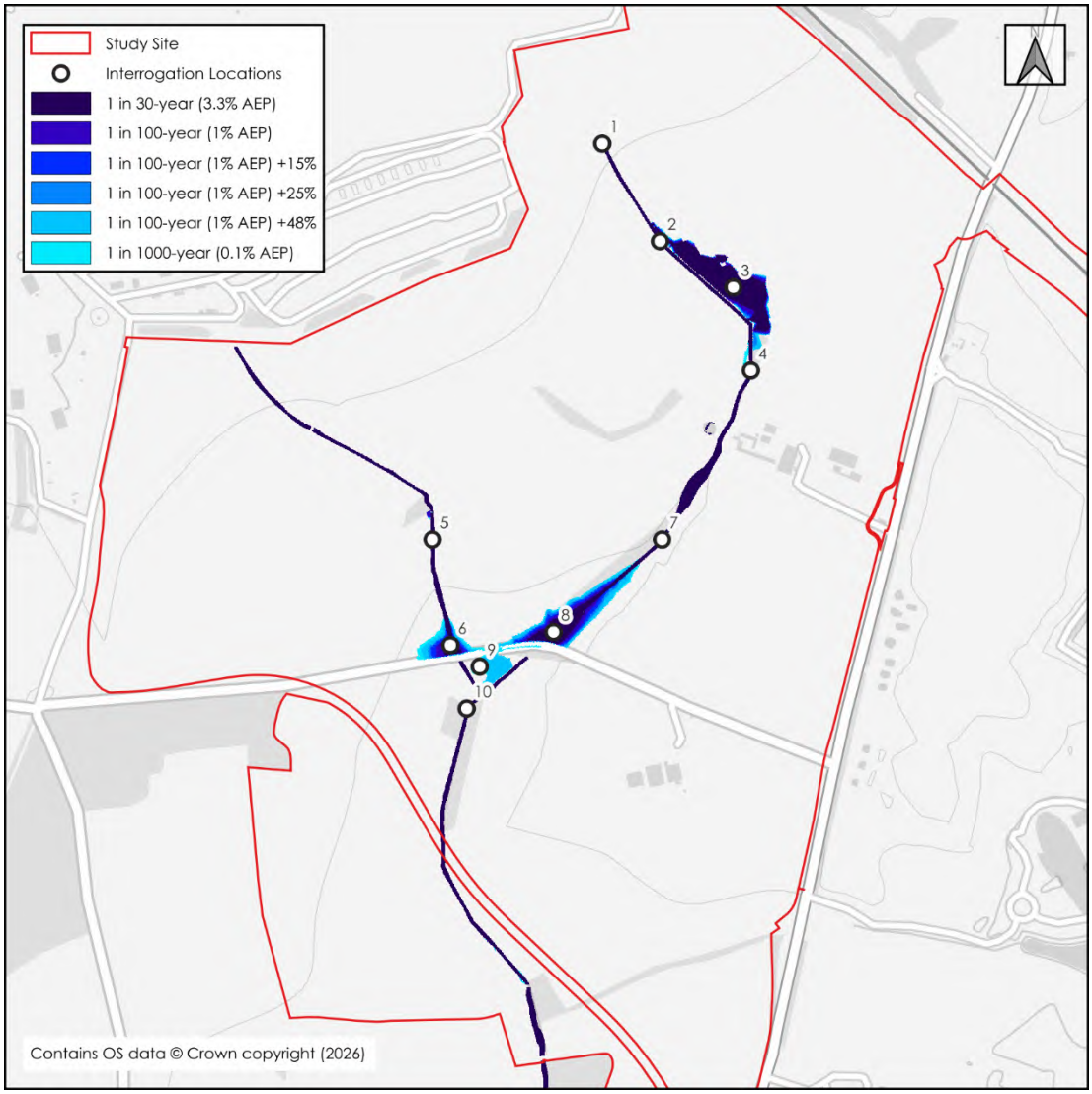


**Figure 3.1: Baseline Modelled Peak Flood Extents – Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook**

**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 | 118.18 | 118.21 | 118.23 |
| 2 | 115.17 | 115.18 | 115.19 | 115.19 | 115.20 | 115.21 |
| 3 | 112.83 | 112.83 | 112.83 | 112.83 | 112.84 | 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 | 107.95 | 108.08 | 108.15 | 108.31 | 108.40 |

| 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 | 108.48 | 108.54 | 108.57 |
| 8 | 107.91 | 108.09 | 108.24 | 108.32 | 108.49 | 108.54 |
| 9 | | | | | | 107.21 |
| 10 | 105.41 | 105.41 | 105.42 | 105.42 | 105.43 | 105.46 |

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**.

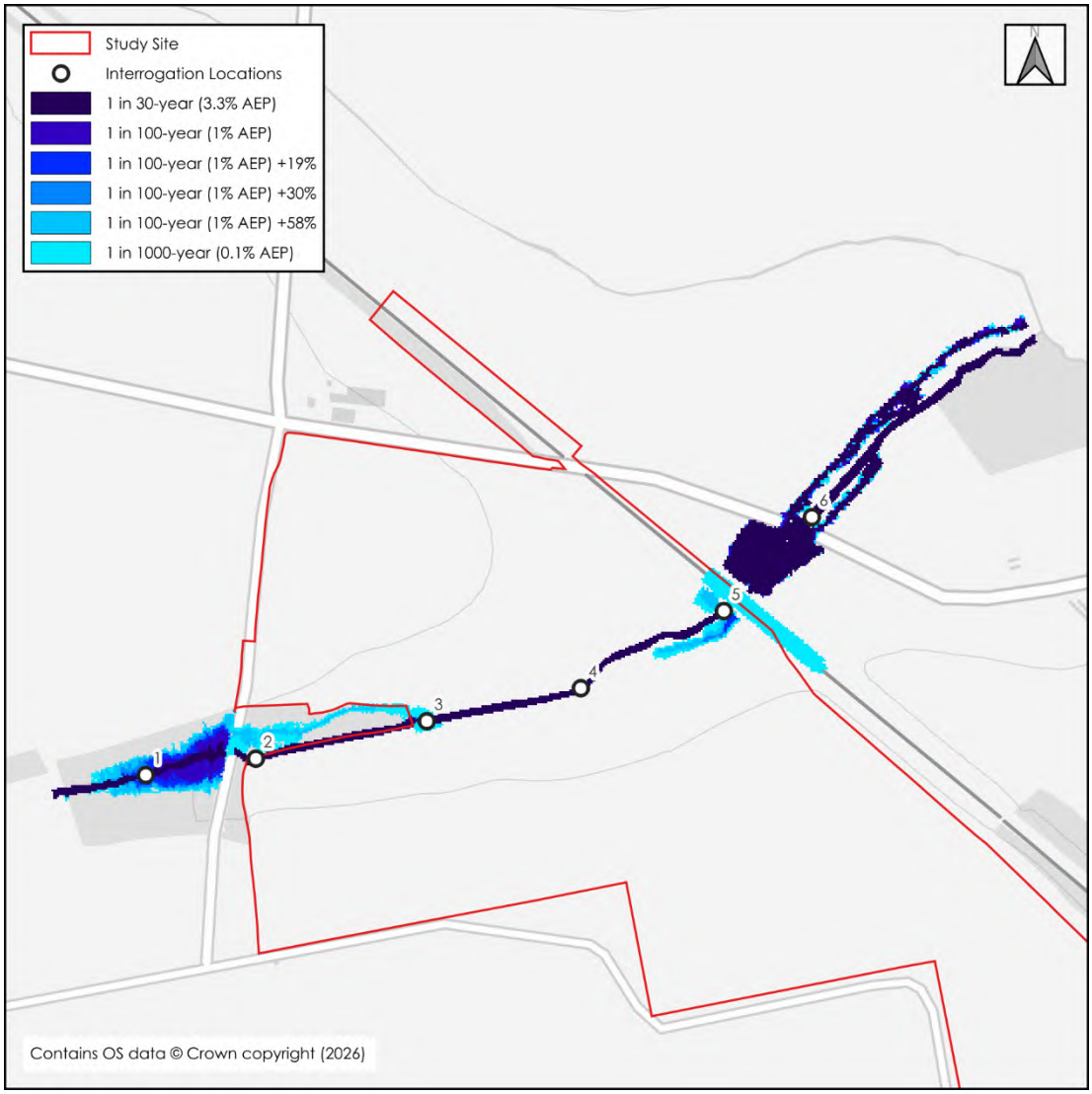


**Figure 3.2: Baseline Modelled Peak Flood Extents – Padbury Brook Tributary**

**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.

3.21 The RoFSW mapping was the latest data used at the time of writing the submitted FRA, however it is noted that the mapping has been updated since the submission. A comparison of the mapping shown negligible differences. In any event, bespoke hydraulic modelling has been undertaken of the watercourse network which provides a more accurate representation of flood risk to these features, further details are included within **Appendix 3**.

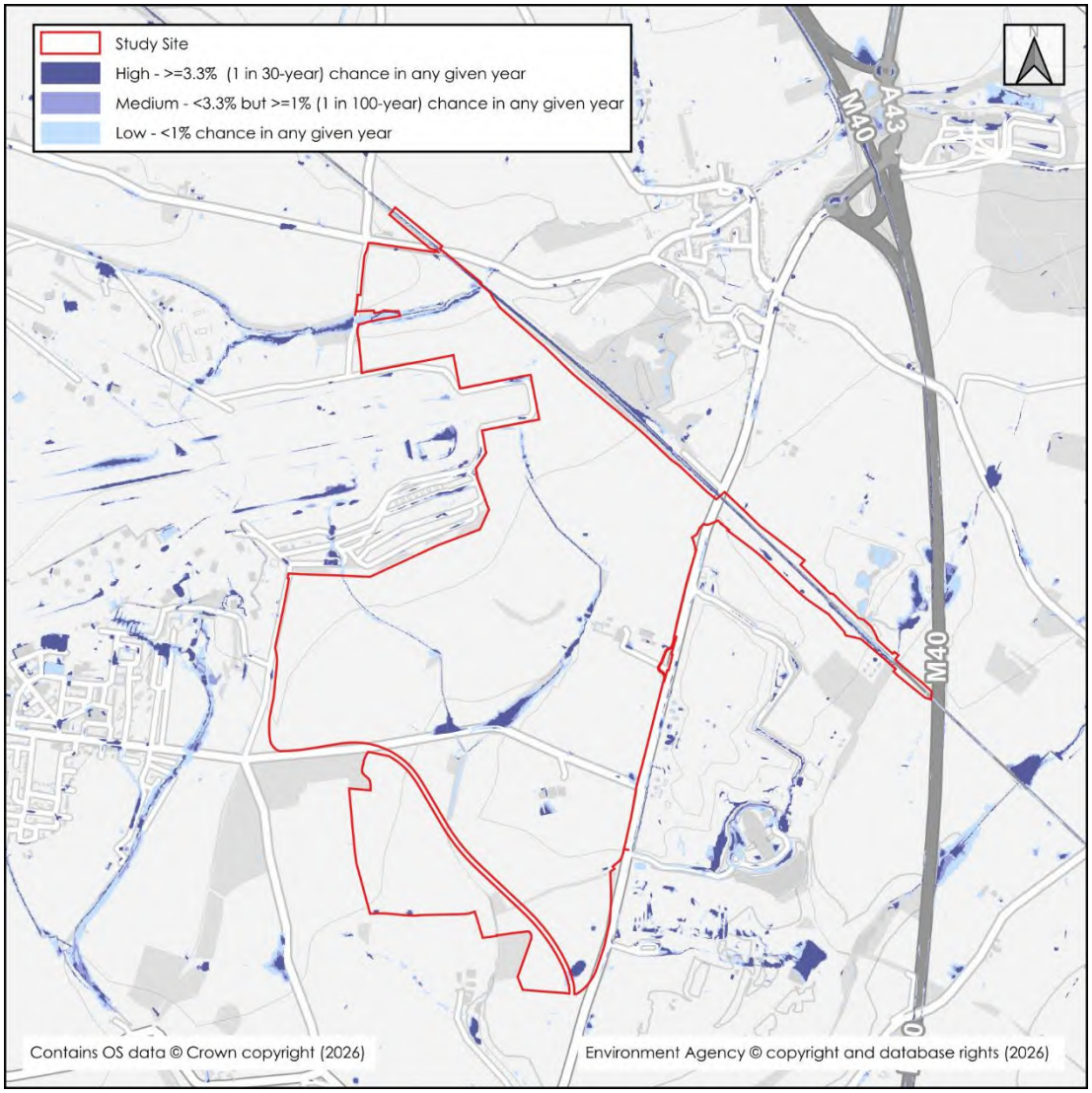


**Figure 3.3: EA Risk of Flooding from Surface Water (yearly Chance of Flooding between 2040 and 2060)**

3.22 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.

3.23 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.

3.24 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.

3.25 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.

3.26 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

3.27 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.

3.28 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).

3.29 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.

3.30 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. |

3.31 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.

3.32 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**.

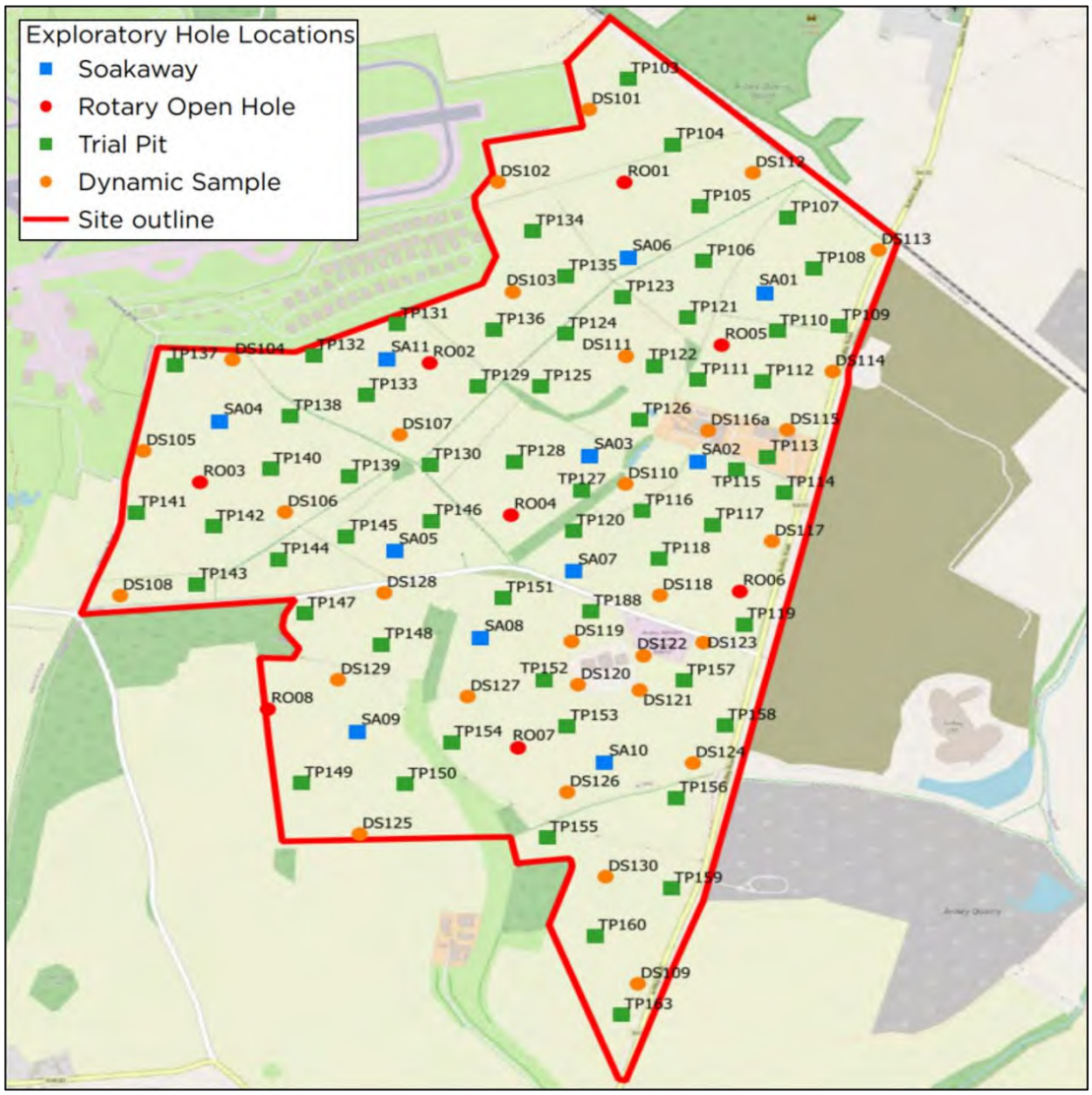


**Figure 3.4: Phase 2 Ground Investigation – Exploratory Hole Locations - BWB Consulting Ltd (September 2024)**

**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) |

3.33 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

3.34 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.

3.35 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**.

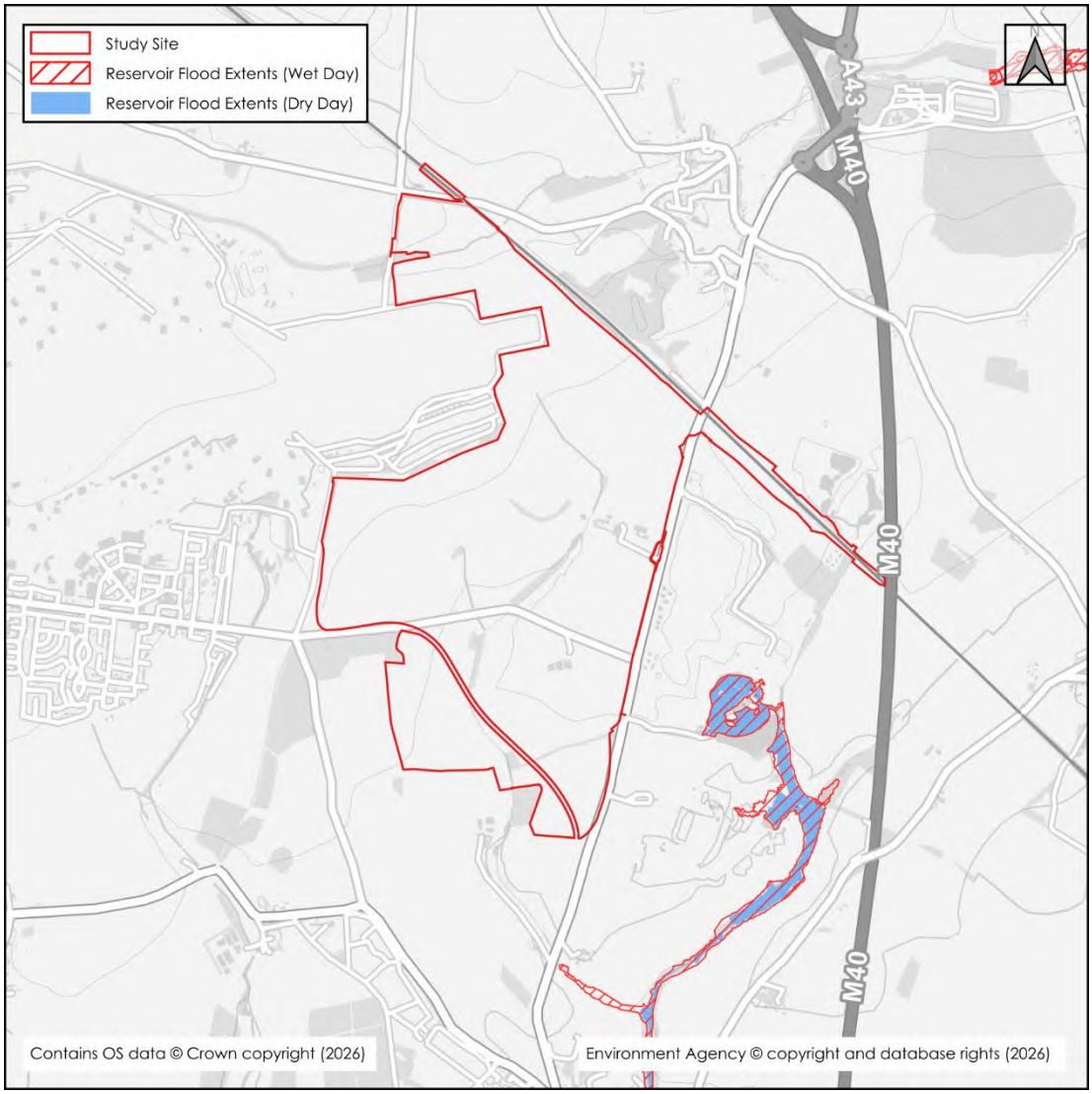


**Figure 3.5: EA Reservoir Failure Extents**

3.36 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.

3.37 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.

3.38 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.

3.39 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

3.40 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.

3.41 The local sewerage undertaker is Thames Water; a copy of their records is included in **Appendix 4**. There are two existing surface water sewers of unrecorded diameters within the study site.

3.42 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**.

3.43 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.

3.44 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.

3.45 Further details on sewer assets in proximity to any Offsite/Highway Improvement Works are included within **Appendix 1**.

### Effect of Development on Wider Catchment

Displacement of Floodplain/Impedance of Flood Flows

3.46 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

3.47 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 3** 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 As stated on Figure 4.1, the upper reaches of the Ashgrove Brook and Ashgrove Brook Tributary will be realigned and designed to mimic the existing flow regime within these reaches. This is proposed to be undertaken during detailed design. To provide a conservative assessment at this stage, the inflows have been moved further downstream, and have not been adjusted to take into account of the additional channel storage that would be provided by the realignment of both watercourse reaches.

4.5 Detailed mapping of the proposed development conditions is included within **Appendix 3** 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**.

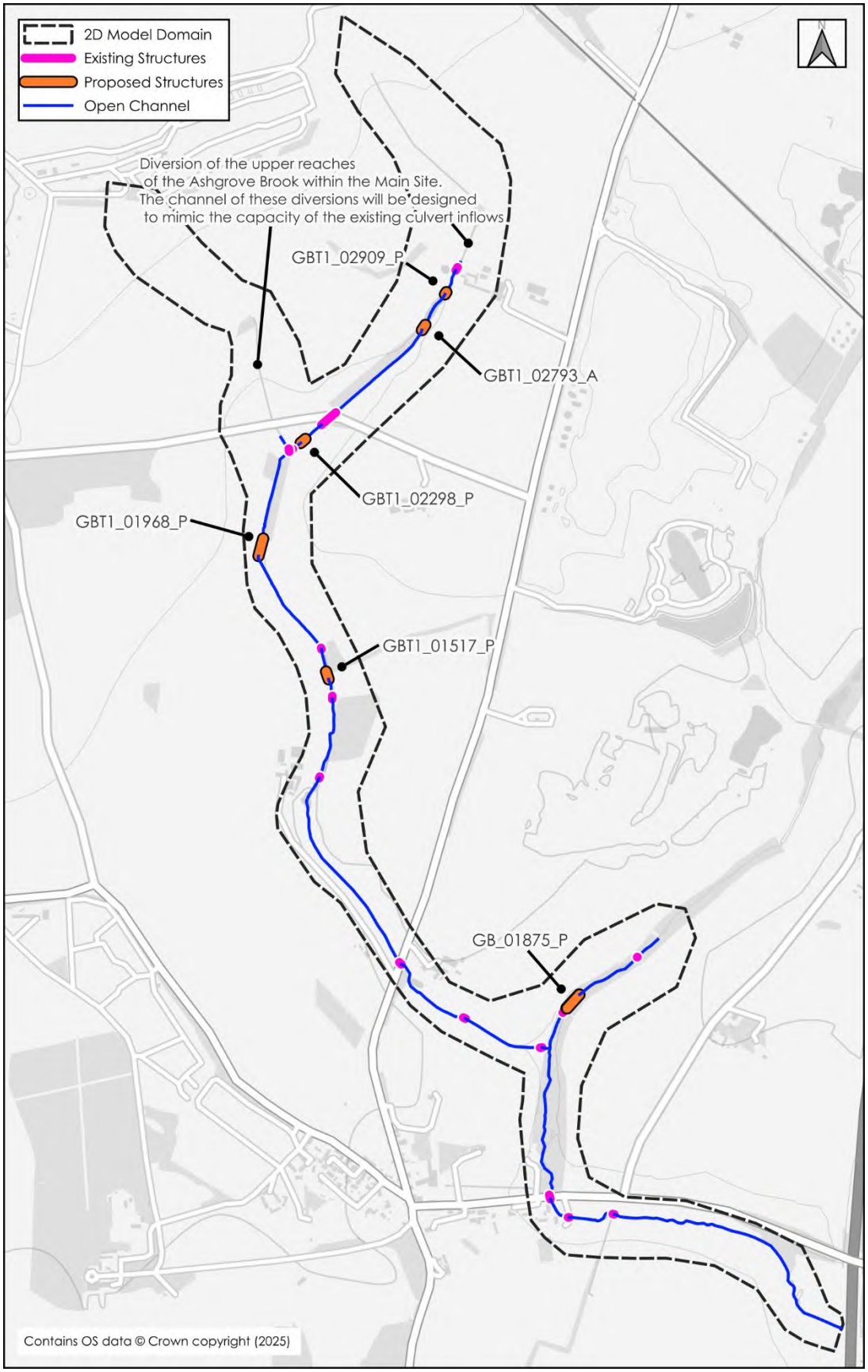


**Figure 4.1: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Structures**

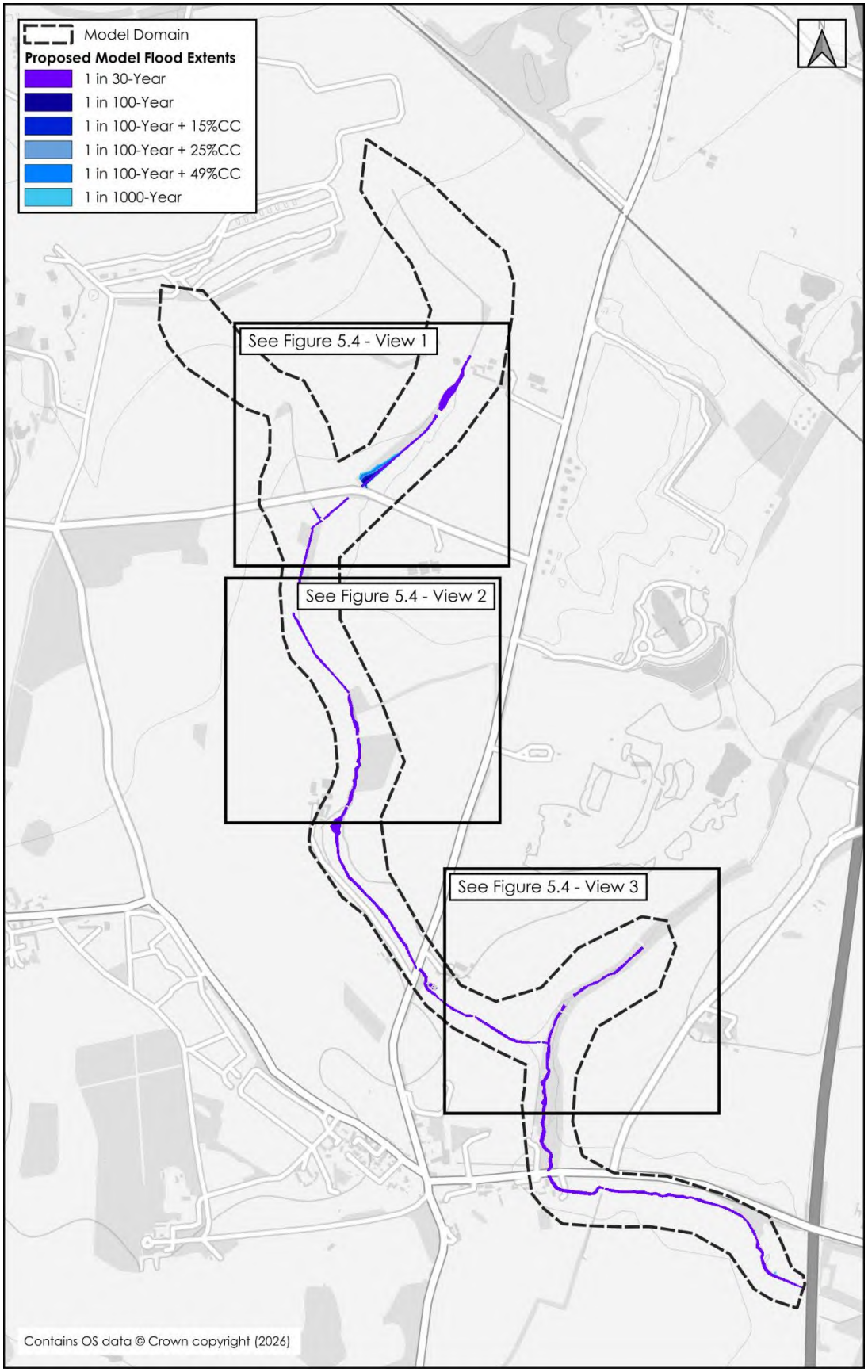


**Figure 4.2: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Modelled Flood Extents**

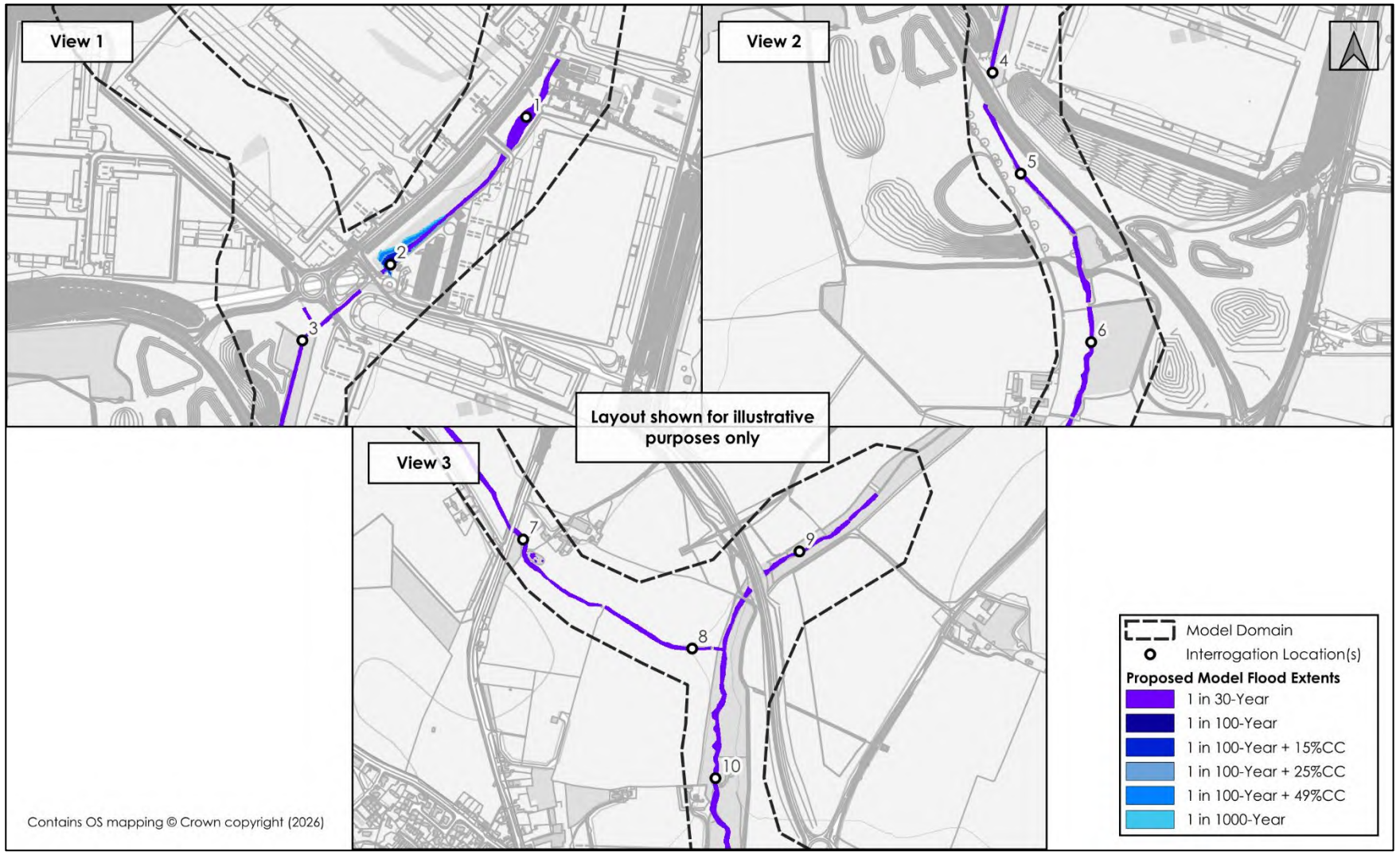


**Figure 4.3: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Proposed Modelled Flood Extents – Locations 1, 2 and 3**

**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 | 108.98 |
| 2 | 106.84 | 107.54 | 107.74 | 107.85 | 108.08 | 108.22 |
| 3 | 105.38 | 105.39 | 105.40 | 105.40 | 105.42 | 105.42 |
| 4 | 104.69 | 104.70 | 104.72 | 104.72 | 104.74 | 104.75 |
| 5 | 102.92 | 102.93 | 102.94 | 102.95 | 102.96 | 102.97 |
| 6 | 100.39 | 100.41 | 100.42 | 100.43 | 100.45 | 100.46 |
| 7 | 94.94 | 94.95 | 94.97 | 94.97 | 94.99 | 95.01 |
| 8 | 88.92 | 88.94 | 88.95 | 88.96 | 89.02 | 89.03 |
| 9 | 89.45 | 89.49 | 89.52 | 89.53 | 89.56 | 89.59 |
| 10 | 86.32 | 86.36 | 86.38 | 86.40 | 86.43 | 86.46 |

4.6 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.

4.7 The proposed culverts demonstrate the required freeboard during the 1 in 100-year +15% CC event in line with CIRIA c786 guidance as outlined in **Table 4.2**. The culverts also demonstrate freeboard within the 1 in 100-year +49% CC event.

**Table 4.2: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook – Proposed Hydraulic Structures Freeboards**

| Structure ID | Culvert Type/Size | 1 in 100-year +15% CC Modelled Peak Flood Level (mAOD) | Freeboard 1 in 100-year +15% CC (mm) | 1 in 100-year +49% CC Modelled Peak Flood Level (mAOD) | Freeboard 1 in 100-year +49% CC (mm) |
|---|---|---|---|---|---|
| GBT1_02909_P | Clear span bridge | - | - | - | - |
| GBT1_02793_A | 900mm circular culvert | 108.744 | 410 | 108.793 | 361 |
| GBT1_02298_P | 1m x 1m Rectangular Culvert | 105.943 | 388 | 105.963 | 368 |
| GBT1_01968_P | 1200mm circular culvert | 104.667 | 746 | 104.697 | 716 |

| | | | | | |
|---|---|---|---|---|---|
| GBT1_01517_P | 1m x 1m rectangular culvert | 101.594 | 441 | 101.634 | 401 |
| GB_01875_P | 4m x 6m rectangular/irregular (600m wide mammal shelf on both sides of culvert) | 88.436 | 727 | 88.479 | 684 |

4.8 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 3**; the comparison mapping for the design event (1 in 100-year + 15%) is illustrated in **Figure 4.4** and discussed below.

4.9 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.

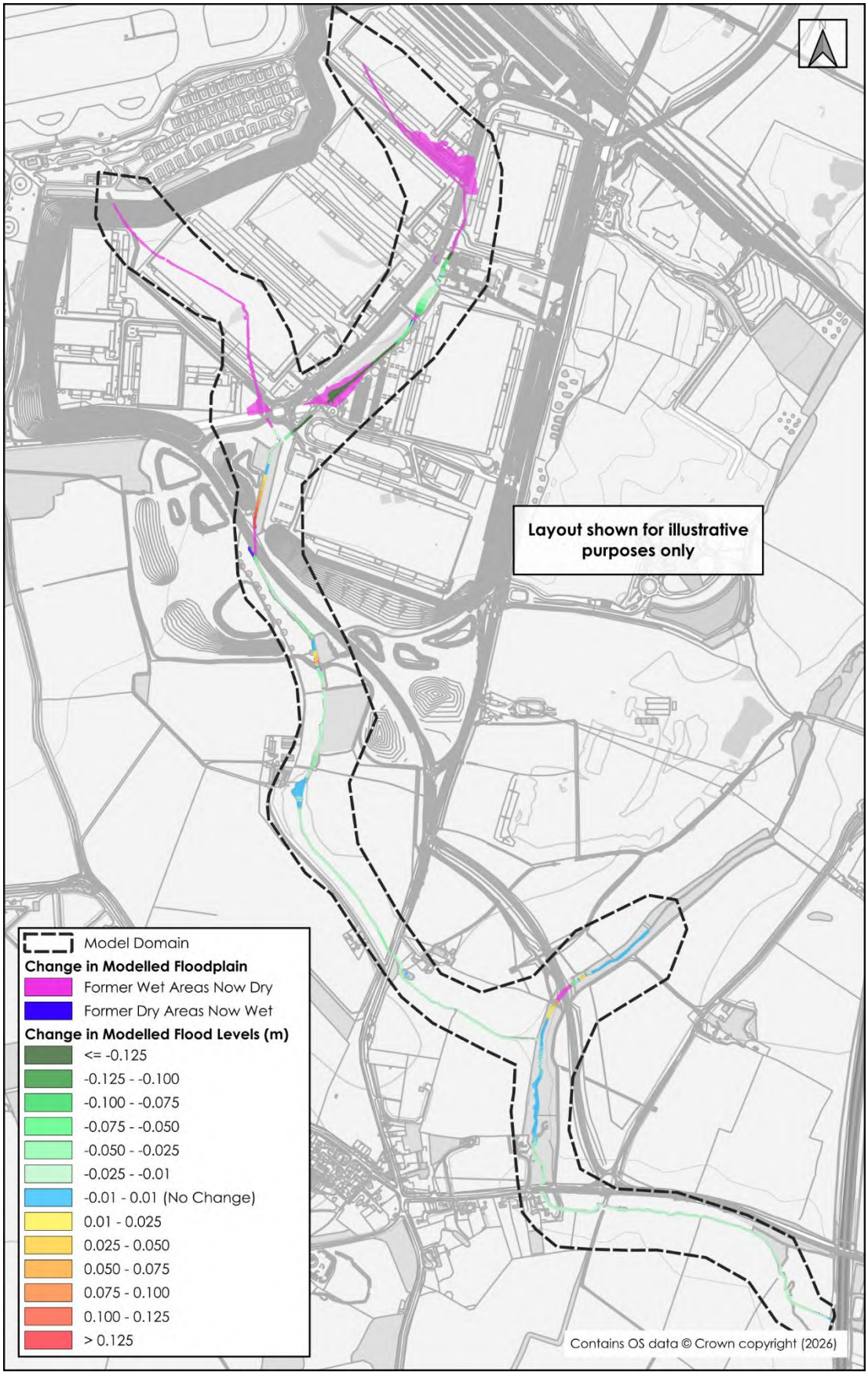
Layout shown for illustrative purposes only
Model Domain
Change in Modelled Floodplain
Former Wet Areas Now Dry
Former Dry Areas Now Wet
Change in Modelled Flood Levels (m)
<= -0.125
-0.125 - -0.100
-0.100 - -0.075
-0.075 - -0.050
-0.050 - -0.025
-0.025 - -0.01
-0.01 - 0.01 (No Change)
0.01 - 0.025
0.025 - 0.050
0.050 - 0.075
0.075 - 0.100
0.100 - 0.125
> 0.125
Contains OS data © Crown copyright (2026)

**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

4.10 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**.

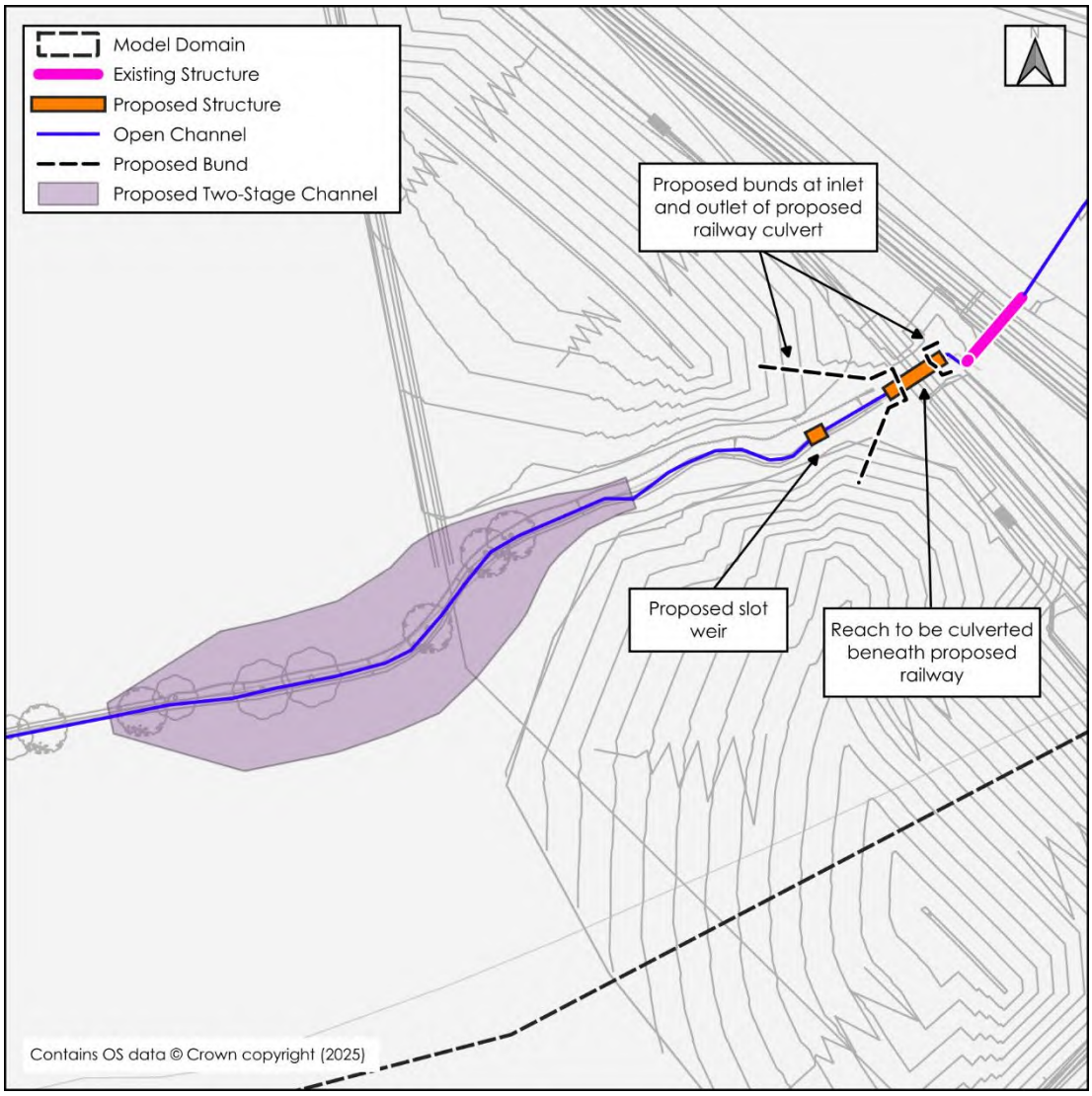


**Figure 4.5: Padbury Brook Tributary – Proposed Works**

4.11 Detailed mapping of the proposed development conditions is included within **Appendix 3** and summarised below. The floodplain extents are shown in **Figure 4.6**, with modelled flood levels outlined within **Table 4.3**.

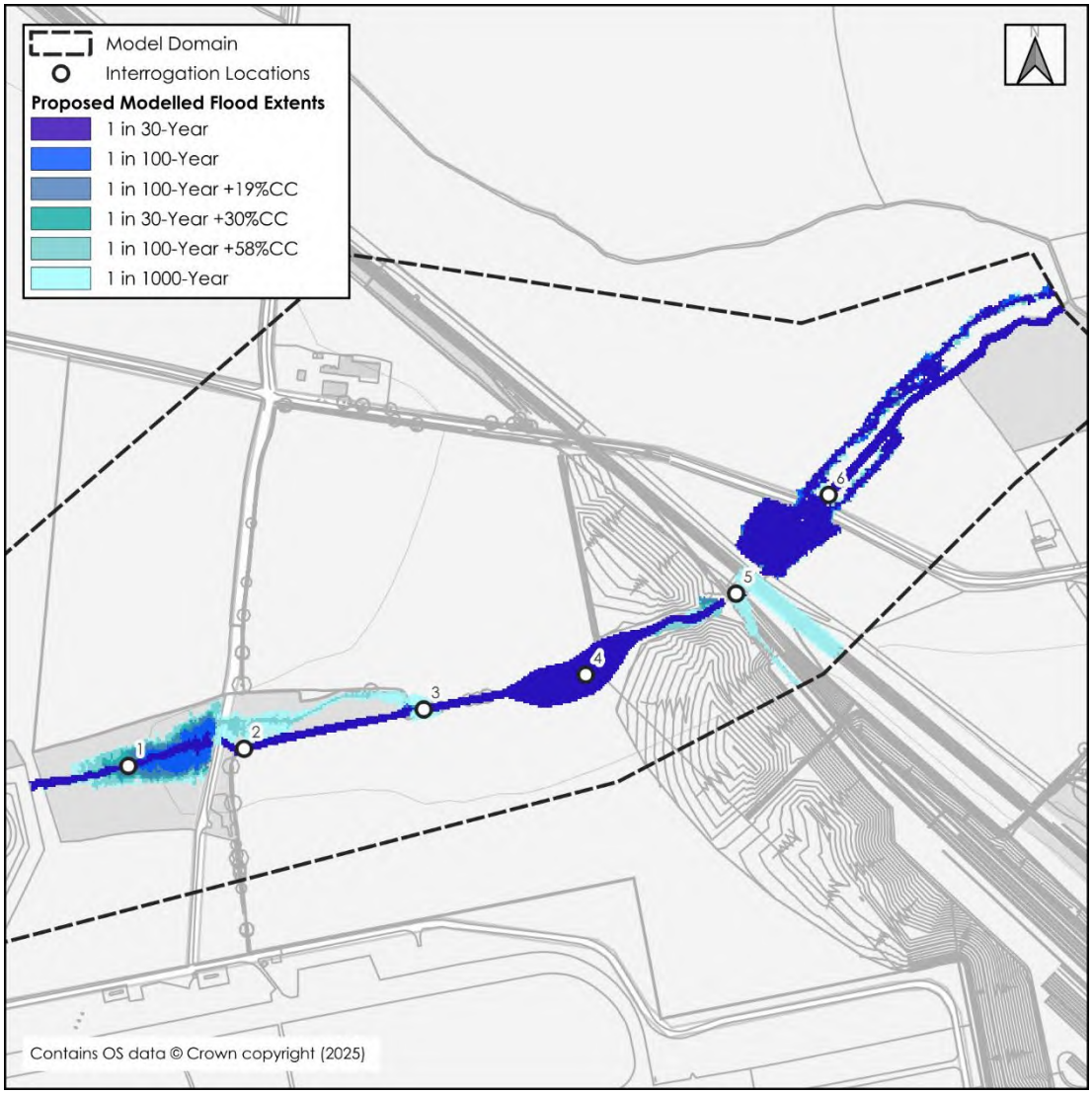


**Figure 4.6: Padbury Brook Tributary – Proposed Modelled Flood Extents**

**Table 4.3: 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 |

4.12 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 3**; the comparison mapping for the design event (1 in 100-year + 19%) is illustrated in **Figure 4.7** and discussed below.

4.13 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.

4.14 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.

4.15 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.

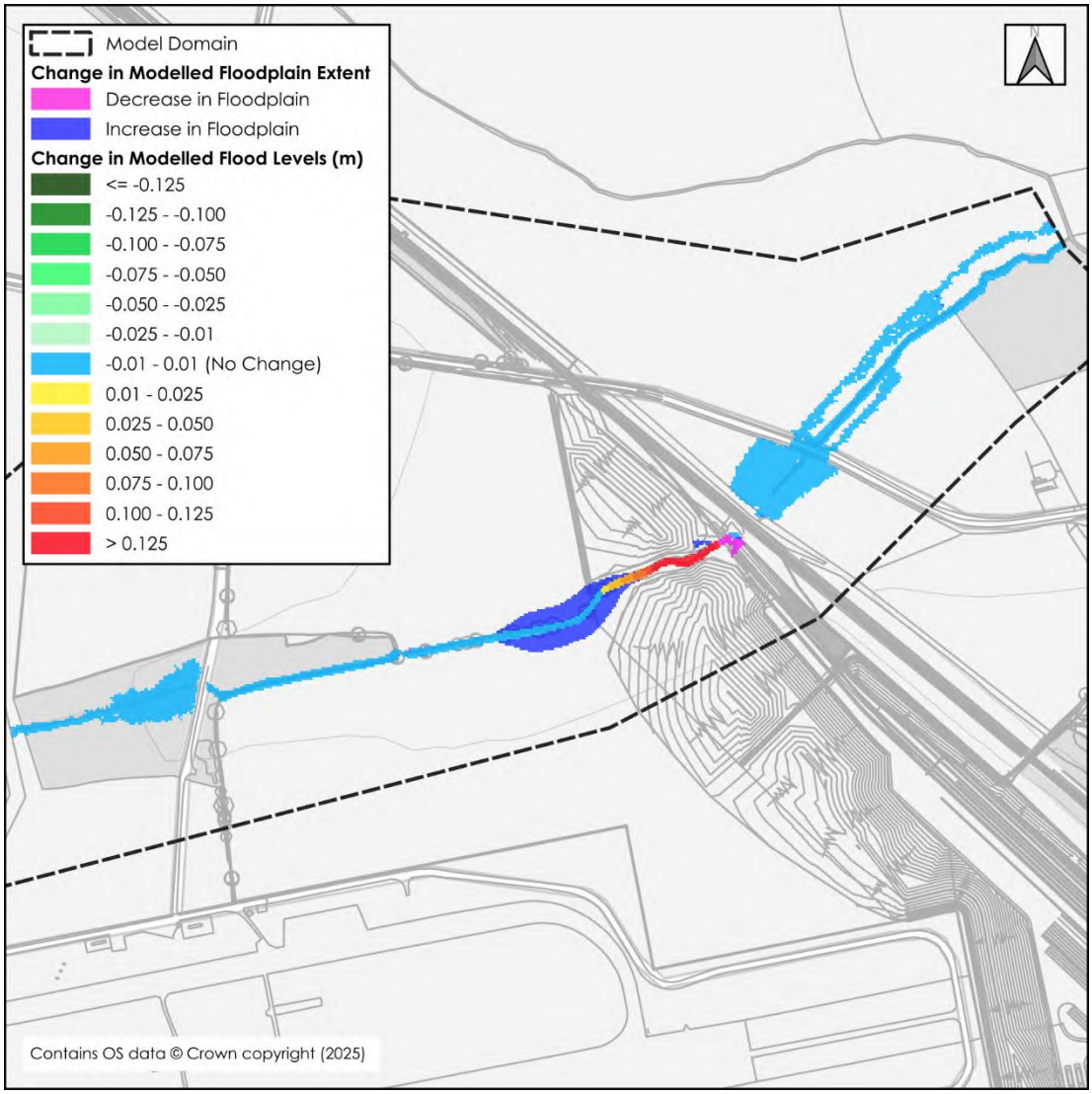


**Figure 4.7: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook - Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 15% Climate Change**

## Development Levels

4.16 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. A comparison of the proposed development levels against the modelled peak flood level is included in **Table 4.4**.

**Table 4.4: Ashgrove Brook, Ashgrove Brook Tributary and Gagle Brook – Development Levels Freeboards**

| Node | 1 in 100-year +15% CC Peak Flood Level (mAOD) | 1 in 100-year +49% CC Peak Flood Level (mAOD) | Minimum Development Level (mAOD) | Freeboard to 1 in 100-year +15% CC Peak Flood Level (m) | Freeboard to 1 in 100-year +49% CC Peak Flood Level (m) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | 108.96 | 108.97 | 113.365 | 4.41 | 4.40 |
| 2 | 107.74 | 108.08 | 113.365 | 5.63 | 5.29 |
| 3 | 105.40 | 105.42 | 110.715 | 5.32 | 5.23 |

4.17 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

4.18 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

4.19 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.

4.20 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**.

4.21 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 4.5**, 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.

4.22 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.

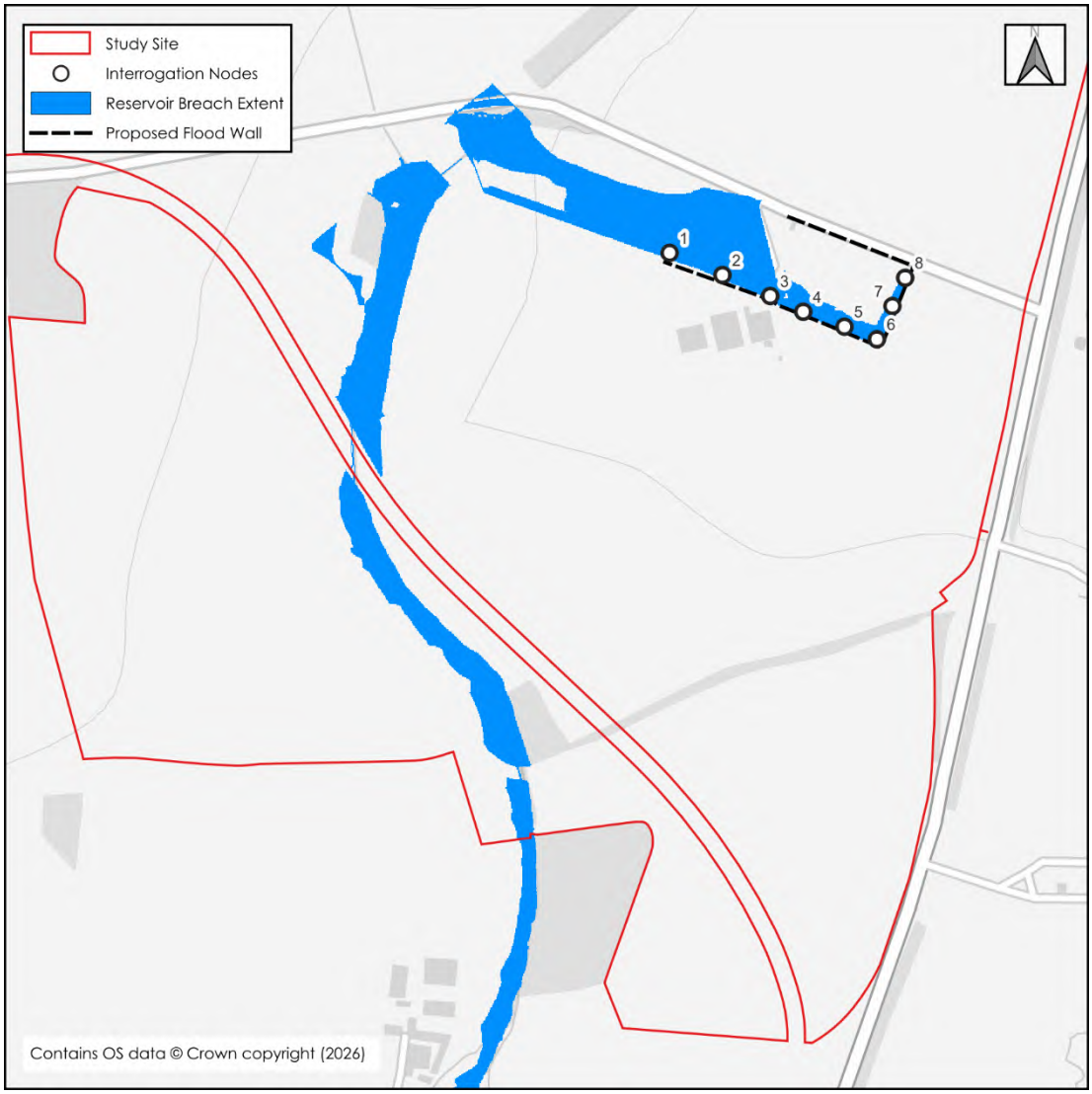


**Figure 4.8: Ardley Reservoir and Water Pumping Station Modelled Breach Extents Post Mitigation**

**Table 4.5: 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

4.23 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

4.24 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.

4.25 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.

4.26 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.

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

4.28 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.

4.29 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.

4.30 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.

4.31 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.<br><br>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.<br><br>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.<br><br>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).<br><br>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.<br><br>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.<br><br>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.<br><br>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.<br><br>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.<br><br>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 Assessment – Offsite and Highways Works

# DOCUMENT ISSUE RECORD

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| P02 | 19/05/26 | S2 | Minor updates for consistency | CC | SR | CG |
| P03 | XX/10/26 | S2 | Updated in line with Flood Risk and Drainage responses for Deadline 2 | CC | MD | MD |

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Table 1.1: Summary of Highway Works
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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 B430 Station Road.
  - 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.

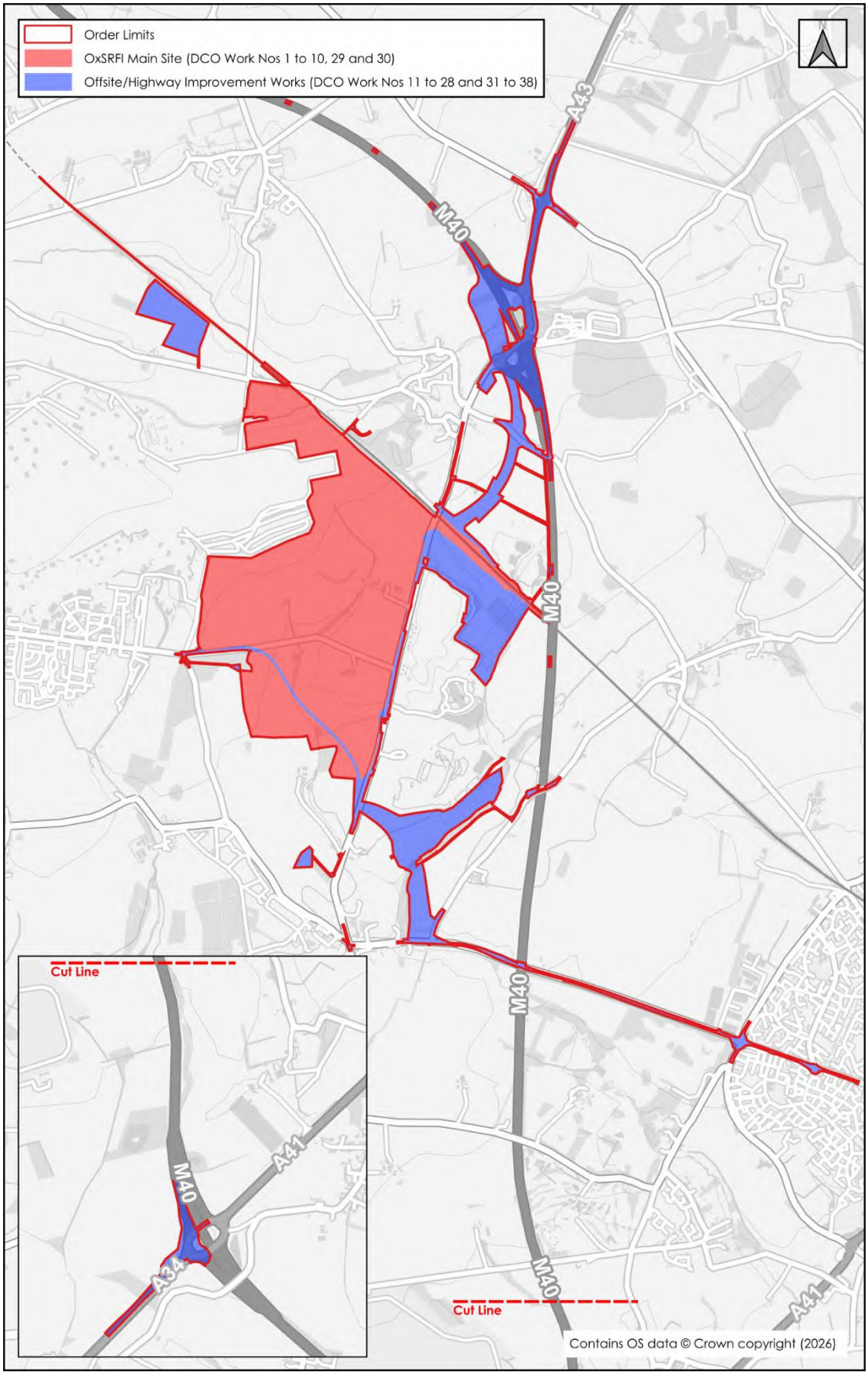


**Figure 1.1: Site Location**

**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 | Alterations to the B430 Station Road between the Chiltern Main line railway bridge and Upland Cottage south of Ardley. | Flood Zone 1 | Screened Out – 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. |
| 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

1.7 The RoFSW mapping was the latest data used at the time of writing the submitted FRA, however it is noted that the mapping has been updated since the submission. A comparison of the mapping shown negligible differences. In any event, bespoke hydraulic modelling has been undertaken of the watercourse network which provides a more accurate representation of flood risk to these features.

[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**.

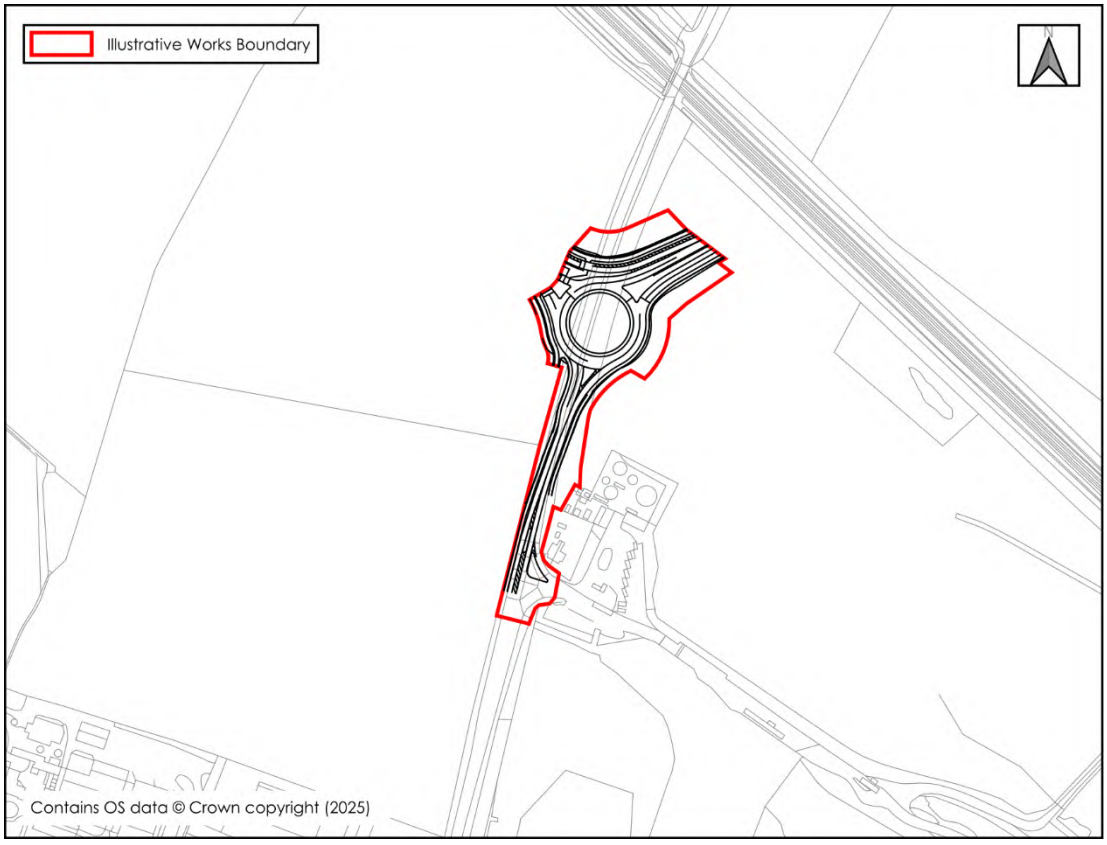


**Figure 2.1: Illustrative Works - Works No. 11**

## 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**.

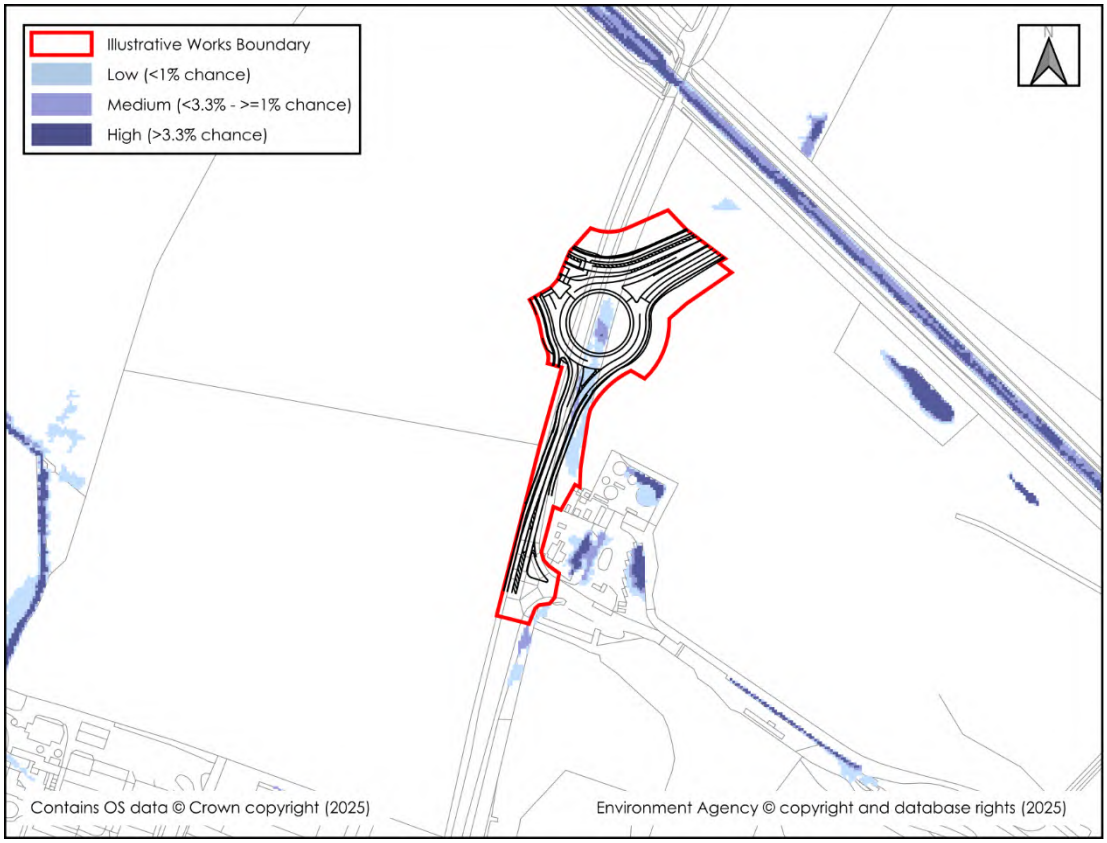


**Figure 2.2: EA RoFSW data - Works No. 11**

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**.

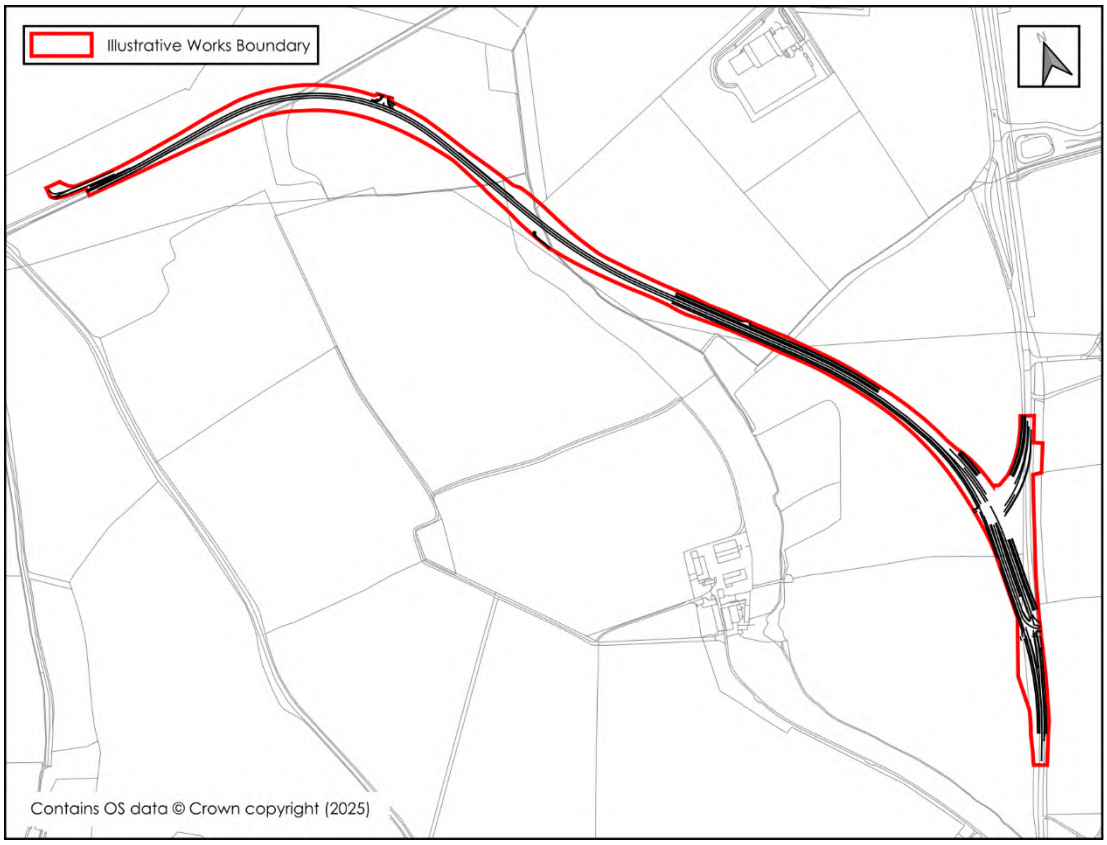


**Figure 3.1: Illustrative Works Boundary - Works No. 12**

## 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**.

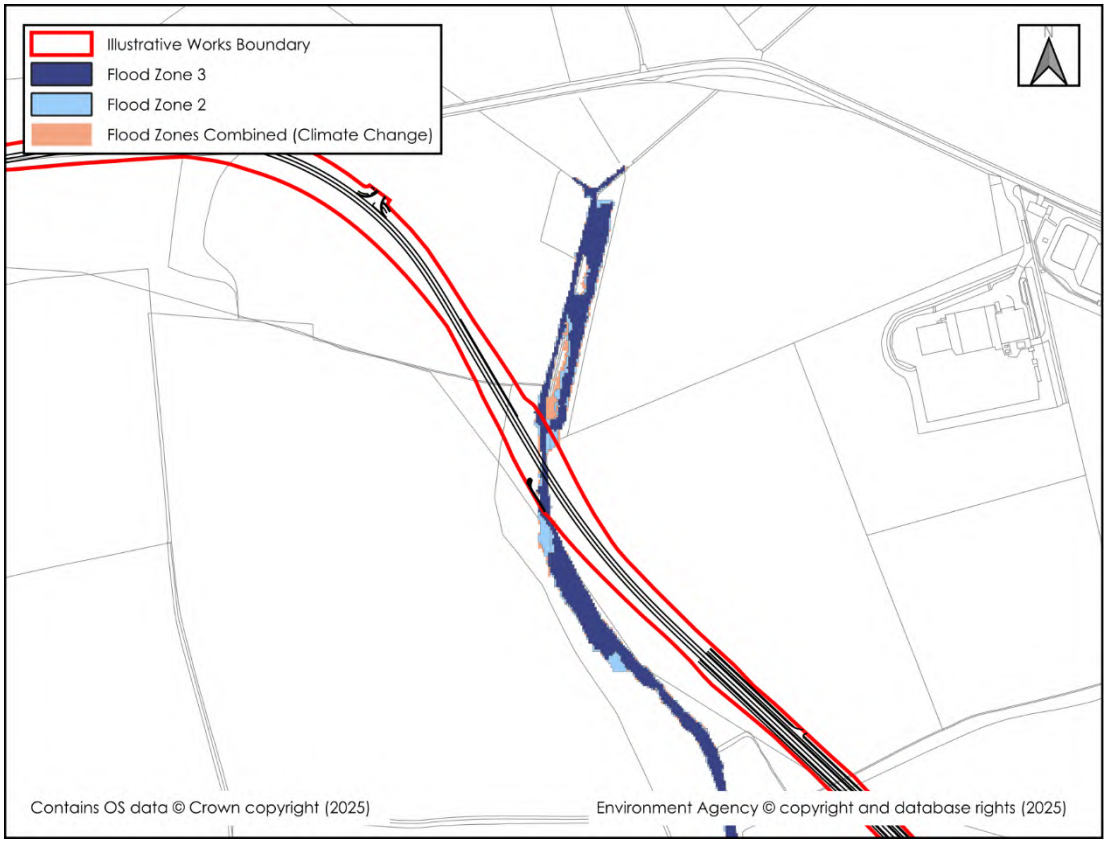


**Figure 3.2: EA Flood Map for Planning – Works No. 12**

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.

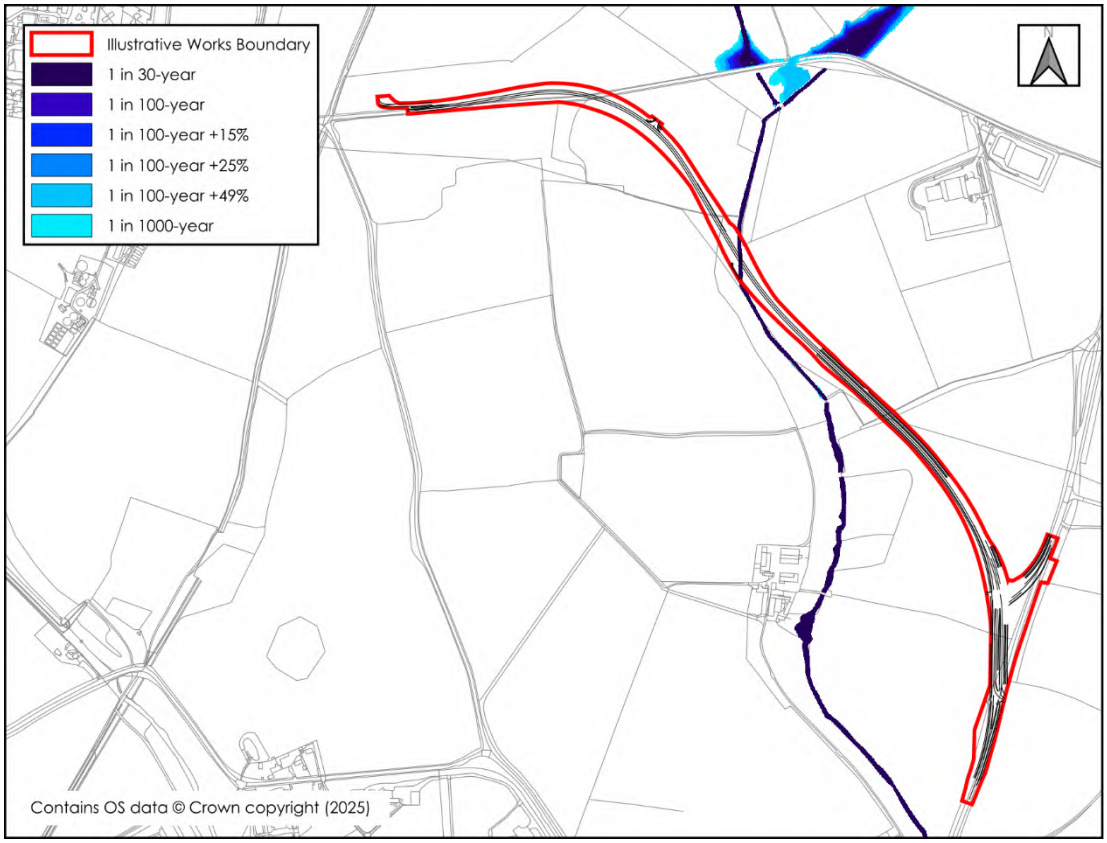


**Figure 3.3: BWB Baseline Modelled Flood Extents – Works No. 12**

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)

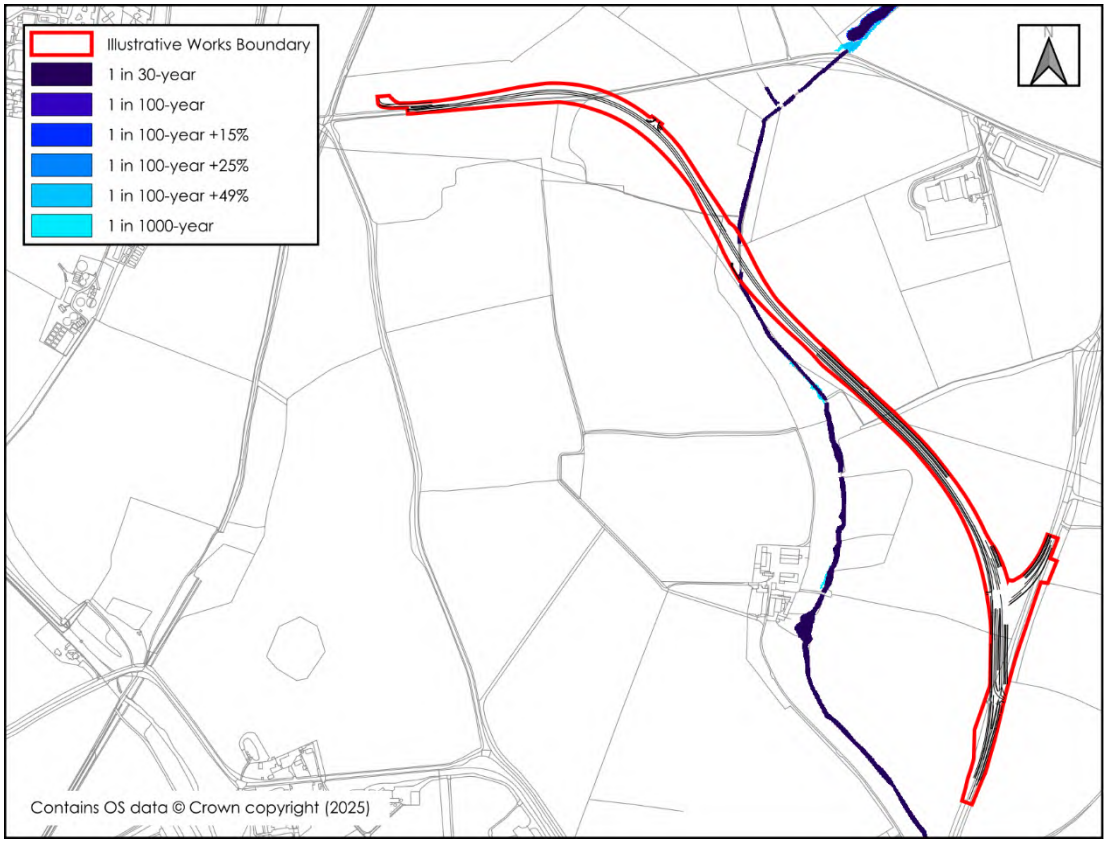


**Figure 3.4: BWB Proposed Modelled Flood Extents – Works No. 12**

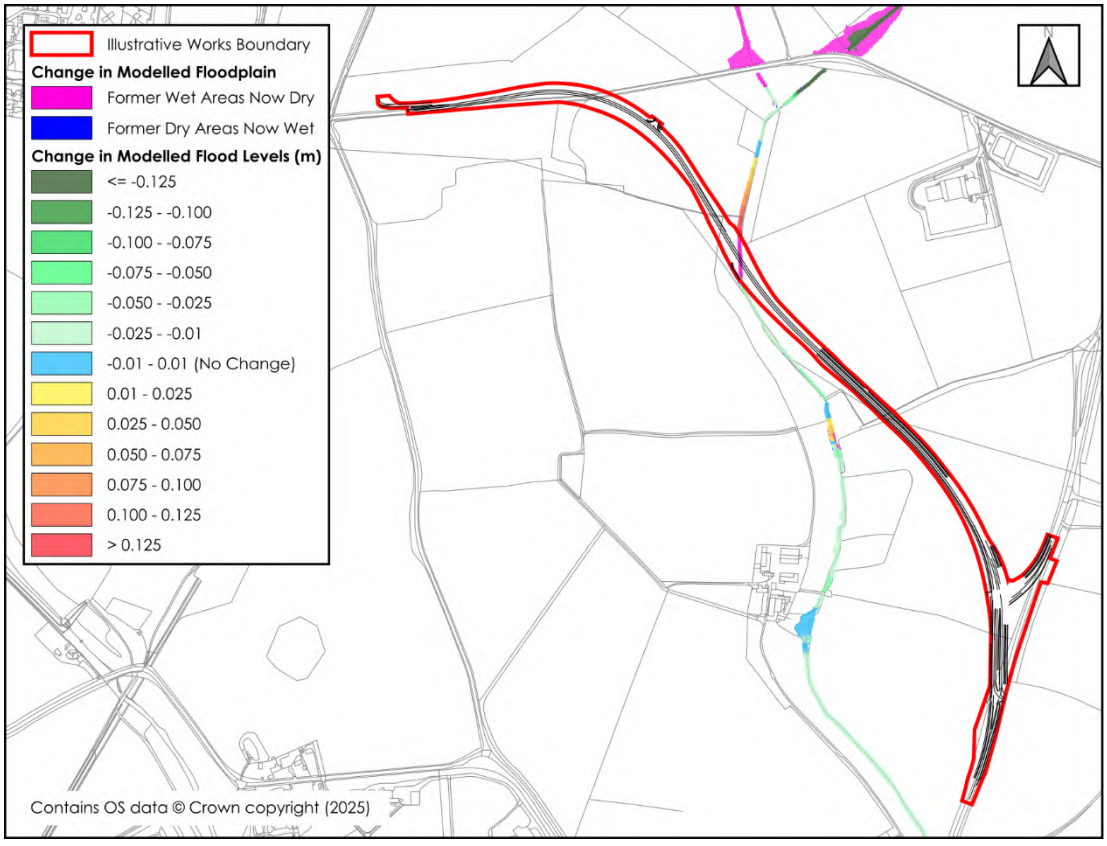


**Figure 3.5: 1 in 100-year +15% Floodplain Comparison – Works No. 12**

### 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.

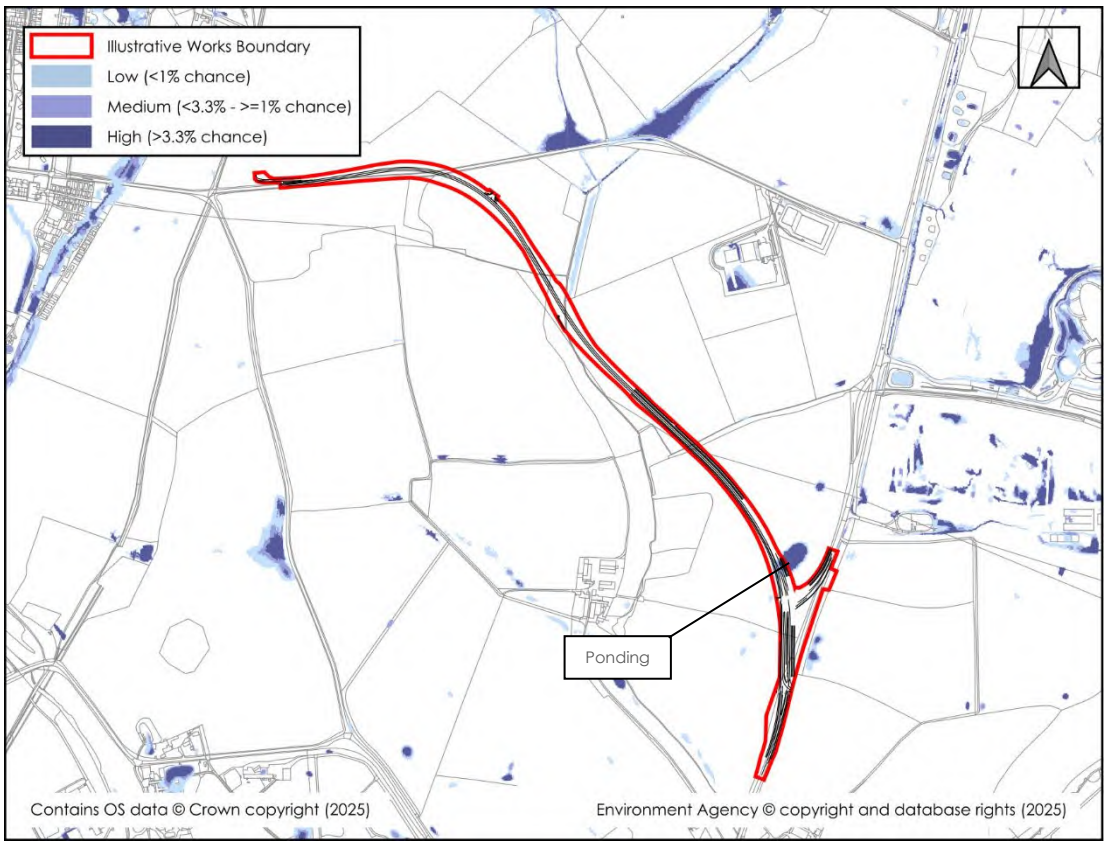


**Figure 3.6: EA RoFSW - Works No. 12**

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**.

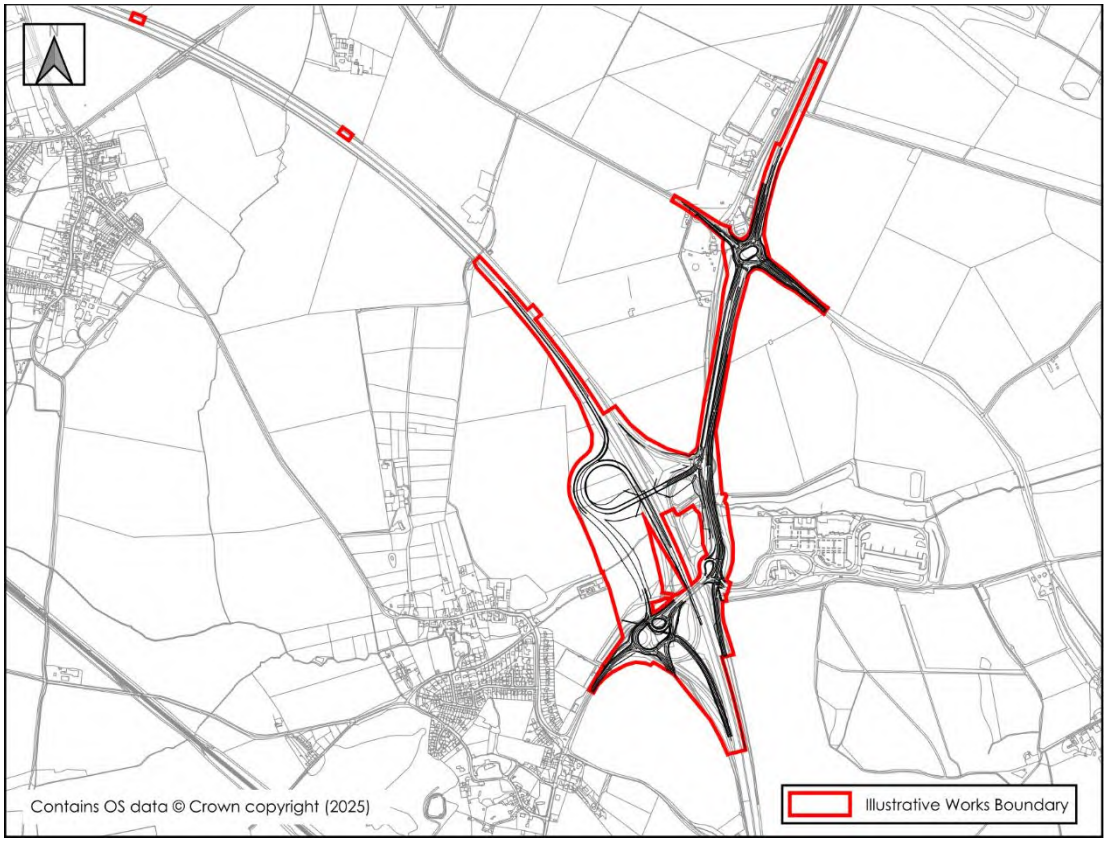


**Figure 4.1: Illustrative Works – Works No. 14 to 18**

## 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**.

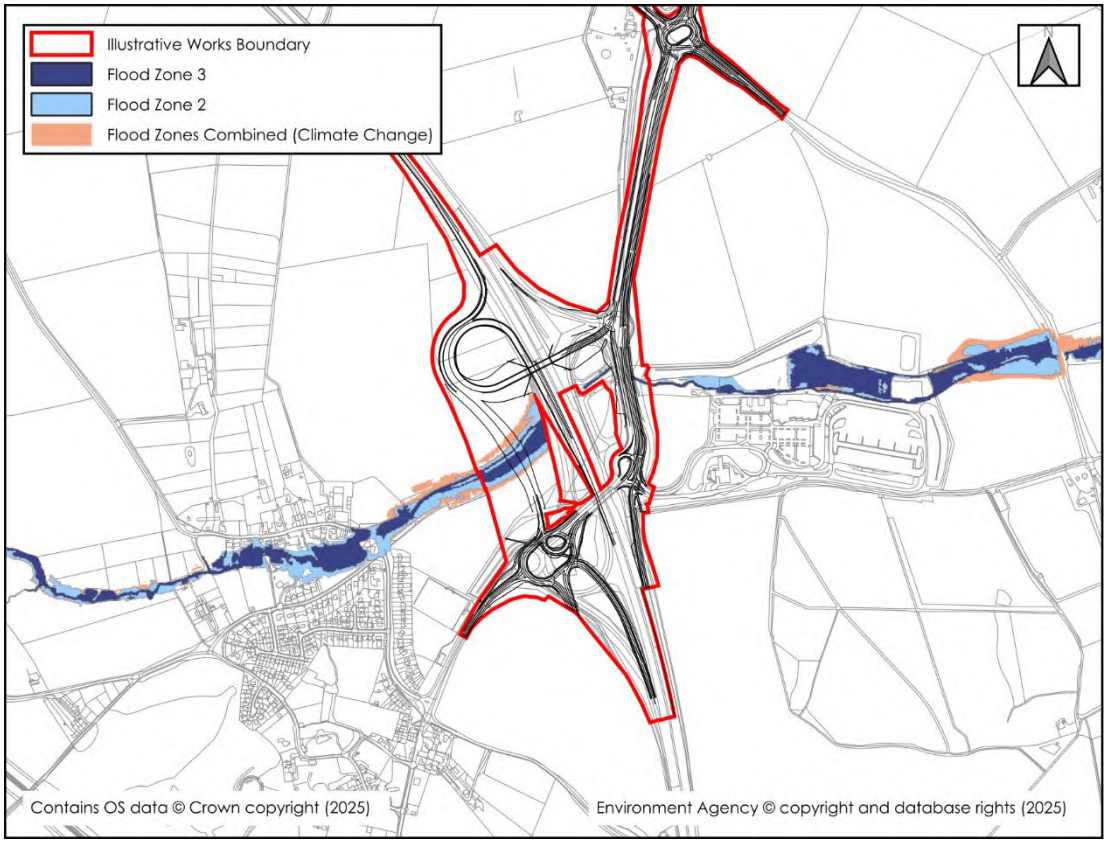


**Figure 4.2: EA Flood Map for Planning - Works No. 14 to 18**

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.

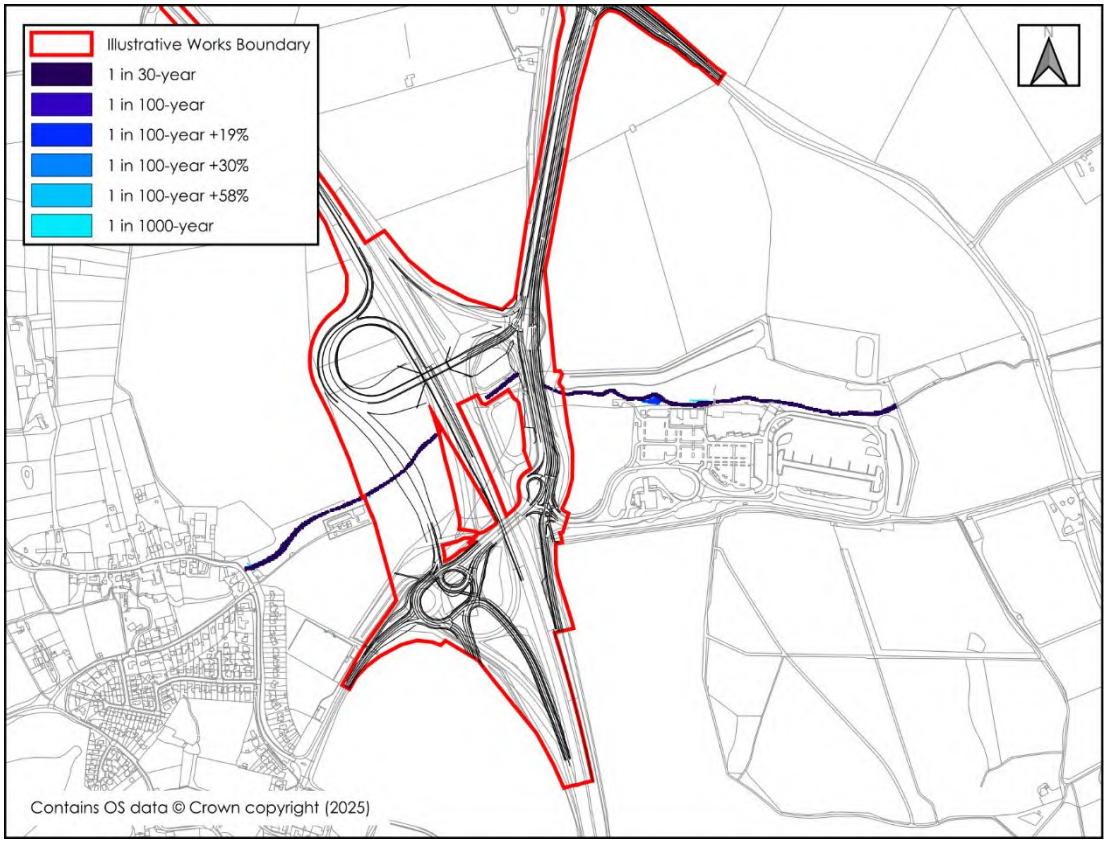


**Figure 4.3: BWB Baseline Modelled Flood Extents - Works No. 14 to 18**

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 390mm freeboard in the 1 in 100-year +19% climate change event and 299mm freeboard in the 1 in 100-year +58% climate change event.

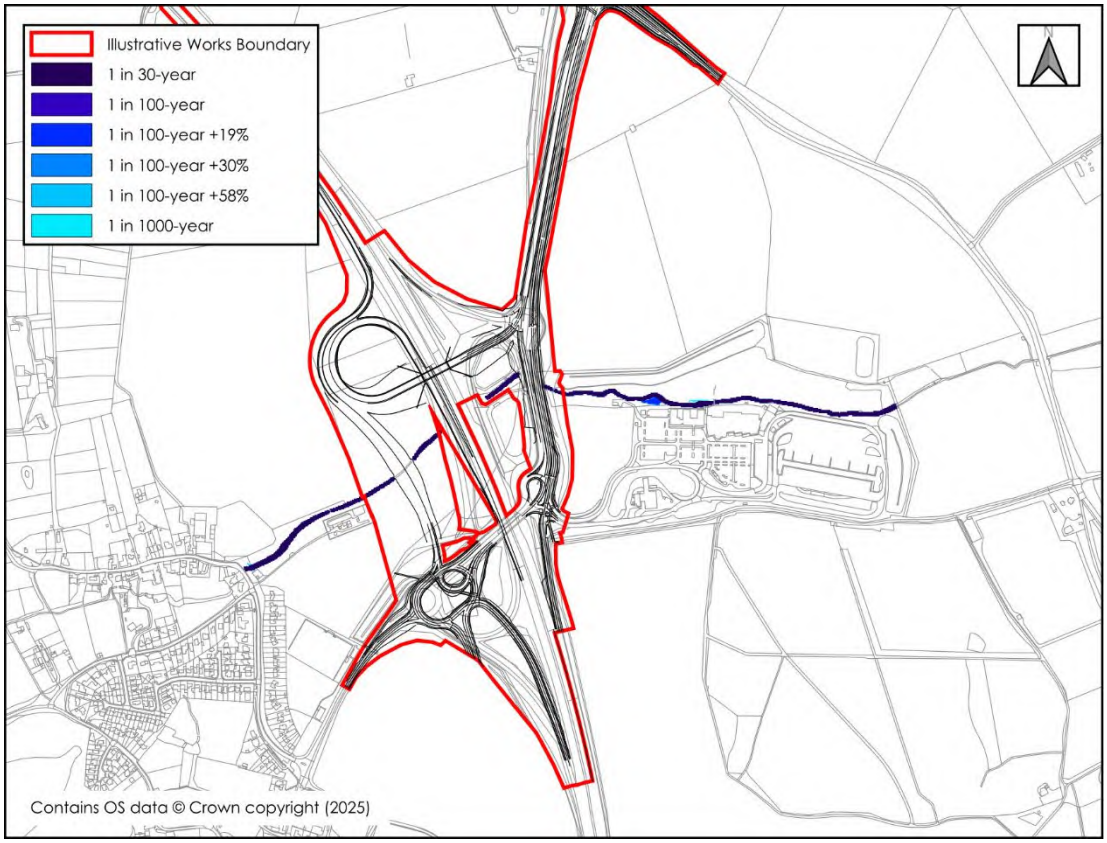


**Figure 4.4: BWB Proposed Modelled Flood Extents - Works No. 14 to 18**

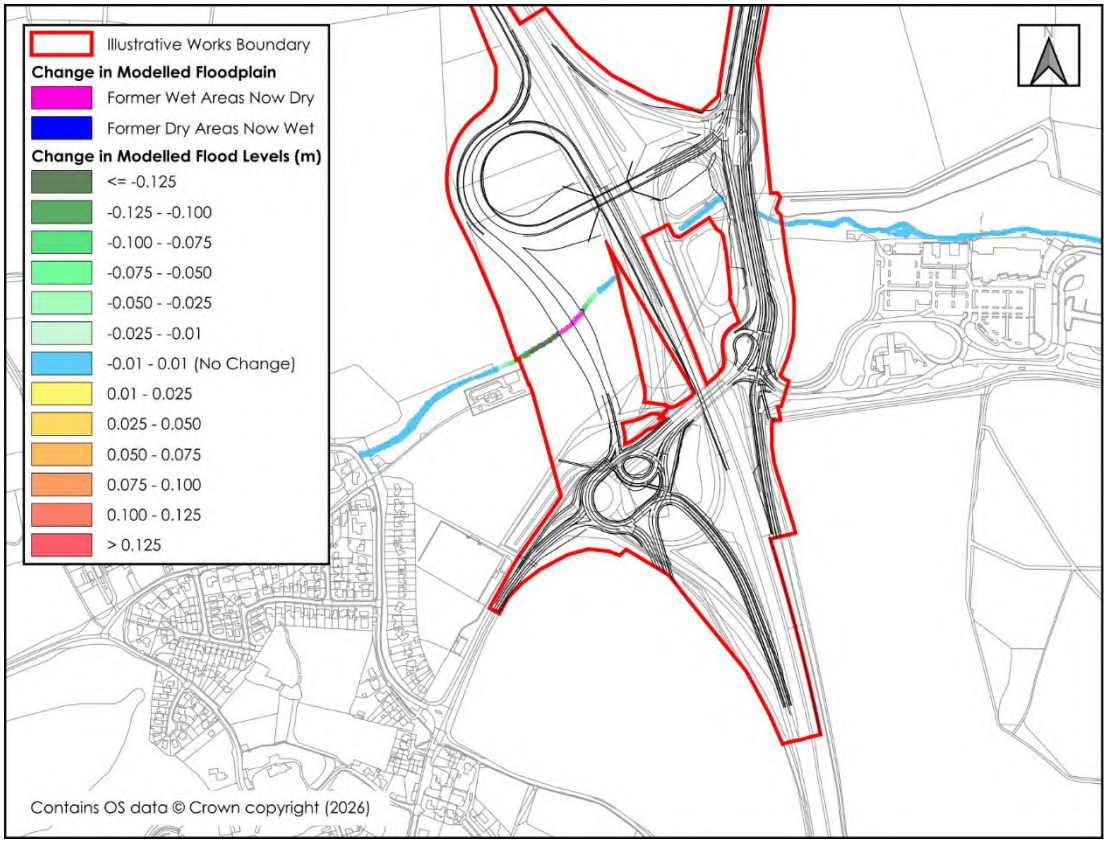


**Figure 4.5: 1 in 100-year +19% Floodplain Comparison - Works No. 14 to 18**

## 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.

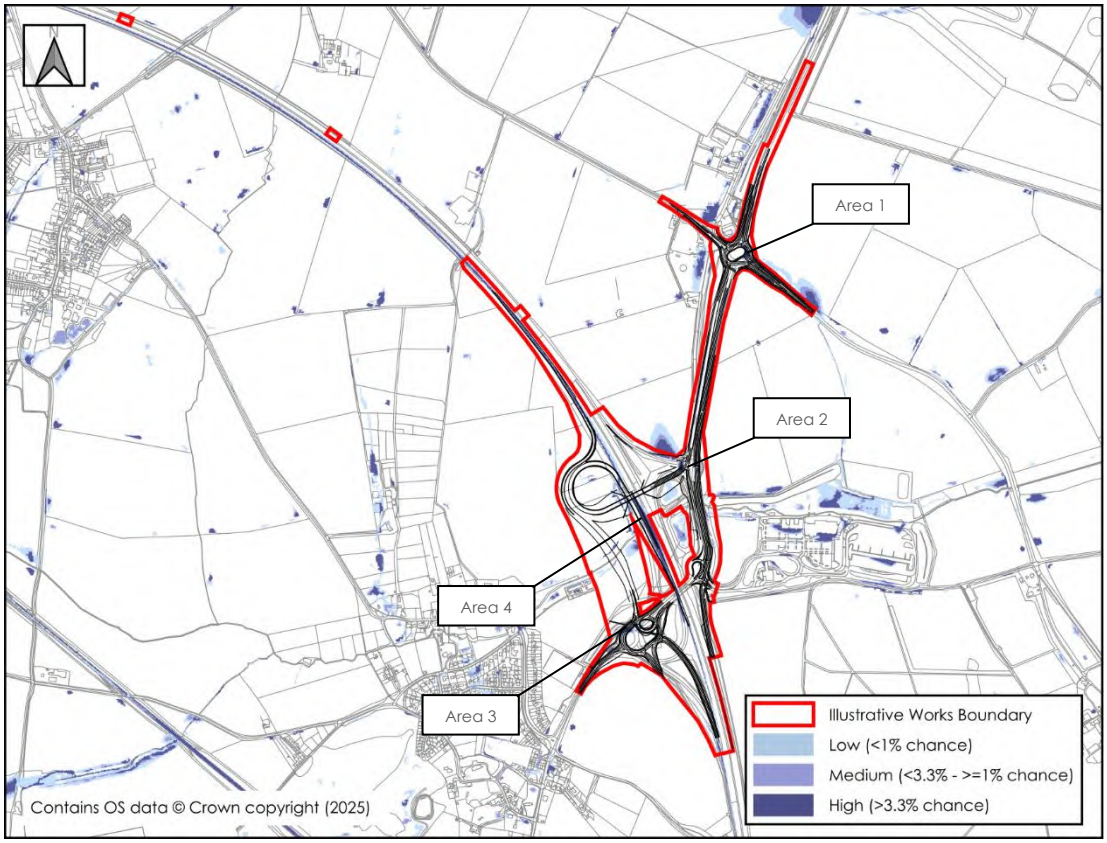


**Figure 4.6: EA Risk of Flooding from Surface Water - Works No. 14 to 18**

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.

4.15 An Anglian Water highly pressurised rising main is located within a section of the proposed works, while not considered to pose a flood risk to the works the asset is to be retained and protected within the proposals.

### Groundwater Flood Risk

4.16 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.

4.17 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

4.18 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

4.19 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**.

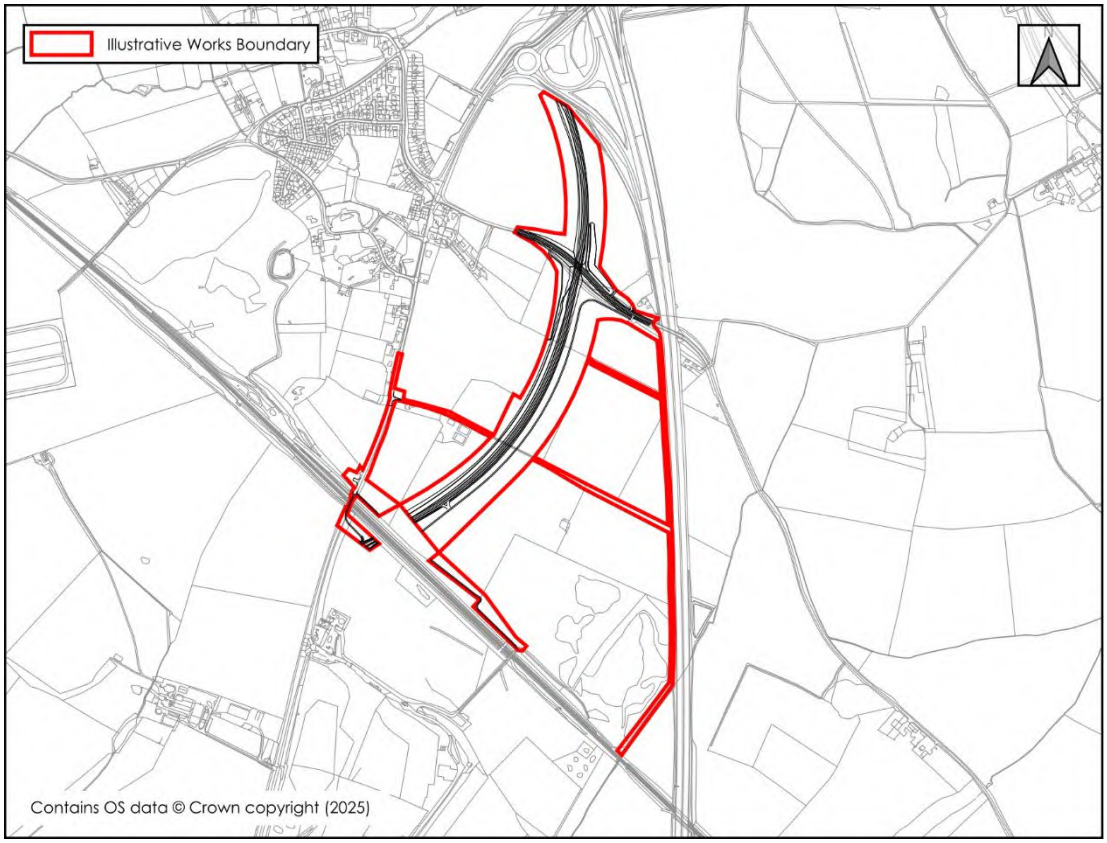


**Figure 5.1: Illustrative Works Boundary - Works No. 19 to 21**

## 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.

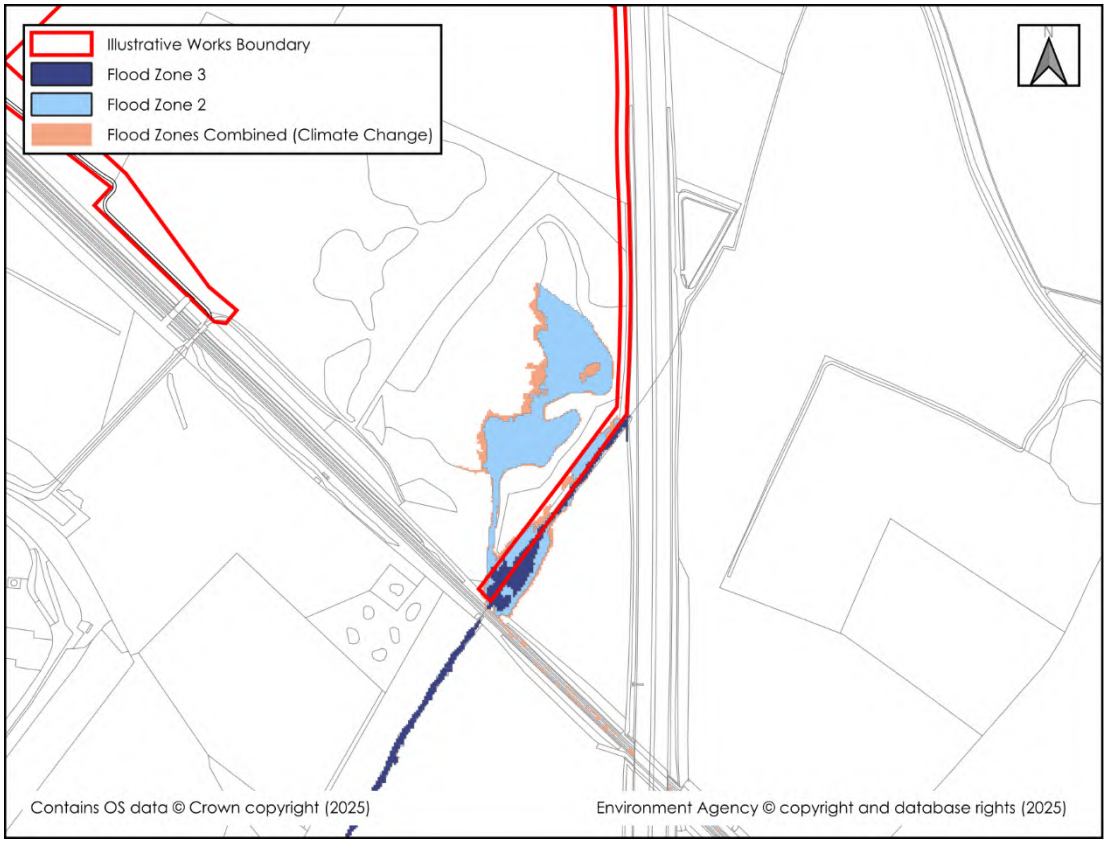


**Figure 5.2: EA Flood Map for Planning – Works No. 19 to 21**

### 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**.

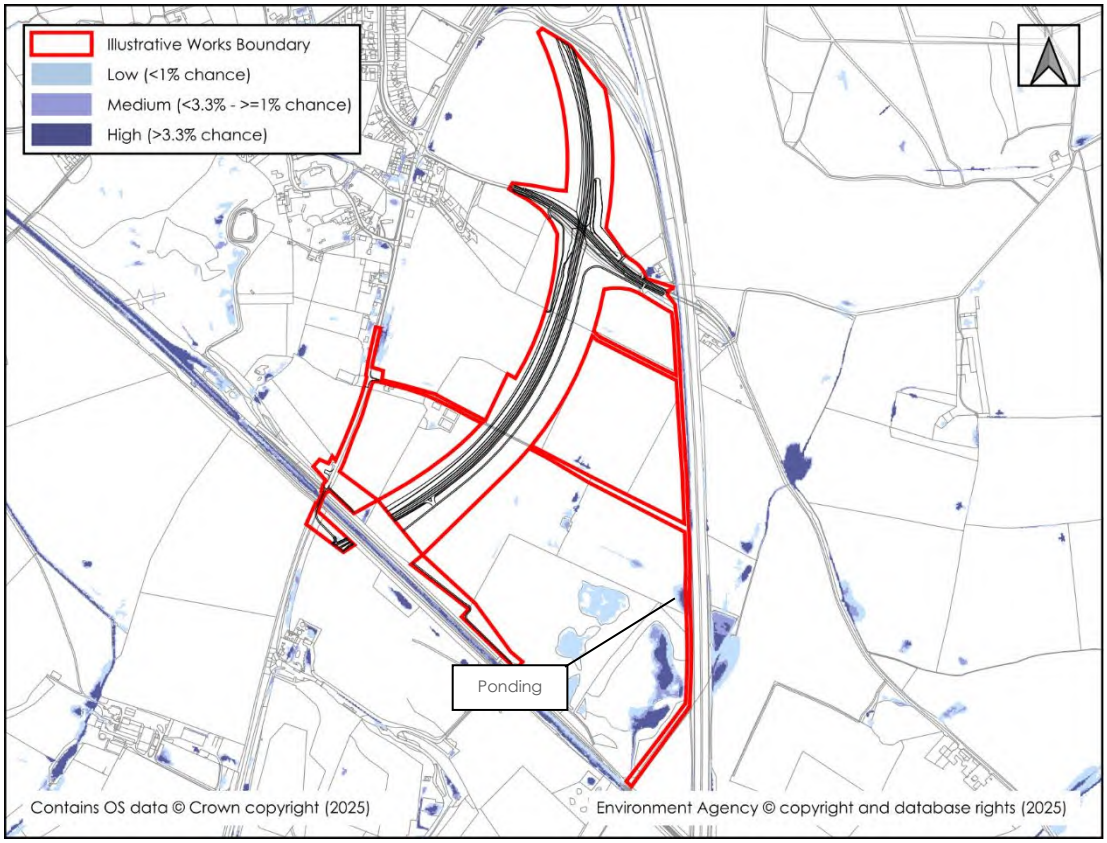


**Figure 5.3: EA Risk of Flooding from Surface Water - Works No. 19 to 21**

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**.

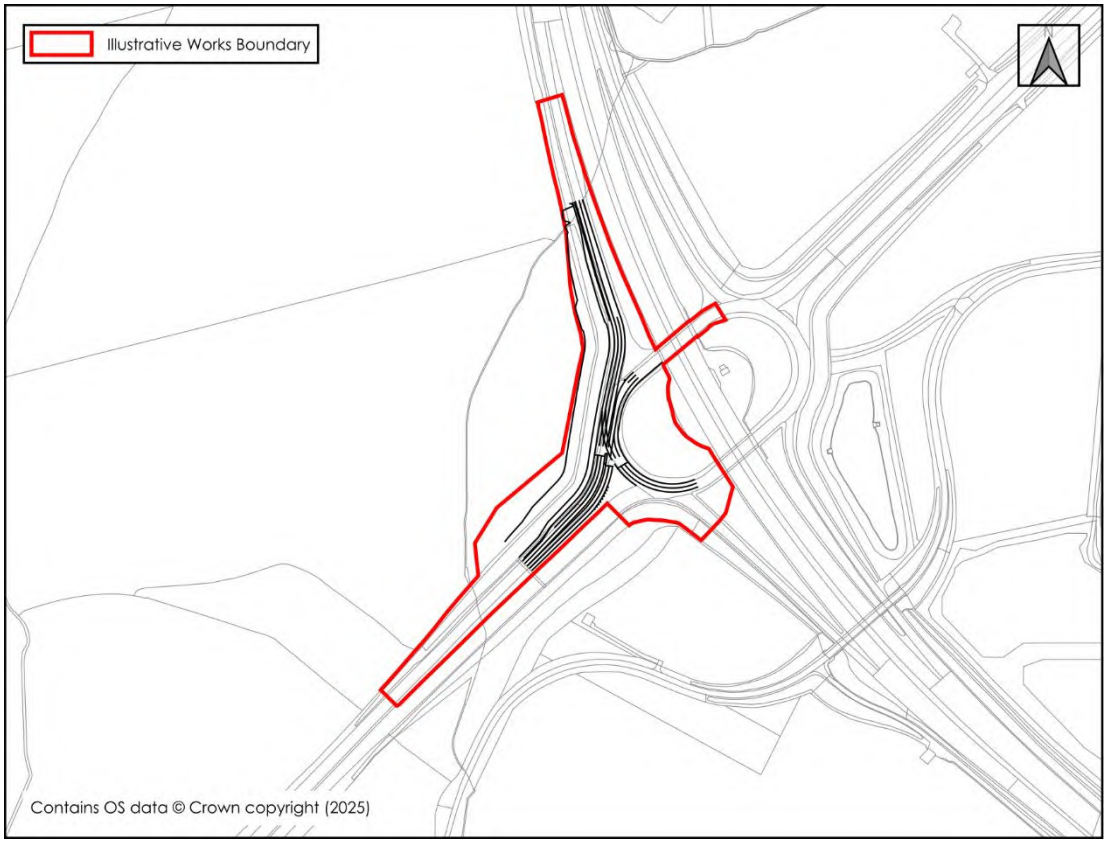


**Figure 6.1: Illustrative Works Boundary - Works No. 22**

## 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.

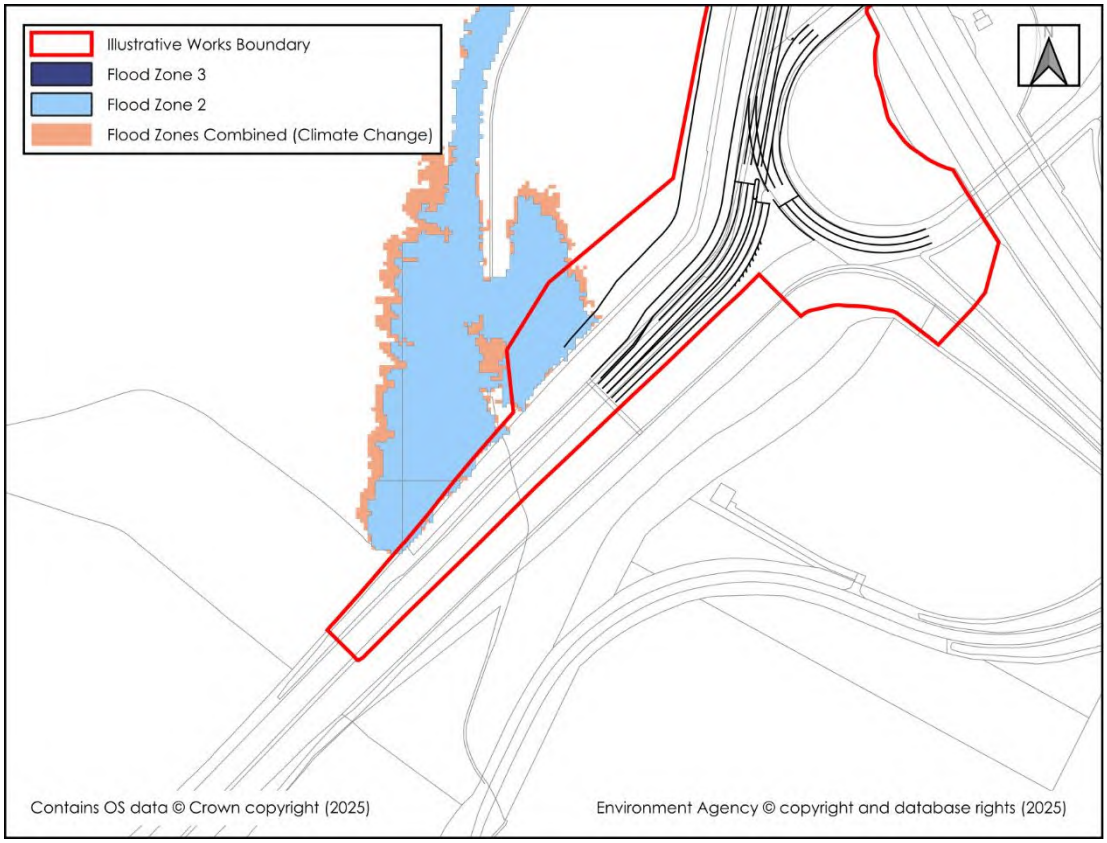


**Figure 6.2: EA Flood Map for Planning – Works No. 22**

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.

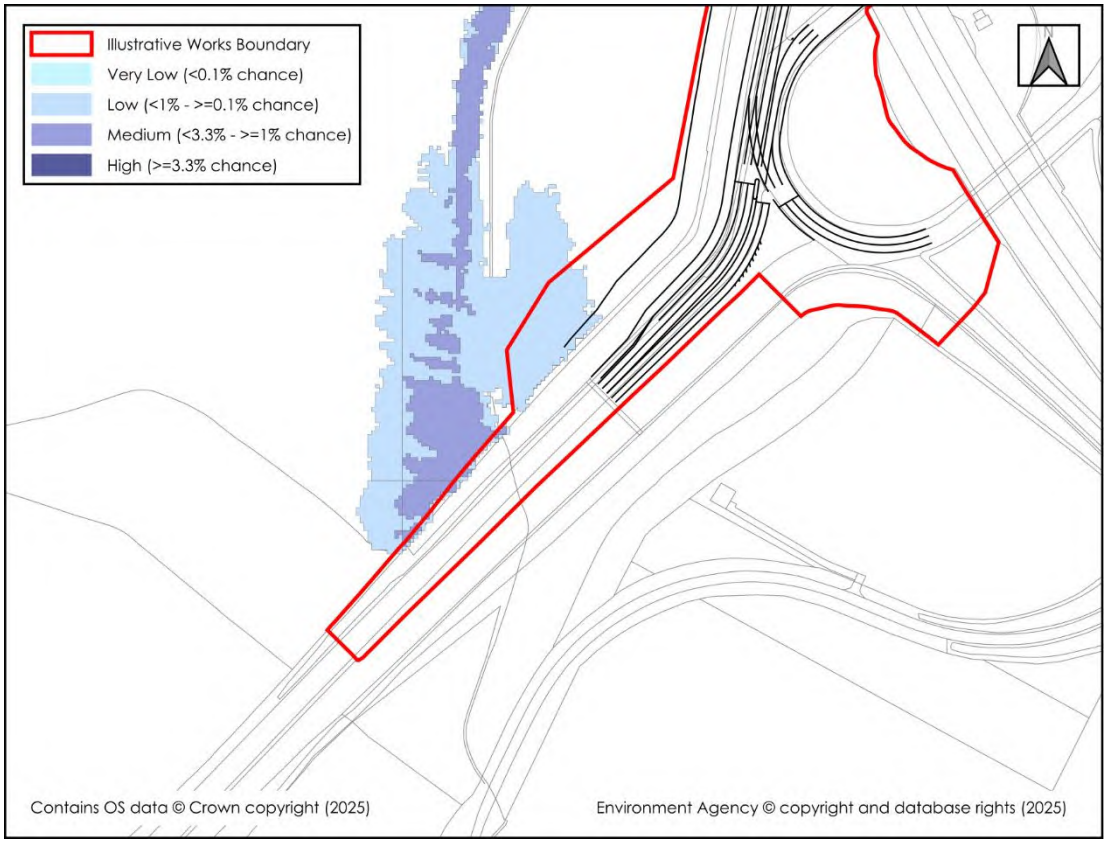


**Figure 6.3: EA Risk of Flooding from Rivers and Sea – Works No. 22**

## 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 .

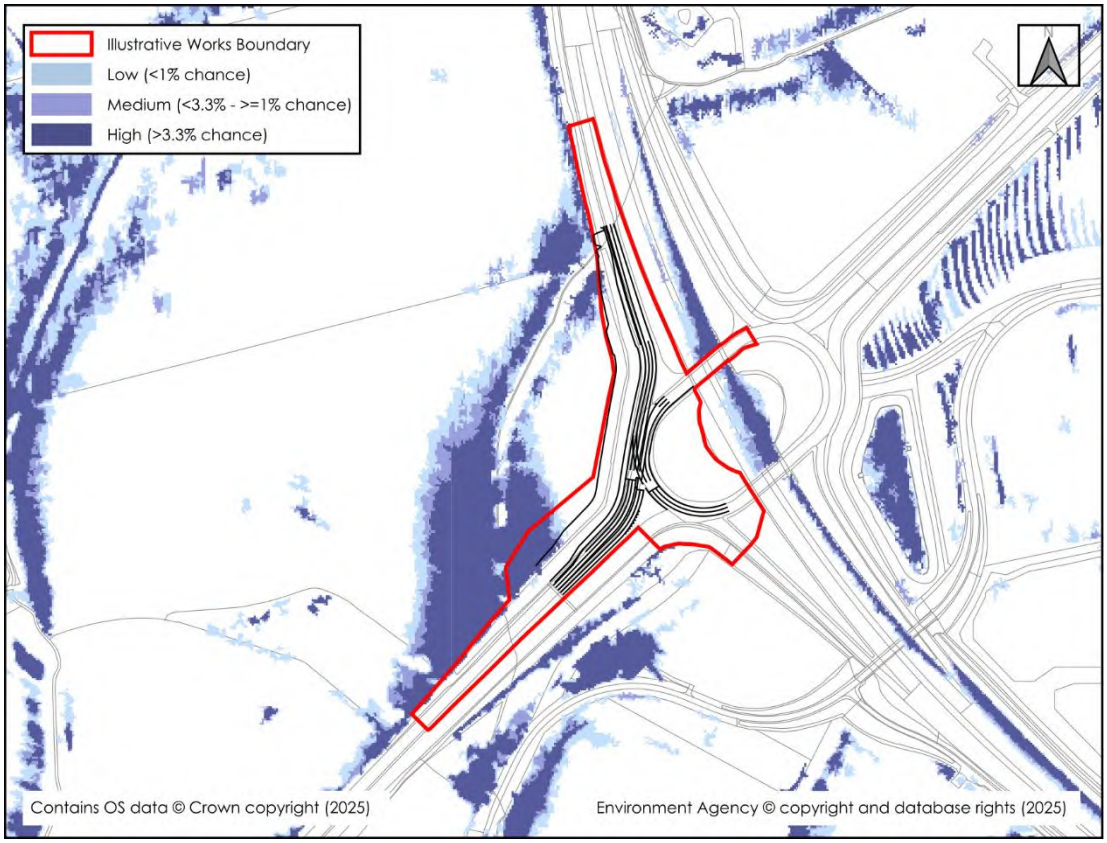


**Figure 6.4: EA Risk of Flooding from Surface Water – Works No. 22**

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**.

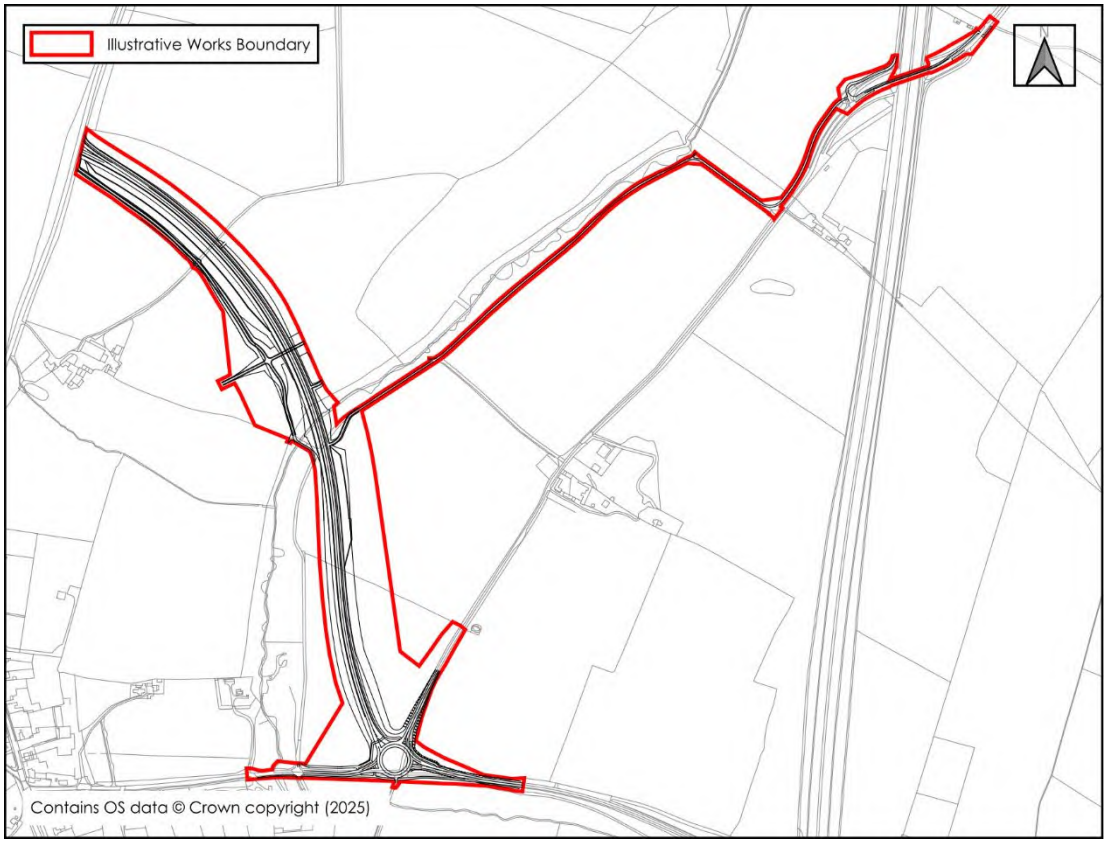


**Figure 7.1: Illustrative Works Boundary - Works No. 23 and 24**

## 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.

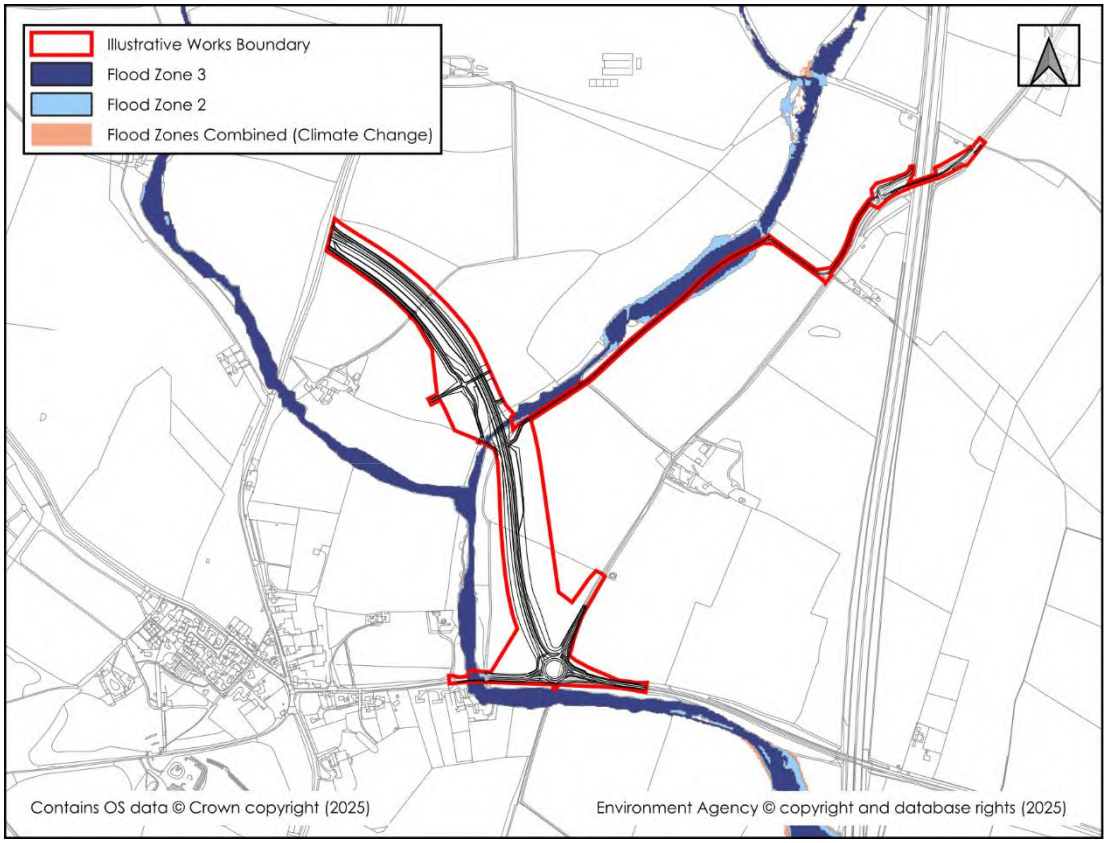


**Figure 7.2: EA Flood Map for Planning – Works No. 23 and 24**

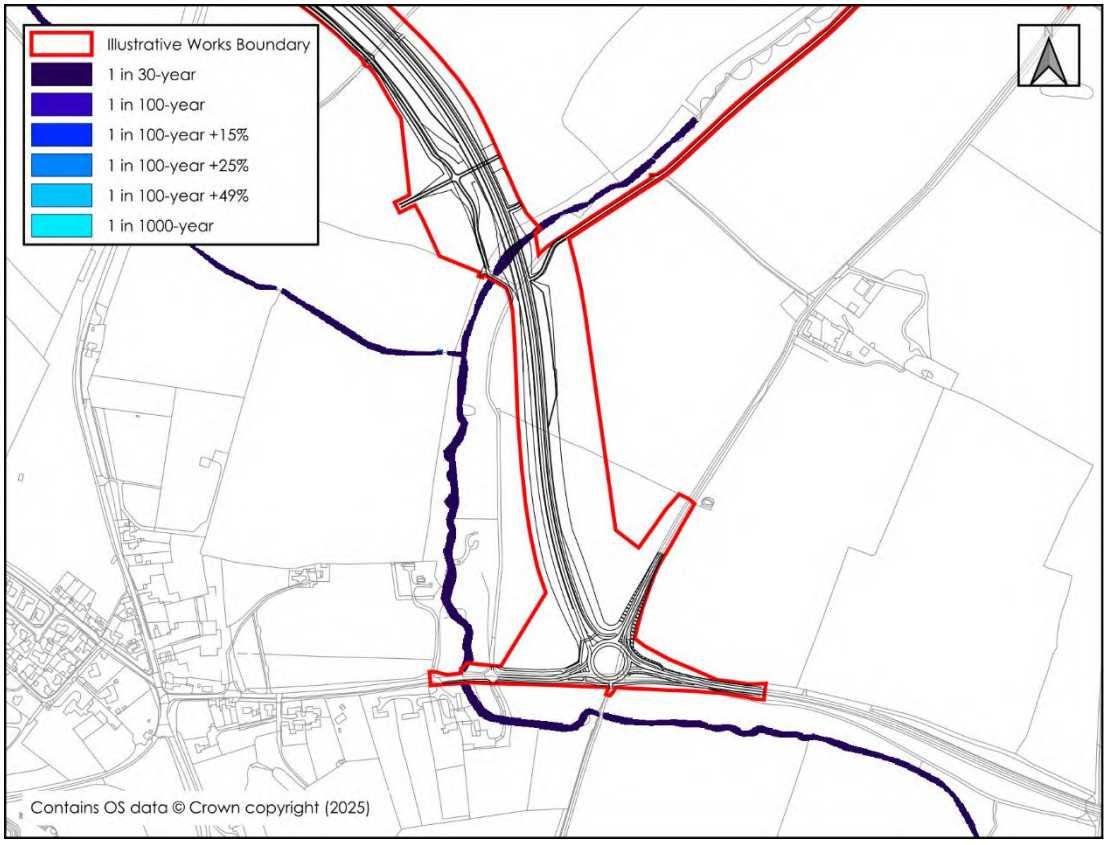


**Figure 7.3: BWB Baseline Modelled Flood Extents – Works No. 23 and 24**

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.

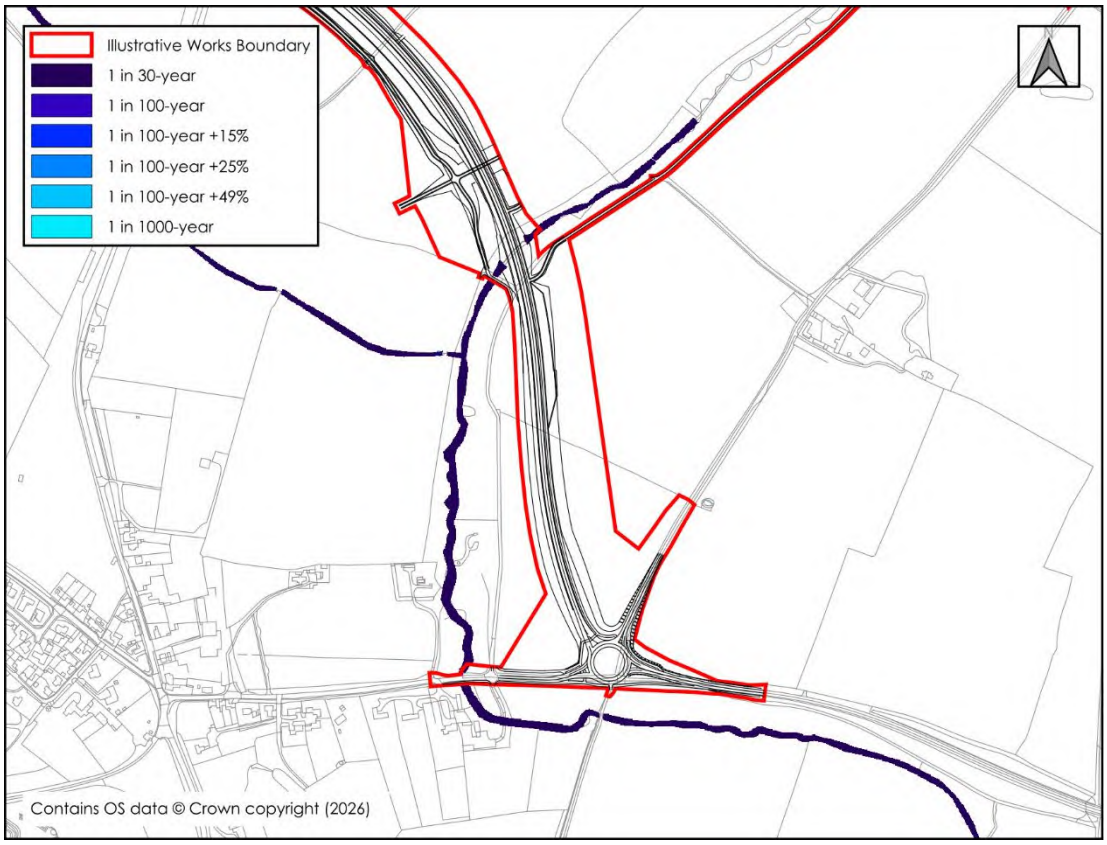


**Figure 7.4: BWB Proposed Modelled Flood Extents – Works No. 23 and 24**

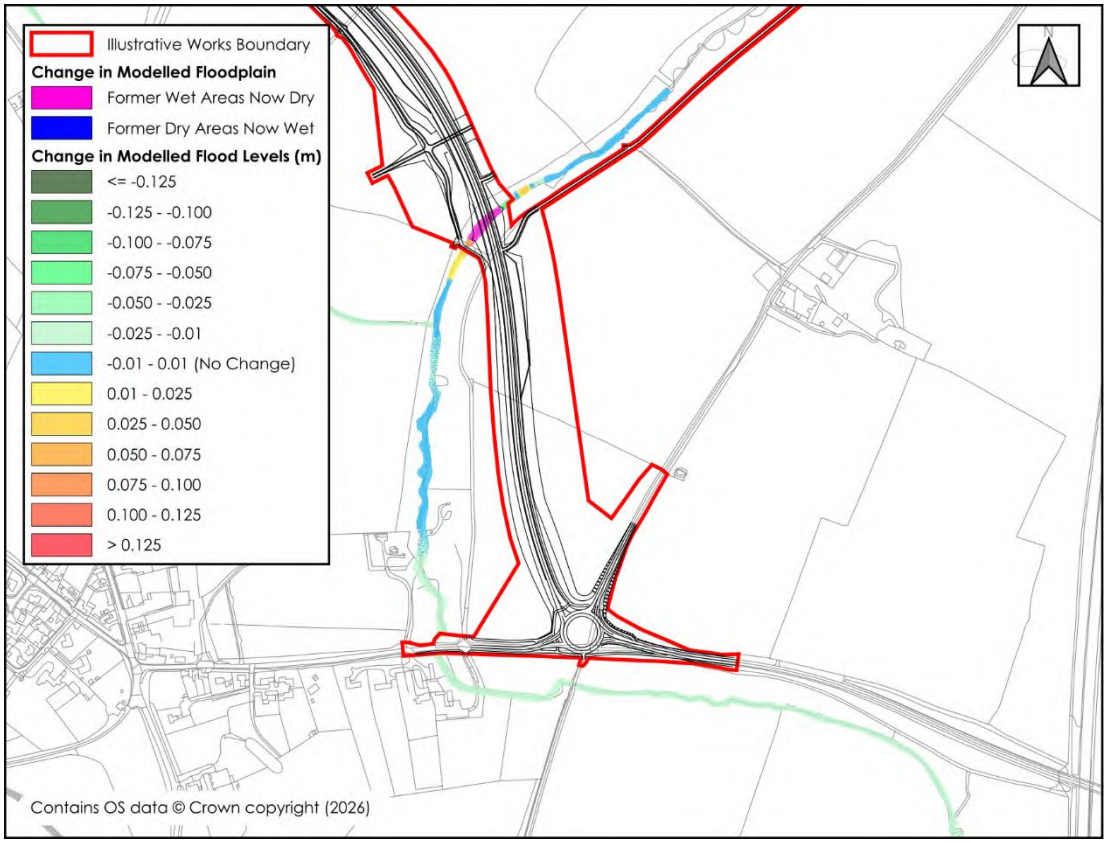


**Figure 7.5: 1 in 100-year +15% Floodplain Comparison – Works No. 23 and 24**

## 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

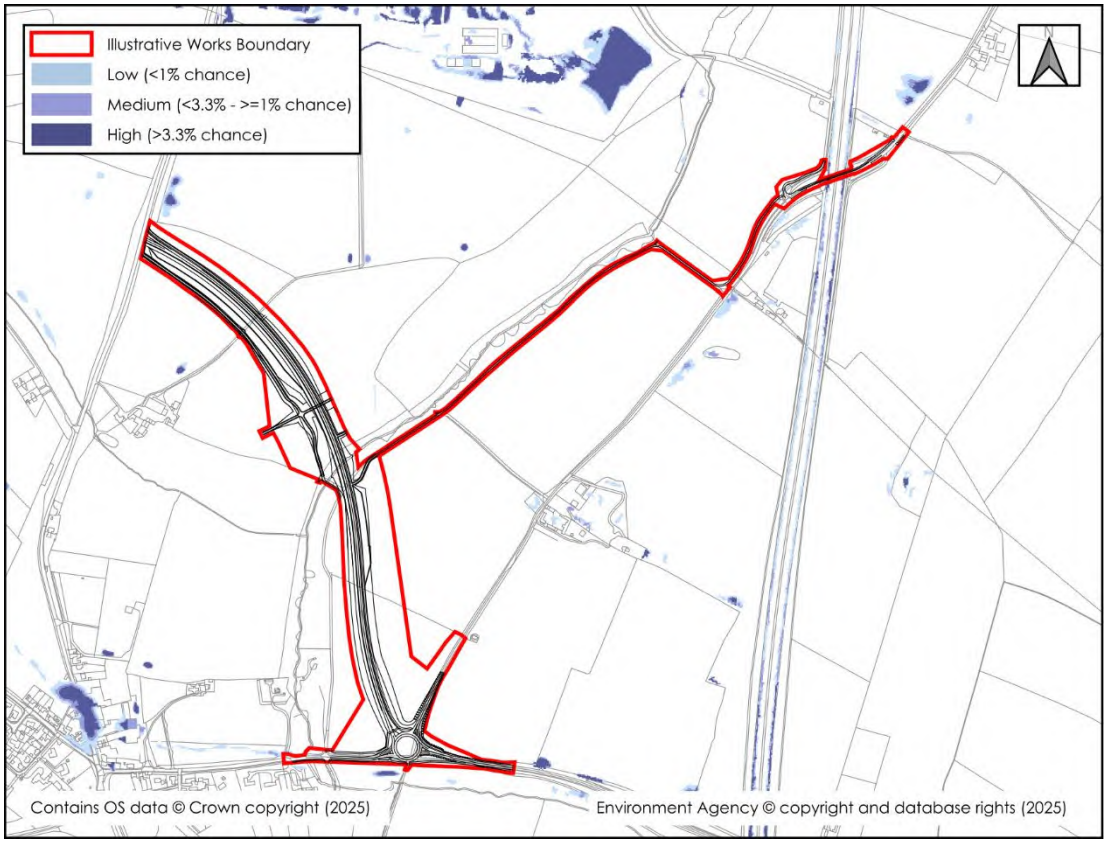


**Figure 7.6: EA Risk of Flooding from Surface Water – Works No. 23 and 24**

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**.

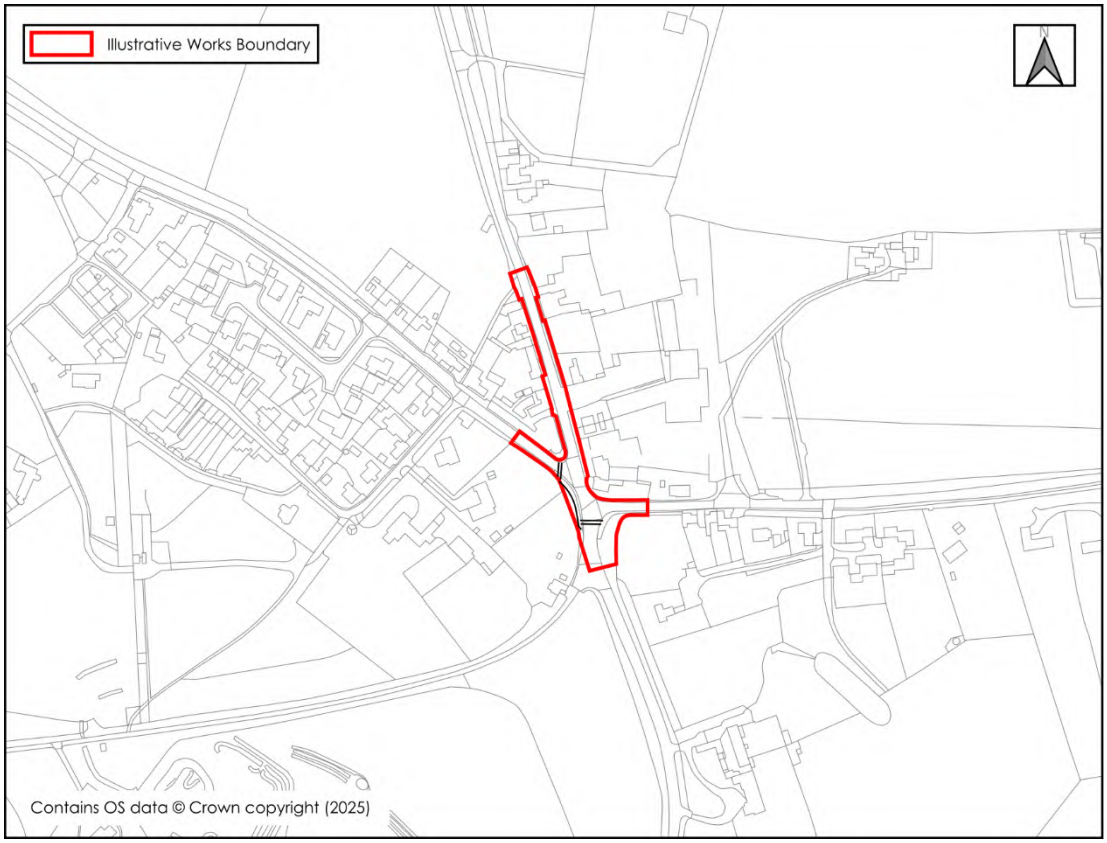


**Figure 8.1: Illustrative Works Boundary - Works No. 27**

## 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.

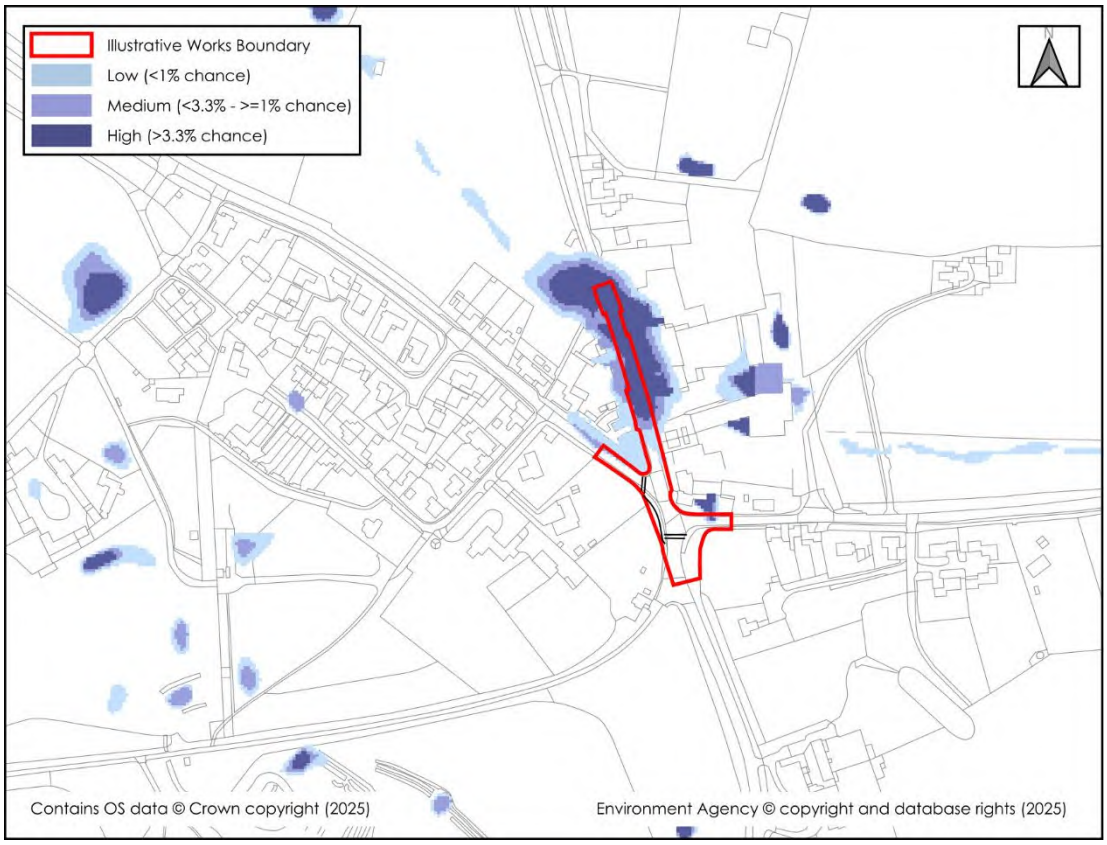


**Figure 8.2: EA Risk of Flooding from Surface Water – Works No. 27**

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**.

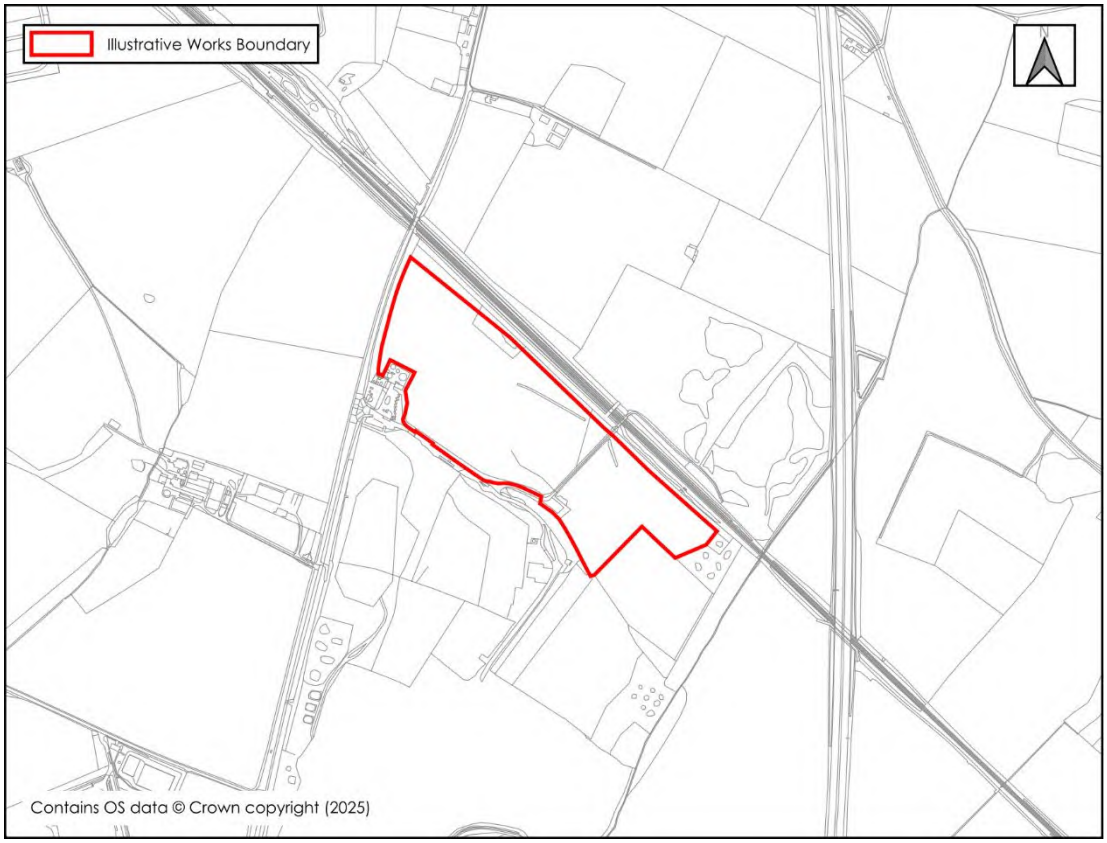


**Figure 9.1: Illustrative Works Boundary - Works No. 34**

## 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.

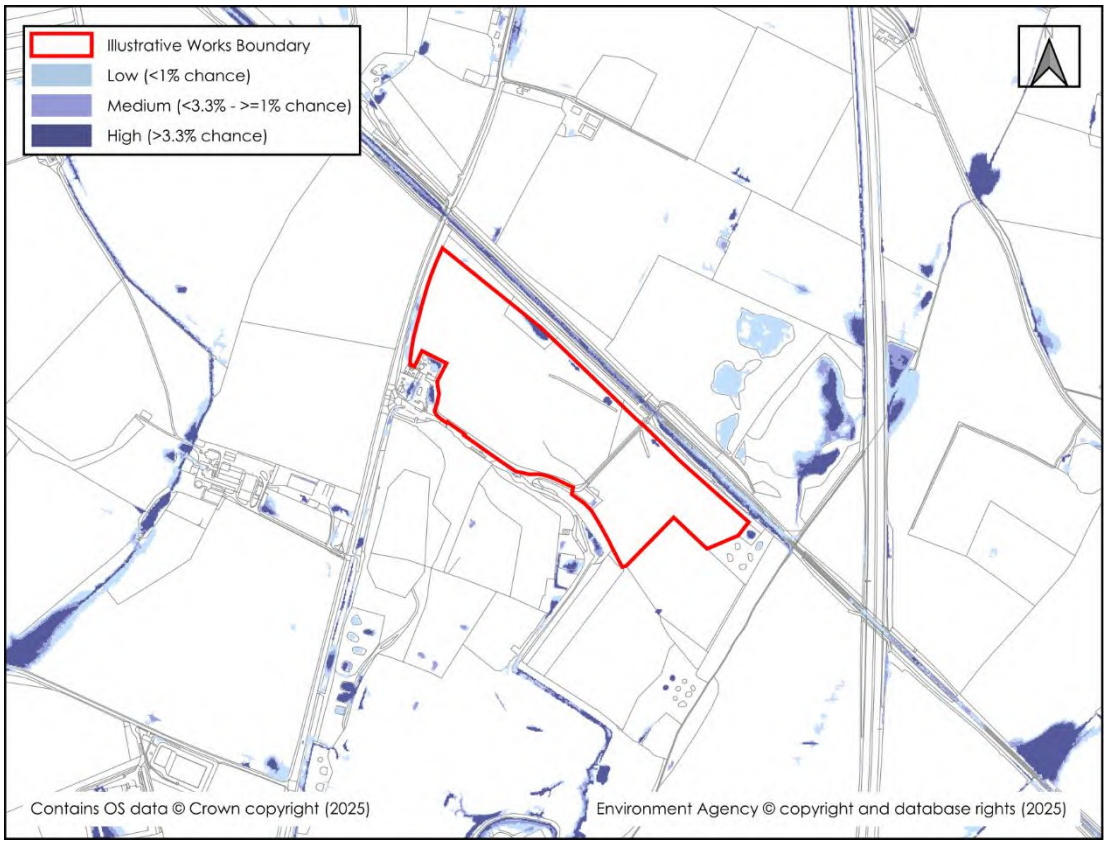


**Figure 9.2: EA Risk of Flooding from Surface Water – Works No. 34**

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 – 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**

# Oxfordshire Railfreight Limited
# Oxfordshire RFI
# Oxfordshire
# Hydraulic Model Report

www.bwbconsulting.com

**ADVISORY**

# Oxfordshire Railfreight Limited
# Oxfordshire RFI
# Oxfordshire
# Hydraulic Model Report

**Birmingham**
**Livery Place, 35 Livery Street, Colmore Business District, Birmingham, B3 2PB**
**T: 0121 233 3322**

Leeds
Whitehall Waterfront, 2 Riverside Way, Leeds
LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11 Portland Street, Manchester, M1 3HU
0161 233 4260

Nottingham
Waterfront House, Station Street, Nottingham NG2 3DQ
T: 0115 924 1100

March 2026

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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.**

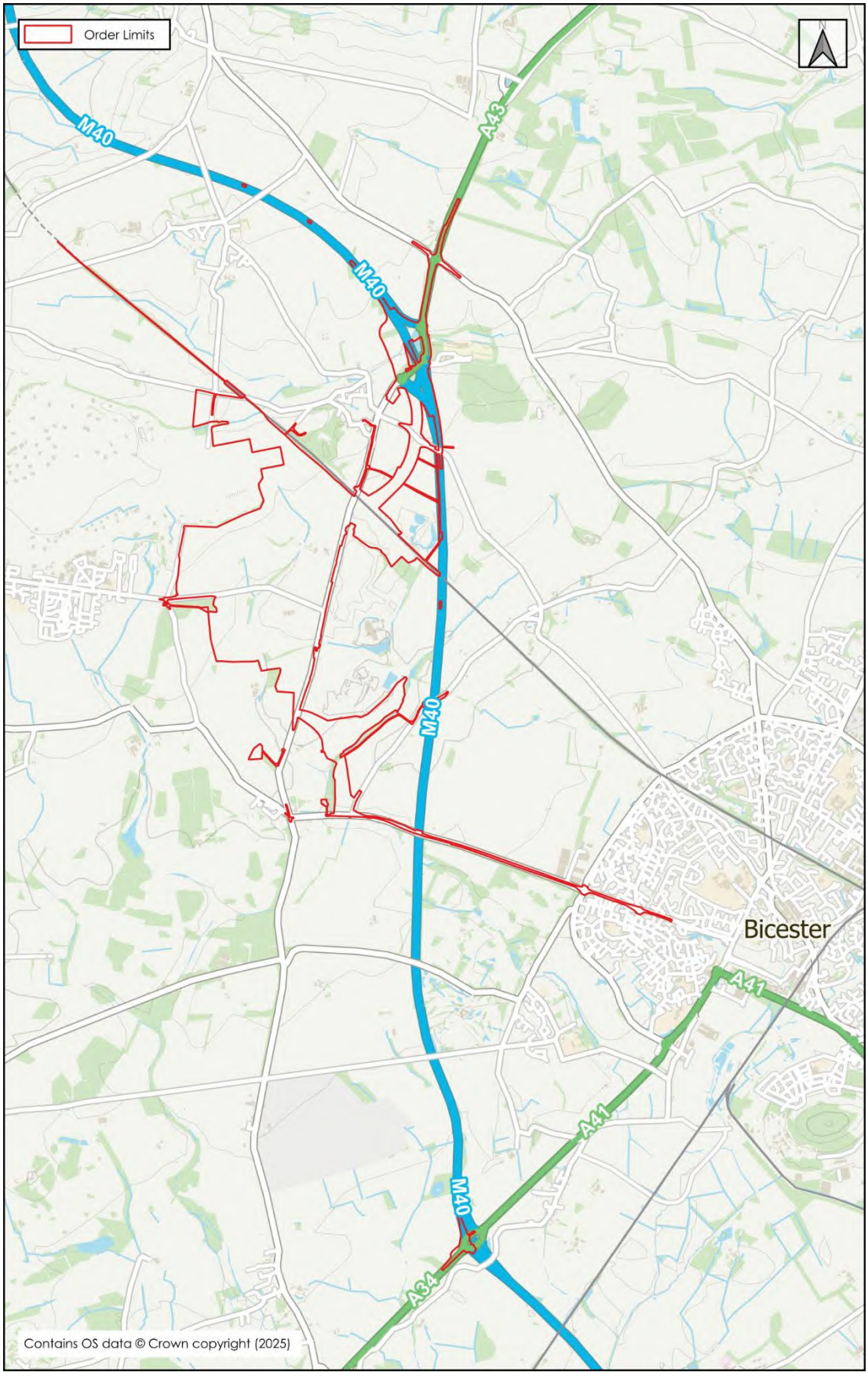



**Figure 1.1: Site Location**

## 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.

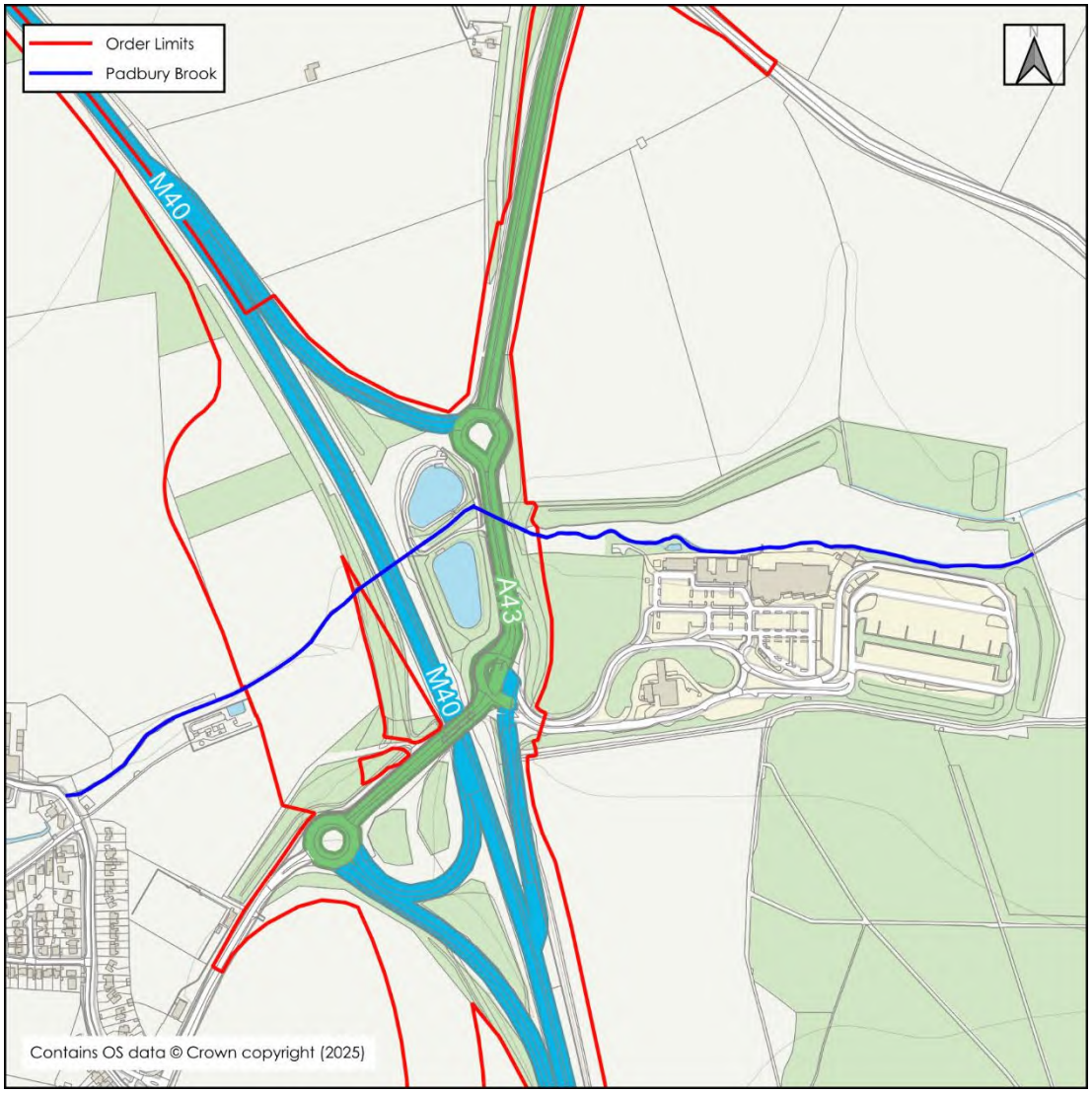



**Figure 1.2: Watercourse Network**

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**.

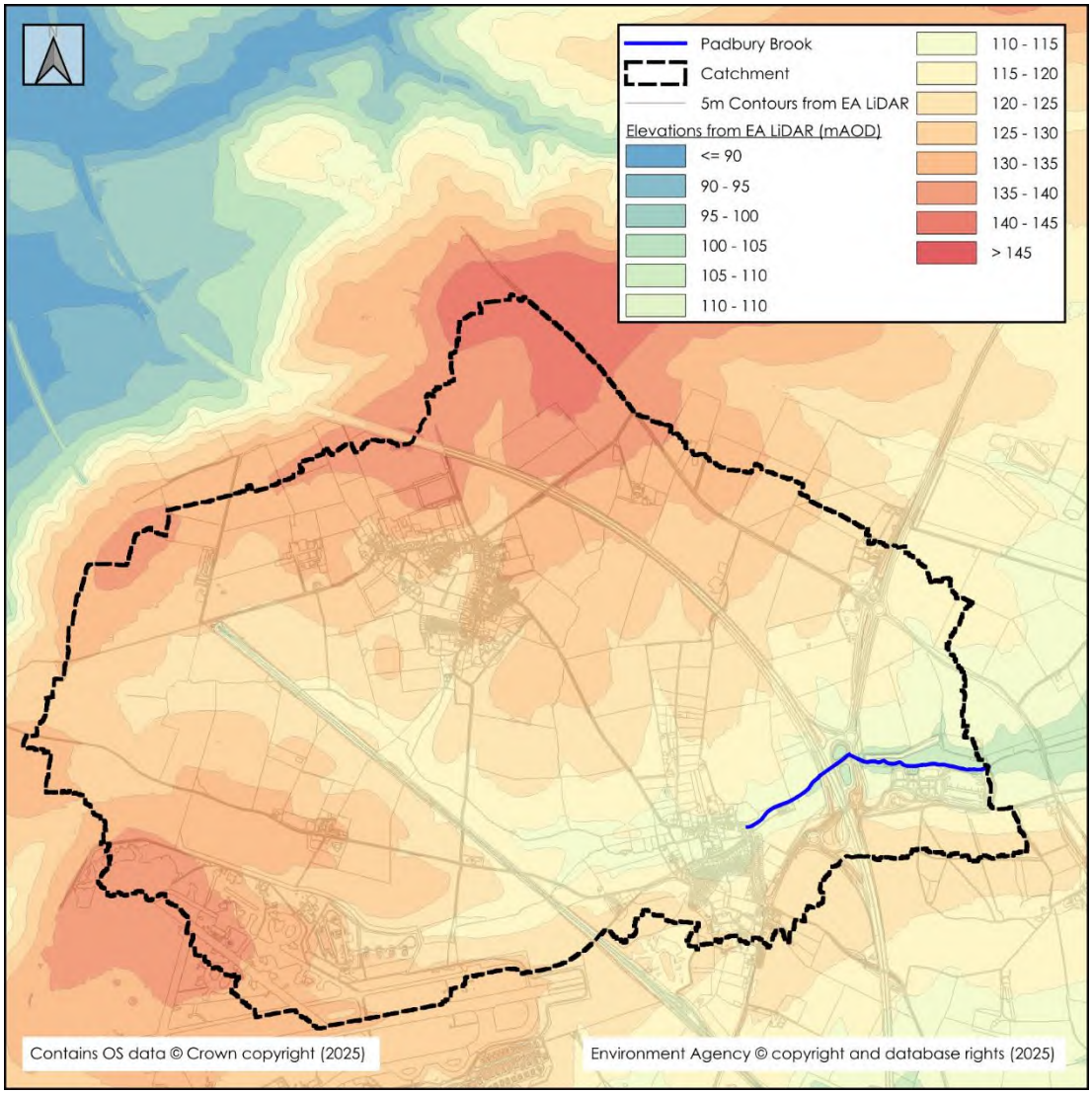



**Figure 1.3: Padbury Brook Catchment Topography**

## 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**.

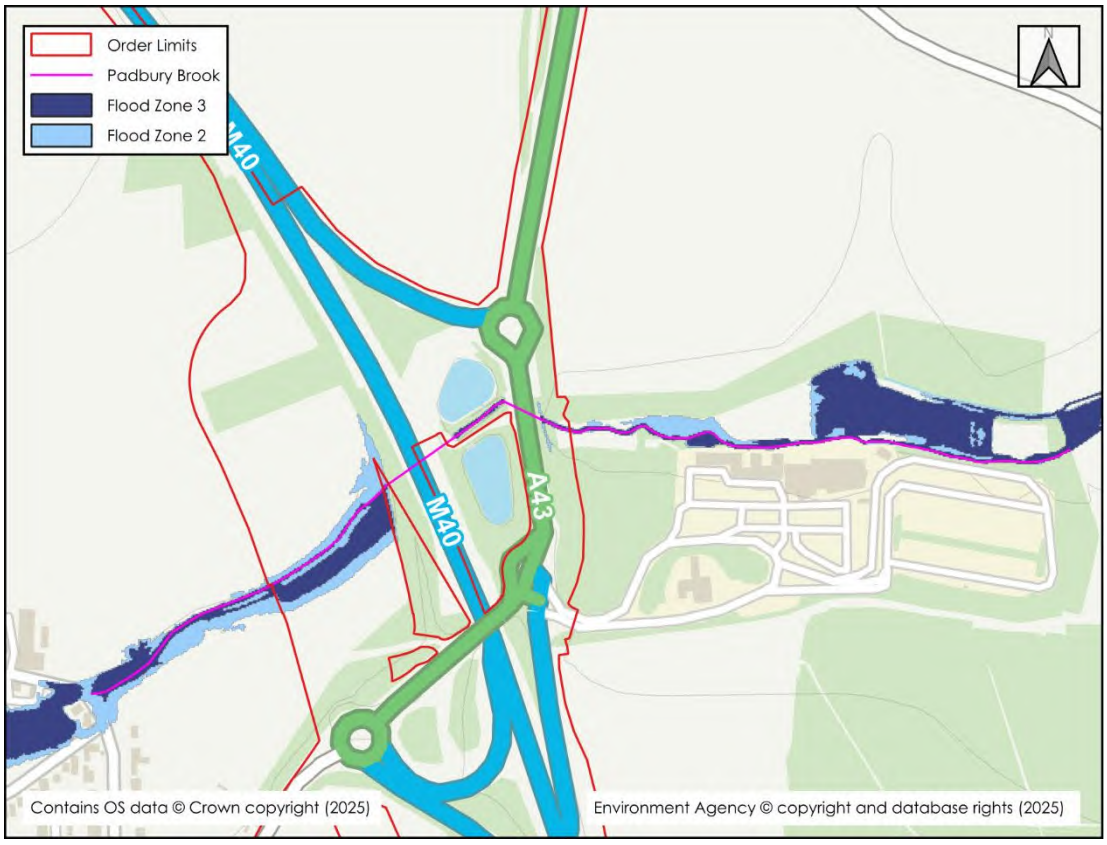



**Figure 1.4: EA Flood Map for Planning**

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)

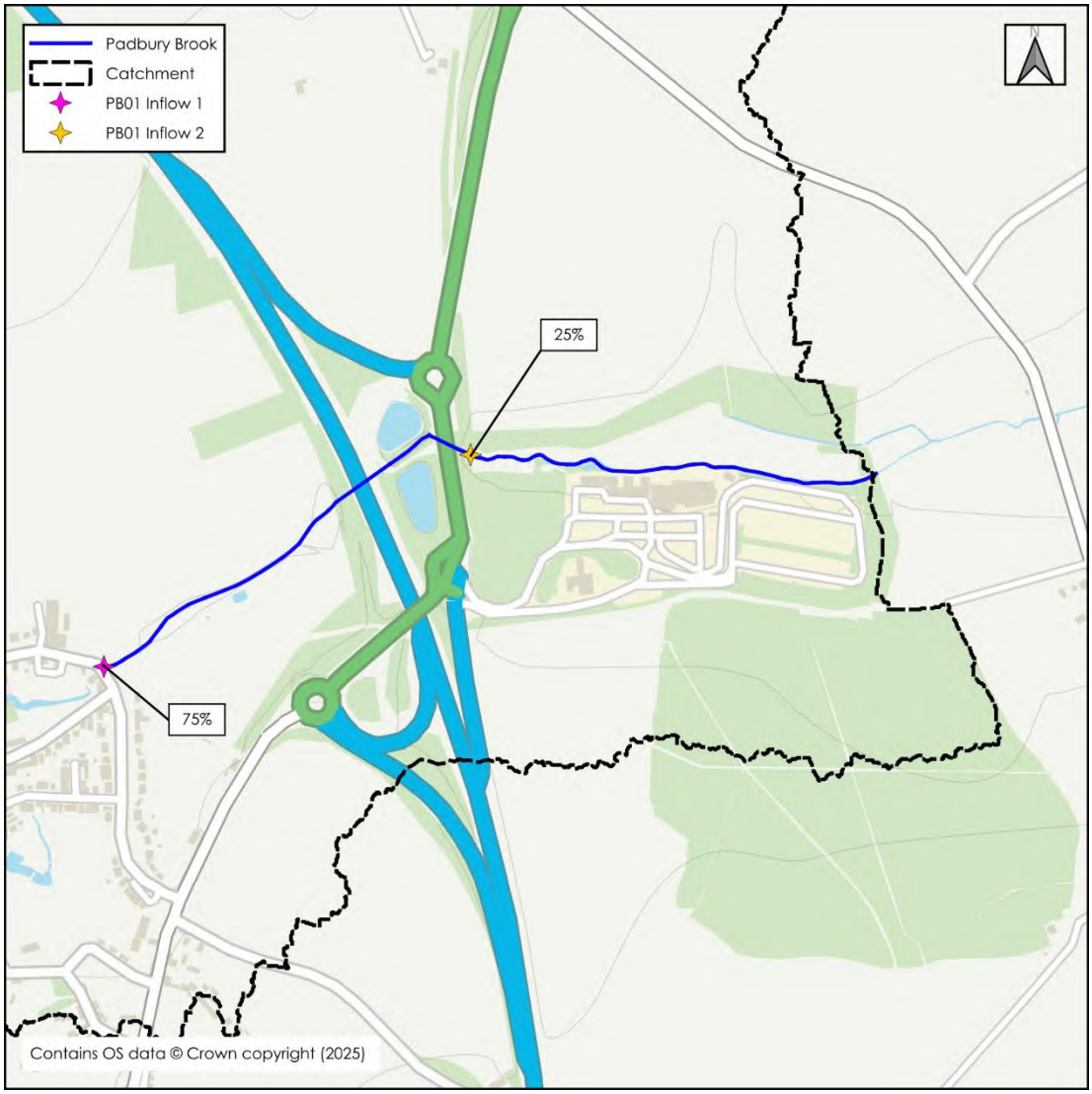



**Figure 2.1: Distribution of Model Inflows**

## 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 model build detailed within this section has been updated to reflect the EA model review undertaken in February 2026, with the full response included in **Appendix 3**.

## 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<br>Main Channels<br>Clean straight no riffles or pools, very light bank vegetation but some stones and weeds |  |
| PB_01069 | 0.05<br>Main Channels<br>Winding with pools and riffles and stones/weeds, medium bank vegetation |  |
| PB_00614 | 0.045<br>Floodplain<br>Grass - long |  |

| Model ID | Values chosen and description | Photograph |
|---|---|---|
| PB_01369 | 0.07<br>Floodplain<br>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 4**.

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.

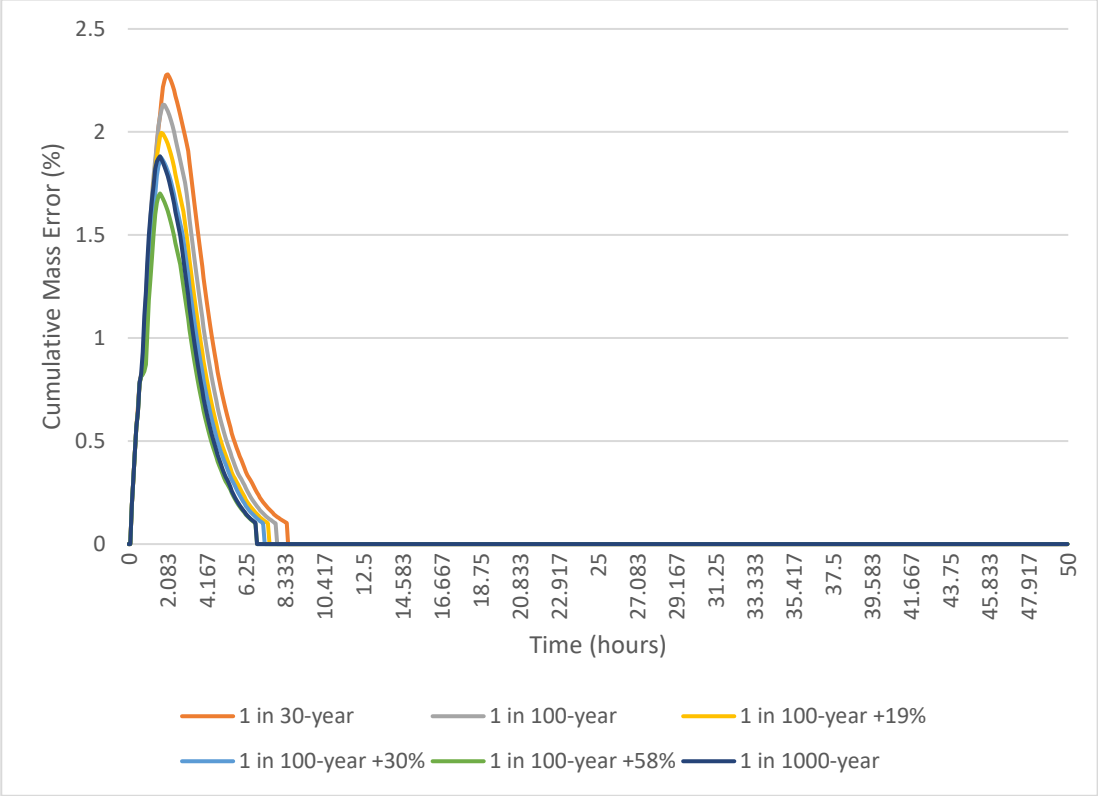



**Figure 3.2: Cumulative Mass Error**

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<br>1 in 100-Year<br>1 in 1000-Year<br>1 in 100-Year+19%CC<br>1 in 100-Year+30%CC<br>1 in 100-Year+58%CC | Representative of 'as surveyed' conditions. |
| Proposed | 1 in 30-Year<br>1 in 100-Year<br>1 in 1000-Year<br>1 in 100-Year+19%CC<br>1 in 100-Year+30%CC<br>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 5** 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**.

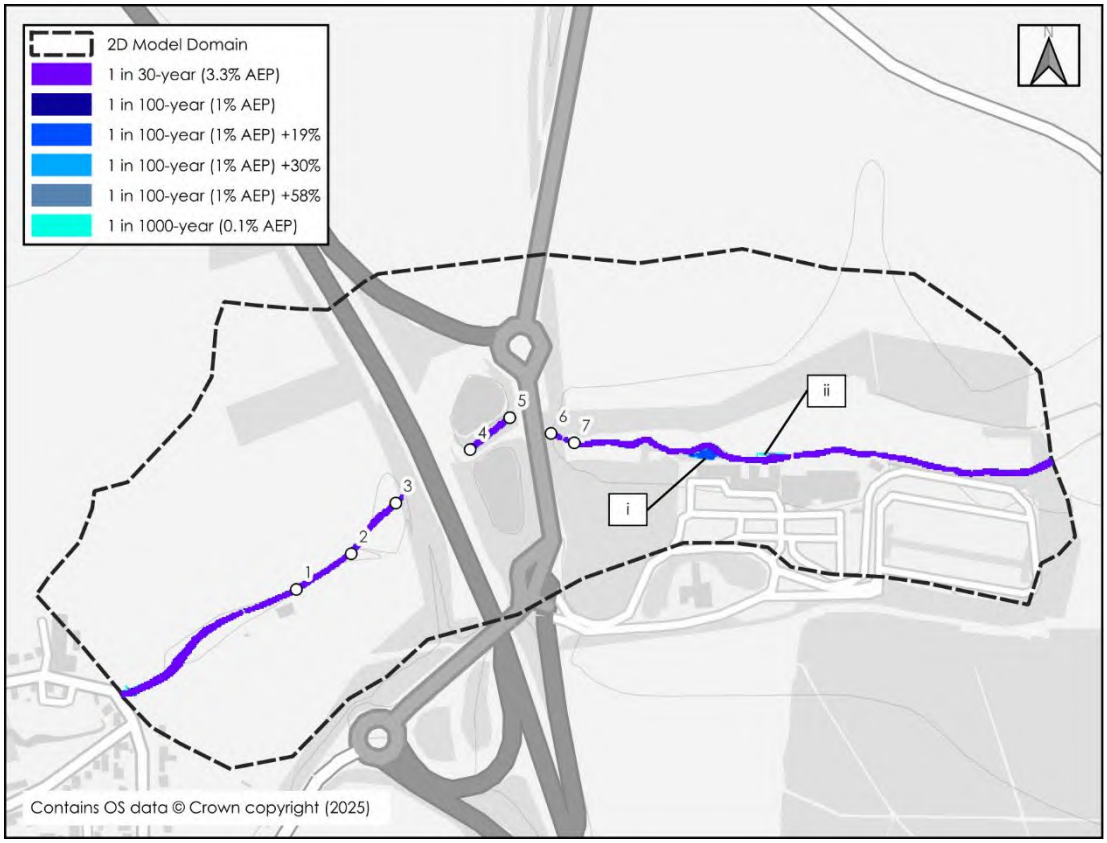



**Figure 4.1: Baseline Fluvial Flood Extents**

**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**.

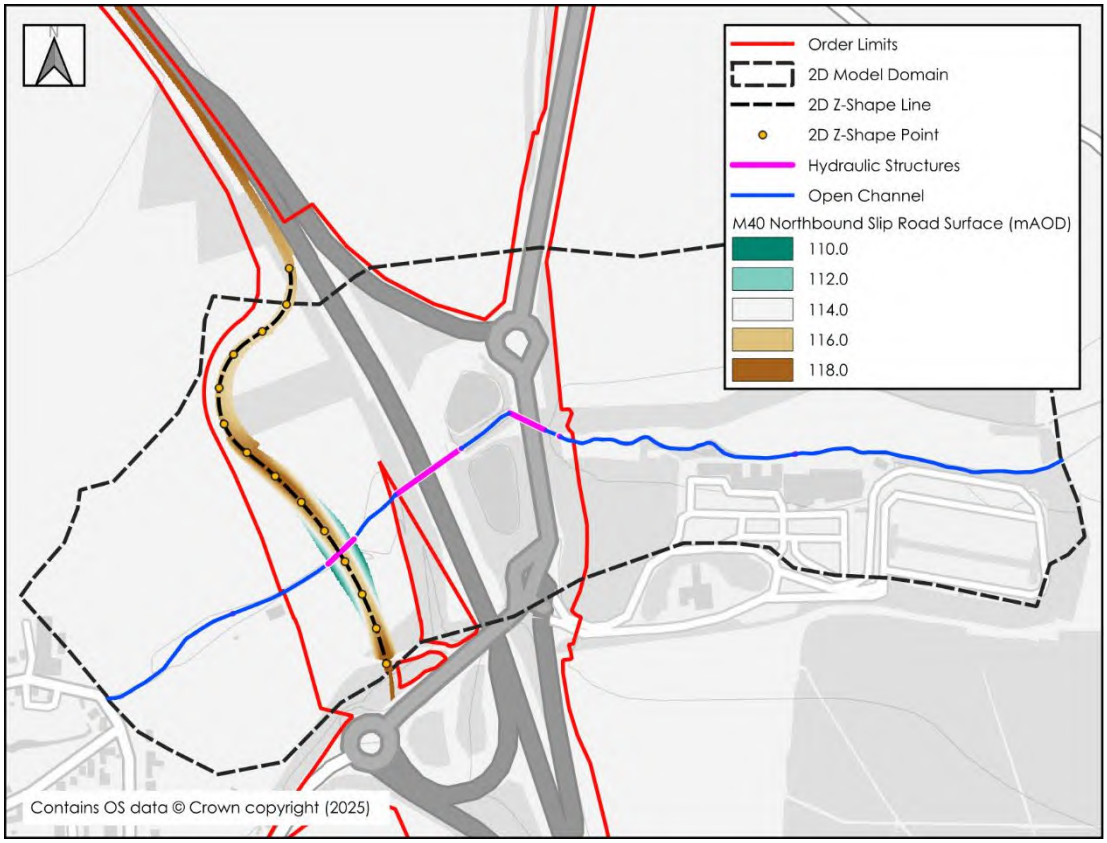



**Figure 5.1: Proposed Model Schematic**

### 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**.

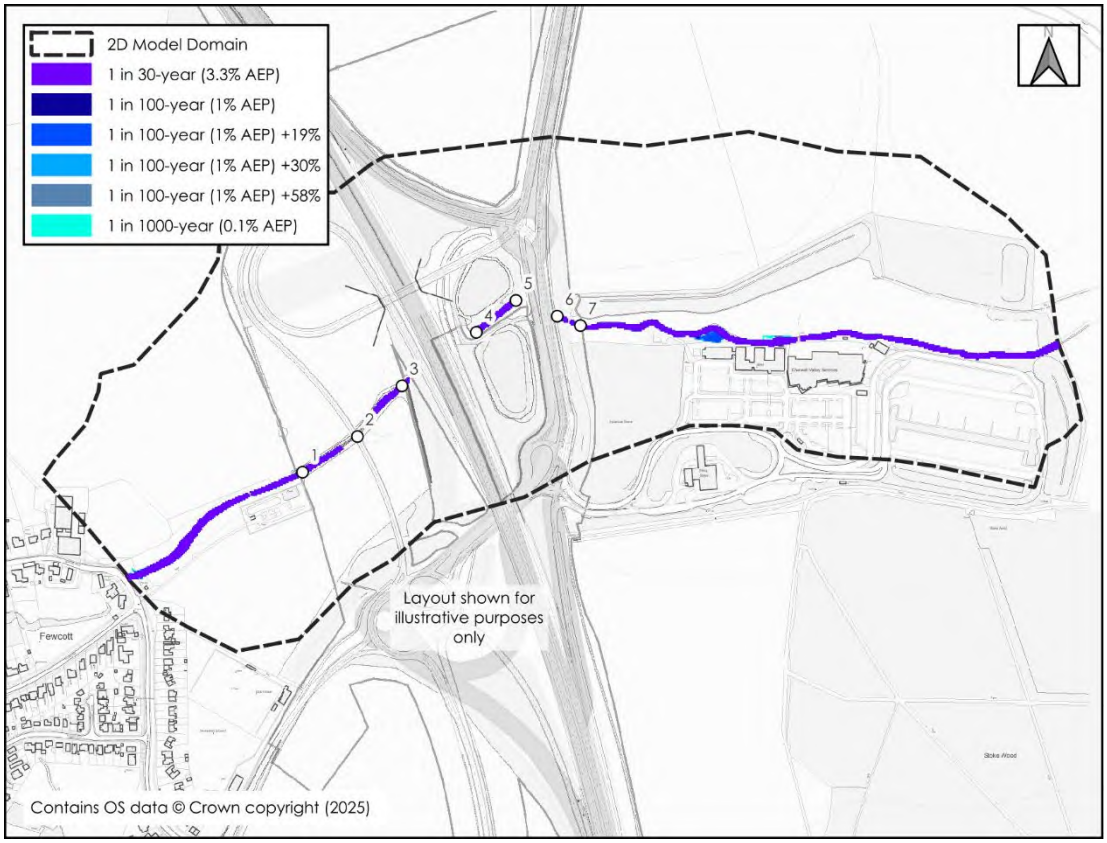



**Figure 5.2: Proposed Development Floodplain Extents**

**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 7**; the comparison mapping for the design event (1 in 100-year +19% climate change event) is illustrated in **Figure 5.3** and discussed below.

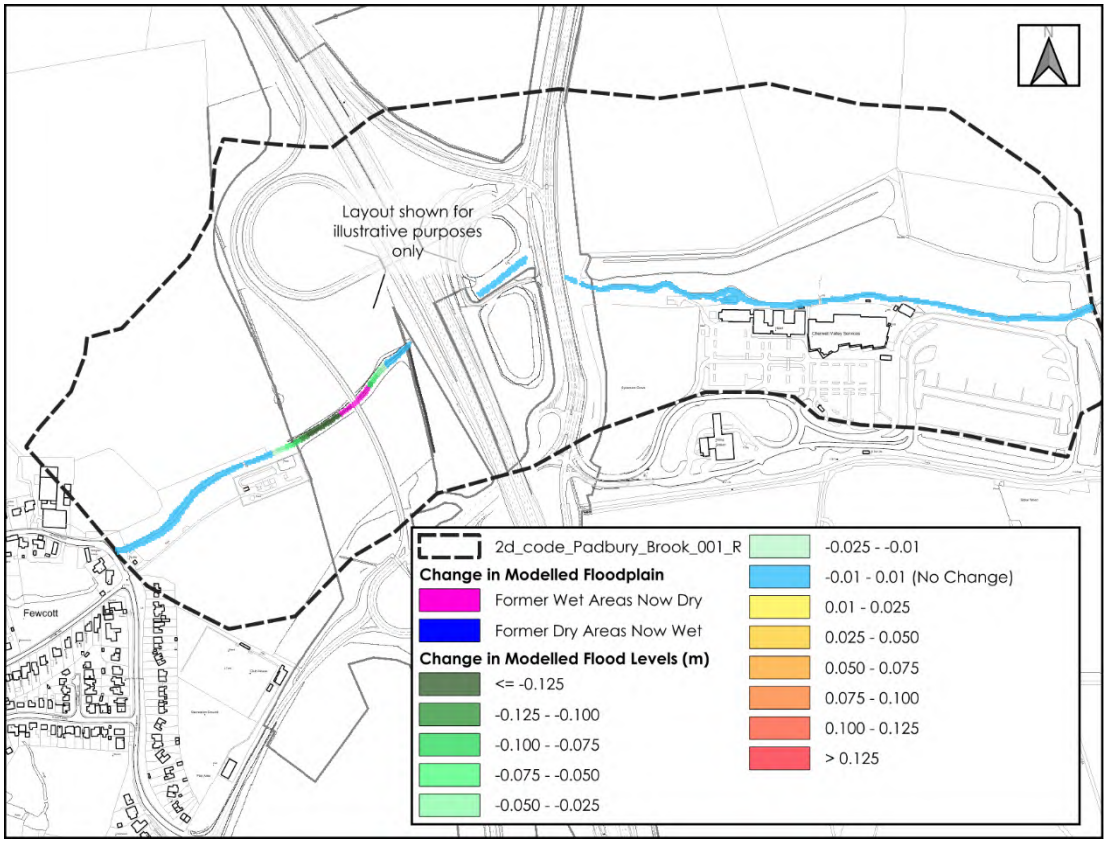



**Figure 5.3: Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 19% Climate Change**

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 150mm within the Order Limits.

# 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 8**.

### 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.

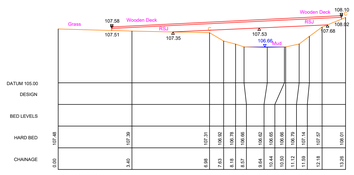
7.4 The baseline results show water to largely remain in channel within the Order Limits, with the exception of a small area of ponding adjacent to the Cherwell Valley Motorway Service Area downstream of the site during the 1 in 100-year +19% climate change and above return periods.

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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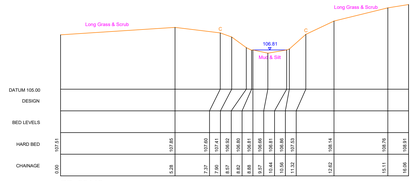


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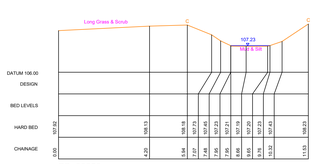


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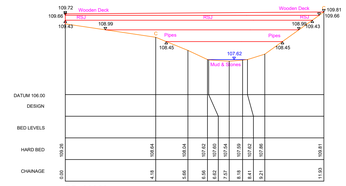


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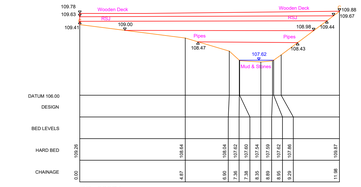


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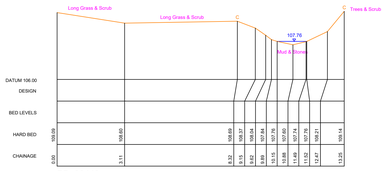


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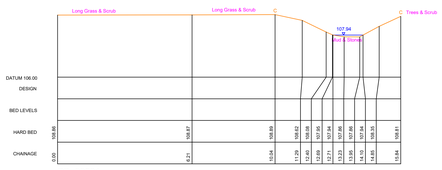


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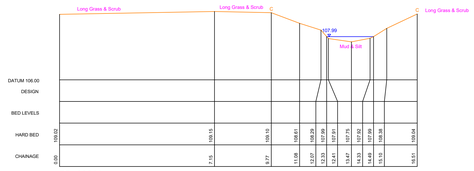


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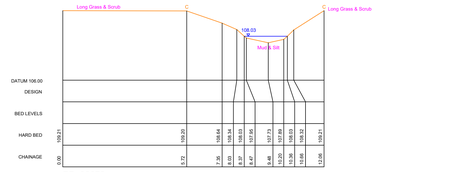


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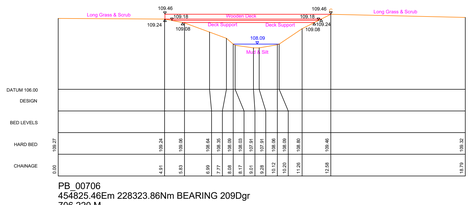


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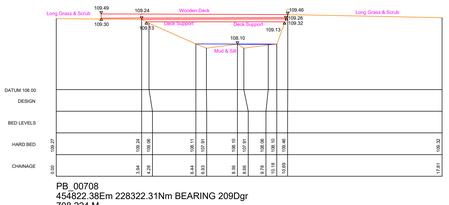


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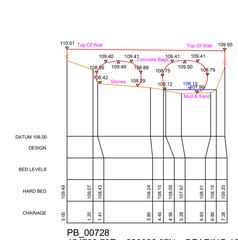


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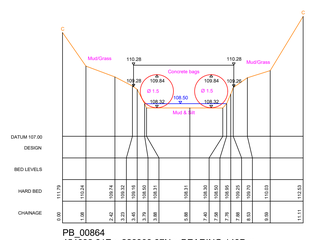


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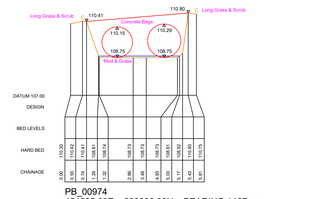


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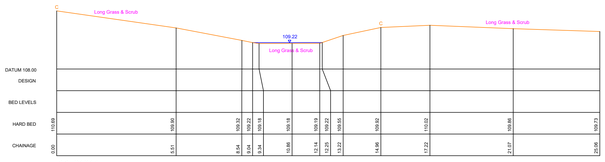


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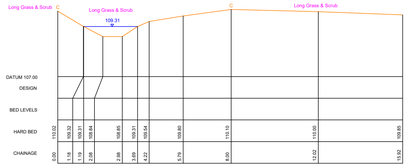


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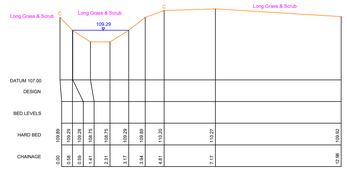


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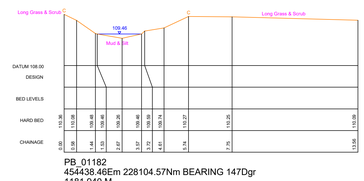


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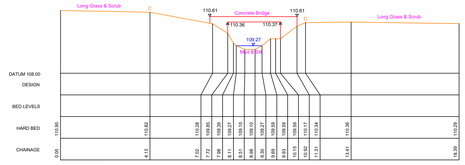


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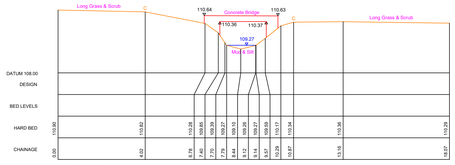


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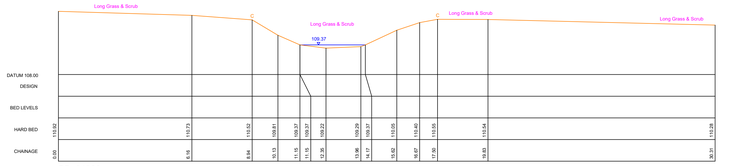


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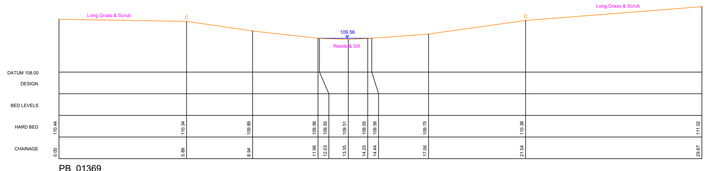


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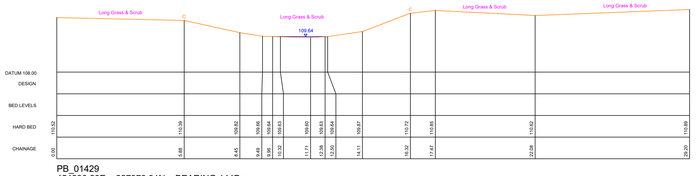


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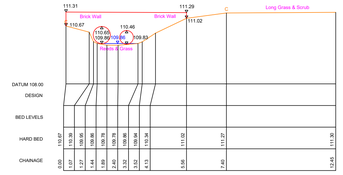


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## Notes

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 | 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**

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|---|---|---|---|
| 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-09-ZZ-M2-G-0060** | **S2** | **P1** |

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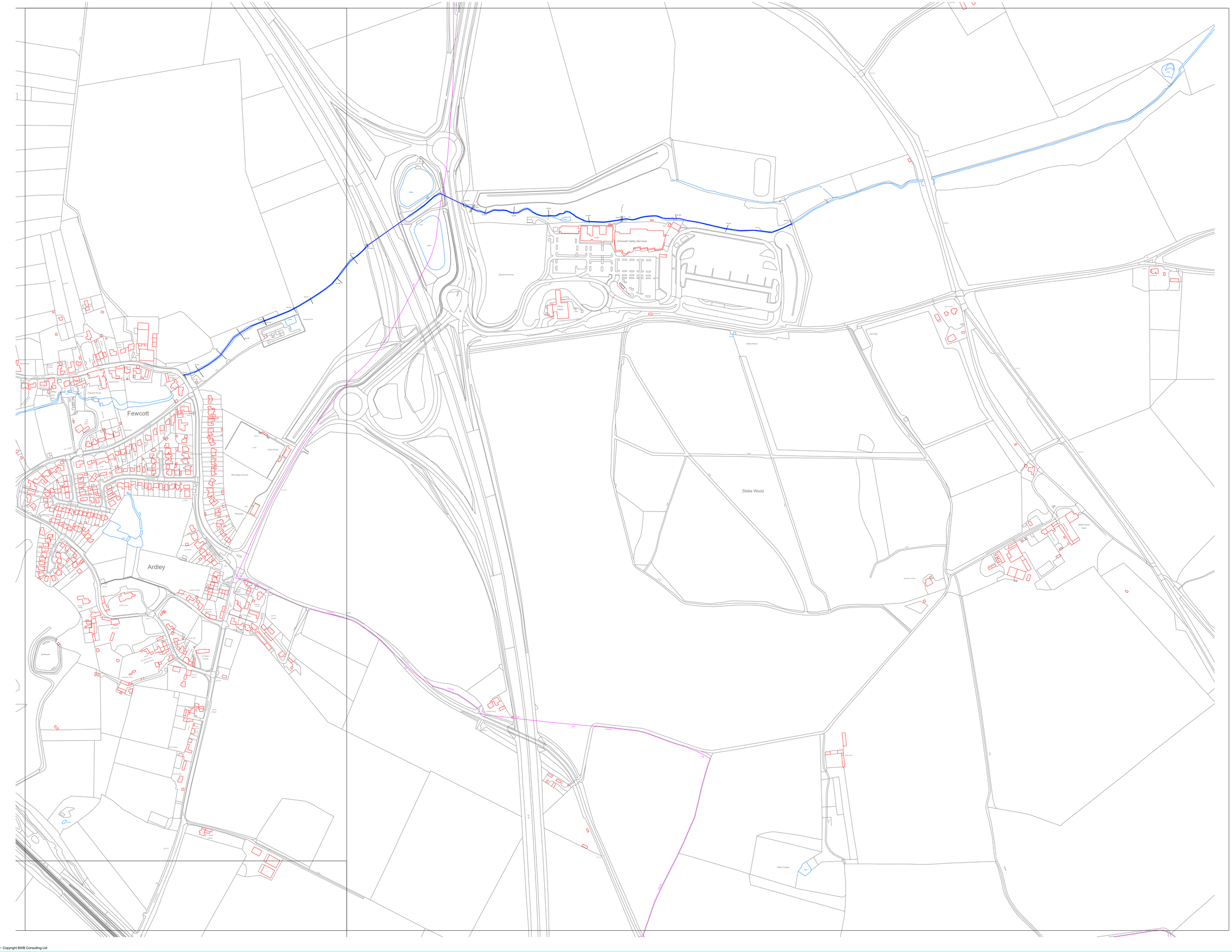
Fewcott
Ardley
Stoke Wood
Cherwell Valley Services
Hotel
Filling Station
Fewcott House
French Farm
Club House
Recreation Ground
Play Area
Village Hall
Primary School
Church
Old Rectory
Manor Farm
Earthwork
Ardley Cutting
Ardley Tunnel
Ardley Cutting
Ardley Embankment
Stoke Wood
Old Park
Stoke Wood Farm
Stoke Wood Cottages
Stoke Wood Lodge

# Appendix 2: Hydrological Assessment

A CAF GROUP COMPANY

**ADVISORY**

# Oxfordshire Rail Freight Limited
# Oxfordshire RFI
# Oxfordshire
# Flow Estimation Record

www.bwbconsulting.com

**ADVISORY**

# Oxfordshire Rail Freight Limited
# Oxfordshire RFI
# Oxfordshire
# Flow Estimation Record

Birmingham
Livery Place, 35 Livery Street, Colmore Business District
Birmingham, B3 2PB
T: 0121 233 3322

Leeds
Whitehall Waterfront, 2 Riverside Way
Leeds, LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11 Portland Street
Manchester, M1 3HU
T: 0161 233 4260

**Nottingham**
**5th Floor, Waterfront House, Station Street**
**Nottingham, NG2 3DQ**
**T: 0115 924 1100**

August 2025

# DOCUMENT ISSUE RECORD

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| **BWB Reference:** | NTH2479-FER |

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| **Checked:** | [redacted] |
| **Approved:** | [redacted] |

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

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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.**

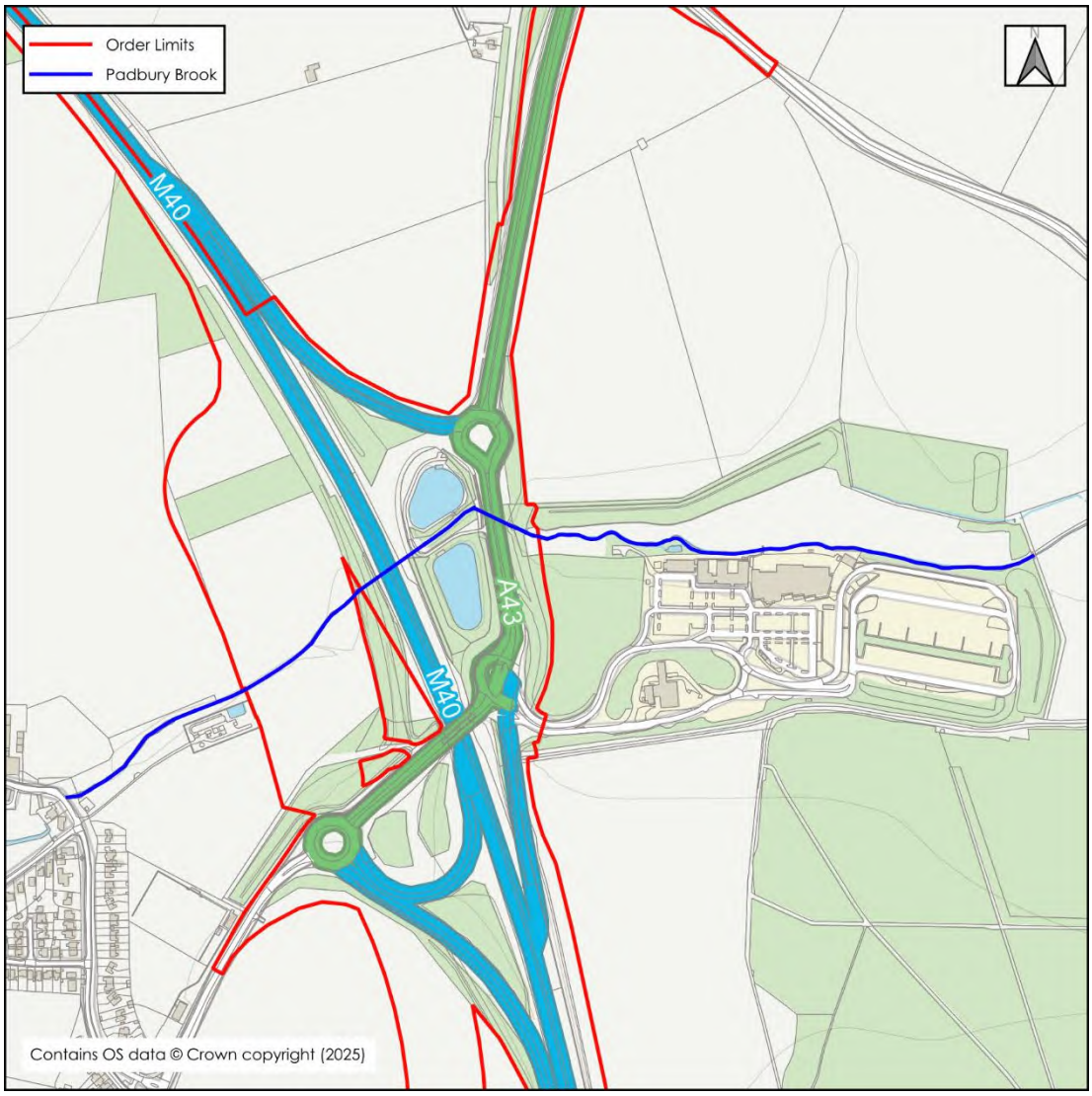


**Figure 1.1: Site Location Plan**

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)

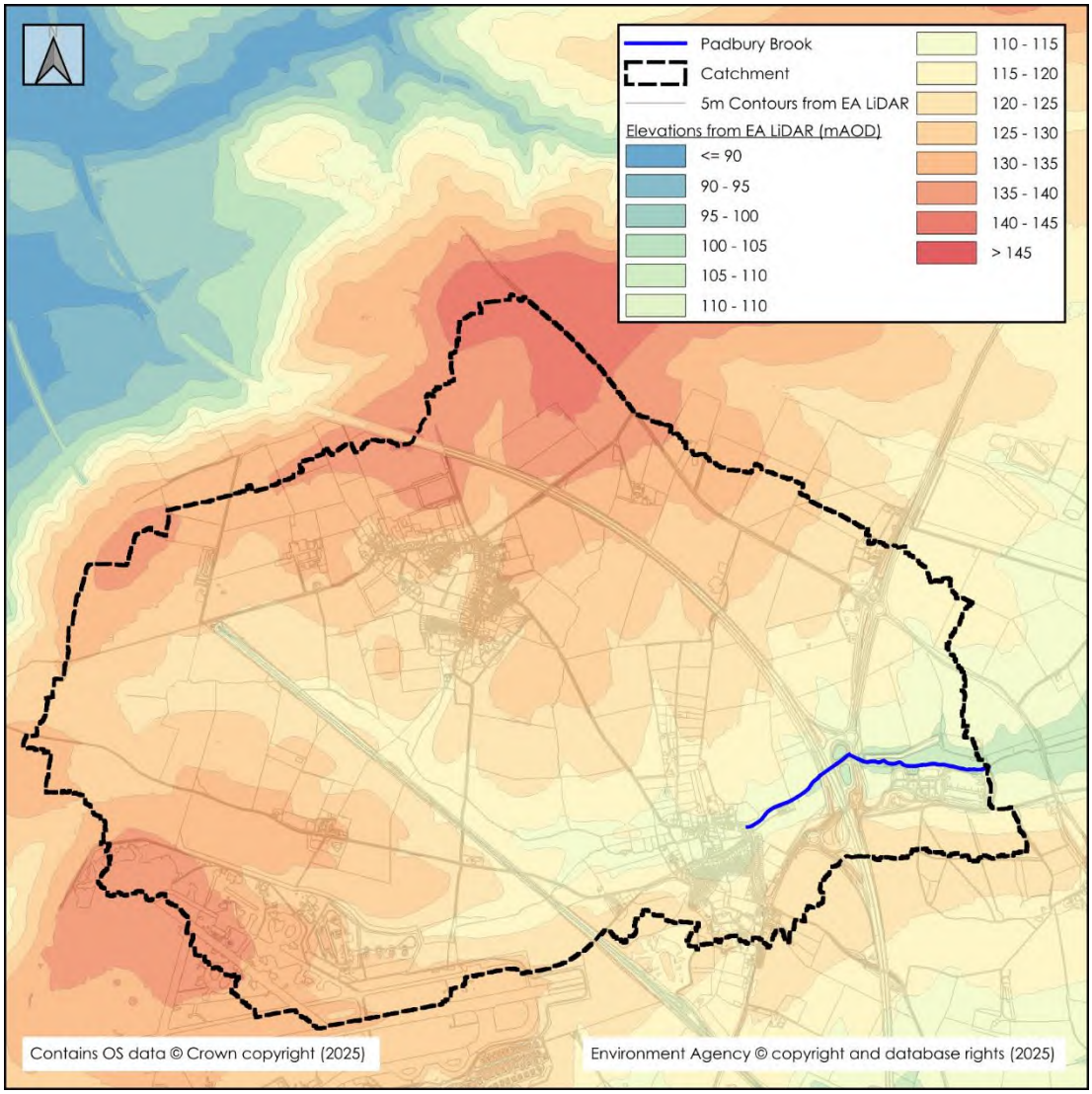


**Figure 1.2: Catchment Topography**

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.<br><br>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.<br><br>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.<br><br>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.<br><br>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.<br><br>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. | | | | |

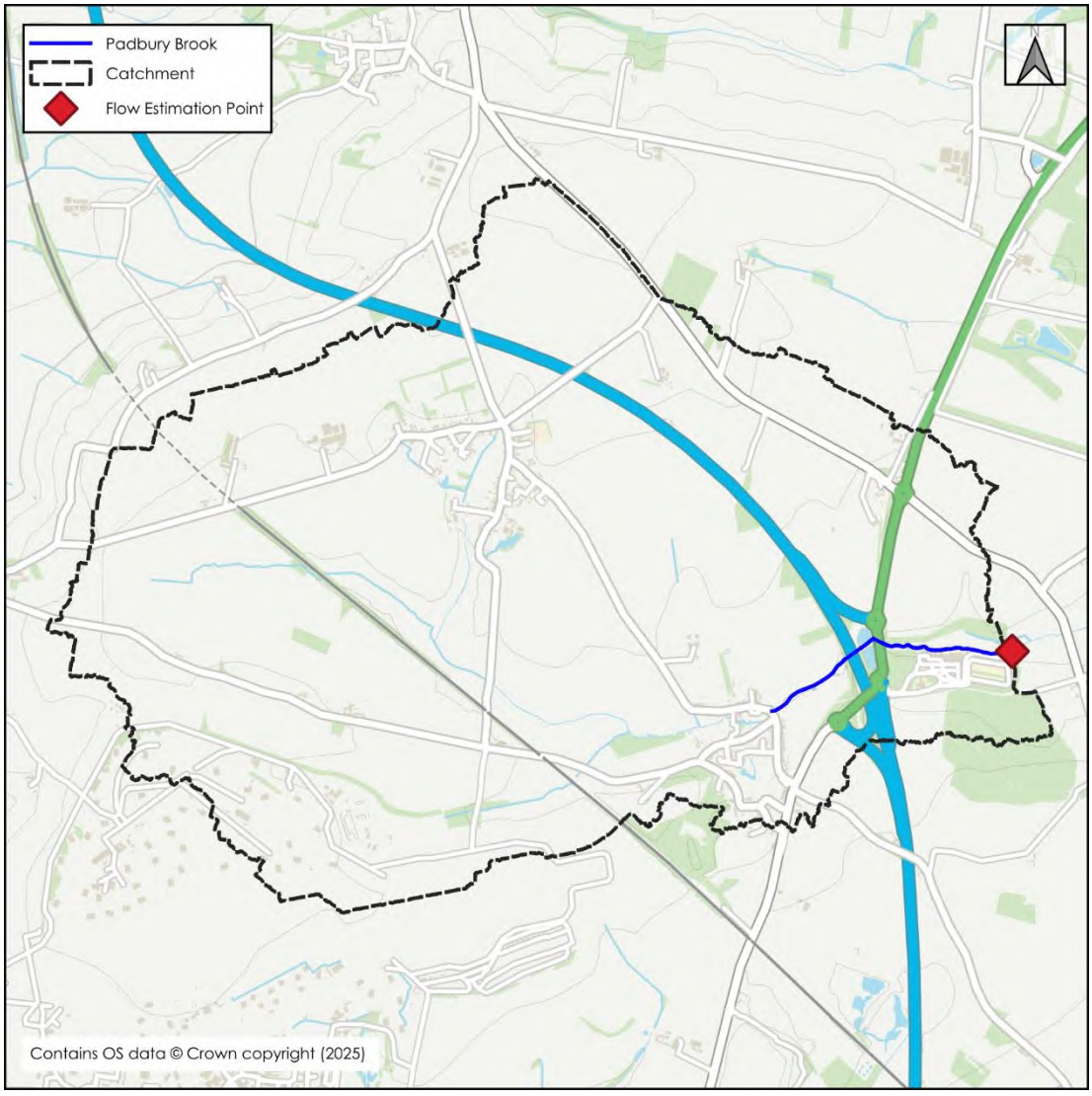


**Figure 2.1: Flow Estimation Locations**

## 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.<br><br>BFIHOST and SPRHOST values are reasonable based on the geology and soils of the catchments.<br><br>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 |

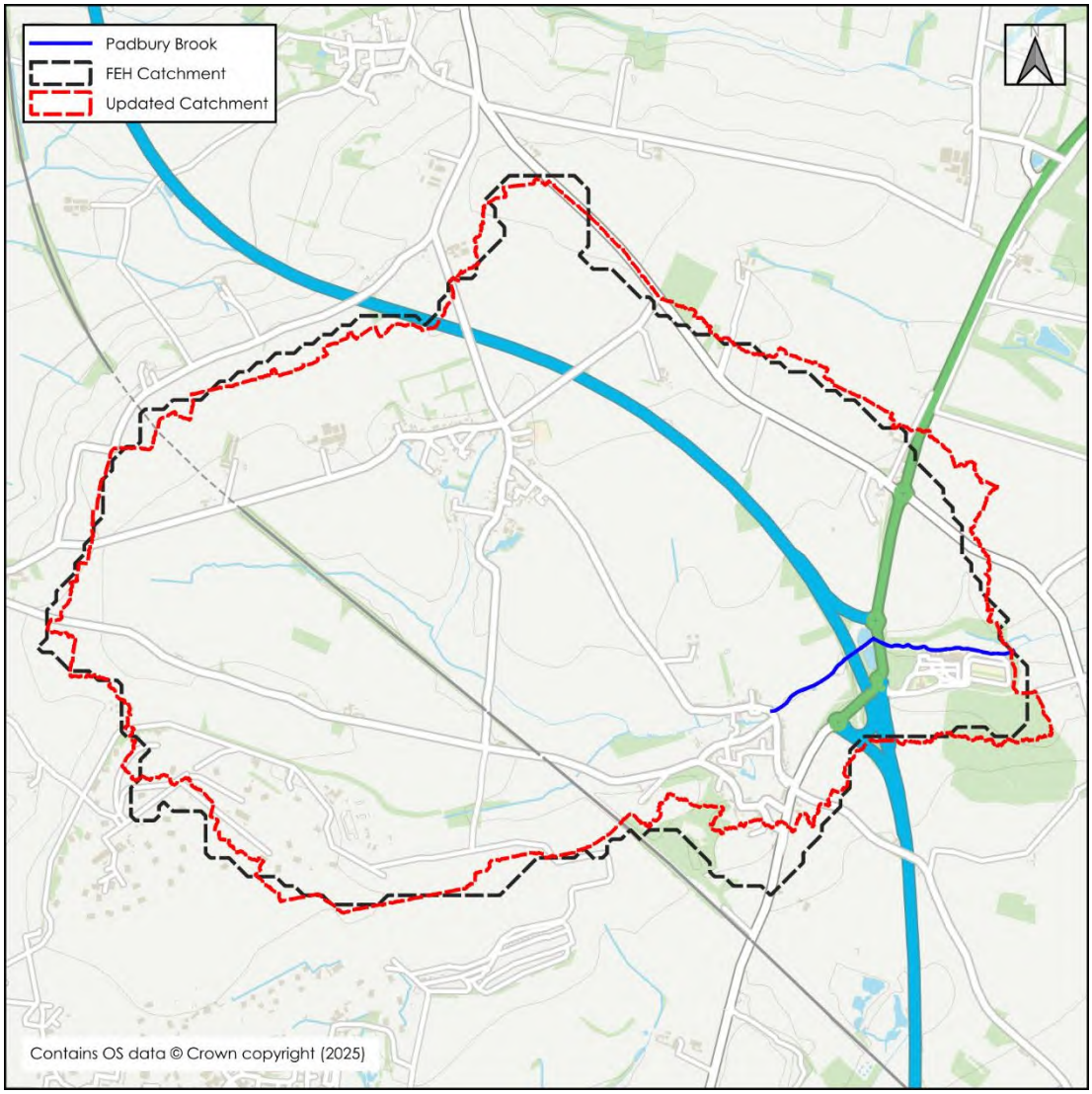


**Figure 2.2: Original and Amended Catchment Boundaries**

# 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:**<br>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.<br><br>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.<br><br>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<br>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.<br><br>**Stations Added:**<br>25013 – Added to get the pooling group record above 500 years.<br><br>36004 - Added to get the pooling group record above 500 years.<br><br>**Comments:**<br>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<br>OPT: Optimisation<br>BR: Baseflow recession fitting<br>CD: Catchment descriptors<br>DT: Data transfer | Tp (hours)<br>Time to peak | $C_{max}$ (mm)<br>Maximum storage capacity | BL (hours)<br>Baseflow lag | BR<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 |

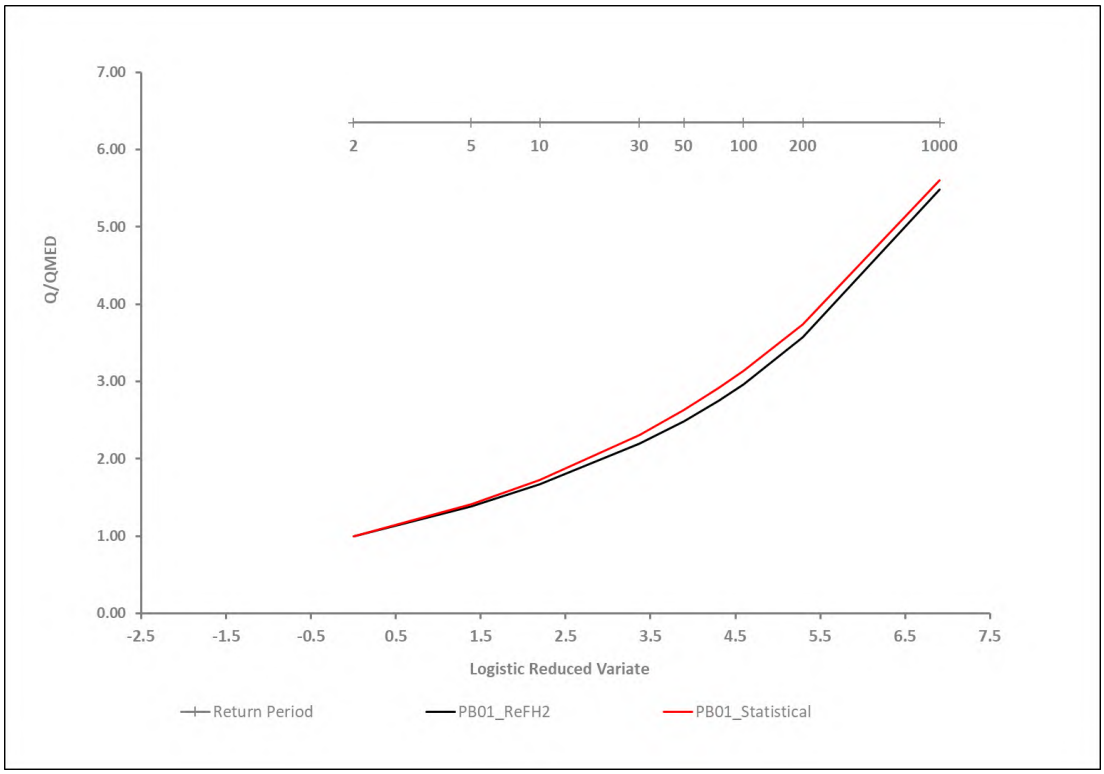


**Figure 5.1: Comparison of Statistical Method and ReFH Growth Curves**

## 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.<br><br>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.<br><br>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.<br>• The ReFH2 hydrograph shape is representative of the catchment response.<br>• Tp and storm duration are representative of the catchment response.<br>• 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.<br>• There are no swallow-holes or springs within the catchment and the groundwater catchment corresponds to the topographical catchment.<br>• 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.<br>• There is no observed flow data within the catchment with which to verify the flow estimates.<br>• 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.<br>• 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).<br><br>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).<br><br>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.<br><br>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.<br><br>The ReFH2 method 1 in 100-year growth factor is 2.97.<br><br>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<br><br>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% |

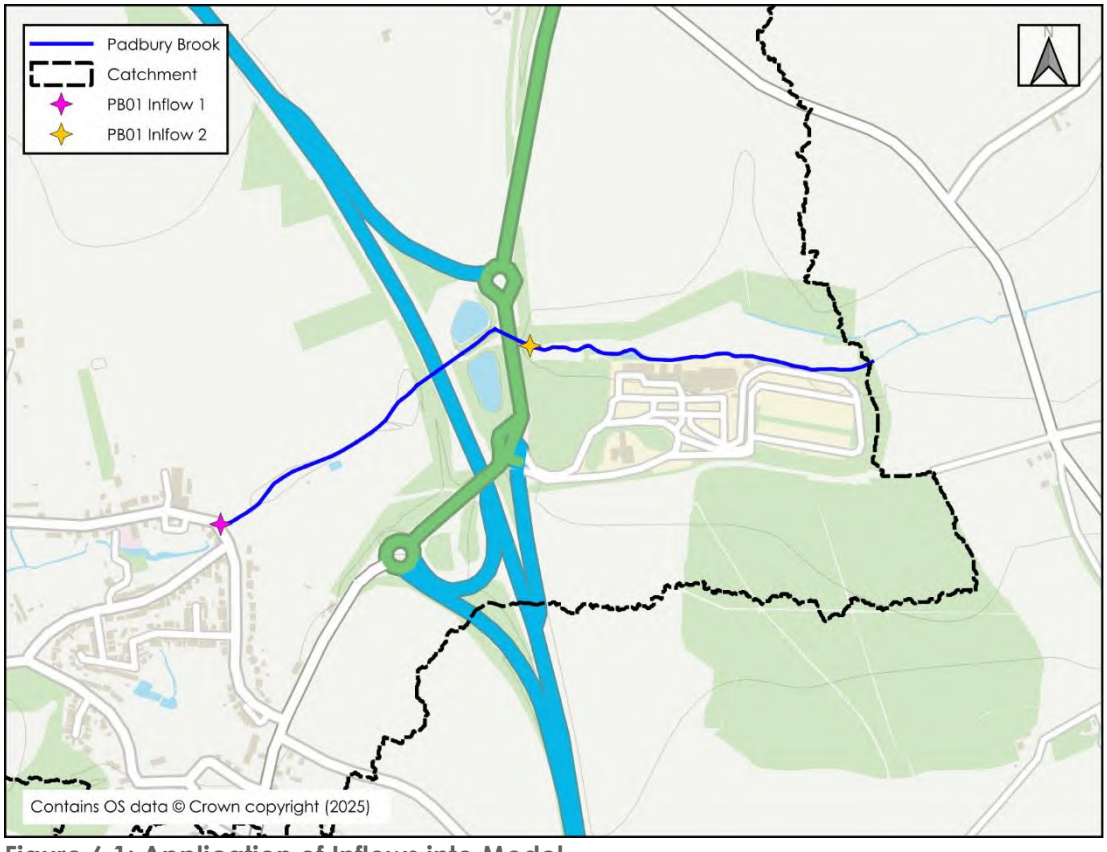


**Figure 6.1: Application of Inflows into Model**

# 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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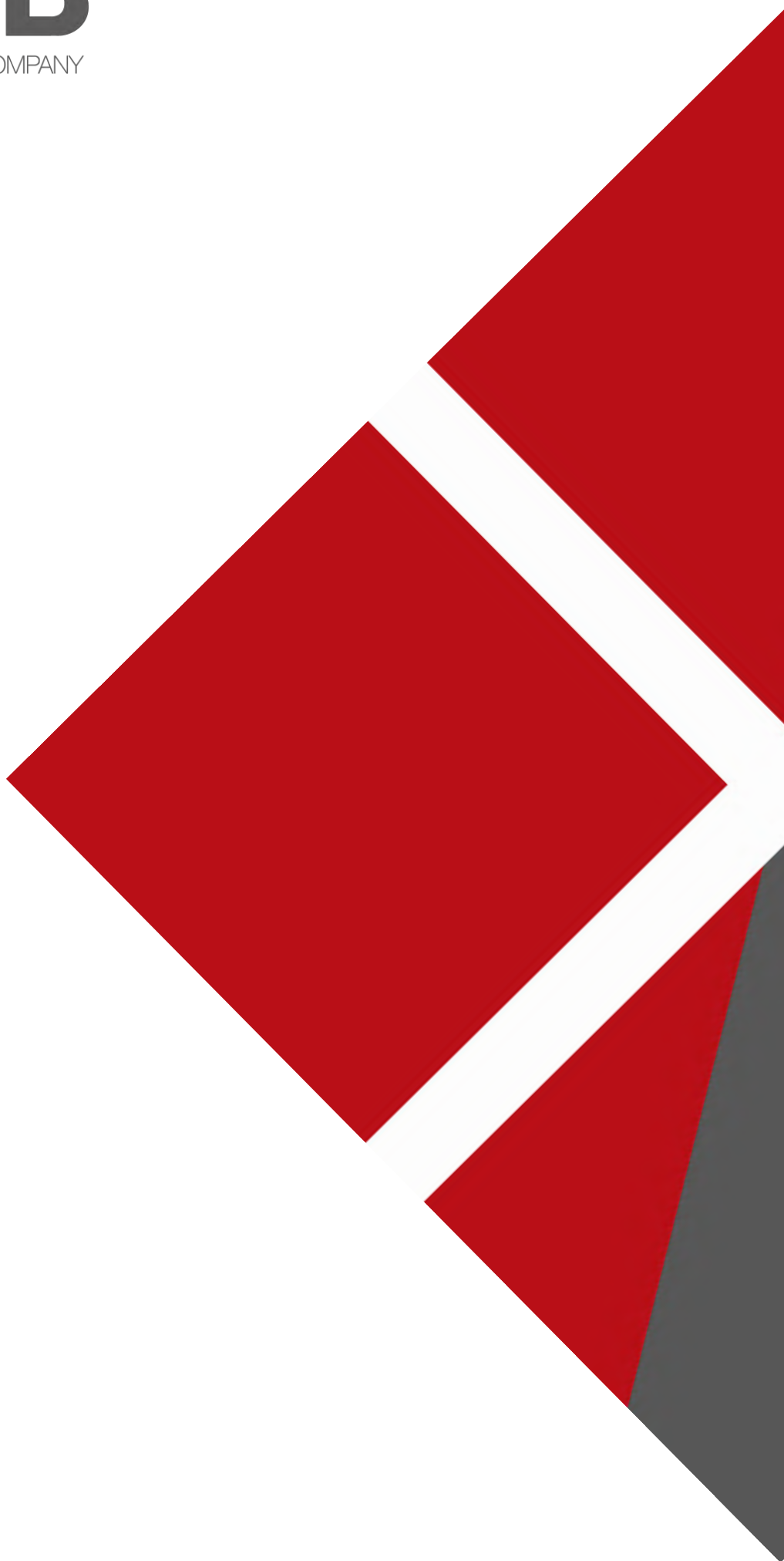

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# Appendix 3: EA Hydraulic Model Review

## Content details

| | |
|---|---|
| Title | Non-real time Hydraulic Model Review Template |
| Audience | Environment Agency, Defra |
| Type | Template |
| Reference | LIT 17617 |
| Version | 9.0 |
| Security marking | OFFICIAL |

## CONTROLLED CONTENT

# NON-REAL TIME HYDRAULIC MODEL REVIEW INTRODUCTION

Below is an overview of what information is required in each sheet. An example has been shown below each description.

A model review process summary is provided below the example. This includes information on the RAG status and how this is decided.

Fill out summary tab first. Here details any stop/go actions. These must be completed before continuing on.

There is a tab titled: *"Reference_info._EA_Staff"*. This tab is for internal Environment Agency staff only and references tools only available within the EA.

For further information or details on this document please contact: MSQA@environment-agency.gov.uk

To provide feedback on this document, please use this form: Quality Assurance Feedback Form

| **Sheet title** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Sub-section title | | | | | | | |
| **Item number** | **Item question** | **Stop/Go item** | **Model developer comments** | **Reviewer comments** | **RAG** | **Actions for model developer** | **Model developer response** |
| Colour code item number if fluvial only (blue) or coastal only (orange) | Questions to be answered as part of the review | Colour coded to allow reviewer to identify if this is a stop/go action as described on the summary sheet | Model developer to provide comments before review is undertaken within EA | Comments provided by the EA reviewer on the item question. This should detail what has and has not been provided. And justification for their review comments | This is based on the colour coding detailed below | The EA reviewer will detail exactly what is required in this space. These are the actions that are required by the model developer. | This is a space for the model developer to provide comments back based on the actions for model developer comments. |
| | | | | | | | |
| 1.4 | Are all model files provided? | Stop/go point | | Model didn't run in 1D and highlighted that these files are missing:.....<br>Stopped review. | Red | All model files to be provided including these:..... | |

## MODEL REVIEW PROCESS

Hydraulic Model reviews are an essential component of the Hydraulic Modelling Quality Assurance (QA) process that provides confidence in a model's suitability for its intended purpose. Evidence that the model has undergone QA may be requested by external parties
and hence all reviews should be written with an expectation that they could be read externally.

To start the review process select the 'Type of review' and 'Level of Assurance' in the top of the Summary Tab. Note, the 'Level of Assurance' option is for Internal reviews only. If you are an external reviewer or model developer select the 'Full / LUP' option. A Lite review involves the removal of some of the review items which will be greyed out if this option is selected. There are also comments for Lite review in the notes to guide how these checks shall be undertaken.

Should any issue(s) be raised during the review process, which require attention, the reviewer should detail the action(s) required in sufficient detail to allow the modeller to complete the changes as appropriate. Completion of this Model Review document does not automatically constitute model approval. Once the suggested changes have been completed, the reviewer may require that the model be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all amendments have
been completed satisfactorily, will the model be considered appropriate for it's intended purpose.

It is recommended that the reviewer makes use of the Fluvial Design Guide (Chapter 7) relevant software manuals and any available modelling standards when completing the review.

Depending on the work being reviewed some questions or entire sections may not be relevant, in which case they can be set to not applicable. On completion of the review the reviewer may choose to use the following colour coding system below to alert the modeller to
the priority of the actions required (if any).

**Colour coding used:**

**OK** – Good practice.
Minimum response:  No minimum.
Maximum expected response: No maximum.
Planning: No Objection.

**Green** – Consider for future studies. Negligible impact on the results that is unlikely to change the outcome of the study.
Minimum response: Acknowledge the comment in the spreadsheet and update the limitation section of the report.
Maximum expected response: Actions done to address the issue identified.
Planning: No Objection.

*Note: Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.*

**Amber** – Follow recommendation. Potential impact on the results that may change the outcome of the study.
Minimum response: Comments justifying the approach taken and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Consider objecting to the application based on comments highlighted in this category.

*Note: Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.*

**Red** – Must do. Has an impact on the results that may have a significant impact on the outcome of the study.
Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Objection - Application to be objected if comments are highlighted in this category.
*Note: If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidence. If issues highlighted red are ignored, then submissions should always be sent back.*

# NON-REAL TIME HYDRAULIC MODEL REVIEW

Please select from the drop down the type of review you are doing. This will then open the appropriate tabs.
If an Internal EA reviewer, please select 'Level of Assurance' based on the Quality Assurance Record.
External reviewers and model developers should select 'Full / LUP'.
Please note if you select the wrong type of review from the drop down and the sheets do not refresh when you select another option, you can either:
1. Download and start a new sheet
2. Right-click at the bottom where the sheets are and select '*Unhide'*, then select the sheets you require. These should then become visible

| | | | |
|---|---|---|---|
| **Type of review** | Fluvial and/or tidal 1D-2D | **Level of Assurance** | Full / LUP |
| **Project** | Oxfordshire Strategic Rail Freight Interchange (SRFI) project - Padbury Brook | **Job Number** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Software** | Estry/TUFLOW | **Software version:** | TLOW version 2025.01.0- | **2nd review** | **3rd review** | **4th review** |
| **Revision** | 1 | **Date** | 16/02/2025 | | | |
| **Area Client** | National | **Reviewer** | [redacted] | | | |

Hydraulic modelling of the Pabury Brook (Ordinary Watercourse) undertaken using ESTRY-TUFLOW software by BWB Consulting to inform the Oxford SRFI project.

## PROJECT DESCRIPTION & REQUIREMENTS

| | |
|---|---|
| **Please detail what the model is for including project description & requirements** | Hydraulic modelling of the Pabury Brook (Ordinary Watercourse) undertaken using ESTRY-TUFLOW software by BWB Consulting to inform the Oxford SRFI project. |

At the beginning of your review, if you answer 'no' to any of the items listed below, consider whether the review should continue. If the review will be fundamentally impeded by any of these items, stop the review and place on hold until further information is received.

| Item number | Stop/go actions | Yes or no? | Comments | Stop or go |
|---|---|---|---|---|
| 1.3 | Are all model files provided? | Yes | All model files are provided | Go |
| 1.5 | Does the model run? | Yes | g errors within the TGC file, particularly t | Go |
| 1.6 | Have all additional project files been provided to enable a review (i.e. model report, survey etc.)? | Yes | l report and channel cross section and str | Go |
| 10.1 - Coastal | What probability method has been used for the study? Does the approrach conform with best practice? | | Not applicable | |
| 10.4 - Coastal | Has the Coastal Flood Boundary (CFB) data been applied appropriately within the models? | | Not applicable | |
| 11.29 - Coastal | Has emulation been used in the model? If so, is the emulation appropriate to inform the model design runs? | | Not applicable | |

## REVIEW SUMMARY/CONCLUSION

| | |
|---|---|
| **Is the model suitable for intended use?** | **<u>Model review 16-02-2026</u>**<br>The model build for the Padbury Brook is considered reasonable. There were some potential file directory referencing errors in the proposed TGC file but these were easily amended/addressed as part of this review. There are two minor comments on the model. These are listed below. Further details can be found in subsequent sections of this review workbook.<br><br>1. Please review height-width data within *PB_00728_HW_02.csv* compared to the survey drawing. Is the representation correct as the width appears to be underestimated based on two conduits shown on the survey drawing within Appendix 1 of the model report<br>2. The digital terrain model data used in the model is reasonable. Within the TGC file for the proposed scenario asci grid file *LiDAR_1m_v2.asc* is referenced although this was not provided. It is assumed that this should in fact be *1m_2022_LiDAR_DTM.asc* which is referenced in the existing scenario. The TGC file should be corrected to reflect this. |

## Area comments

**This sections is for any comments that area or senior users have on the model that will be reviewed. Please provide comments below**

| Area comments | | |
|---|---|---|
| Item No. | Initials | |
| 200.1 | | |
| 200.2 | | |
| 200.3 | | |
| 200.4 | | |
| 200.5 | | |
| 200.6 | | |
| 200.7 | | |
| 200.8 | | |
| 200.9 | | |
| 201 | | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## MODEL SUMMARY

| MODEL APPROACH & SUMMARY | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Stop/Go item** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 1.1 | What model approach has been adopted? Is it appropriate? **HEC-RAS:** if it is only a steady state model - is it appropriate or is unsteady flow required? | N/A | | OK | A 1d-2d linked approach has been adopted using ESTRY-TUFLOW. This is considered reasonable | No further action required | |
| 1.2 | What model version are you reviewing? | N/A | | OK | First submission | No further action required | |
| 1.3 | Are all model files provided? | Yes. Check summary sheet | | OK | All model files are provided | No further action required | |
| 1.4 | Does the vertical chainage (upstream to downstream) in the model approximately match chainage based on survey or base mapping? | N/A | | OK | Model chainage is considered reasonable | No further action required | |
| 1.5 | Does the model run? | Yes. Check summary sheet | | OK | Yes. A check run was undertaken for the existing 1in in 100 year plus 30% climate change scenario using Tuflow build 2025 for the existing and proposed scenarios. With respect | No further action required | |
| **MODEL MANAGEMENT** | | | | | | | |
| 1.6 | Have all additional project files been provided to enable a review (i.e. model report, survey etc.)? | Yes. Check summary sheet | | OK | Yes. A model report is provided (document reference *OXFRI-BWB-ZZ-XX-T-W-1003_HMR*). Channel cross section and structure survey is provided in Appendix 1 of the model report. | No further action required | |
| 1.7 | Was a suitable file naming, structure & management system used? | N/A | | OK | Model file naming convention is considered reasonable | No further action required | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.8 | Have check files been provided to enable a review or can they be generated via a model re-run? | N/A | | OK | Yes. Check files were supplied with the model | No further action required | |
| 1.9 | Is model reporting sufficient to understand the scope of the project, how the model has been built and the quality of the modelling? | N/A | | OK | The model reporting is sufficiently detailed and provides appropriate information on the existing (baseline) and the proposed scenario model builds | No further action required | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## MODEL SCENARIOS

| EVENTS & SCENARIOS | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 2.1 | Are the simulated events sufficient to meet project requirements? | | OK | Yes. The 1 in 30, 1 in 100), and 1in 1000-year AEP scenarios have been simulated for the existing and proposed scenarios. This is considered reasonable | No further action required | |
| 2.2 | Are climate change runs aligned with current guidance? | | OK | The modelled reach lies within the Upper and Bedford Ouse management catchment. Climate change uplifts for the 2080s epoch are +19% (Central), +30% (Higher Central), and +58% (Upper End). A review of inflow data within *PB_Flood_Flows_006.csv* shows that climate change scaling factors are representative of the 2080s Central, Higher Central, and Upper End uplifts for the Upper and Bedford Ouse management catchment. | No further action required | |
| 2.3 | Are undefended scenarios required (for Flood Zones etc.) and if so have any raised defences and structures been removed in line with guidance? | | N/A | There are no raised defences within the model domain. Undefended modelling for the purposes of updating the Flood Map for Planning is not required. | Not applicable | |
| **SCHEME PROJECTS** | | | | | | |
| 2.4 | Where a scheme is being developed, have appropriate model runs been provided to compare the baseline and with-scheme scenarios? Have the with-scheme scenarios been schematised appropriately? | | N/A | The modelling is not being used for the development of a Flood Alleviation Scheme | Not applicable | |
| 2.5 | Has a study for quantifying uncertainty been undertaken? How was this derived and does it seem sensible? | | N/A | Not applicable. A full residual uncertainty assessment using the 2017 residual uncertainty guidance is not considered necessary for a project of this nature. Sensitivity testing is considered suitable for understanding uncertainties. Please see comment 16.8 within worksheet Model_Performance for further details | Not applicable | |
| **DEVELOPMENT PROJECTS** | | | | | | |
| 2.6 | Where a development is being proposed, have appropriate model runs been provided to compare the baseline and with-development scenarios? | | OK | Yes. Appropriate model runs have been undertaken to compare the baseline and proposed development | No further action required | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.7 | Where post development modelling is required, has this been considered within the modelling adequately and are the proposals represented in line with design drawings? | | OK | In the proposed scenario a new slip road is included within the model. This crosses the Padbury Brook. The slip road is represented using digital terrain model *M40_NB_SR_Surface.asc* . A new culvert is also included under this slip road. The model report describes how it is assumed that the culvert will be the same diameter as the existing culvert neath the M40 downstream of the proposed slip road. A review of the model representation confirms that PB_PROP_1104 (proposed culvert) is the same diameter and number (x2) as PB_00974. Roughness values are also consistent between the two | No further action required | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 1D MODEL BUILD

| 1D NETWORK | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 3.1 | Have appropriate distances between sections and/or nodes been used? | | OK | ESTRY Channel cross section spacing is considered reasonable. | No further action required | |
| 3.2 | Is the model geo-referenced? | | OK | Yes. The model is georeferenced. | No further action required | |
| 3.3 | Do the cross sections and bed profiles look reasonable? | | OK | ESTRY channel cross section geometry looks reasonable. Please see worksheet ***ESTRY_Cross_Section_Check*** for further details | No further action required | |
| 3.4 | Does conveyance look appropriate? | | OK | ESTRY cross section conveyance looks reasonable based on a review of “K” within 1d_ta_tables_check. There are | No further action required | |
| 3.5 | Bank Markers. Are they used and if so, are they suitably located? | | N/A | Not applicable. Bank Markers are not used in ESTRY | Not applicable | |
| 3.6 | What method has been used to estimate roughness? What values have been used for the floodplain (if 1D only model) and channel? Are these appropriate? | | OK | Mannings roughness values for the bed of generally between 0.035 and 0.05 have been applied. These values are considered reasonable | No further action required | |
| 3.7 | **HEC-RAS:** Do the cross sections contain ineffective flow areas. If so, have they been applied correctly? | | N/A | Not applicable. Not a HEC-RAS model | Not applicable | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

| 1D BOUNDARY CONDITIONS | | | | | | |
|---|---|---|---|---|---|---|
| **1D BOUNDARY CONDITIONS** | | | | | | |
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 4.1 | Is there 'glass walling' anywhere in the modelled reaches? Are out of bank flows represented in 1D? If so, how has it been done and is it appropriate? | | N/A | Not applicable. 1d ESTRY cross sections are linked to a 2d domain using Head Exchange boundary *2d_bc_hxi_Padbury_Brook_005_L* in the existing scenario and *2d_bc_hxi_Padbury_Brook_PROP_002_L* in the proposed scenario. | Not applicable | |
| 4.2 | How have the inflows boundaries been applied? | | OK | Flows applied to the hydraulic model using *1d_bc_Padbury_Brook_Inflows_002_P.shp* . Two inflow points are used, one at the upstream end of the modelled reach upstream of the M40 (Inflow1) and one downstream of the M40 (Inflow2). The application of flows is consistent between the existing and proposed scenarios. With respect to Inflow1, total lumped catchment flows are scaled by 0.75 for this inflow point. For Inflow2 total lumped catchment inflows are scaled by 0.25. Lumped catchment flows are contained within *PB_Flood_Flows_006.csv* . Lumped catchment peak flows are as follows 1 in 30 year: 1.15m3/s, 1 in 100 year 1.57m3/s, and 1 in 1000 year : 2.80m3/s. These peak flows align with those shown in table 2.1 page 10 of BWBs modelling report. The total lumped catchment to the downstream end of the modelled reach is around 12.7km2 based on the FEH Webservice catchment. The catchment area to the upstream end of the model domain is around 10km2. On this basis the scaling factors applied to the inflow points within the modelled reach appear reasonable. As part of this review a quick check was undertaken comparing the peak flows shown within table 2.1 of BWBs model report which peak flows generated for the lumped catchment to 455450 228300 with those generated using ReFH2 and FEH22 rainfall and those from the FEH statistical method. For the 1% (1 in 100 year) AEP these methods produced peak flows of 1.5m3/s (urbanised) and 1.34m3/s (donor adjusted QMED) and 1.71m3/s (QMED based on catchment descriptors) for the ReFH2 and FEH statistical methods, respectively. This gives confidence to BWB's calculated peak flows. | No further action required | |
| 4.3 | How is the downstream boundary(s) applied? Have appropriate locations been chosen for the downstream model extents? | | OK | Downstream boundary conditions are applied using 1d_bc_Padbury_Brook_DSBDY_001_P.shp. A Head Time boundary has been used. This is consistent between the existing and proposed scenarios. A fixed water level of 107.01 mAOD is used at the downstream boundary. This is as described in section 3.16 page 17 of BWBs modelling report and is based on a level of 300mm below top of bank level. This looks reasonable based on a review of cross section data at section PB_00000.csv | No further action required | |
| 4.4 | **If tidal -** how has the boundary been derived? | | N/A | Not applicable. The Padbury Brook is not a tidal watercourse | Not applicable | |

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For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 1D STRUCTURES

| 1D STRUCTURES | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 5.1 | Are all structures represented (inc. movable structures)? If not, have explanations for structures not modelled been given in the reporting? | | OK | All key structures are represented within the hydraulic model in both the existing and proposed scenarios | No further action required | |
| 5.2 | Are invert levels correct compared to survey data? | | Amber | For the most part structure representation aligns with the survey data shown in Appendix 1 of the model report. With respect to culvert PB_00728US the survey drawing shows 2 irregular conduits. The maximum width in height-width table *PB_00728_HW_02.csv* is 2.067m. Is this correct based on the survey data? The combined width from the 2 conduits appears to be greater than this based on the survey drawing | Please review height-width data within *PB_00728_HW_02.csv* compared to the survey drawing. Is the representation correct as the width appears to be underestimated based on two conduits shown on the survey drawing within Appendix 1 of the model report | A review of the 1d_nwke line shows that within the EXG scenario the 'Number_of' atrtribute is set to two to duplicate the height-width as a double barrel. This was not reflected in the PRO scenraio or sensitivty testing. The 1d_nwke lines for these simulations have been appropriately amended. |
| 5.3 | Do bridges surcharge? If so has orifice flow been enabled? | | N/A | Not applicable to ESTRY structures. Relevant only for Flood Modeller Arch and USBPR bridges. | Not applicable | |
| 5.4 | Where structures bypass or overtop, have spills been represented correctly to reflect this? | | OK | Spills over structures are represented in either 2d where Head Exchange (HX) lines are placed perpendicular to flow direction or in 1d using an ESTRY weir. In the latter scenario the en1 (spill width) and en2 (spill depth) values have been populated within the 1d_nwke layers for the existing and the proposed scenarios. A review of the corresponding check files (nwk_C_check_L) shows spill elevation is correctly represented when compared to the survey in Appendix 1 of the modelling report. | No further action required | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5.5 | Have structure coefficients been changed from default values? If so, are these changes appropriate and justified? | | OK | Default values adopted. | No further action required | |
| 5.6 | Have appropriate roughness values been used? | | OK | Roughness values for culverts and bridges in the existing and proposed scenarios are considered reasonable. | No further action required | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 2D MODEL BUILD

| DIGITAL TERRIAN MODEL | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 6.1 | What datasets have been used to define the floodplain (i.e. LiDAR, topographic survey etc.) and have these datasets been correctly represented in the model DTM? | | Green | 1 metre resolution Lidar data (*1m_2022_LiDAR_DTM.asc*) and topographical survey (*Topo_Survey_Rev5_PB.asc*) are used to represent the floodplain topography in the existing scenario. In the proposed scenario LiDAR_1m_v2.asc is referenced but this was not included with the model submission. A comparison between the existing and proposed model dtm files (DEM_Z check file) reveals floodplain topography is identical except in the vicinity of the proposed slip road which is represented by *M40_NB_SR_Surface.asc*. It is therefore assumed that *LiDAR_1m_v2.asc* referenced within Padbury_Brook_PROP_002.tgc should actually reference *1m_2022_LiDAR_DTM.asc* | The digital terrain model data used in the model is reasonable. Within the TGC file for the proposed scenario asci grid file *LiDAR_1m_v2.asc* is referenced although this was not provided. It is assumed that this should in fact be *1m_2022_LiDAR_DTM.asc* which is referenced in the existing scenario. The TGC file should be corrected to reflect this. | TGC file updated to reflect the correct file names; however, it is noted both files reflect the same data the change related to the naming only. |
| 6.2 | What grid resolution has been used within the model and is it suitable to capture key flow routes within the model (e.g. between buildings) | | OK | A model grid resolution of 2 metres has been adopted for both the existing and proposed scenarios. This is considered reasonable | No further action required | |
| 6.3 | Has the DTM been rotated to optimise flow route representation? Is this appropriate? | | OK | Grid orientation as defined by 2d_loc_Padbury_Brook_001_L.shp is considered reasonable | No further action required | |
| 6.4 | How have buildings been represented within the DTM? Is this appropriate? | | OK | Buildings within the model are represented using increased roughness. A roughness value of 0.5 has been used for buildings (material number 10021 within *Padbury_Brook_Materials_001.tmf*) | No further action required | |
| 6.5 | Are bank crests accurately represented? | | OK | In the baseline scenario bank crest elevations are represented using 2d_zln_Padbury_Brook_Banks_004_P.shp. In the proposed scenario crest elevations are represented | No further action required | |
| 6.6 | Are raised defences/embankments accurately represented? | | N/A | Not applicable. There are no raised defences along the modelled reach | Not applicable | |
| 6.7 | Are conveyance routes underneath raised embankments accurately represented? | | N/A | Not applicable. There are no 2d floodplain flow routes represented within the model. A review of Ordnance Survey data suggests this to be the case. The only flow route under the respect M40 and A43 embankments is the Padbury Brook (which is represented in 1d using ESTRY) | Not applicable | |
| **2D ROUGHNESS** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6.8 | What method has been used to estimate roughness? What values have been used for the floodplain and channel (for a 2D only model)? Are these appropriate? | | OK | Floodplain roughness values are defined within *Padbury_Brook_Materials_001.tmf*. The adopted values based on different land use classifications appear reasonable. A review of the apportionment of roughness across the model domain based on the respective DEM_M check files shows different land use types have been appropriately mapped and included in the existing and proposed scenarios | No further action required | |
| 6.9 | Is the representation of different roughness areas sufficiently accurate and detailed? | | | | | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 2D BOUNDARIES

| 2D BOUNDARY CONDITIONS | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 7.1 | Have any 2D boundaries been used in the model and if so are these schematised correctly? | | OK | Head Exchange (HX) boundaries are used to link the 1d ESTRY and 2d Tuflow domains of the model. At the downstream boundary of the model a slope is applied which is represented within *2d_bc_Padbury_Brook_DSBDY_001_L.shp* . A slope value of 0.0018 and 0.0016 metres per metre has been applied for the left and right bank floodplains. This is considered reasonable. | No further action required | |
| 7.2 | Is there 'glass walling' anywhere in the modelled reach where outputs reach the model domain boundary? | | OK | The 2d code layer (*2d_code_Padbury_Brook_001_R.shp* ) is large enough to ensure no glass walling occurs. Flood extent is largely contained to the channel. | No further action required | |
| 7.3 | For direct rainfall modelling how has the input rainfall been applied? | | N/A | Not applicable. Not a direct rainfall model. | Not applicable | |

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## 2D STRUCTURES

| 2D STRUCTURES | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 8.1 | Have any structures been included in the 2D domain (floodplain or channel) and how have they been represented? Are structure details (invert, length etc.) correct compared to survey? | | N/A | Not applicable. There are no structures in the 2d domain of the model | Not applicable | |
| 8.2 | Are values of roughness and loss co-efficient suitable for the type of structure? | | N/A | Not applicable. There are no structures in the 2d domain of the model | Not applicable | |

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## 1D/2D MODEL LINKS

| MODEL LINKS | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 13.1 | How have the 1D/2D models been coupled, is it appropriate? Is the digitisation of the links acceptable? | | OK | The 1d and 2d models are coupled using Head Exchange (HX) boundaries. The | No further action required | |
| 13.2 | Is the 2D representation of the river channel comparable in width with the 1D model cross sections? | | OK | Cross section widths are comparable to the width of the deactivated 1d area | No further action required | |
| 13.3 | How is the 1D output represented within the 2D domain and is it schematised correctly? | | OK | Yes, flood risk for the 1d deactivated area is mapped. This is achieved through the use of Water Level Lines (*1d_WLL_Padbury_Brook_004_L.shp* and *1d_WLL_Padbury_Brook_PROP_002_L.shp*) | No further action required | |
| 13.4 | Have any default link parameters been changed (i.e. to improve stability) and are these appropriate and justified? | | OK | Link parameters within 2d_bc_hxi_Padbury_Brook_PROP_002_L.shp and 2d_bc_hxi_Padbury_Brook_005_L.shp are set to default values | No further action required | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## RUN PARAMETERS

| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) |
|---|---|---|---|---|---|---|
| | **1D RUN PARAMETERS** | | | | | |
| 14.1 | What time step has been used for the 1D model? Is it appropriate? | | OK | A 1d ESTRY timestep of 0.5 seconds has been adopted. This is considered reasonable | No further action required | |
| 14.2 | Are 1D initial conditions appropriate for the start of the model run? | | OK | Initial water levels for ESTRY cross sections are defined using *1d_iwl_Padbury_Brook_001_P.shp* for the existing scenario and *1d_iwl_Padbury_Brook_PROP_002_P.shp* for the proposed scenario. ESTRY 1d initial water levels are identical between the existing and proposed scenarios. Initial water levels appear to be based on the surveyed water levels shown on the channel cross sections in Appendix 1 of the model report. This is considered reasonable | No further action required | |
| 14.3 | Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified? | | OK | Run parameters are set to default values. | No further action required | |
| | **2D RUN PARAMETERS** | | | | | |
| 14.4 | What time step has been used for the 2D model? Is it appropriate? | | OK | A 2d time step of 1 second has been adopted. This is half the 2d grid resolution and is considered reasonable | No further action required | |
| 14.5 | Have initial water levels been applied and are these appropriate for the scenario being run? | | N/A | Initial water levels are not used in the 2d domain of the existing and proposed models | Not applicable | |
| 14.6 | Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default? If so, has it been justified? | | OK | 2d run parameters are set to default values | No further action required | |

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## MODEL STABILITY

| 1D MODEL STABILITY | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 15.1 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | | OK | The following warnings and messages are observed WARNING 2073 - Null Shape object ignored. Only Regions, Lines, Polylines & Multiple Polylines used | No further action required | |
| 15.2 | Is 1D mass balance from the model run within expected limits? Have they been investigated and resolved where potentially impacting the model results? | | OK | Mass error is within acceptable bounds (+/1%). There is an initial slight spike but this soon settled to below 1% | No further action required | |
| 15.3 | Have any periods of non-convergence within the model run been investigated and resolved where potentially impacting the model results? | | OK | A review of ESTRY stage time series data across multiple events shows reasonable water level change. There are no periods of notable water level oscillation. Results appear stable | No further action required | |
| 15.4 | Under a range of different scenarios do the animations and graphed outputs give an indication of good model stability? | | OK | Yes, as noted above ESTRY stage time series reveals a stable change in water levels for all scenarios | No further action required | |
| **2D MODEL STABILITY** | | | | | | |
| 15.5 | Is 2D mass balance from the model run within expected limits? Where outside of expected tolerance, have they been investigated and resolved where potentially impacting the model results? | | OK | Mass error is within acceptable bounds (+/1%). There is an initial slight spike but this soon settled to below 1% | No further action required | |
| 15.6 | Are CE and dV values relatively stable and remain so once the run has got going? | | OK | Volume exchange is considered reasonable across multiple scenarios. | No further action required | |
| 15.7 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | | OK | Please see comment 15.1 above | No further action required | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15.8 | Are negative depths being created during the model run? If so, have these been investigated and resolved where appropriate? | | OK | There a no negative depths within any of the simulations | No further action required | |
| 15.9 | Under a range of different scenarios do the animations and graphed outputs give an indication of good model stability? | | OK | Inspection of model results using Tuflow viewer within QGIS reveals reasonable flood progression and increasing flood extents for rarer AEP scenarios | No further action required | |
| 15.10 | **HPC Models Only** - Do the appropriate HPC output files show any indication of instability? If so, has this been investigated and resolved where appropriate? | | N/A | Not a HPC model. Tuflow classic has been used | Not applicable | |

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## MODEL PERFORMANCE

| CALIBRATION/VERIFICATION | | | | | | |
|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** |
| 16.1 | Have calibration/verification runs been completed based on locally gauged and recorded data? | | N/A | There are no gauges along the Padbury Brook within the modelled reach. The nearest gauge is at Bourton Grounds around 25 kilometres downstream of the modelled reach. This is a level only gauge. As there are no gauges within the modelled reach it is therefore not possible to formally calibrate or verify the hydraulic model. The Environment Agency do not hold any recorded flood outlines for the Padbury Brook | Not applicable | |
| 16.2 | Are the simulated hydrograph peaks reasonably similar to the recorded peaks? Is the shape of the simulated hydrograph and therefore the volume suitably similar? | | | | | |
| 16.3 | Are simulated floodplain extents similar to recorded extents? Are flow routes similar? | | | | | |
| 16.4 | Has suitable effort been made to attempt and improve calibration. Have attempted changes been documented with a quantification of impact? | | | | | |
| **RECONCILIATION** | | | | | | |
| 16.5 | Is there good reconciliation between estimates at flow estimation points and the model for given exceedance probabilities? | | OK | There is good reconciliation between the calculated peak flows based on the FEH statistical method as shown in table 2.1 of the model report and the flows extracted at the downstream end of the model for the Padbury Brook (section PB_00142I3). Please see worksheet ***Flow_Comparisons*** for details. | No further action required | |
| **VALIDATION** | | | | | | |
| 16.6 | Where calibration is not possible due to data availability, have checks been made against other recorded data (wrack marks, flood extents, photographs etc.) and how do these compare? | | N/A | The Environment Agency do not hold any recorded outlines or wrack mark data for the Padbury Brook. | Not applicable | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16.7 | If no recorded or historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large difference, does it seem sensible? | | OK | The Environment Agency does not hold any detailed hydraulic models for the Padbury Brook upstream of the M40. Downstream of the M40 the Environment Agency undertook broadscale modelling using Tuflow (2d only) of the Padbury Brook as part of the Upper River Great Ouse (Capital Symonds, 2011) study. The outputs from this study show flood risk largely constrained to the channel in the upper reaches of the Padbury Brook. | No further action required | |
| | **SENSITIVITY TESTING** | | | | | |
| 16.8 | Have appropriate model parameters been chosen for sensitivity testing?<br><br>Typical tests include:<br>□ Sensitivity to roughness ± 20% ( Manning's "n" both in 1D and 2D)<br>□Sensitivity to flows ± 20% (From central estimate)<br>□ Sensitivity to downstream boundary<br>□ Key structure blockage(s) | | OK | Sensitivity testing has been undertaken on Mannings roughness, flow, and downstream boundary conditions. Blockage tests have also been undertaken. The model results are not particularly sensitive to changes in roughness or downstream boundary conditions. Much of the flood risk is contained within the channel | No further action required | |
| 16.9 | Do the results of the tests show the models to be particularly sensitive to certain parameters? | | | | | |
| | **DEVELOPMENT PROJECTS** | | | | | |
| 16.10 | For development modelling, has the uncertainty of the modelling been quantified and reported, is this reasonable? Does it describe what it means to the conclusions of the assessment (design of the development/mitigation)? | | OK | A full residual uncertainty assessment using the 2017 accounting for residual uncertainty guidance is not considered necessary for a study of this nature. The sensitivity testing undertaken on various model parameters as highlighted in comment 16.8 demonstrates that model results and flood risk to the proposed development site are not particularly sensitive to a number of secondary variables within the hydraulic model. | No further action required | |
| 16.11 | Has an assessment of post scheme/development on third party flood risk been undertaken? Has justification been provided for any off-site change and is this reasonable? | | OK | Details of the impact of the proposed slip road crossing over the Padbury Brook is presented in section 5.11 of the model report. Water level difference mapping is presented in figure 5.3 of the model report. There are no downstream impacts on flood risk or increases in flood risk to third parties because of the scheme. In terms of pass forward flow at the downstream end of the model, this remains the same between the existing and proposed scenarios. Please see worksheet ***Flow_Comparisons*** | No further action required | |

Multiple streams ESTIM area sectors threatened work associated train buses multiple airports the Feathers Road

PM_234564.csv

| h | p | hs |
|---|---|---|
| 4 | 1677.85 | 0.45 |
| 9.864 | 1617.24 | 0.45 |
| 8.864 | 1617.24 | 0.45 |
| 8.364 | 1627.84 | 0.435 |
| 8.364 | 1627.84 | 0.435 |
| 9.864 | 1636.825 | 0.435 |
| 10.364 | 1636.825 | 0.435 |
| 10.436 | 1636.825 | 0.435 |
| 11.116 | 1636.764 | 0.435 |
| 11.116 | 1636.764 | 0.435 |
| 12.176 | 1637.24 | 0.45 |
| 13.26 | 1638.512 | 0.45 |

PM_234.6.csv

| h | p | hs |
|---|---|---|
| 3.285 | 1627.853 | 0.45 |
| 7.874 | 1627.8 | 0.45 |
| 8.364 | 1627.84 | 0.435 |
| 8.874 | 1636.816 | 0.435 |
| 8.816 | 1636.8 | 0.435 |
| 8.816 | 1636.816 | 0.435 |
| 8.872 | 1636.853 | 0.435 |
| 10.436 | 1636.814 | 0.435 |
| 10.436 | 1636.814 | 0.435 |
| 11.001 | 1637.832 | 0.45 |
| 12.624 | 1638.144 | 0.45 |

PM_23453.csv

| h | p | hs |
|---|---|---|
| 4.001 | 1636.152 | 0.435 |
| 8.364 | 1636.181 | 0.435 |
| 7.868 | 1627.73 | 0.435 |
| 7.868 | 1627.84 | 0.435 |
| 7.864 | 1627.839 | 0.435 |
| 7.864 | 1627.368 | 0.435 |
| 8.364 | 1627.368 | 0.435 |
| 8.852 | 1627.368 | 0.435 |
| 9.791 | 1627.201 | 0.435 |
| 11.524 | 1636.816 | 0.435 |
| 11.524 | 1636.205 | 0.435 |

PM_23456.csv

| h | p | hs |
|---|---|---|
| 4.177 | 1636.843 | 0.45 |
| 8.864 | 1636.837 | 0.45 |
| 8.364 | 1627.817 | 0.435 |
| 7.868 | 1627.84 | 0.435 |
| 7.364 | 1627.836 | 0.435 |
| 8.365 | 1627.836 | 0.435 |
| 8.364 | 1627.836 | 0.435 |
| 9.01 | 1627.865 | 0.45 |
| 11.524 | 1636.813 | 0.45 |

PM_23577.csv

| h | p | hs |
|---|---|---|
| 4.177 | 1636.81 | 0.45 |
| 4.865 | 1636.843 | 0.435 |
| 4.9 | 1636.837 | 0.435 |
| 7.364 | 1627.817 | 0.435 |
| 7.377 | 1627.836 | 0.435 |
| 8.364 | 1627.836 | 0.435 |
| 8.364 | 1627.836 | 0.435 |
| 8.85 | 1627.817 | 0.435 |
| 9.284 | 1627.865 | 0.435 |
| 11.043 | 1636.84 | 0.45 |

PM_23640.csv

| h | p | hs |
|---|---|---|
| 9.124 | 1636.868 | 0.45 |
| 8.364 | 1636.843 | 0.435 |
| 8.364 | 1636.843 | 0.435 |
| 8.862 | 1627.836 | 0.435 |
| 8.364 | 1627.836 | 0.435 |
| 10.364 | 1627.824 | 0.435 |
| 11.524 | 1636.816 | 0.435 |
| 11.524 | 1637.776 | 0.435 |
| 12.214 | 1638.211 | 0.45 |
| 13.264 | 1639.144 | 0.45 |

PM_23653.csv

| h | p | hs |
|---|---|---|
| 10.636 | 1636.868 | 0.45 |
| 11.26 | 1636.82 | 0.45 |
| 12.397 | 1636.864 | 0.45 |
| 12.77 | 1637.844 | 0.435 |
| 12.77 | 1637.844 | 0.435 |
| 13.237 | 1637.863 | 0.435 |
| 14.364 | 1637.844 | 0.435 |
| 14.3695 | 1637.844 | 0.435 |
| 14.843 | 1636.848 | 0.45 |
| 15.77 | 1638.144 | 0.45 |
| 17 | 1639.51 | 0.45 |

PM_2367.1.csv

| h | p | hs |
|---|---|---|
| 7.454 | 1636.764 | 0.645 |
| 8.733 | 1636.697 | 0.645 |
| 12.397 | 1636.864 | 0.645 |
| 12.457 | 1636.253 | 0.645 |
| 12.77 | 1637.844 | 0.645 |
| 13.41 | 1637.844 | 0.645 |
| 15.473 | 1637.752 | 0.645 |
| 15.473 | 1637.844 | 0.645 |
| 15.457 | 1637.863 | 0.645 |
| 16.164 | 1638.375 | 0.645 |
| 16.558 | 1638.841 | 0.45 |

PM_23675.csv

| h | p | hs |
|---|---|---|
| 5.714 | 1636.168 | 0.645 |
| 8.364 | 1636.843 | 0.645 |
| 8.352 | 1636.835 | 0.645 |
| 8.373 | 1636.836 | 0.645 |
| 8.364 | 1636.836 | 0.645 |
| 8.463 | 1637.836 | 0.645 |
| 10.4 | 1637.866 | 0.645 |
| 12.397 | 1638.864 | 0.645 |
| 12.681 | 1638.533 | 0.47 |
| 12.658 | 1639.211 | 0.47 |

PM_23705.csv

| h | p | hs |
|---|---|---|
| 4.915 | 1636.043 | 0.39 |
| 8.364 | 1636.862 | 0.45 |
| 8.965 | 1638.842 | 0.46 |
| 8.364 | 1636.836 | 0.435 |
| 8.58 | 1636.837 | 0.435 |
| 8.407 | 1636.83 | 0.435 |
| 8.364 | 1636.836 | 0.435 |
| 9.277 | 1637.811 | 0.435 |
| 10.117 | 1638.835 | 0.435 |
| 11.524 | 1638.816 | 0.435 |
| 11.456 | 1638.764 | 0.45 |
| 12.564 | 1639.483 | 0.46 |

PM_23725.csv

| h | p | hs |
|---|---|---|
| 3.84 | 1636.203 | 0.39 |
| 4.362 | 1636.864 | 0.39 |
| 8.364 | 1636.843 | 0.435 |
| 8.363 | 1637.811 | 0.435 |
| 8.364 | 1636.845 | 0.435 |
| 8.364 | 1636.836 | 0.435 |
| 9.784 | 1638.855 | 0.435 |
| 11.524 | 1638.816 | 0.435 |
| 10.614 | 1638.264 | 0.46 |

PM_23727.csv

| h | p | hs |
|---|---|---|
| 2 | 1636.427 | 0.39 |
| 1.189 | 1636.093 | 0.39 |
| 3.364 | 1636.843 | 0.435 |
| 3.854 | 1636.872 | 0.435 |
| 4.45 | 1636.42 | 0.435 |
| 4.364 | 1636.836 | 0.435 |
| 4.364 | 1637.83 | 0.435 |
| 8.63 | 1638.868 | 0.435 |
| 7.364 | 1638.843 | 0.435 |
| 7.381 | 1638.833 | 0.46 |

PM_23728B3.csv

| h | p | hs |
|---|---|---|
| 1.862 | 1.612.258 | 0.39 |
| 2.416 | 1636.758 | 0.45 |
| 3.364 | 1634.52 | 0.46 |
| 3.364 | 1636.843 | 0.435 |
| 3.79 | 1636.833 | 0.435 |
| 3.874 | 1636.845 | 0.435 |
| 3.364 | 1636.836 | 0.435 |
| 7.364 | 1636.864 | 0.435 |
| 7.793 | 1636.843 | 0.45 |
| 7.793 | 1636.843 | 0.46 |
| 8.364 | 1636.836 | 0.435 |
| 8.553 | 1636.791 | 0.46 |
| 8.987 | 1636.1 | 0.46 |

PM_23804.csv

| h | p | hs |
|---|---|---|
| 1.862 | 1.612.258 | 0.39 |
| 2.416 | 1636.758 | 0.39 |
| 3.364 | 1634.52 | 0.46 |
| 3.79 | 1636.833 | 0.435 |
| 3.874 | 1636.845 | 0.435 |
| 7.364 | 1636.864 | 0.435 |
| 7.793 | 1636.843 | 0.45 |
| 7.793 | 1636.843 | 0.46 |
| 7.874 | 1636.267 | 0.46 |
| 8.553 | 1636.791 | 0.46 |
| 8.987 | 1636.1 | 0.46 |

PM_23873.csv

| h | p | hs |
|---|---|---|
| 8 | 1.612.251 | 0.39 |
| 1.862 | 1.612.258 | 0.39 |
| 2.757 | 1.612.45 | 0.435 |
| 1.364 | 1636.857 | 0.435 |
| 2.364 | 1636.843 | 0.435 |
| 2.868 | 1636.79 | 0.435 |
| 3.464 | 1636.726 | 0.435 |
| 3.364 | 1636.836 | 0.435 |
| 3.551 | 1636.836 | 0.435 |
| 5.168 | 1636.824 | 0.435 |
| 6.364 | 1636.843 | 0.46 |
| 6.868 | 1.612.748 | 0.46 |
| 8 | 1.612.767 | 0.46 |

PM_2.24.1.csv

| h | p | hs |
|---|---|---|
| 2.311 | 1636.868 | 0.39 |
| 8.365 | 1636.832 | 0.435 |
| 8.364 | 1636.836 | 0.435 |
| 8.356 | 1636.176 | 0.435 |
| 10.852 | 1636.184 | 0.435 |
| 11.524 | 1636.816 | 0.435 |
| 12.254 | 1636.203 | 0.435 |
| 13.264 | 1636.864 | 0.46 |
| 14.36 | 1636.82 | 0.46 |

PM_23.4858.csv

| h | p | hs |
|---|---|---|
| 4 | 1.612.251 | 0.39 |
| 2 | 1.612.253 | 0.39 |
| 1.862 | 1636.516 | 0.39 |
| 2.364 | 1636.843 | 0.39 |
| 2.364 | 1636.843 | 0.39 |
| 2.68 | 1636.843 | 0.39 |
| 4.364 | 1636.84 | 0.39 |
| 4.219 | 1636.843 | 0.39 |
| 5.74 | 1636.767 | 0.39 |
| 8.364 | 1.612.888 | 0.39 |

PM_2.11.4.csv

| h | p | hs |
|---|---|---|
| 2 | 1.612.753 | 0.39 |
| 2.364 | 1.612.843 | 0.39 |
| 3.27 | 1636.851 | 0.39 |
| 4.59 | 1.612.276 | 0.435 |
| 2.364 | 1636.843 | 0.435 |
| 2.364 | 1636.79 | 0.39 |
| 3.364 | 1636.843 | 0.39 |
| 3.825 | 1636.865 | 0.39 |
| 4.868 | 1.612.251 | 0.39 |

PM_2.11.5.csv

| h | p | hs |
|---|---|---|
| 8 | 1.612.863 | 0.37 |
| 1.862 | 1.612.753 | 0.37 |
| 1.405 | 1636.79 | 0.37 |
| 1.924 | 1636.405 | 0.39 |
| 2.364 | 1636.843 | 0.39 |
| 3.27 | 1636.405 | 0.39 |
| 3.715 | 1636.591 | 0.39 |
| 4.364 | 1636.843 | 0.39 |
| 5.741 | 1.612.268 | 0.37 |
| 7.742 | 1.612.245 | 0.37 |

PM_2.5.6.6.csv

| h | p | hs |
|---|---|---|
| 4.126 | 1.612.81 | 0.39 |
| 7.319 | 1.612.261 | 0.39 |
| 7.364 | 1636.843 | 0.39 |
| 7.861 | 1636.868 | 0.39 |
| 8.364 | 1636.843 | 0.39 |
| 8.923 | 1636.1 | 0.39 |
| 8.364 | 1636.843 | 0.39 |
| 8.861 | 1636.871 | 0.37 |
| 9.864 | 1636.591 | 0.39 |
| 10.364 | 1636.843 | 0.39 |
| 10.173 | 1636.821 | 0.39 |
| 10.915 | 1.612.168 | 0.39 |
| 11.658 | 1.612.536 | 0.39 |

PM_2.1.6.6.csv

| h | p | hs |
|---|---|---|
| 4.924 | 1.612.81 | 0.39 |
| 7.319 | 1.612.261 | 0.39 |
| 7.364 | 1636.843 | 0.39 |
| 7.764 | 1636.268 | 0.39 |
| 8.364 | 1636.1 | 0.39 |
| 8.408 | 599.1 | 0.39 |
| 9.124 | 1636.261 | 0.39 |
| 9.364 | 1636.843 | 0.39 |
| 9.364 | 1636.831 | 0.39 |
| 10.266 | 1.612.168 | 0.39 |
| 10.915 | 1.612.536 | 0.39 |

PM_2.1.6.6.6.csv

| h | p | hs |
|---|---|---|
| 8.364 | 1.612.253 | 0.37 |
| 10.103 | 1636.812 | 0.37 |
| 11.124 | 1636.816 | 0.39 |
| 11.148 | 1636.868 | 0.39 |
| 12.25 | 1636.231 | 0.39 |
| 12.364 | 1636.843 | 0.39 |
| 12.167 | 1636.868 | 0.39 |
| 12.914 | 1.612.648 | 0.37 |
| 13.915 | 1.612.168 | 0.39 |
| 17.169 | 1.612.81 | 0.37 |

PM_2.1.6.6.6.csv

| h | p | hs |
|---|---|---|
| 8.862 | 1.612.84 | 0.37 |
| 8.364 | 1636.843 | 0.37 |
| 11.204 | 1636.85 | 0.39 |
| 11.524 | 1636.816 | 0.39 |
| 12.254 | 1636.816 | 0.39 |
| 13.264 | 1636.864 | 0.46 |
| 17.169 | 1636.764 | 0.37 |
| 17.915 | 1.612.862 | 0.37 |

PM_2.1.6.6.6.csv

| h | p | hs |
|---|---|---|
| 8.875 | 1.612.268 | 0.37 |
| 8.407 | 1636.822 | 0.39 |
| 8.855 | 1636.853 | 0.39 |
| 10.364 | 1636.843 | 0.39 |
| 10.319 | 1636.826 | 0.39 |
| 11.714 | 1636.827 | 0.39 |
| 12.364 | 1636.843 | 0.39 |
| 12.455 | 1636.841 | 0.39 |
| 14.167 | 1636.871 | 0.37 |
| 16.124 | 1.612.758 | 0.37 |

PM_2.1.6.6.7.csv

| h | p | hs |
|---|---|---|
| 7 | 1.612.81 | 0.37 |
| 1.862 | 1.612.753 | 0.37 |
| 1.864 | 1.612.865 | 0.37 |
| 1.268 | 1636.843 | 0.37 |
| 2.364 | 1636.843 | 0.37 |
| 1.867 | 1.612.764 | 0.39 |
| 2.364 | 1636.843 | 0.39 |
| 3.364 | 1636.864 | 0.39 |
| 3.364 | 1636.843 | 0.39 |
| 4.124 | 1.612.84 | 0.37 |
| 5.864 | 1.612.261 | 0.37 |
| 6.364 | 1.612.276 | 0.37 |

PM_PROP_23.6B3.csv

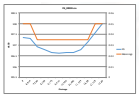
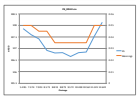
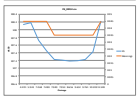
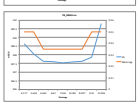
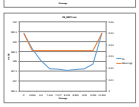
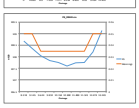
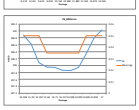
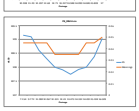
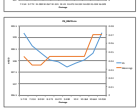
| h | p | hs |
|---|---|---|
| 8 | 1.612.42 | 0 |
| 1.862 | 1.612.753 | 0 |
| 2.757 | 1.612.42 | 0.435 |
| 1.364 | 1636.877 | 0.435 |
| 2.364 | 1636.843 | 0.435 |
| 2.868 | 1636.79 | 0.435 |
| 3.464 | 1636.798 | 0.435 |
| 3.364 | 1636.843 | 0.435 |
| 3.551 | 1636.875 | 0.435 |
| 5.168 | 1636.864 | 0.435 |
| 6.364 | 1636.843 | 0.46 |
| 6.868 | 1.612.142 | 0 |
| 8 | 1.612.142 | 0 |

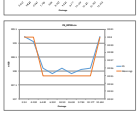
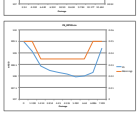
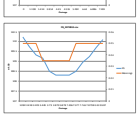
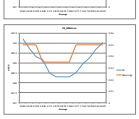
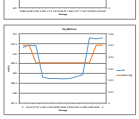
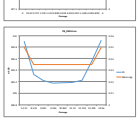
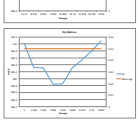
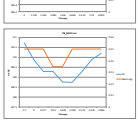
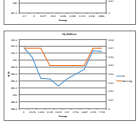
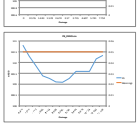
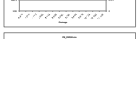
PM_PROP_23.6B.csv

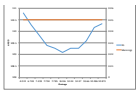
| h | p | hs |
|---|---|---|
| 8 | 1.612.252 | 0 |
| 2.757 | 1.612.252 | 0.435 |
| 1.364 | 1636.877 | 0.435 |
| 1.862 | 1636.81 | 0.435 |
| 2.868 | 636.8 | 0.435 |
| 3.364 | 1636.864 | 0.435 |
| 3.551 | 1636.875 | 0.435 |
| 5.168 | 1636.864 | 0.435 |
| 6.364 | 1636.843 | 0.46 |
| 6.868 | 1.612.142 | 0 |
| 8 | 1.612.142 | 0 |

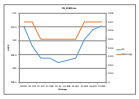
PM_PROP_23.6B.csv

| h | p | hs |
|---|---|---|
| 8 | 1.612.252 | 0 |
| 2.757 | 1.612.252 | 0.435 |
| 1.364 | 1636.877 | 0.435 |
| 1.862 | 1636.81 | 0.435 |
| 2.868 | 636.8 | 0.435 |
| 3.364 | 1636.864 | 0.435 |
| 3.551 | 1636.875 | 0.435 |
| 5.168 | 1636.864 | 0.435 |
| 6.364 | 1636.843 | 0.46 |
| 6.868 | 1.612.142 | 0 |
| 8 | 1.612.142 | 0 |

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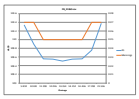
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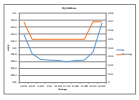
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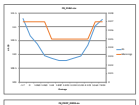
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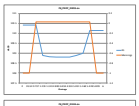
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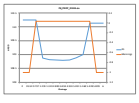
Average


Hg_1.6dB.csv
Average

# Appendix 4: Table of Hydraulic Structures

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

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

## Appendix 5: 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 |
|---|---|---|---|---|
| | | | | |
| | | | | |
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Client

**Oxfordshire Railfreight Limited**

Project Title

**OxSRFI**
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

**Baseline**
**Model Floodplain Extents**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| BWB Ref: | NTH2479 | Date: | 27.03.23 | Scale@A3: | 1:5,000 |

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| OXSRFI-BWB-ZZ-XX-D-W-1101 | S2 | P02 |

0 50 100 150 200 250 m

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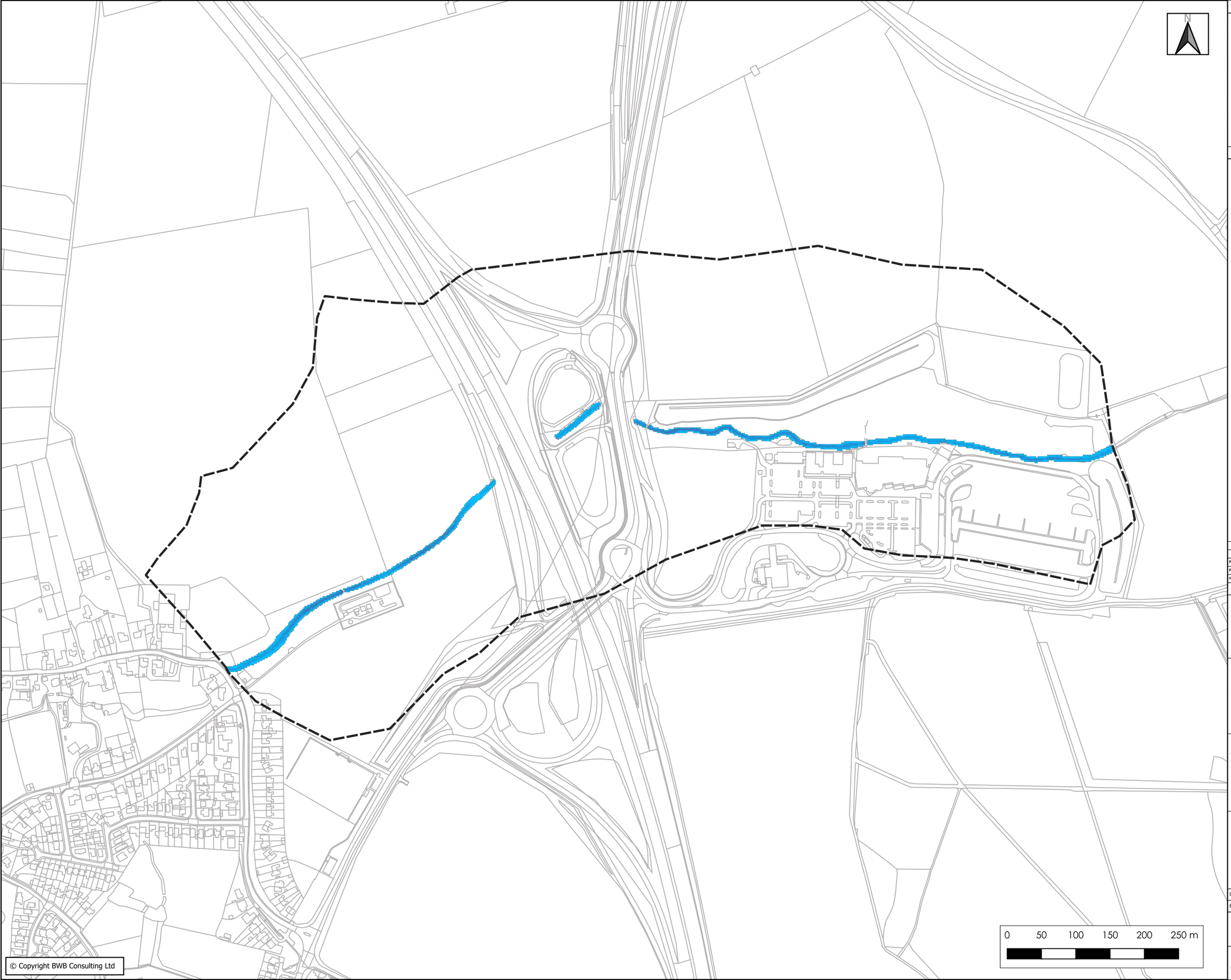


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3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.

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

**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 30-Year**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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N

0 50 100 150 200 250 m

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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

| Rev | Date | Details of issues/ revision | Drw | Rev |
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Drawing Title

# Baseline Modelled Flood Depths 1 in 100-Year

Drawn: [redacted]

| BWB Ref: | NTH2479 | Date: | 27.03.23 | Scale@A3: | 1:5,000 |
|---|---|---|---|---|---|

Drawing Status

**PRELIMINARY**

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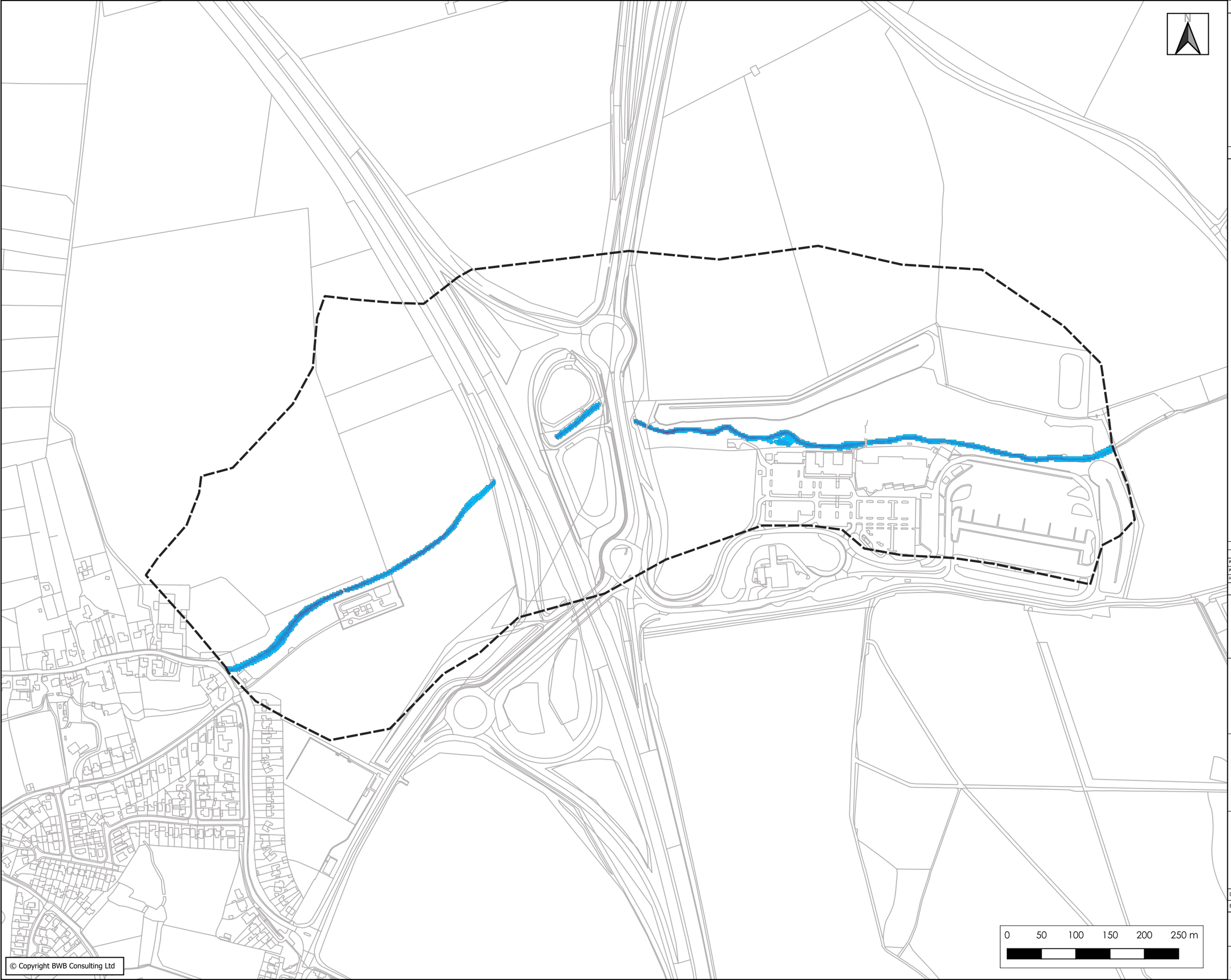


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5. Model not yet peer reviewed.

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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

| 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 + 19%CC**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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N

0 50 100 150 200 250 m

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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

| 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 + 30%CC**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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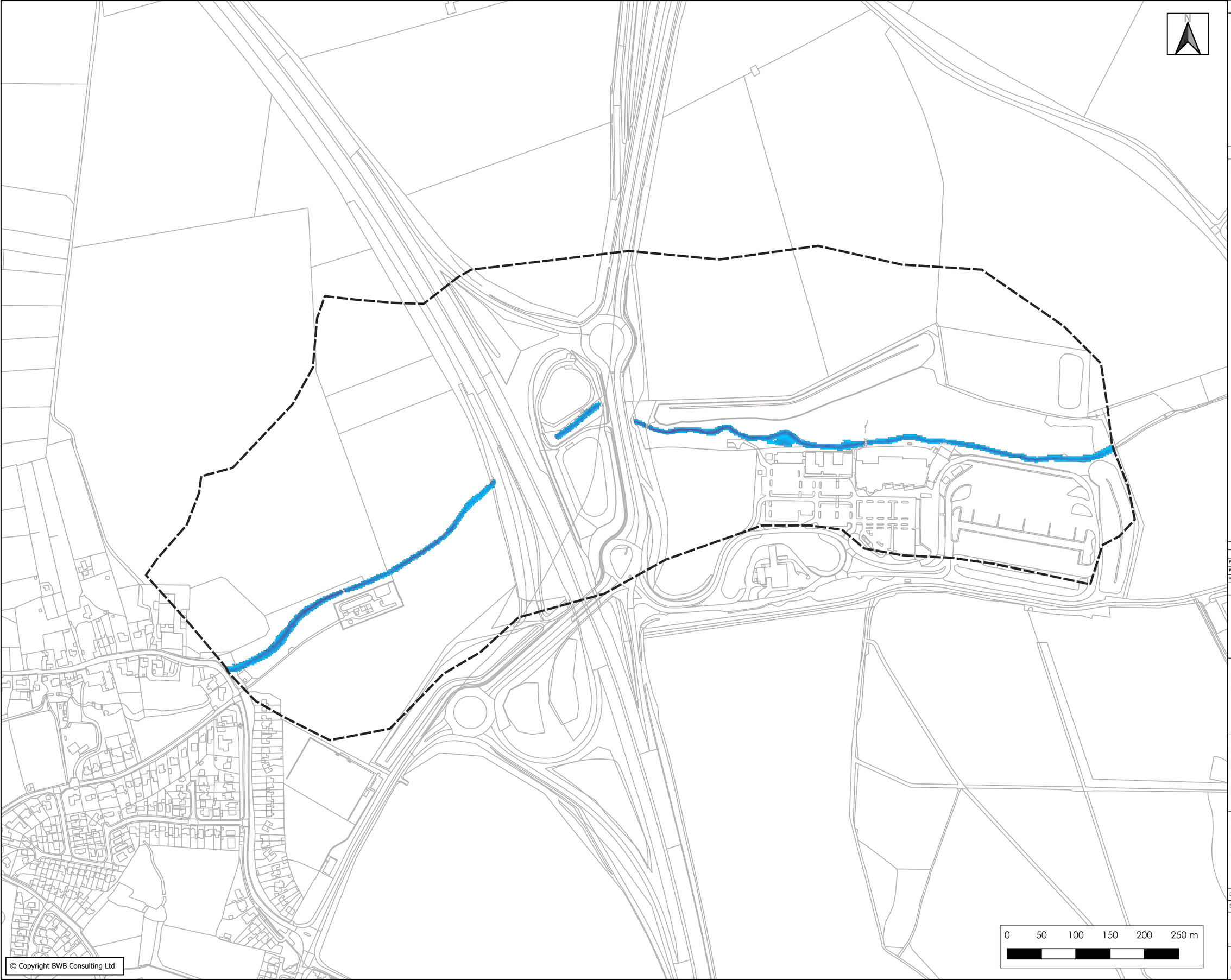


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4. Any discrepancies noted on site are to be reported to the engineer immediately.

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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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: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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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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**Oxfordshire Railfreight Limited**

Project Title

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OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

**Baseline**
**Modelled Flood Depths**
**1 in 1000-Year**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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 6: Proposed Floodplain Maps

## Notes

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## 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

0 50 100 150 200 250 m

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Project Title

**OxSRFI**
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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

**Proposed Model Floodplain Extents**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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N

0 50 100 150 200 250 m

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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

| Rev | Date | Details of issues/ revision | Drw | Rev |
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Project Title

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OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

# Proposed Modelled Flood Depths 1 in 30-Year

Drawn: [redacted]

| 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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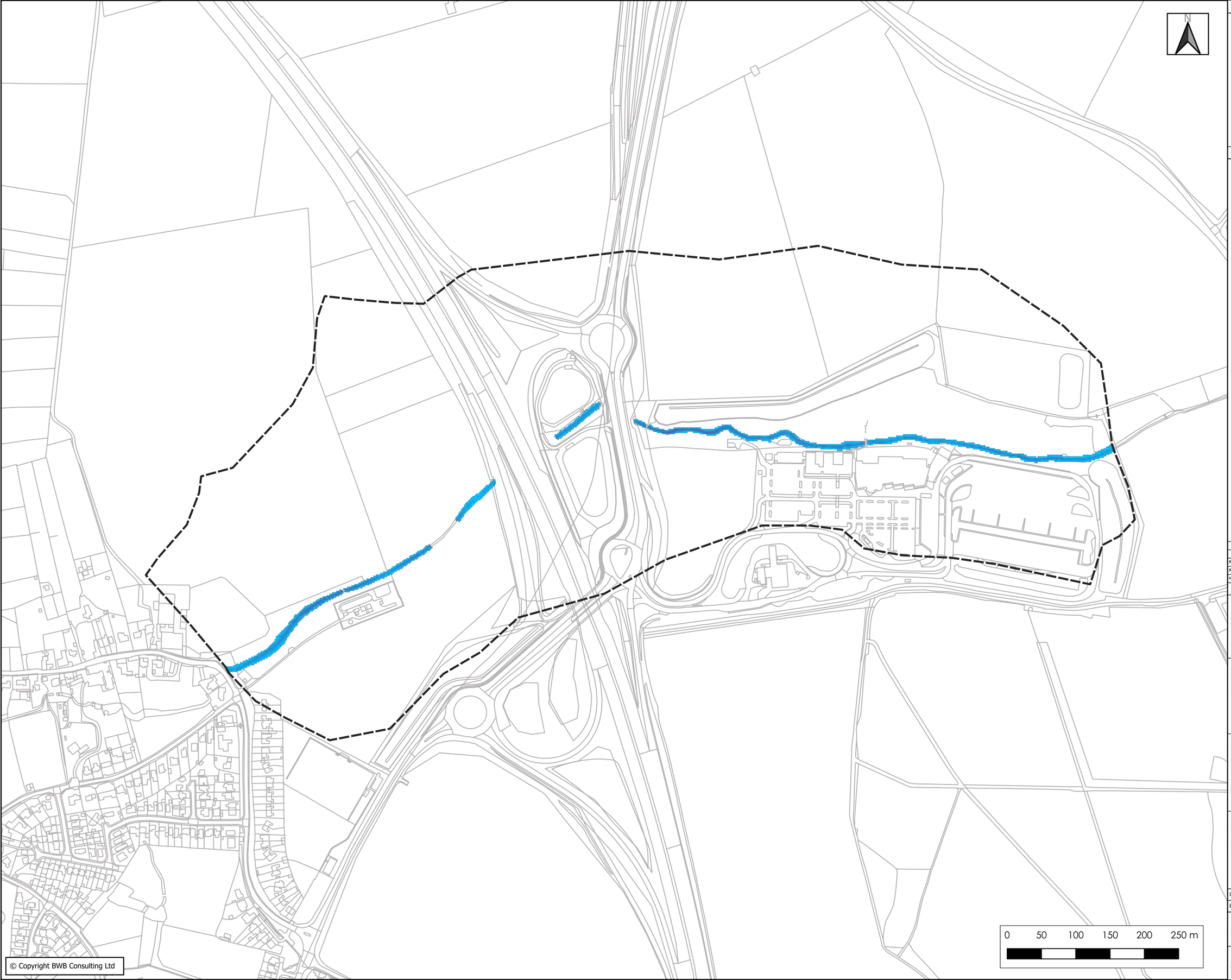


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4. Any discrepancies noted on site are to be reported to the engineer immediately.

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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OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

**Proposed Modelled Flood Depths 1 in 100-Year**

Drawn: [redacted]

| BWB Ref: | NTH2479 | Date: | 27.03.23 | Scale@A3: | 1:5,000 |
|---|---|---|---|---|---|

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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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Client

**Oxfordshire Railfreight Limited**

Project Title

**OxSRFI**
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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

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

Drawn: [redacted]

| 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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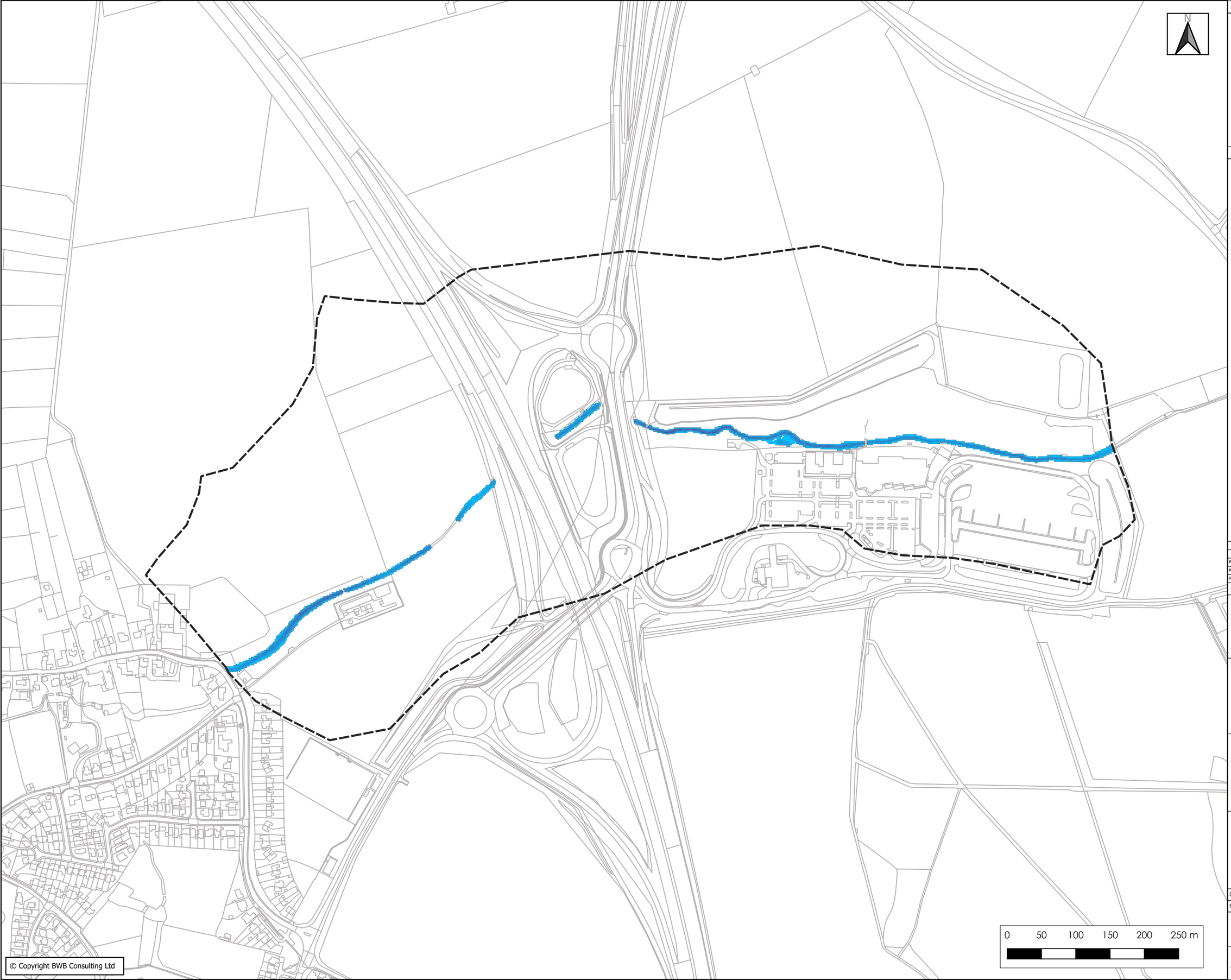


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4. Any discrepancies noted on site are to be reported to the engineer immediately.

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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 |
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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 + 30%CC**

Drawn: [redacted]

| BWB Ref: | NTH2479 | Date: | 27.03.23 | Scale@A3: | 1:5,000 |
|---|---|---|---|---|---|

Drawing Status

**PRELIMINARY**

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|---|---|---|
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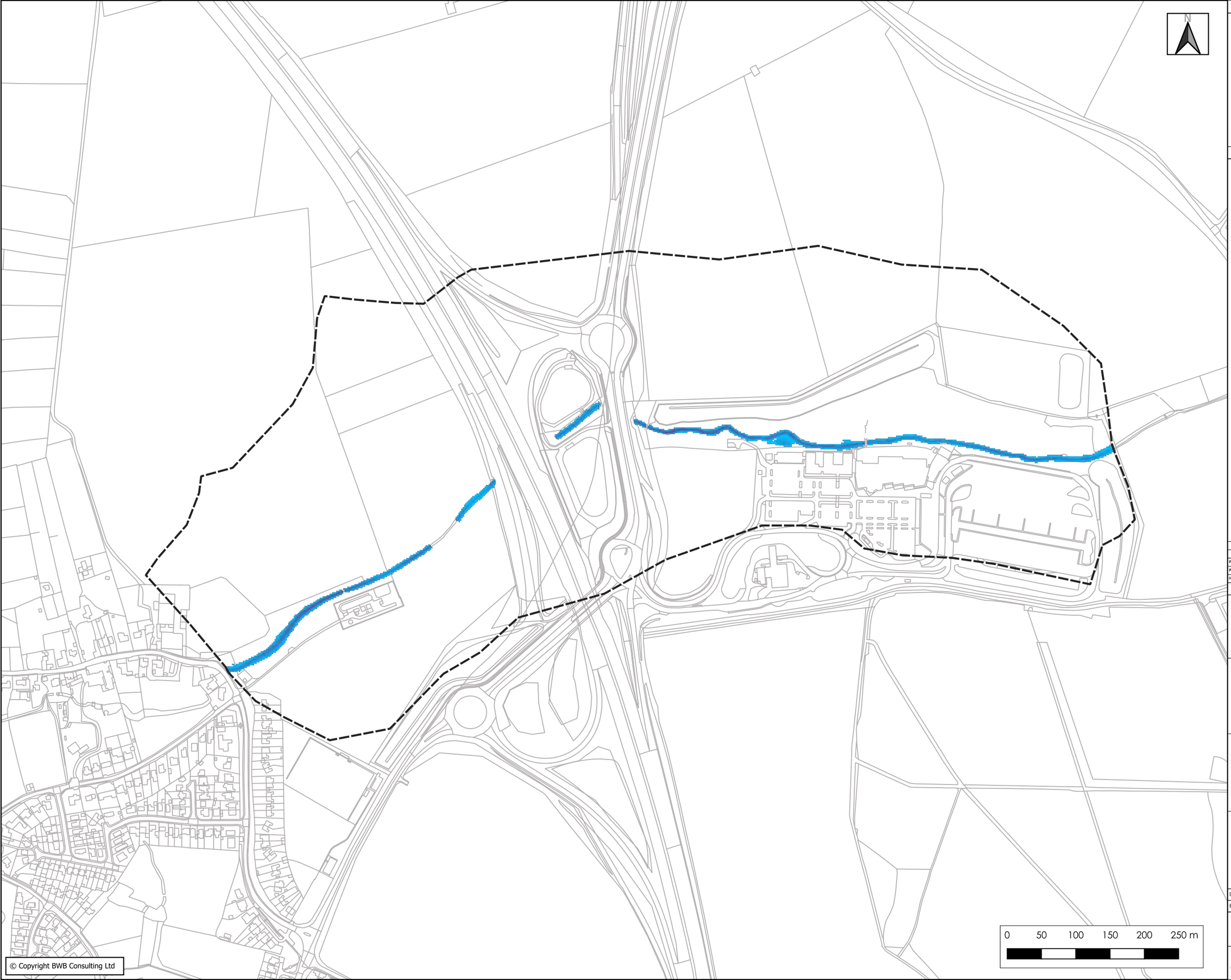


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5. Model not yet peer reviewed.

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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

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

Drawn: [redacted]

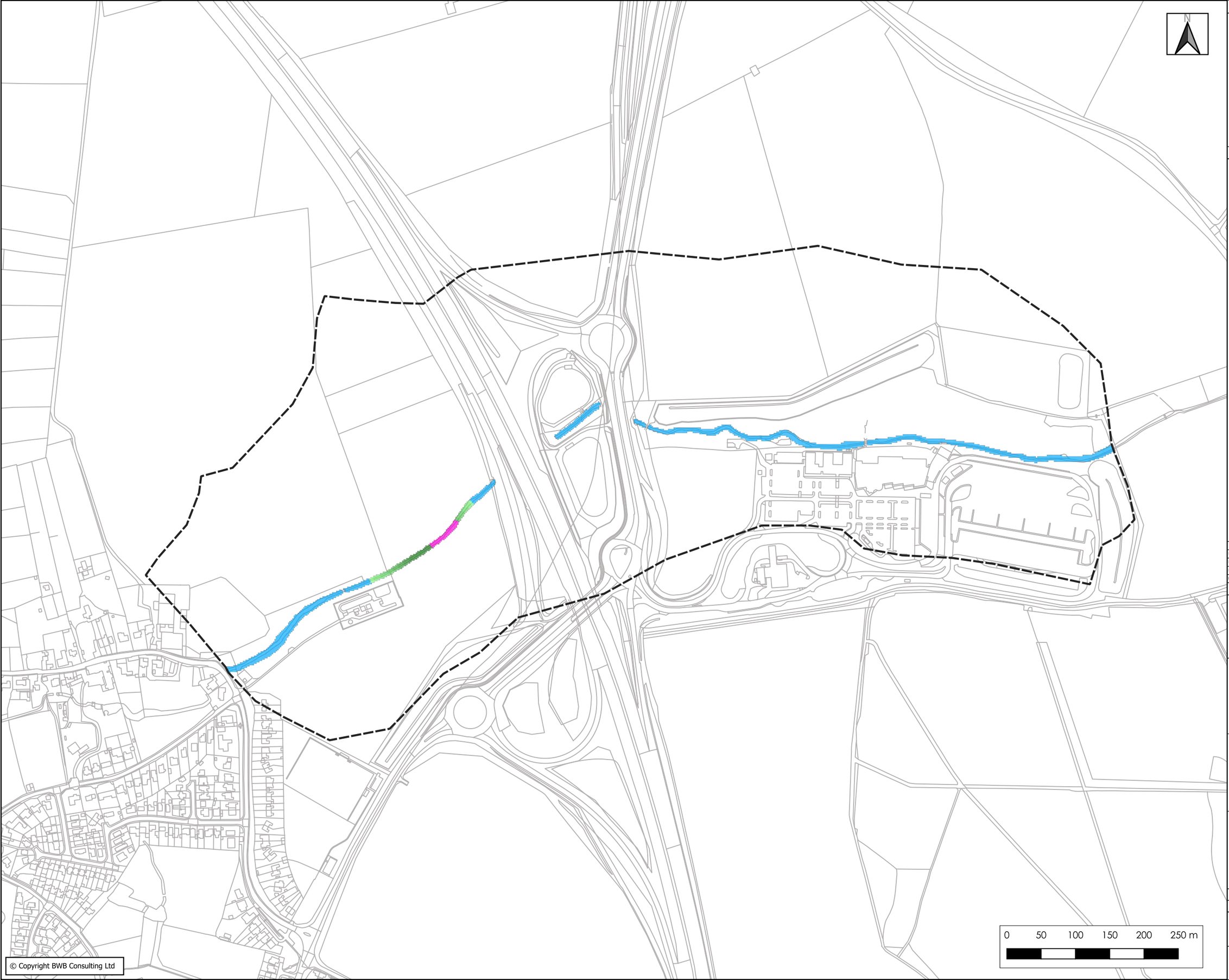
| BWB Ref: | NTH2479 | Date: | | Scale@A3: | 1:5,000 |
|---|---|---|---|---|---|

Drawing Status

**PRELIMINARY**

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

# Appendix 7: Comparison Mapping

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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 | 23.03.26 | MODEL UPDATES FROM EA REVIEW | CC | CC |
| 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

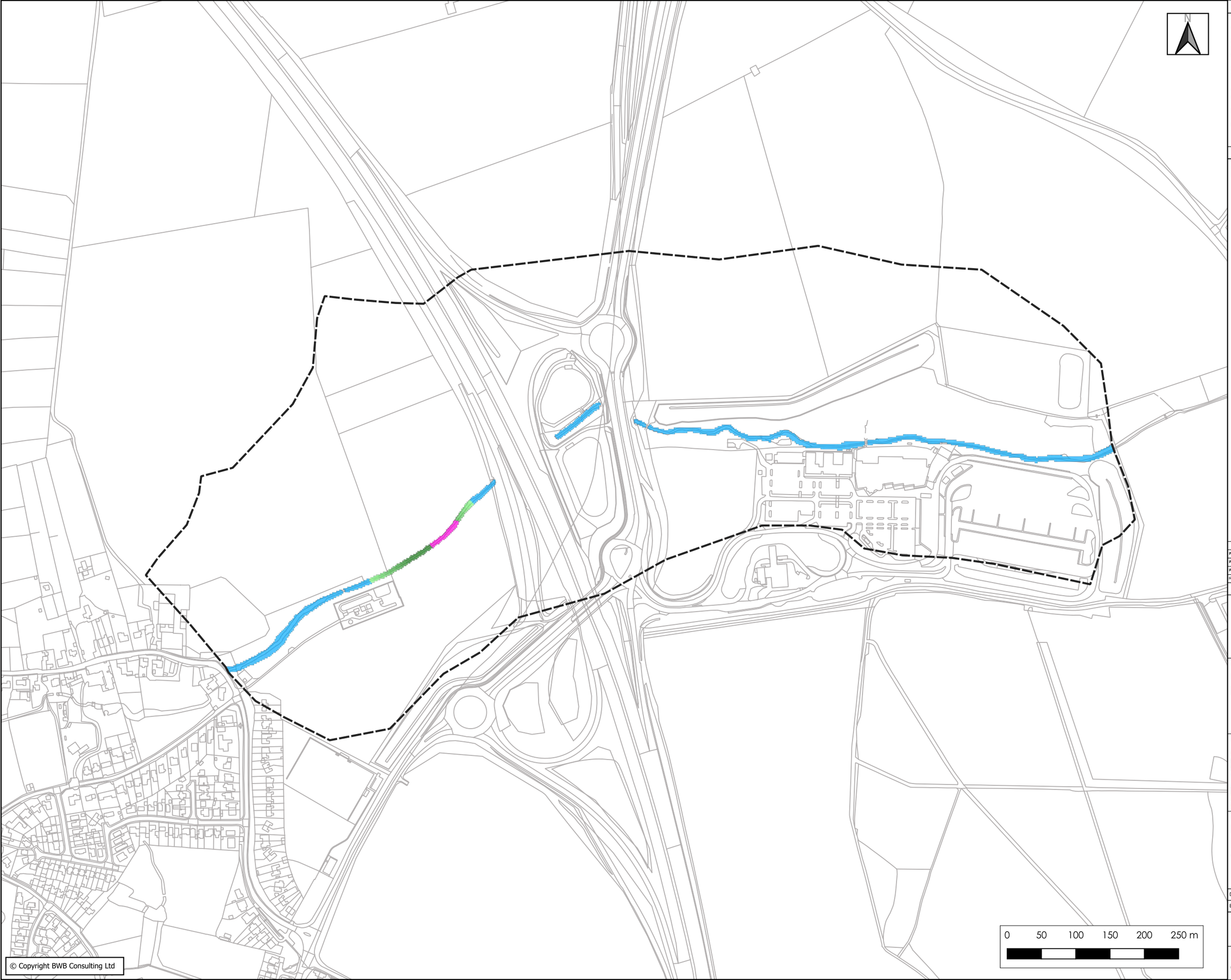
**Proposed Impact Analysis 1 in 30-Year**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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 |




## 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

| Rev | Date | Details of issues/ revision | Drw | Rev |
|---|---|---|---|---|
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| P02 | 28.07.25 | UPDATED HYDROLOGY AND SOFTWARE | MN | CC |
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Project Title

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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

# Proposed Impact Analysis 1 in 100-Year

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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N

0 50 100 150 200 250 m

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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 |
|---|---|---|---|---|
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STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

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

Drawn: [redacted]

| 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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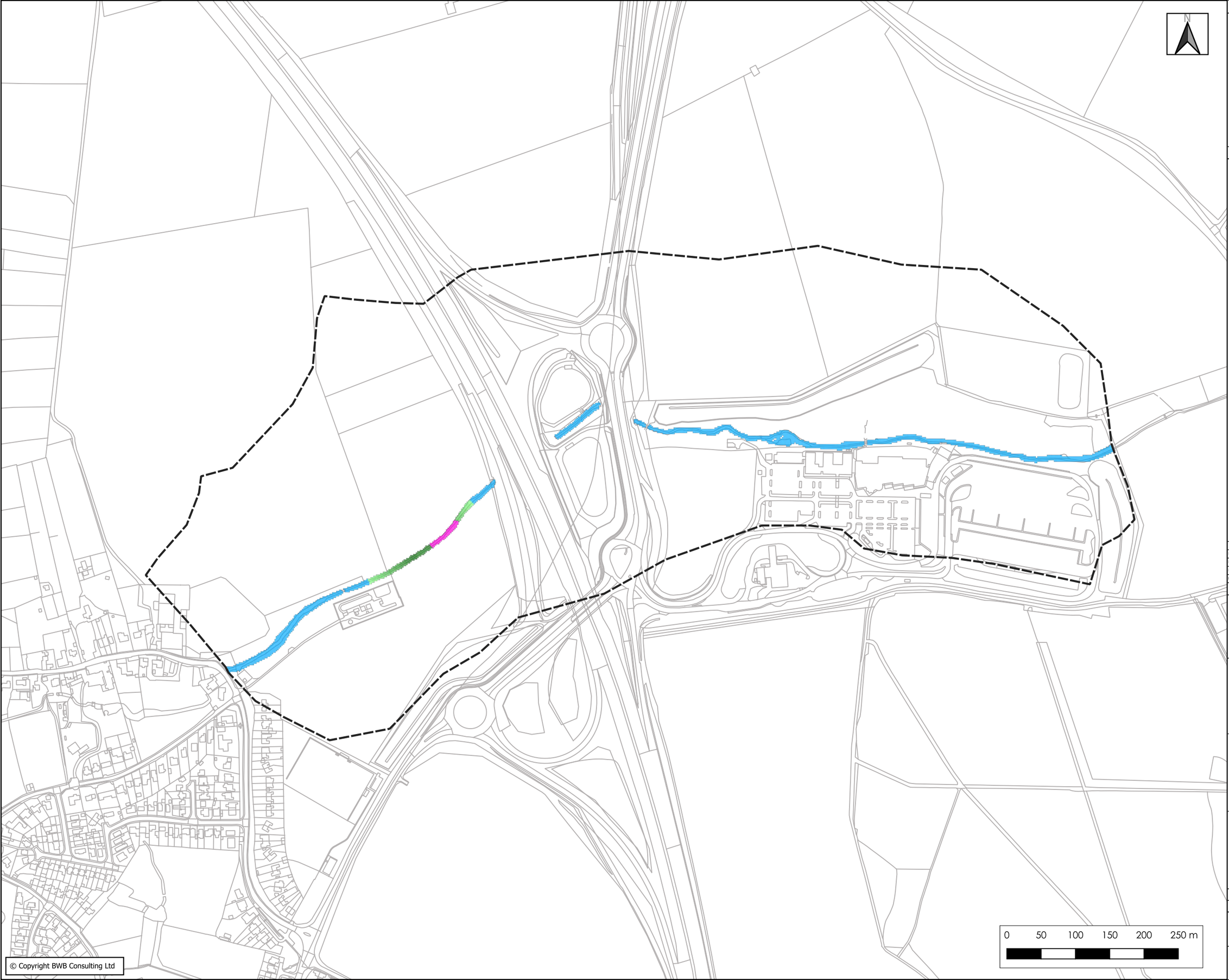


## Notes

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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 | 23.03.26 | MODEL UPDATES FROM EA REVIEW | CC | CC |
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Project Title

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Drawing Title

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

Drawn: [redacted]

| 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

0 50 100 150 200 250 m

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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 |
|---|---|---|---|---|
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Drawing Title

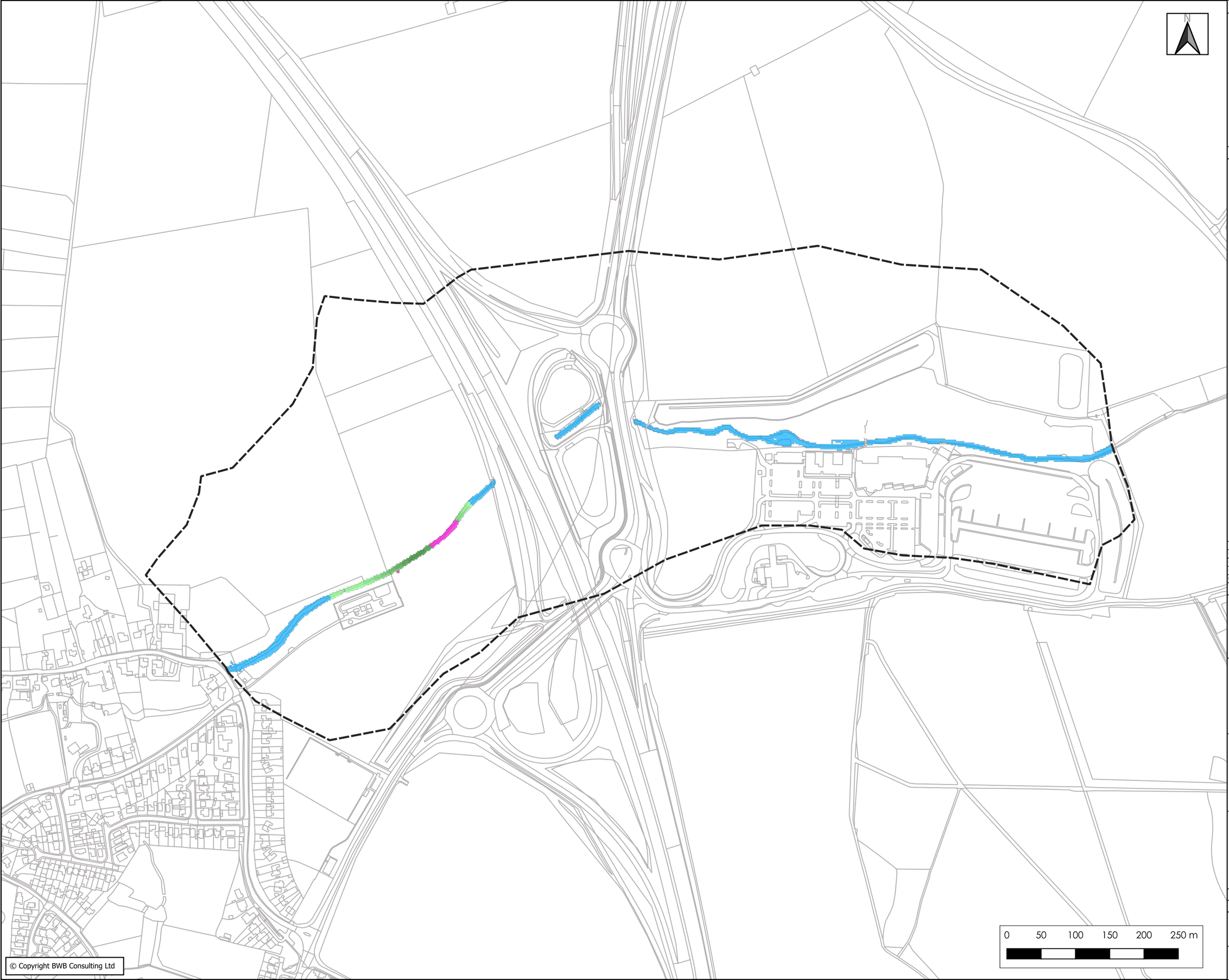
# Proposed Impact Analysis 1 in 100-Year + 58%CC

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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 |

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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 |
|---|---|---|---|---|
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Drawing Title

# Proposed Impact Analysis 1 in 1000-Year

Drawn: [redacted]

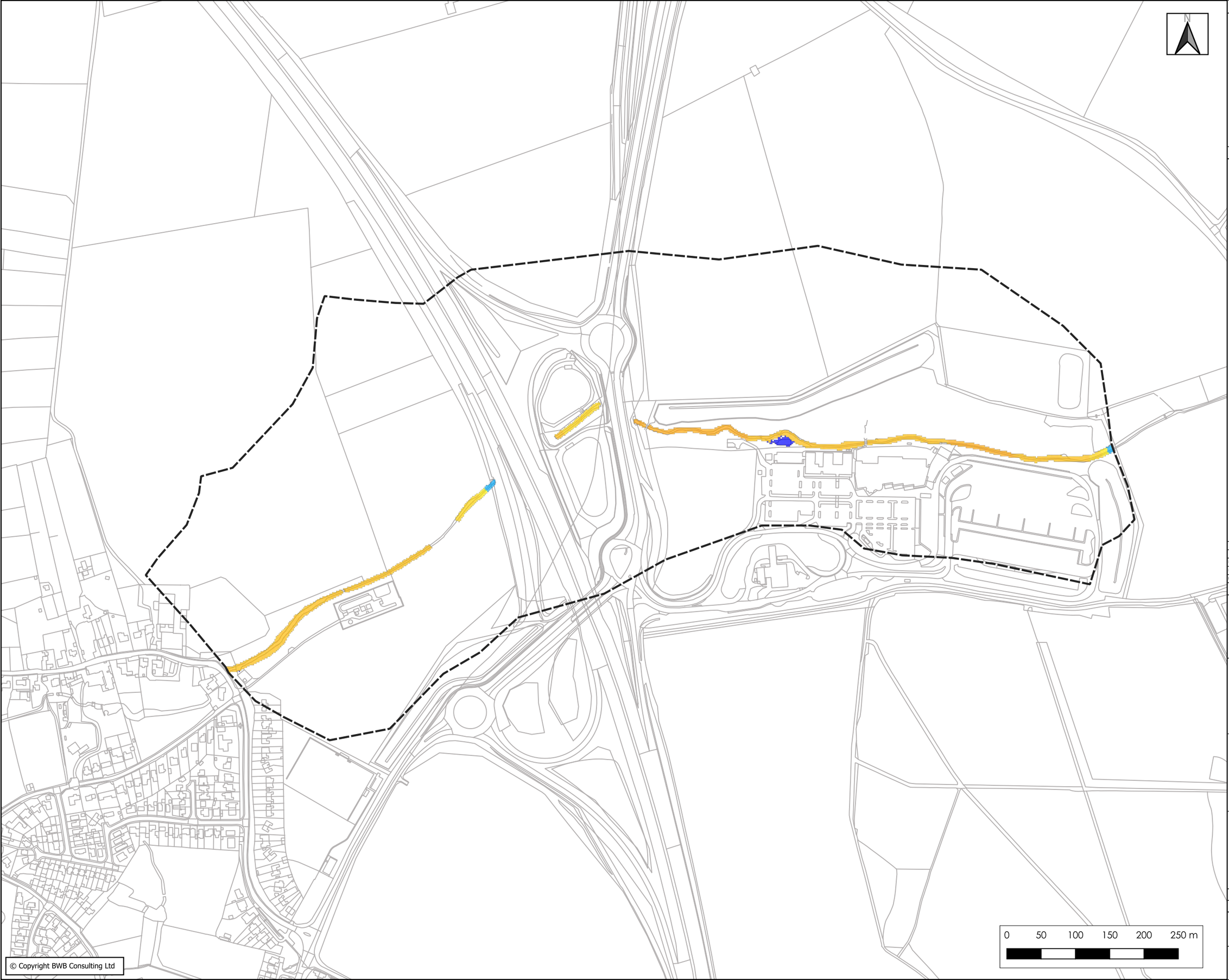
| BWB Ref: | NTH2479 | Date: | 27.03.23 | Scale@A3: | 1:5,000 |
|---|---|---|---|---|---|

Drawing Status

**PRELIMINARY**

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

# Appendix 8: 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.

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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Project Title

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Drawing Title

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

Drawn: [redacted]

| 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-1140 | 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

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

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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 |

N

0 50 100 150 200 250 m

## 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

| 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

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

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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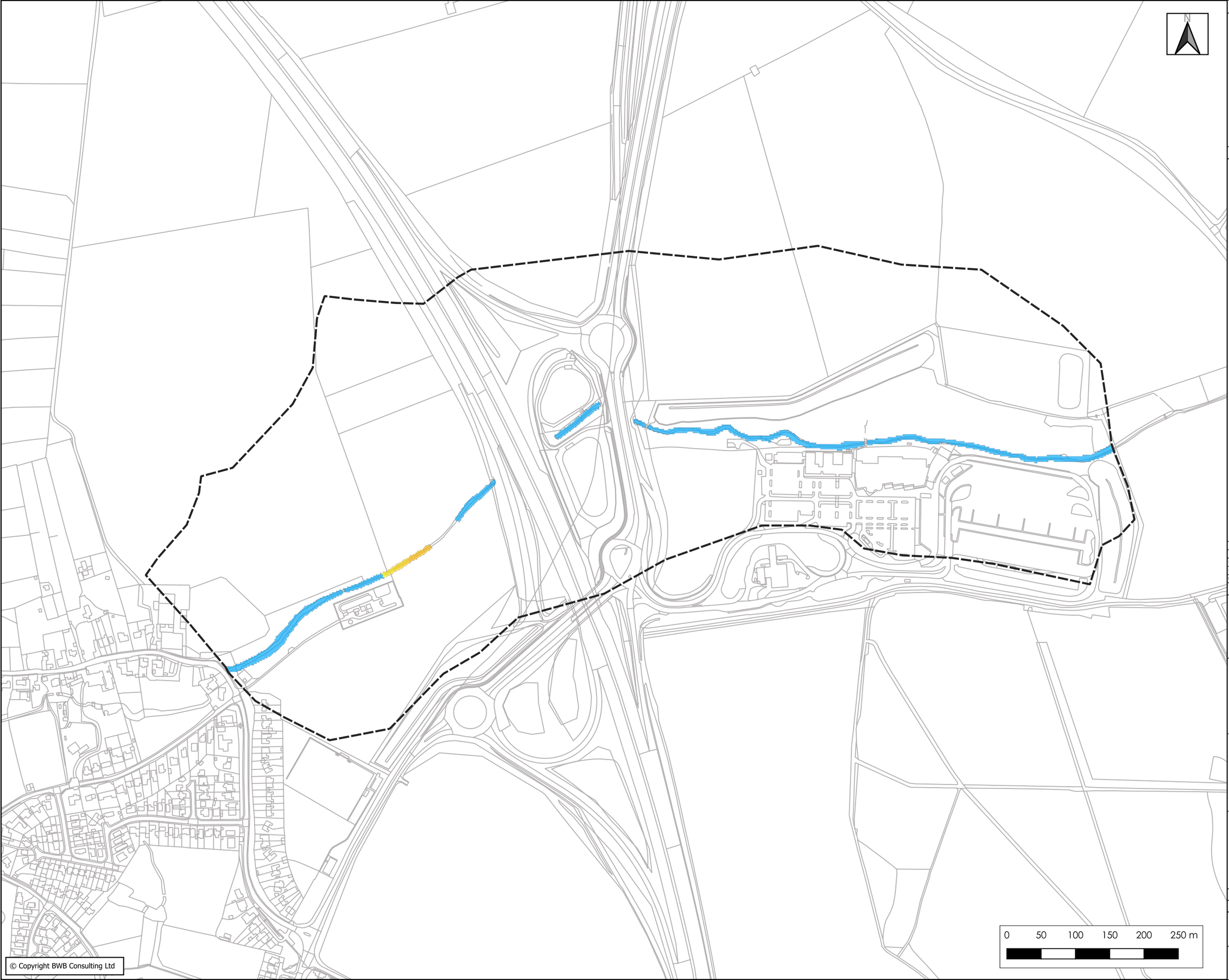


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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

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 |
|---|---|---|---|---|
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Client

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Project Title

**OxSRFI**
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Drawing Title

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

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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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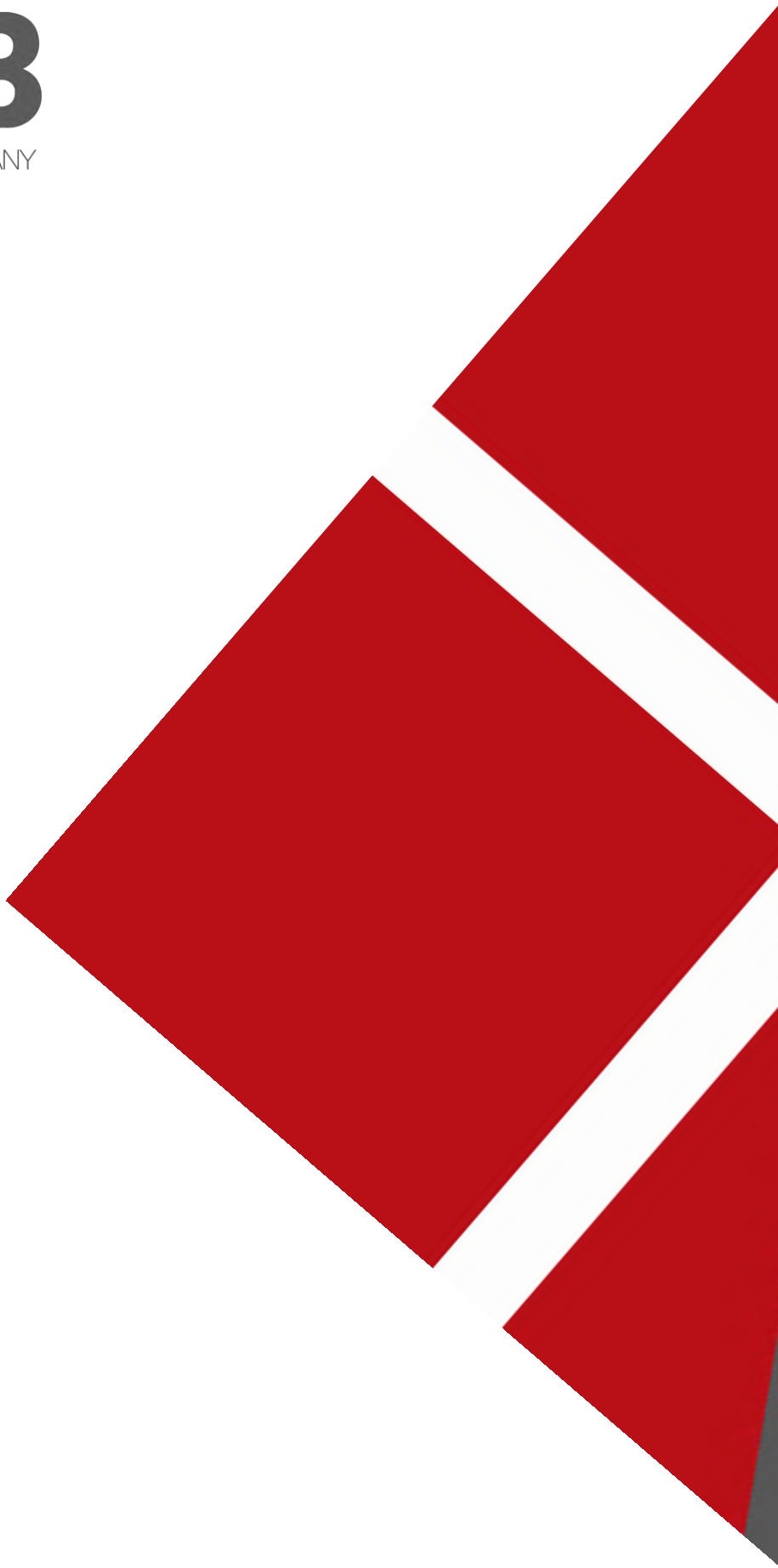

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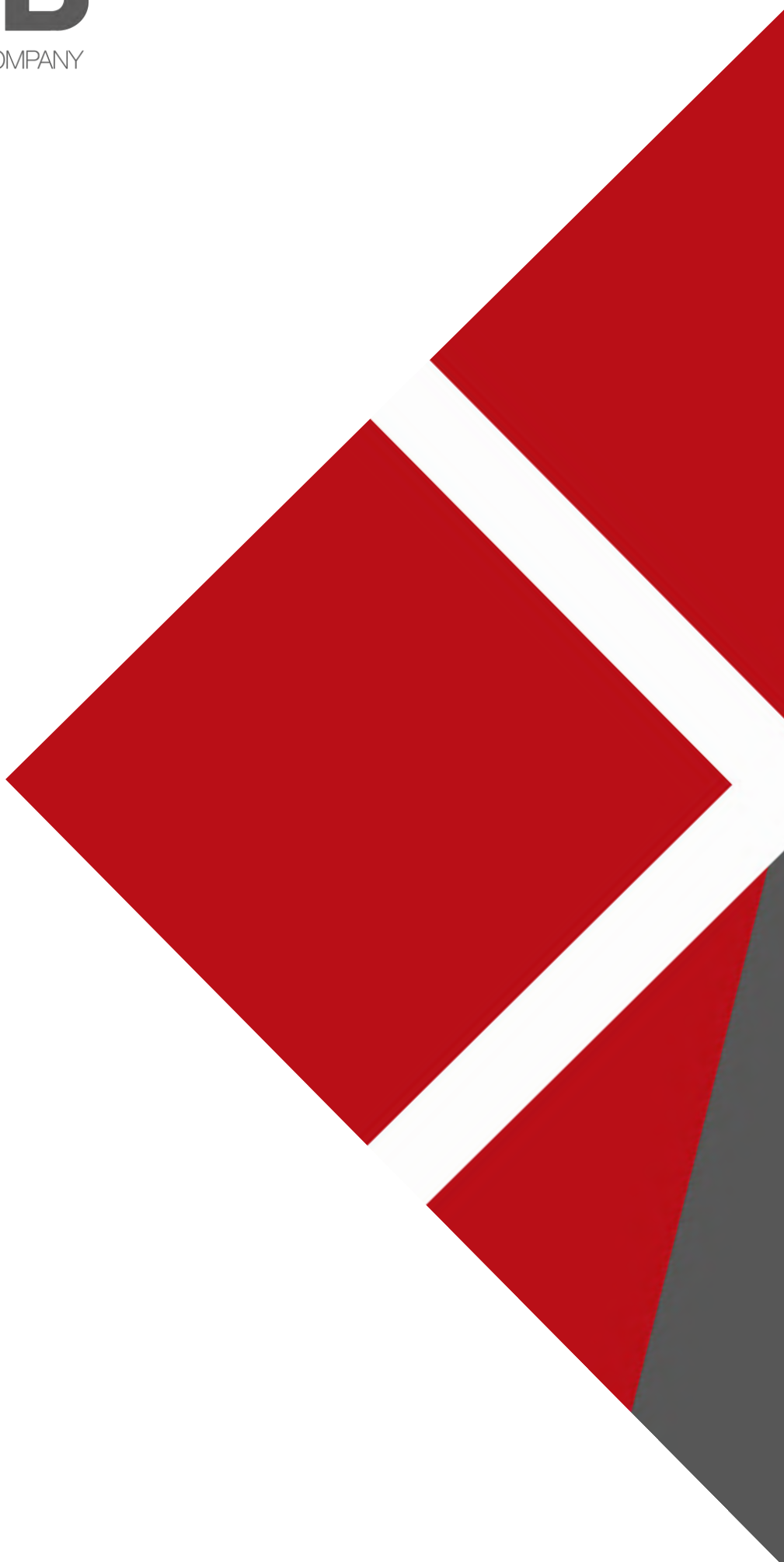

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## Appendix 2: Topographical Survey


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
Heyford Farm
Caravan Park
Leachmere Farm
Field Barn Farm
Hangar
Control Tower
Car Park
Village Pond
Fritwell Pond
Fritwell Cricket Ground
Cricket Ground
Home Wood
Gordon Cottages
Villiers Piggery
Old Nursery
Pond
Hill View House
Caulcott Farm
Caulcott Lodge
Caulcott Cottages
Manor Farm Barn
Pond House
Bicester Road
Ardley Road
Middleton Road
Fritwell Road
Ardley Road
Hangar
Hangar
Hangar

## Appendix 3: Hydraulic Modelling Reports

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**ADVISORY**

# Oxfordshire Railfreight Limited
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# Oxfordshire
# Hydraulic Model Report

Birmingham
Livery Place, 35 Livery Street, Colmore Business District, Birmingham, B3 2PB
T: 0121 233 3322

Cambridge
14-16 High Street, Histon, Cambridge
CB24 9JD
T: 01223 235 173

Leeds
Whitehall Waterfront, 2 Riverside Way, Leeds
LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11 Portland Street, Manchester, M1 3HU
0161 233 4260

Market Harborough
12a Woodcock House, Compass Point Market Harborough, Leicestershire, LE16 9HW
T: 01858 455020

**Nottingham**
**Waterfront House, Station Street, Nottingham NG2 3DQ**
**T: 0115 924 1100**

May 2026

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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.**

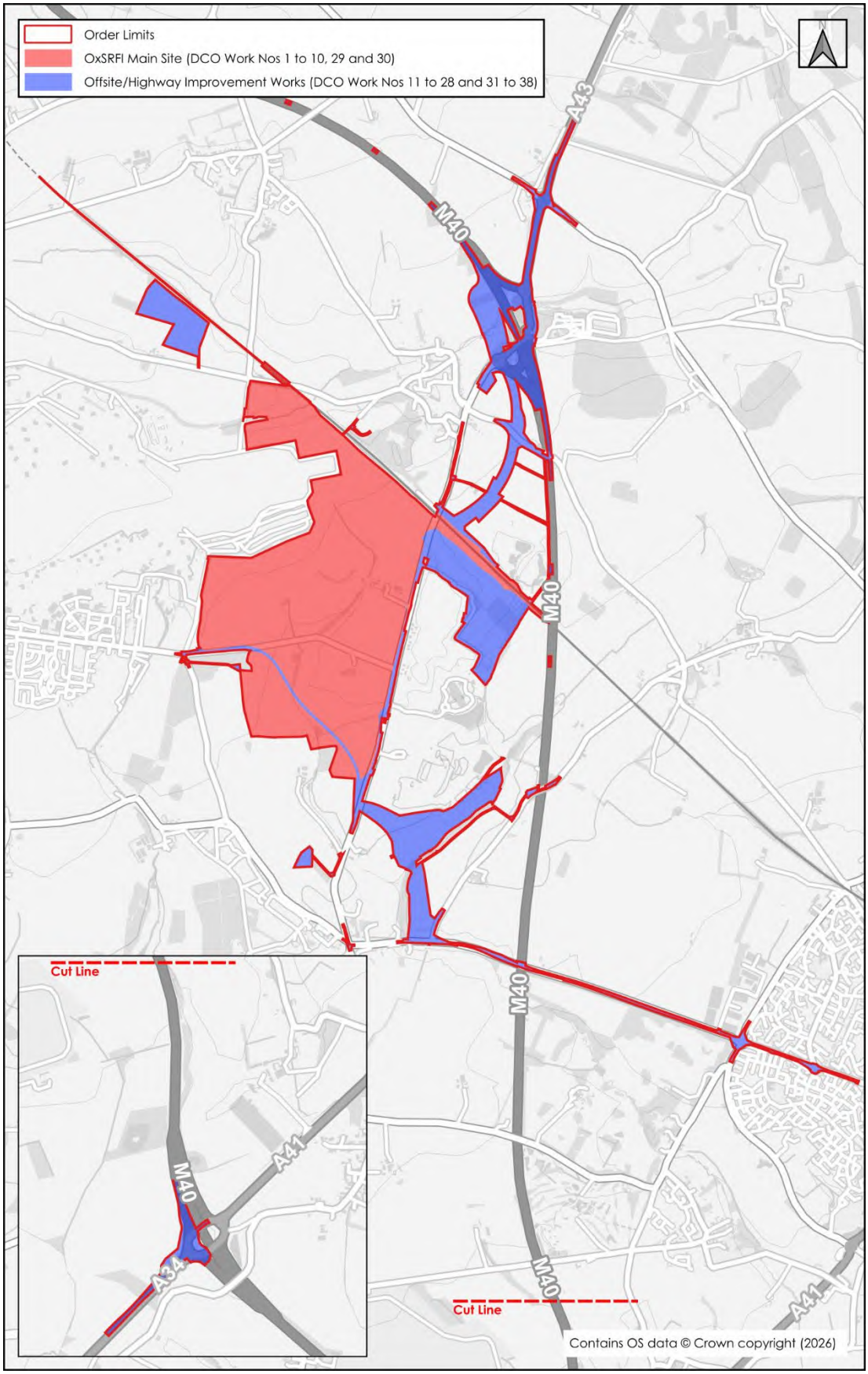



**Figure 1.1: Site Location**

## 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.

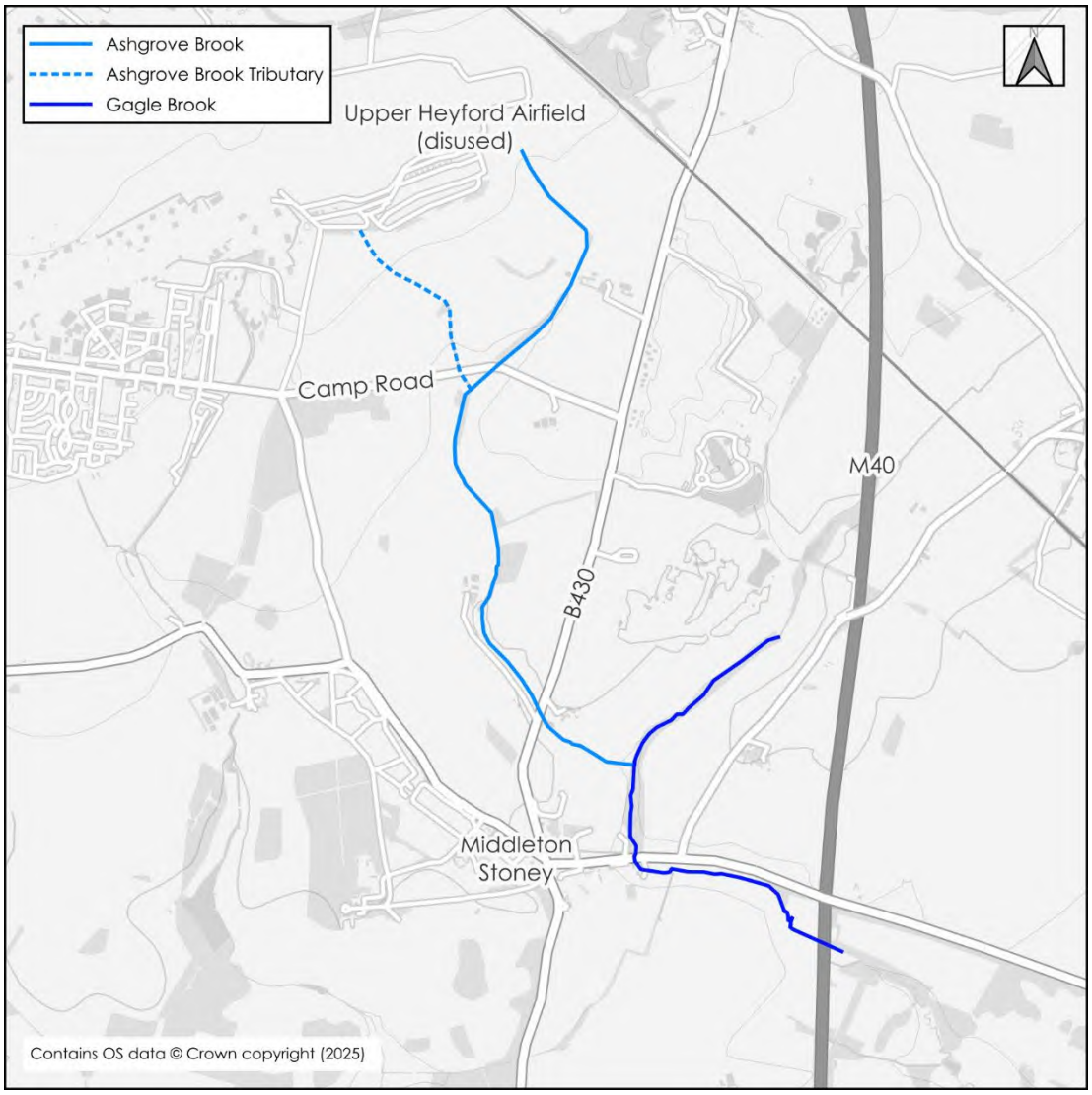



**Figure 1.2: Watercourse Network**

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**.

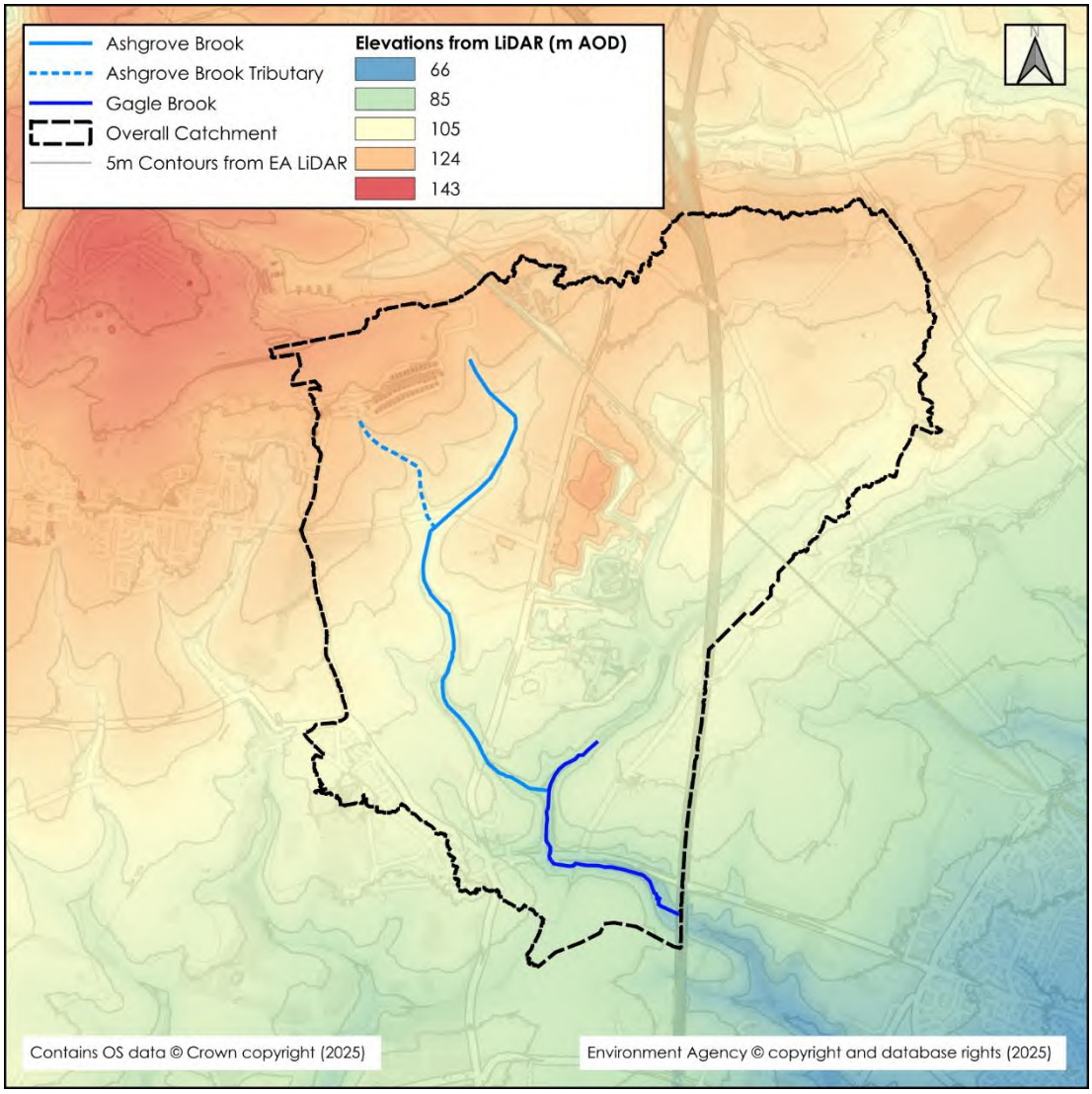



**Figure 1.3: Gagle Brook and Ashgrove Brook Catchment Topography**

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$^2$).

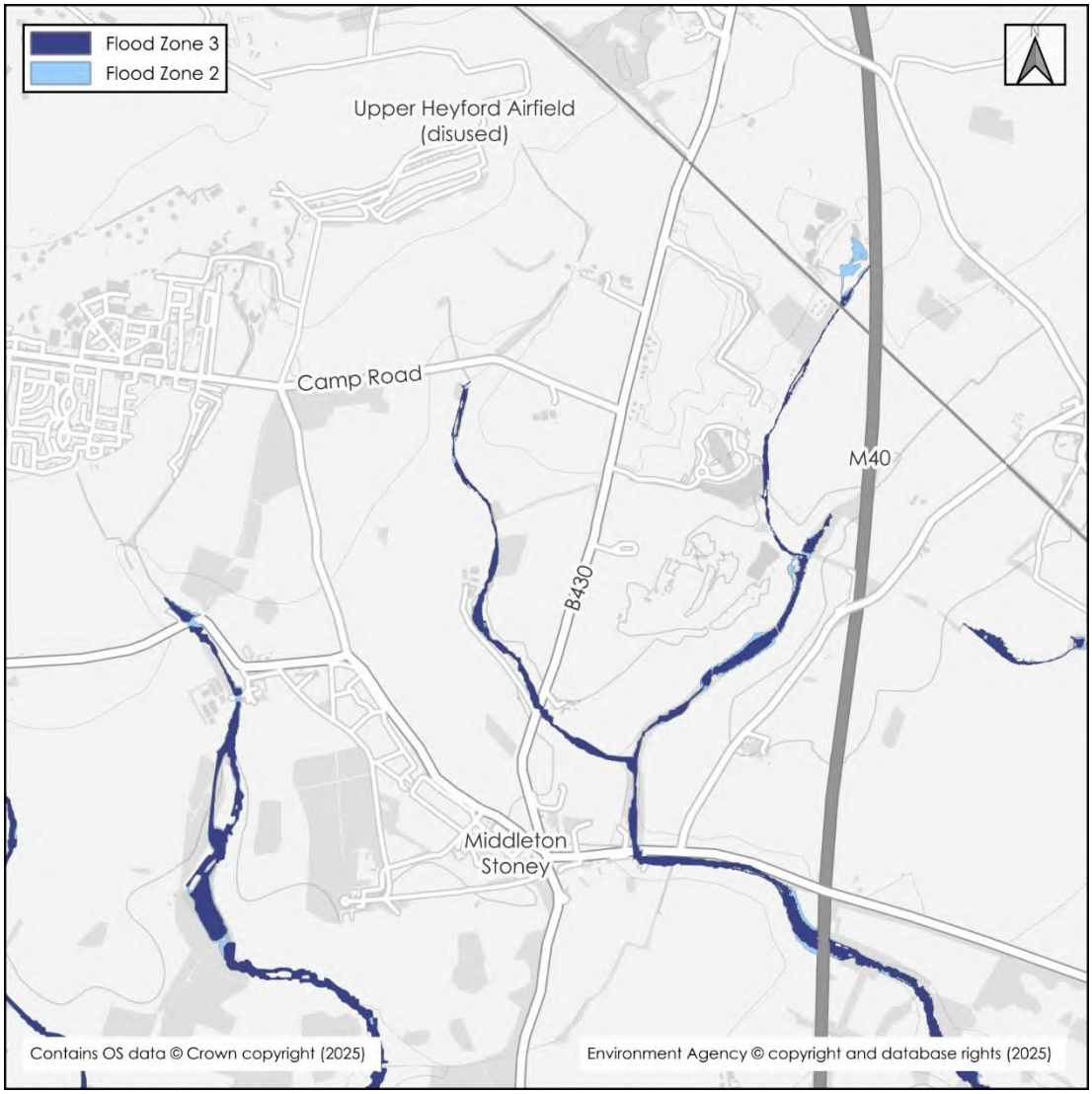



**Figure 1.6: Flood Map for Planning**

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.

### 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.

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

- 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.
- The proposed sections upstream and downstream of the proposed culvert GB_01875, have been lowered and widened to the proposed invert level of 88.213m AOD (upstream) and 88.002 (downstream), in order to accommodate the 4.8m-6.0m wide proposed structure. The geometry of the sections are based on GB_01833. The channel geometry is returned to existing approximately 22m downstream, upstream of the existing culvert at GB_01809.

# 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)

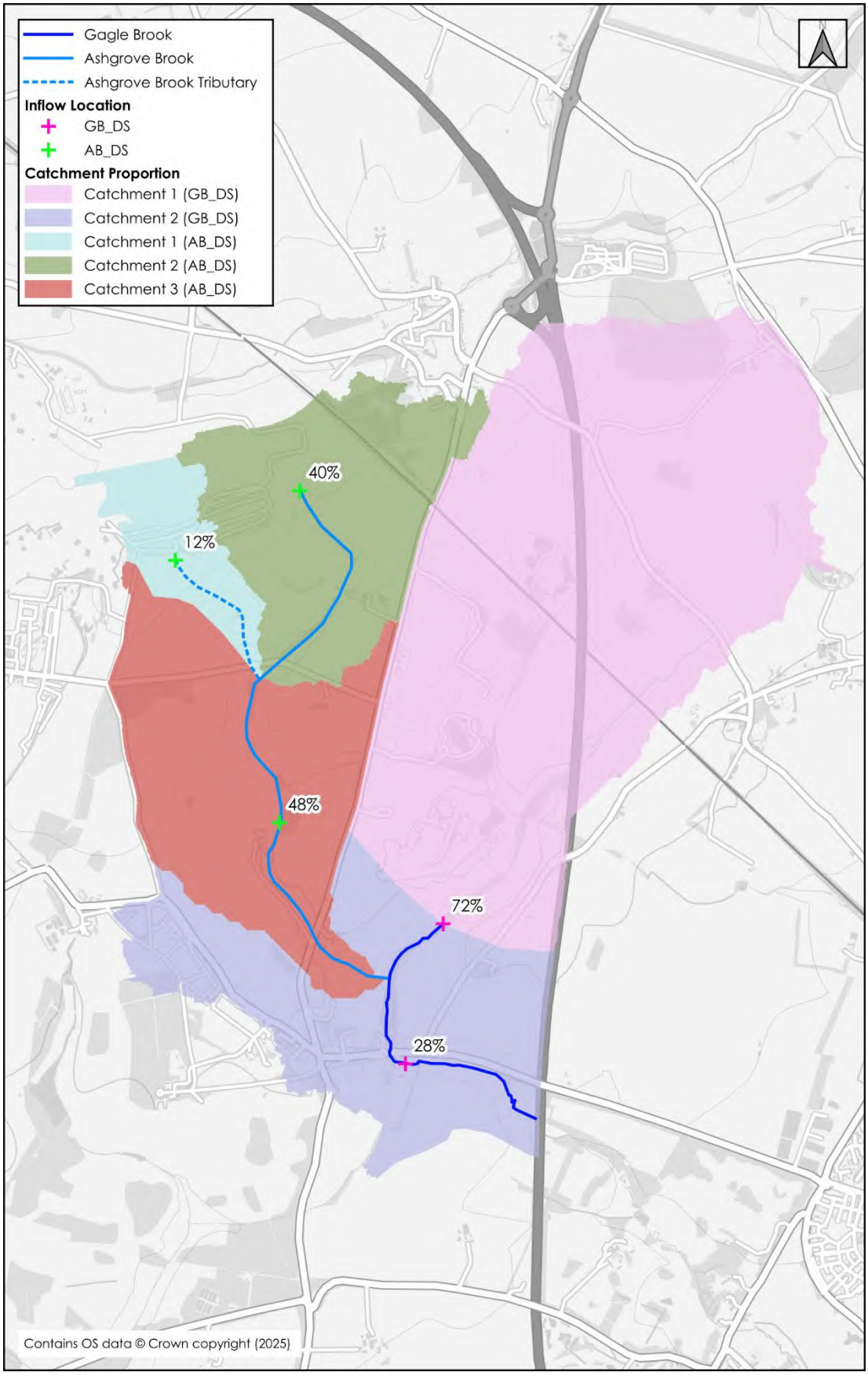



**Figure 2.1: Distribution of Model Inflows**

## 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

3.1 A model review was undertaken by the EA in February 2026. The review noted that the existing and proposed models are well schematised with only a few minor comments for further consideration. The majority of these comments have been addressed within this report, however, the model review is included for reference in **Appendix 3**.

## Software and Solver

3.2 TUFLOW version 2025.2.2-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

3.3 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

3.4 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.

3.5 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**.

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

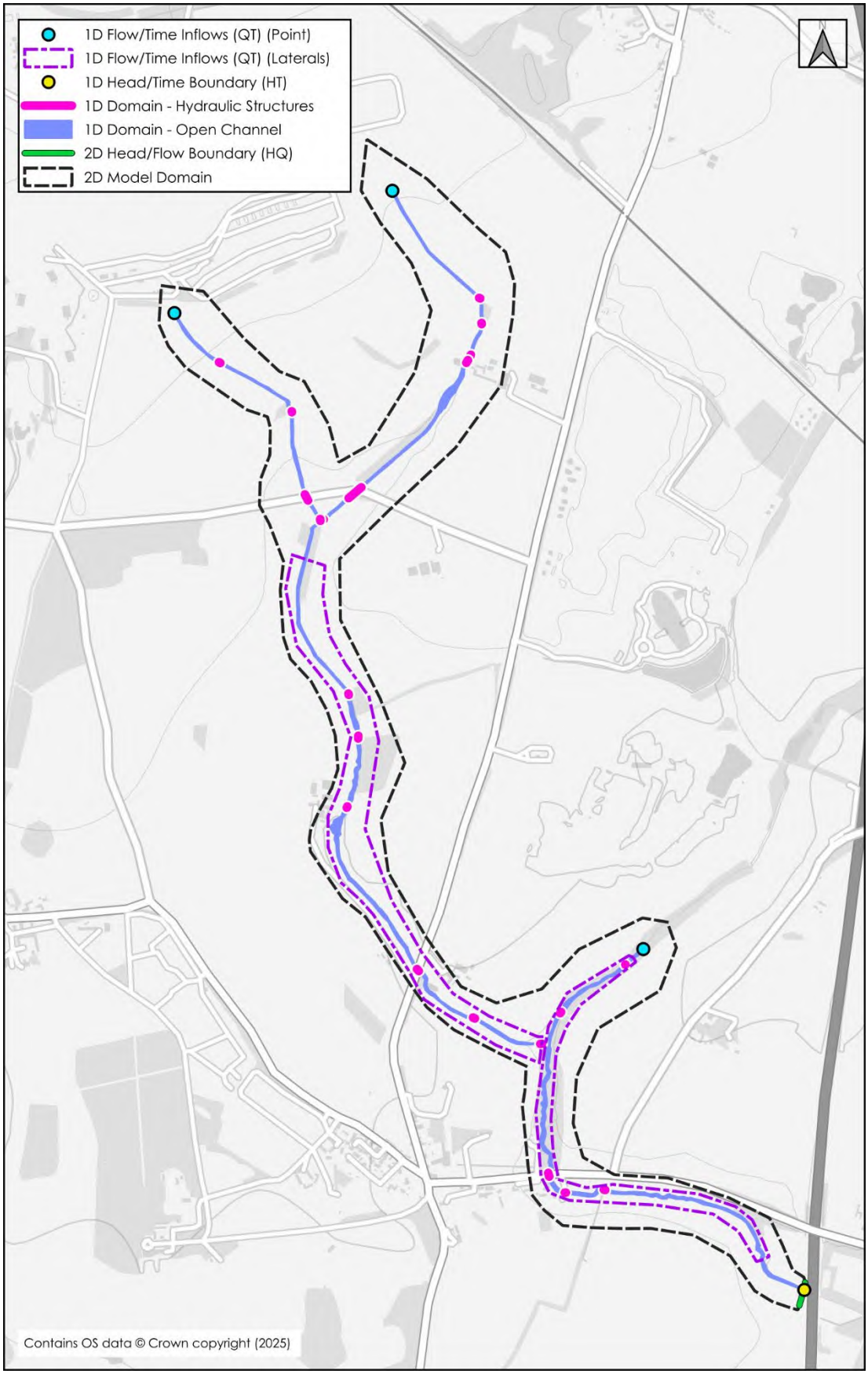



**Figure 3.1: Baseline Model Schematic**

Hydraulic Roughness

3.7 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)[8]. 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 CSV file.

3.9 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**<br>Main Channels<br>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**<br>Floodplains<br>Brush - light |  |
| GBT2_00549 | **0.06**<br>Floodplains<br>Trees – medium density with sprouts |  |

Hydraulic Structures

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

3.11 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 4**.

Boundary Conditions

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

3.13 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.

3.14 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

3.15 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

3.16 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 5-7m along the Gagle Brook and Ashgrove Brook.

### 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 (5-7m width = 2-3 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 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.

3.25 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 | 0.015 |
| Rail | 0.050 |
| Woodland | 0.150 |
| Buildings | 0.500 |

Floodplain Topography and Amendments

3.26 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.

3.27 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 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

3.28 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 "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

3.31 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.

3.32 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

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

3.34 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

3.35 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 1/10$^{th}$ 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 1/10$^{th}$ 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.

3.36 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.

3.37 No HCN's, or 1D negative depths were reported.

3.38 The remaining values highlighted above were considered acceptable.

### Model Runs

3.39 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<br>1 in 100-Year<br>1 in 1000-Year<br>1 in 100-Year+15%CC<br>1 in 100-Year+25%CC<br>1 in 100-Year+49%CC | Representative of 'as surveyed' conditions |
| Proposed | 1 in 30-Year<br>1 in 100-Year<br>1 in 1000-Year<br>1 in 100-Year+15%CC<br>1 in 100-Year+25%CC<br>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_P) | 1 in 100-Year | 25% blockage of culvert |

# 4. BASELINE RESULTS

4.1 The results from the existing conditions model are mapped in **Appendix 5** 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**.

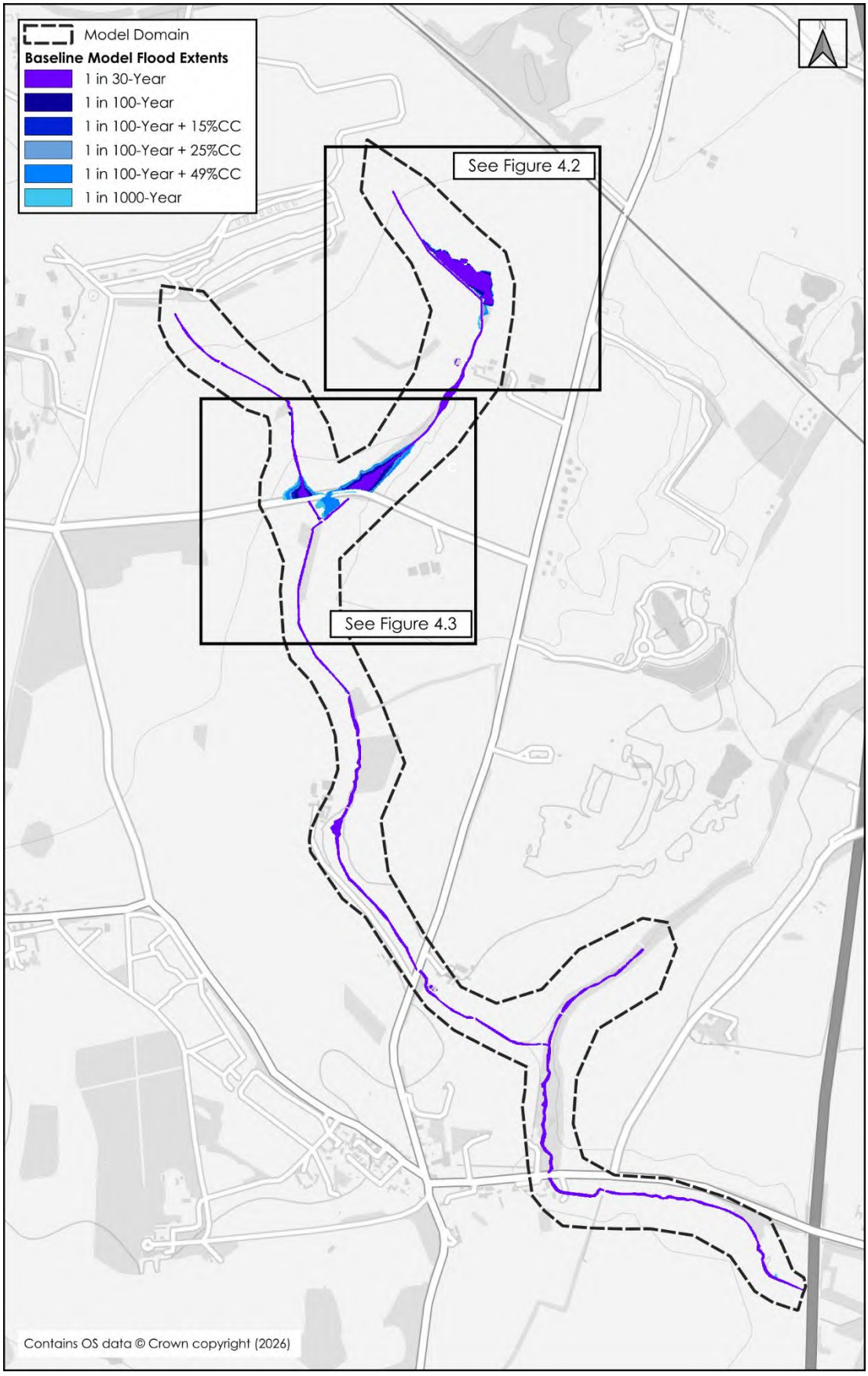



**Figure 4.1: Baseline Modelled Flood Extents**

Location 1

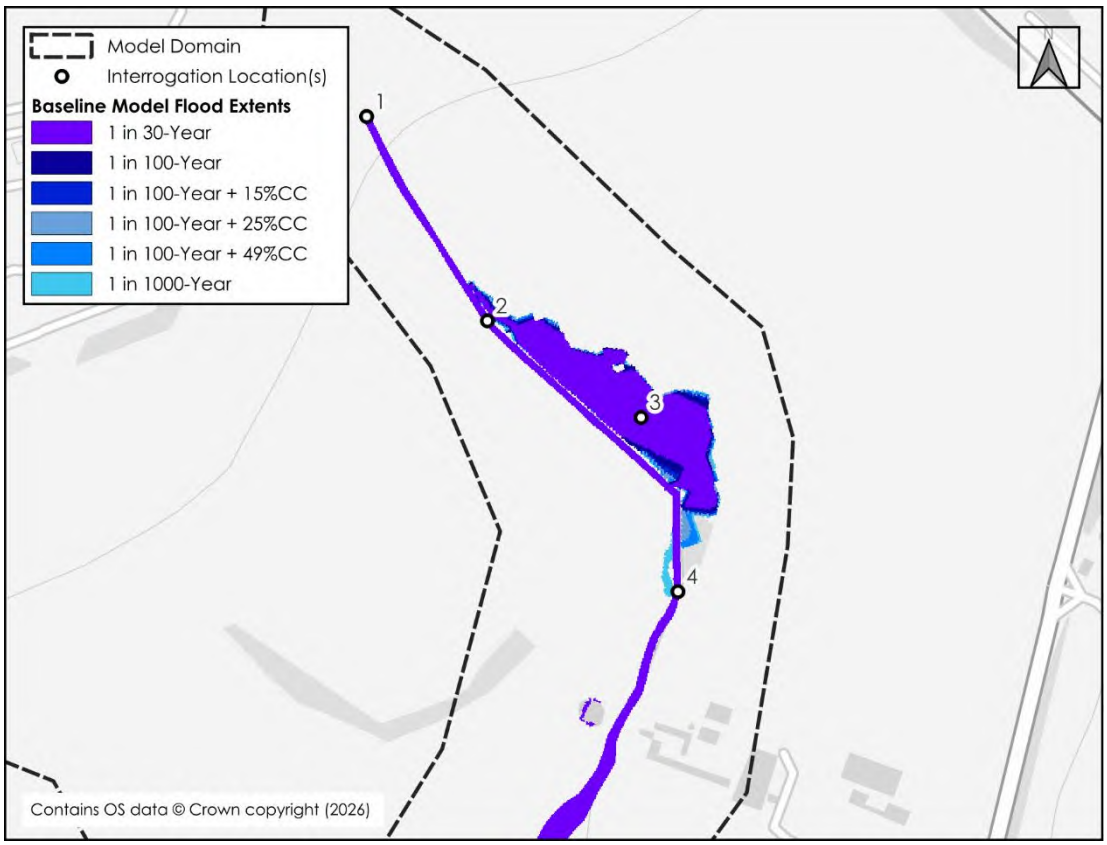



**Figure 4.2: Baseline Modelled Flood Extents - Location 1**

**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 | 107.95 | 108.08 | 108.15 | 108.31 | 108.40 |
| 7 | 108.42 | 108.44 | 108.46 | 108.47 | 108.54 | 108.57 |
| 8 | 107.90 | 108.09 | 108.24 | 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 | Irregular Culvert | 4.0m x 6.0m (600mm wide integrated mammal shelf on both sides of culvert) | 400mm ( | 400mm |

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

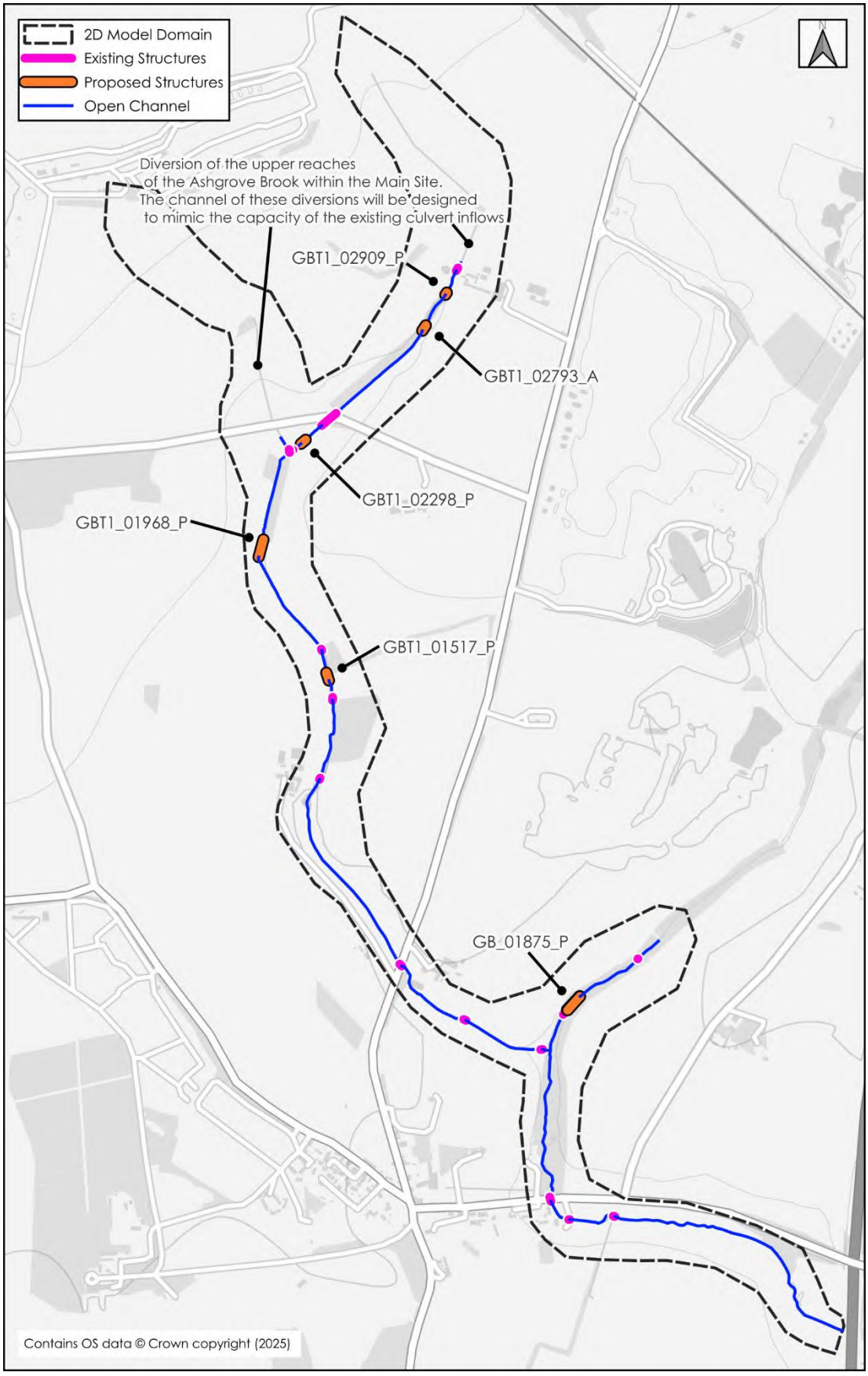



**Figure 5.1: Proposed Structures**

### 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 (**Figure 5.2**) and has therefore been excluded from the proposed inflows.
- 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.

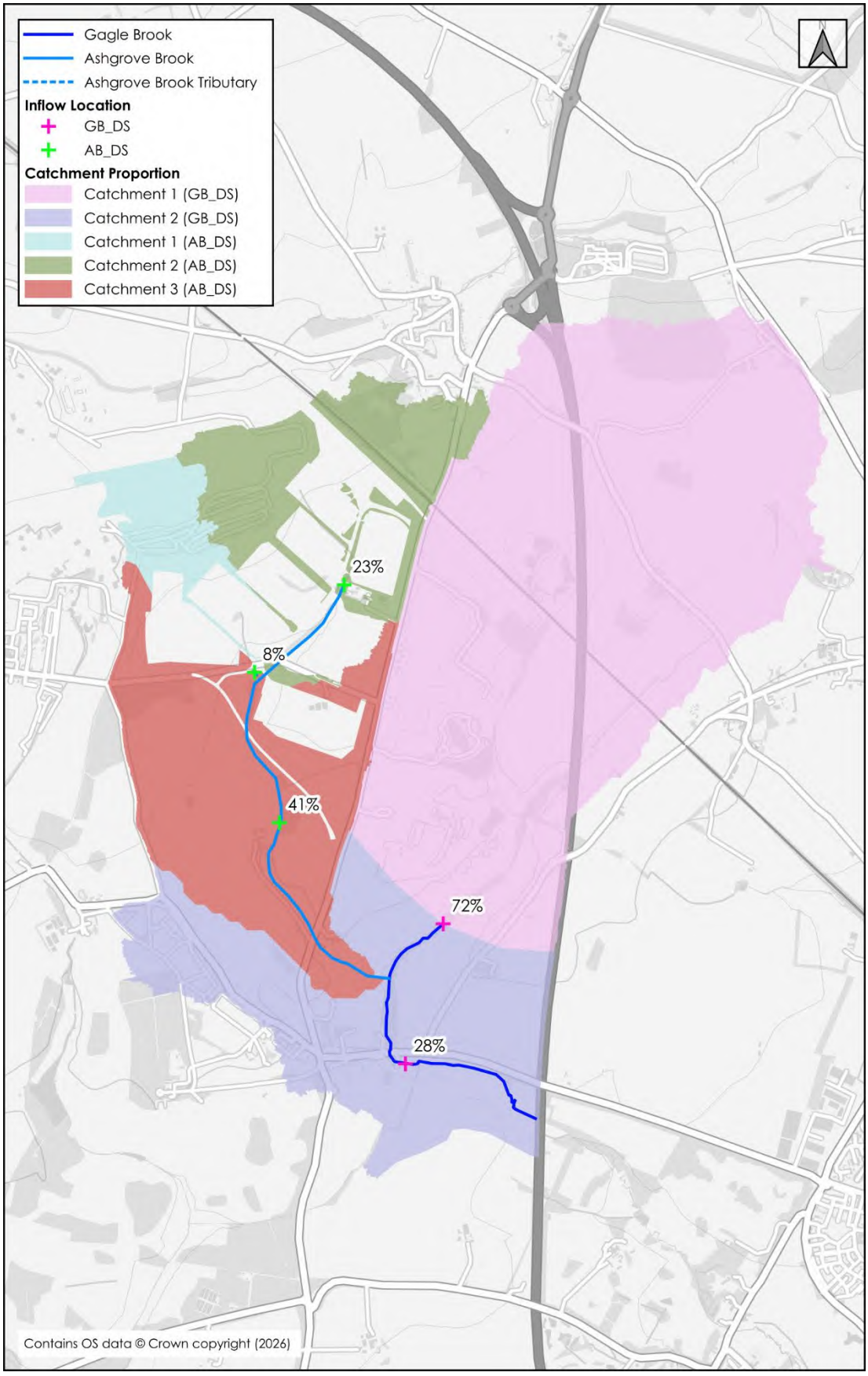



**Figure 5.2: Proposed Distribution of Model Inflows**

### 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 6** and summarised below. The floodplain extents are shown in **Figure 5.3** and **Figure 5.4**, with modelled flood levels outlined within **Table 5.2**.

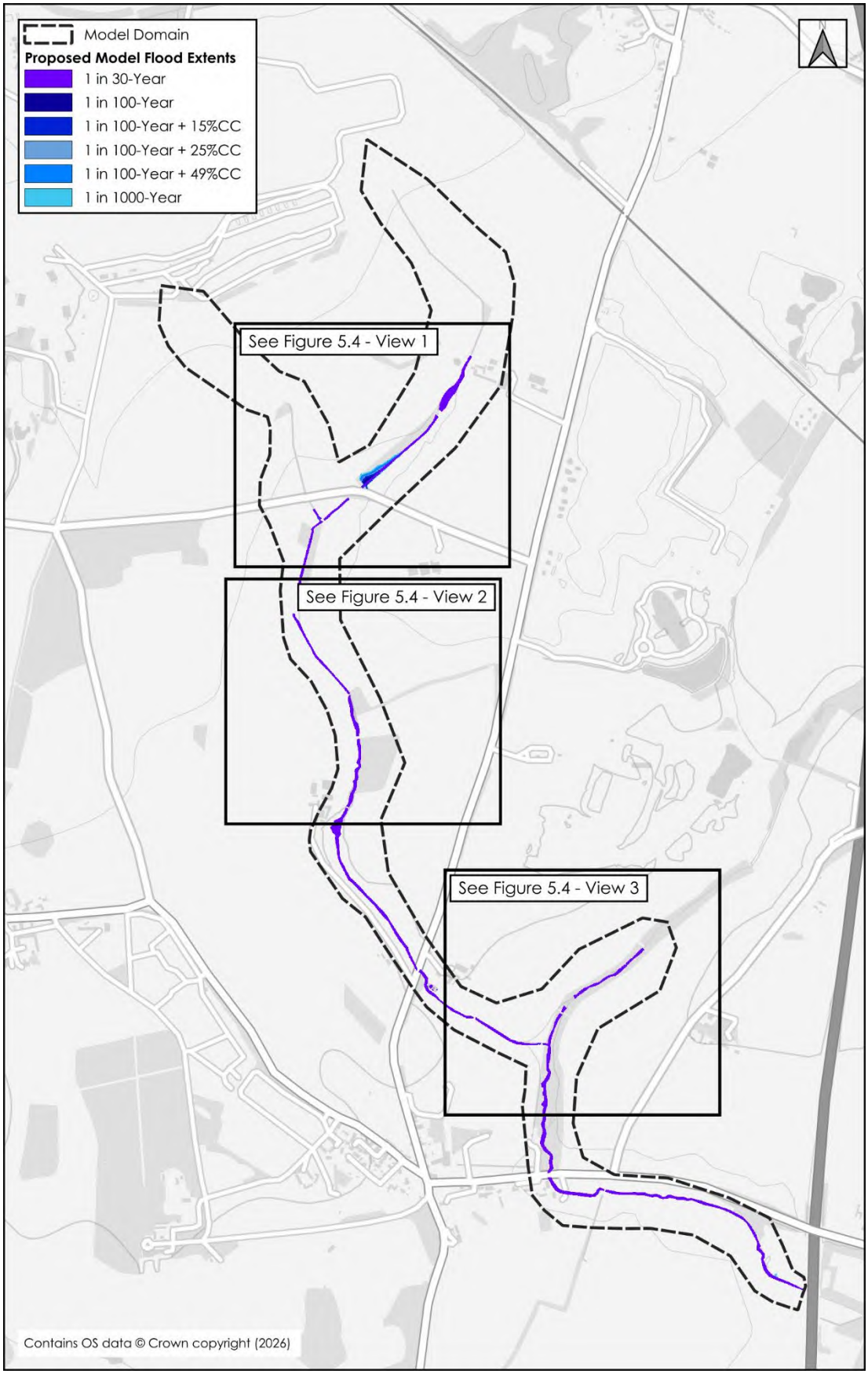



**Figure 5.3: Proposed Modelled Flood Extents**

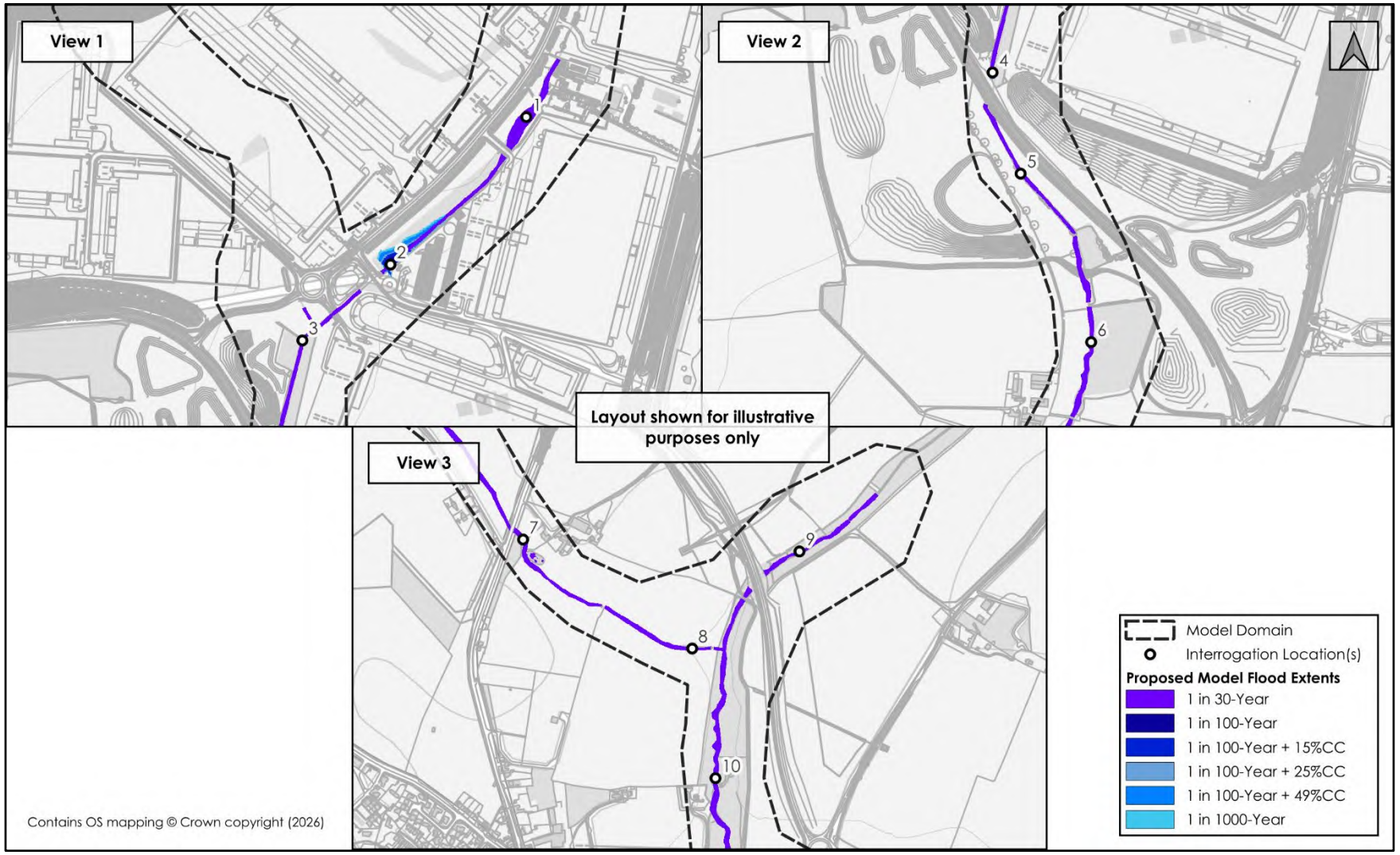



**Figure 5.4: Proposed Modelled Flood Extents – Location 1, 2 and 3**

**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 | 108.98 |
| 2 | 106.84 | 107.54 | 107.74 | 107.85 | 108.08 | 108.22 |
| 3 | 105.38 | 105.39 | 105.40 | 105.40 | 105.42 | 105.42 |
| 4 | 104.69 | 104.70 | 104.72 | 104.72 | 104.74 | 104.75 |
| 5 | 102.92 | 102.93 | 102.94 | 102.95 | 102.96 | 102.97 |
| 6 | 100.39 | 100.41 | 100.42 | 100.43 | 100.45 | 100.46 |
| 7 | 94.94 | 94.95 | 94.97 | 94.97 | 94.99 | 95.01 |
| 8 | 88.92 | 88.94 | 88.95 | 88.96 | 89.02 | 89.03 |
| 9 | 89.45 | 89.49 | 89.52 | 89.53 | 89.56 | 89.59 |
| 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 7**; the comparison mapping for the design event (1 in 100-year + 15%CC) is illustrated in **Figure 5.5** 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, and upstream and downstream of structure GB_01875_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.

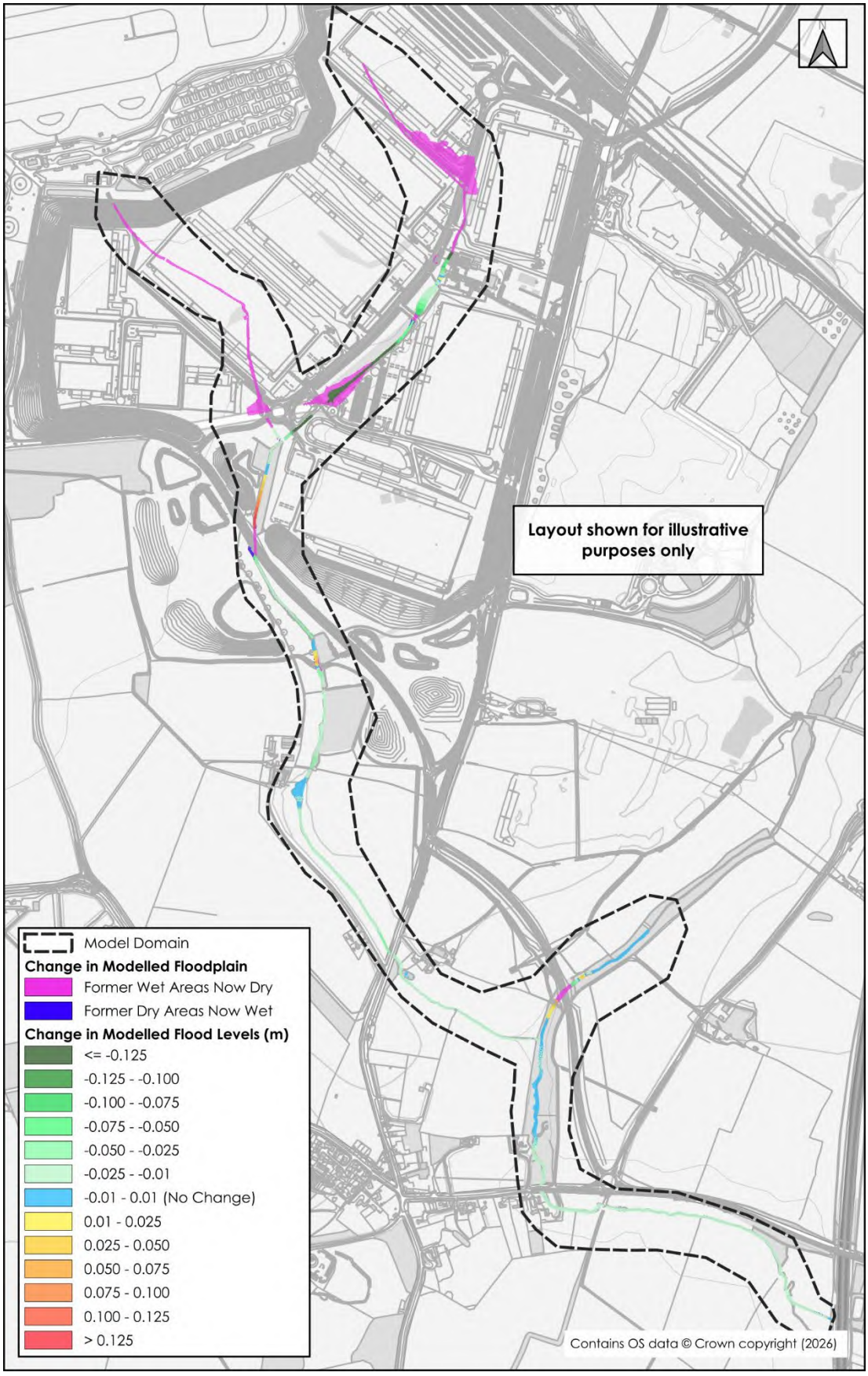



**Figure 5.5: Baseline vs Proposed Comparison Mapping - 1 in 100-Year + 15%CC**

# 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 8**.

## 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 8**.

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 270mm. 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_P)

6.29 An irregular culvert 4.0m x 6.0m (with 600mm wide integrated mammal shelves on both sides) is proposed beneath the Middleton Stoney Relief Road, to the east of the proposed development. Therefore, a 25% blockage of the 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 50mm. 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.

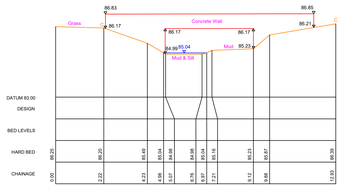
7.4 The baseline results generally show flows to remain in channel for large stretches along the Ashgrove Brook, and tributary, and the Gagle Brook. Along the northern section of the Ashgrove Brook, flows overtop the left and right banks and travel along the floodplain. Flows back up behind restrictive 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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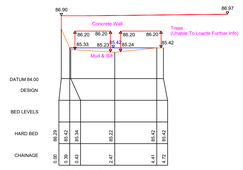


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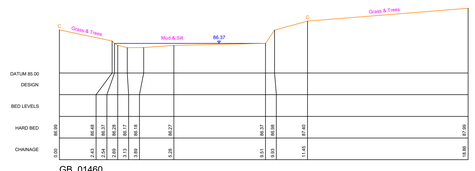


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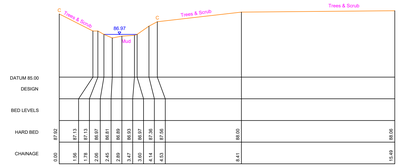


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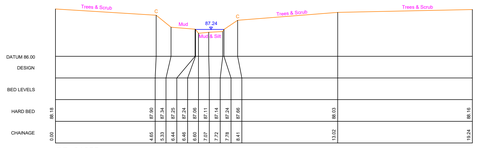


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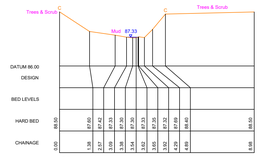


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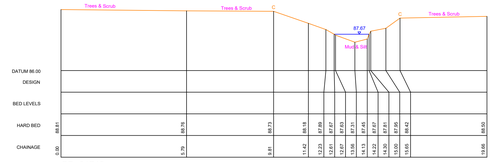


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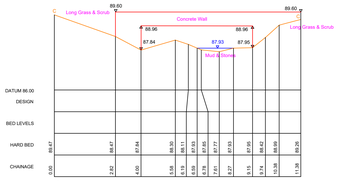


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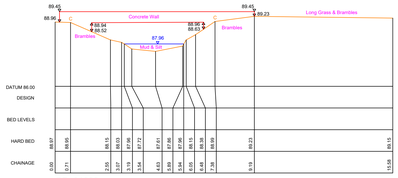


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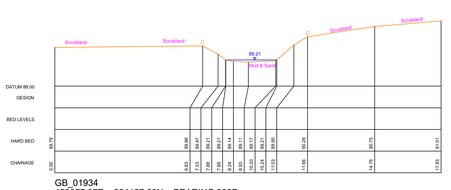


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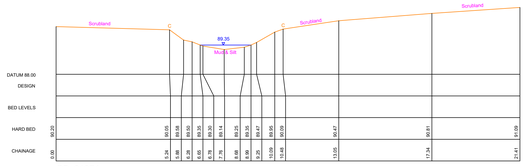


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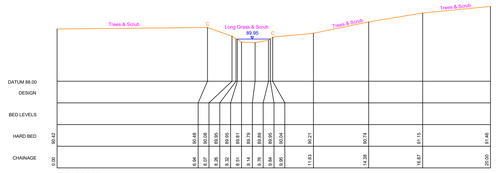


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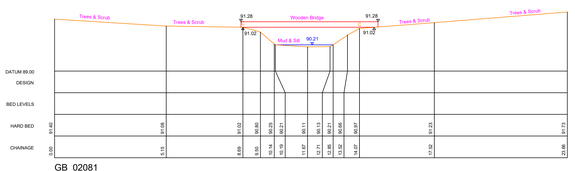


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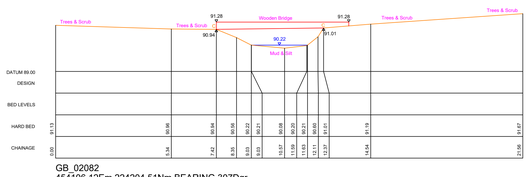


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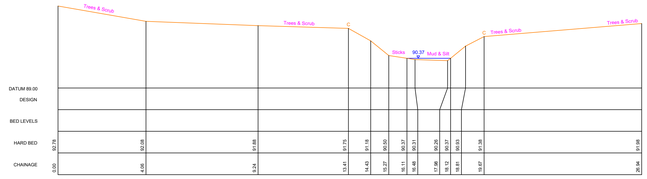


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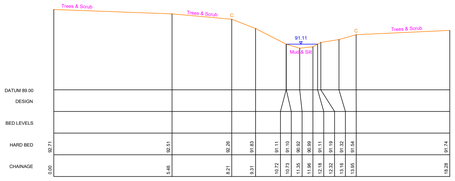


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## Notes

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.
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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 | 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 SHEET 1 OF 13**

| Drawn: | [redacted] | Reviewed: | [redacted] | |
|---|---|---|---|---|
| BWB Ref: | [redacted] | 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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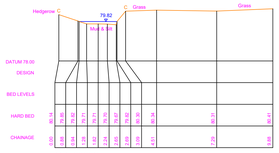


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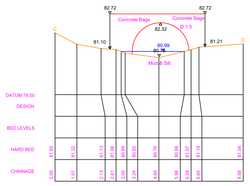


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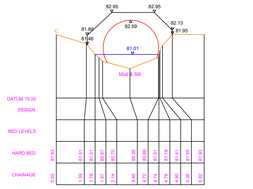


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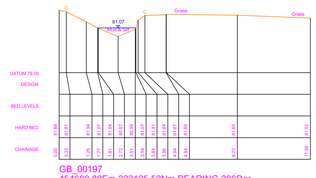


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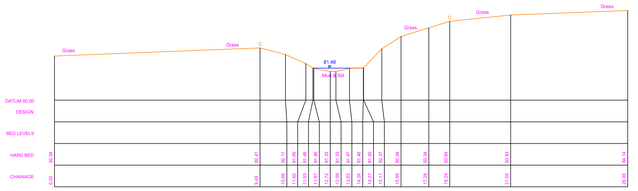


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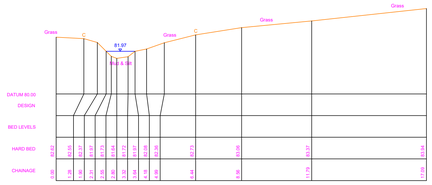


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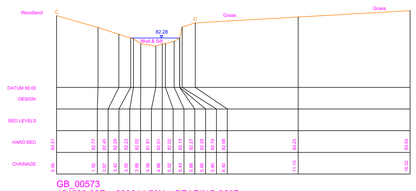


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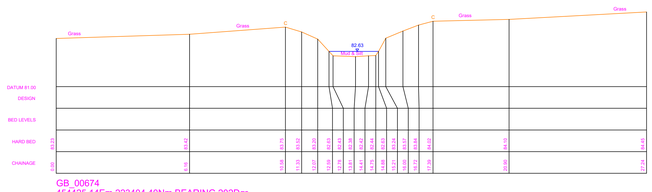


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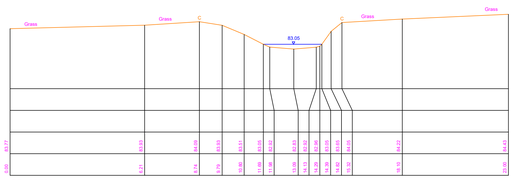


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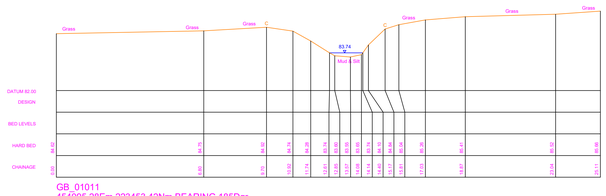


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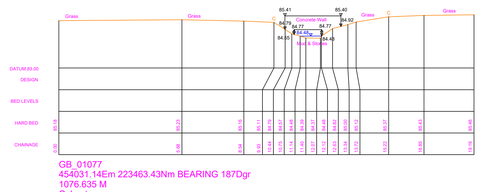


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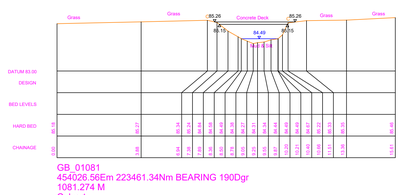


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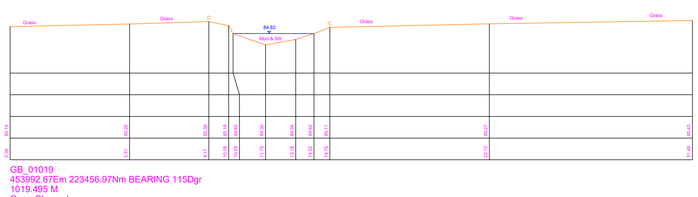


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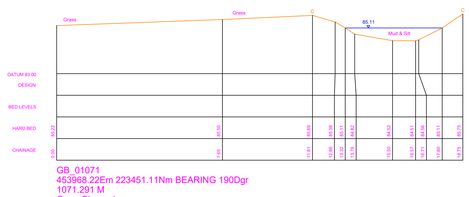
01/03/2022

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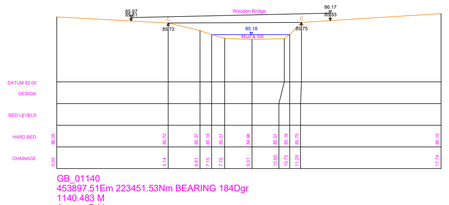


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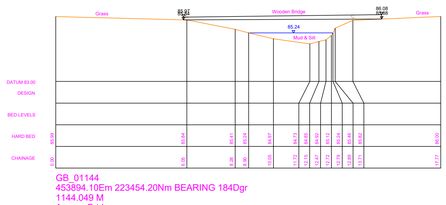


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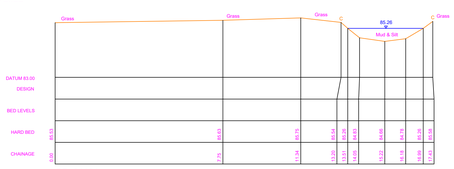


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01/03/2022

## 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: | [redacted] | | Reviewed: | [redacted] | |
| 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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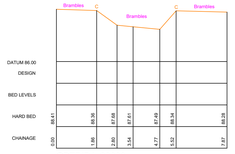


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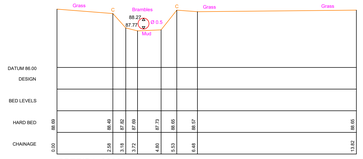


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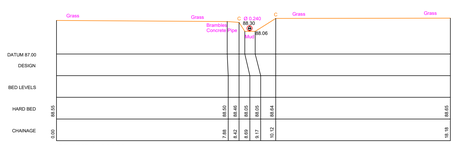


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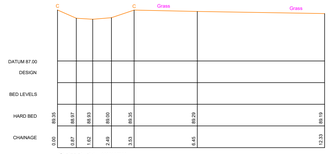


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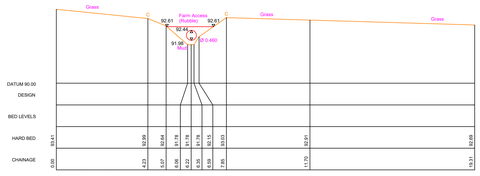


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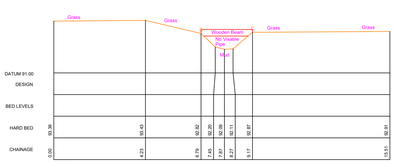


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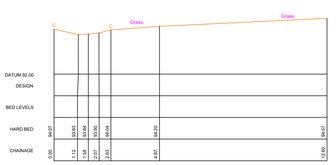


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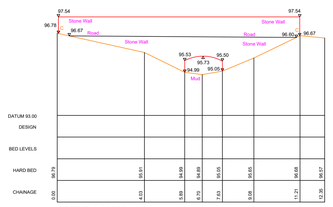


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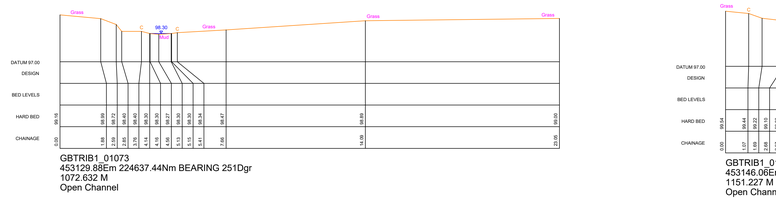


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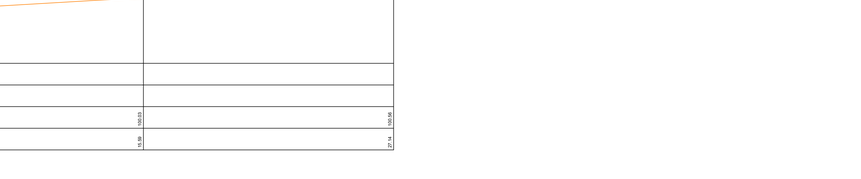


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## Notes

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 | | Contour Lines |
| | Surveyed Buildings | | Inspection Chamber |
| | Building | 0.25 | Flow direction and pipe diameter |
| | Wall | | Station and Name |
| | Kerb Channel Line | BH 1 | 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 | 50.00 | Spot Level |
| | Centre Line | | Assumed Surface Water Drainage Line |
| | Watercourse Centre Line | | Surface Water Drainage 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 | 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 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**

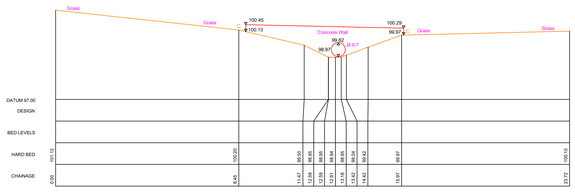
Project Title
**OXFORDSHIRE RFI**

Drawing Title
**WATERCOURSE SURVEY GAGGLE BROOK TRIBUTARY 1 SHEET 2 OF 13**

| | | | |
|---|---|---|---|
| Drawn: | [redacted] | Reviewed: | [redacted] |
| BWB Ref: | [redacted] | Date: | 18.10.21 |
| | | Scale@A2: | 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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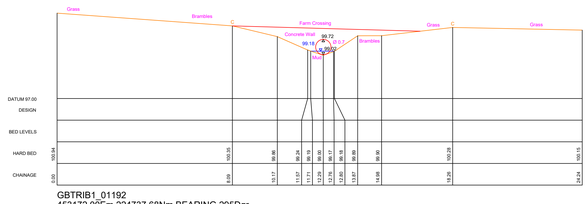


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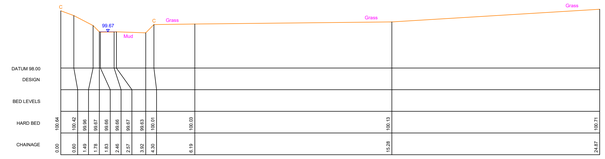


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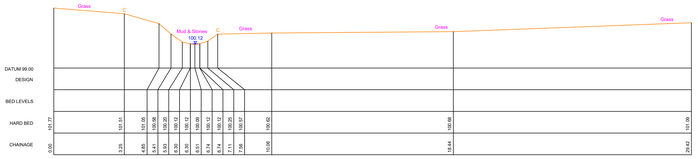


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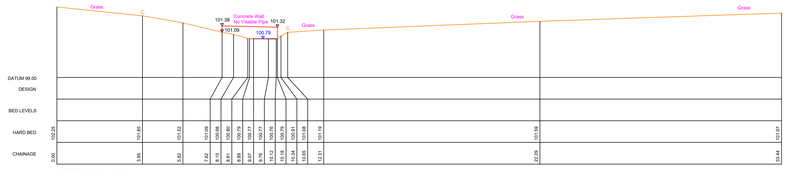


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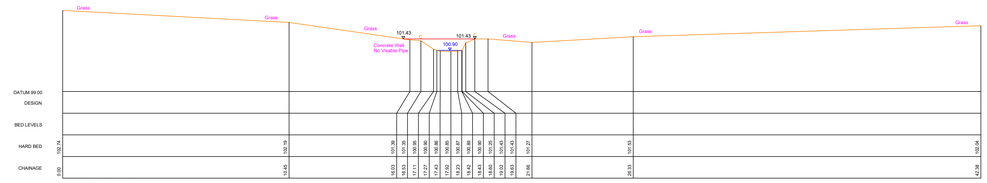


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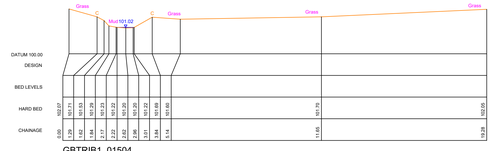


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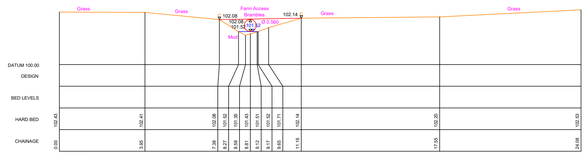


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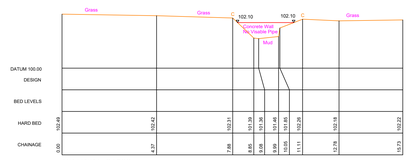


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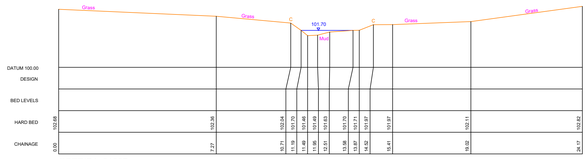


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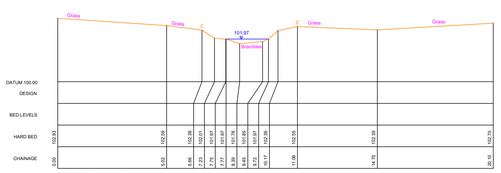


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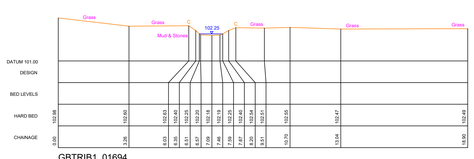


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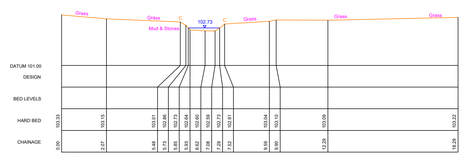


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## Notes

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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 | 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: | [redacted] | Reviewed: | [redacted] | |
|---|---|---|---|---|
| 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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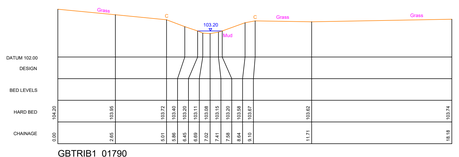


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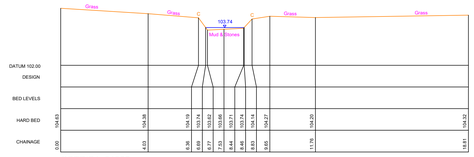


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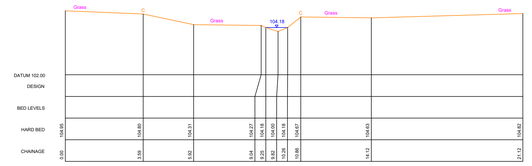


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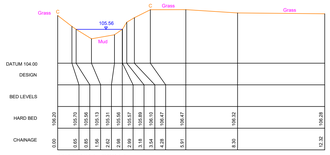


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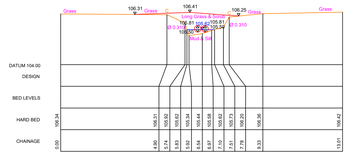


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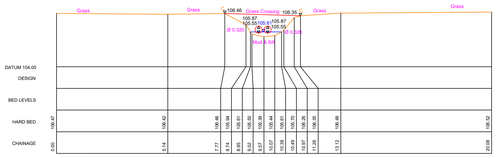


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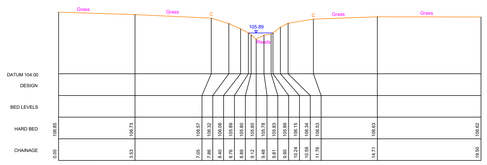


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Open Channel




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GBTRIB1_03125
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3125.218 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
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
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 | | |
| | | 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 4 OF 13**

| | | | |
|---|---|---|---|
| Drawn: | [redacted] | Reviewed: | [redacted] |
| BWB Ref: | [redacted] | 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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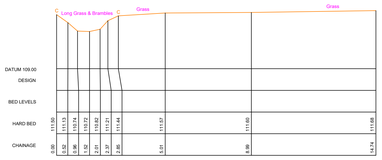


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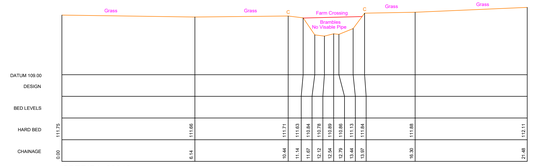


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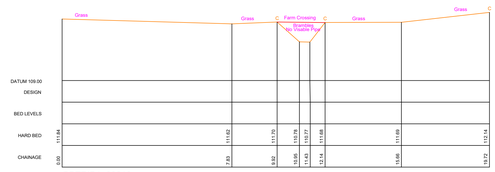


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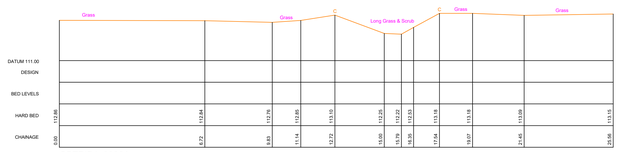


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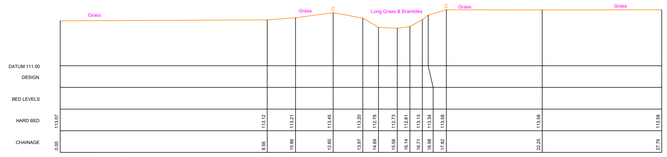


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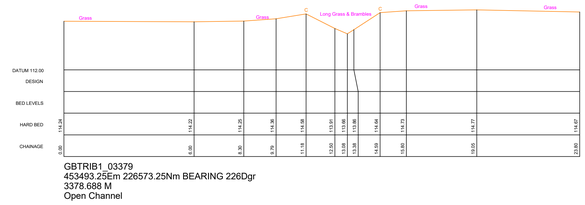


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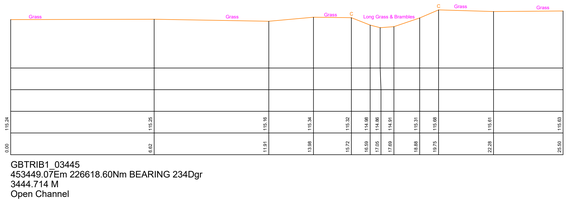


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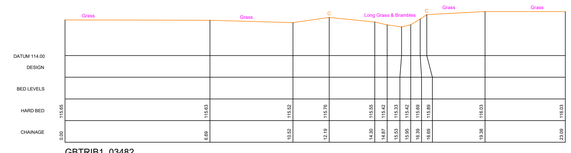


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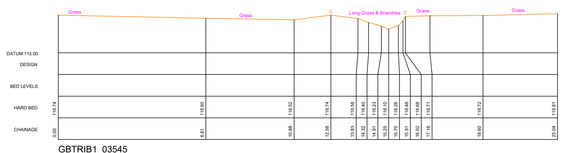


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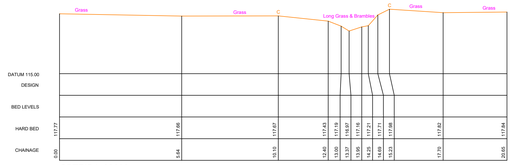


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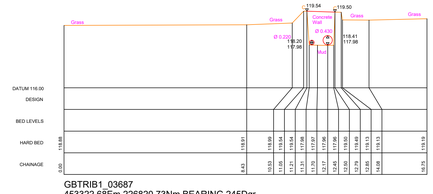


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Culvert

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## Key Plan

## Legend

OS Buildings
Surveyed Buildings
Building
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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
Monitoring Borehole
Tree / Bush / Sapling
Area of Vegetation/ Extent of Tree Canopy
Hedge
Body of Water
Body of Water from OS
Spot Level
Assumed Surface Water Drainage Line
Surface Water Drainage Line

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| BO | Bollard | FCL | Fence Chain Link |
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| BT | British Telecom | FMP | Fence Metal Panel |
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| CL | Cover Level | FOB | Fence Open Board |
| CMP | Cable Marker Post | FPW | Fence Post & Wire |
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| CCTV | Security Camera | FWM | Fence Wire Mesh |
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| | | Gas | Gas |
| DK | Drop Kerb | GV | Gas Valve |
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| Elec | Electric | Ht | Height |
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| LB | Litter Bin |
| LP | Lamp Post |
| MH | Manhole |
| Mtr | Service Marker |
| PB | Post Box |
| PT | Post |
| RE | Rodding Eye |
| SP | Sign Post |
| ST | Stop Tap |
| SV | Stop Valve |
| TCB | Telephone Call Box |
| THL | Threshold Level |
| TL | Traffic Light |
| TP | Telegraph Post |
| TS | Traffic Signal |
| UTS | Unable to Survey |
| WL | Water Level |
| WM | Water Meter |
| 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 5 OF 13**

| | | | | | |
|---|---|---|---|---|---|
| Drawn: | [redacted] | | Reviewed: | [redacted] | |
| 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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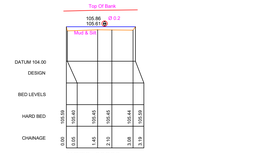


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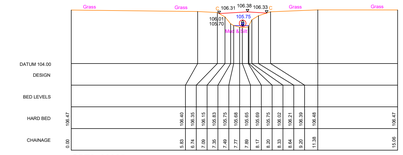


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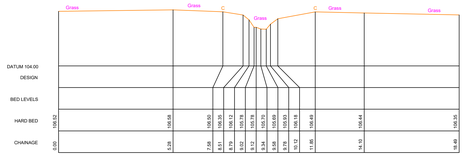


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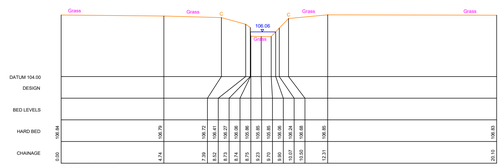


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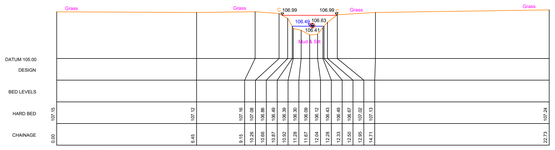


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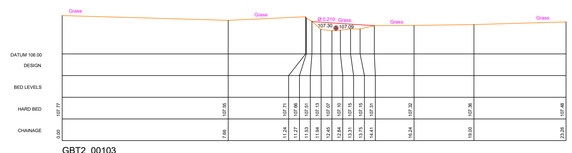


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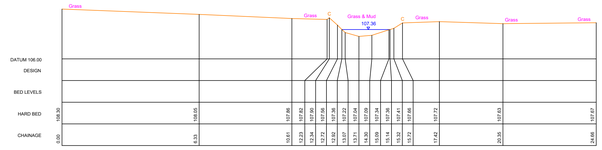


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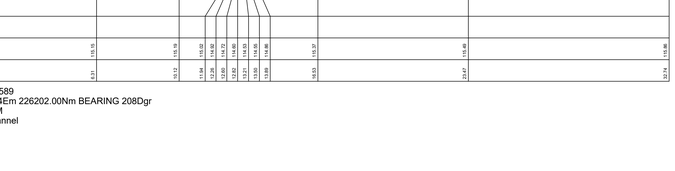


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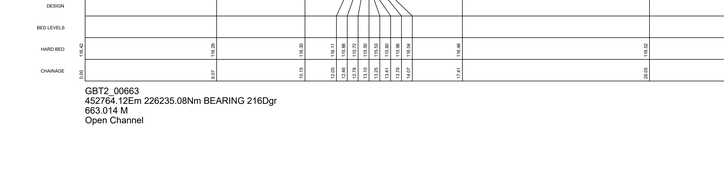


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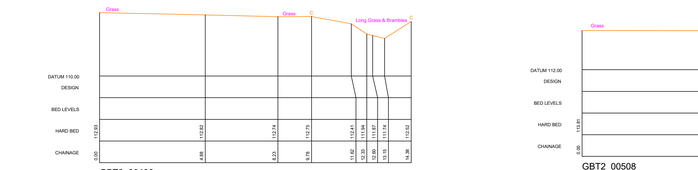


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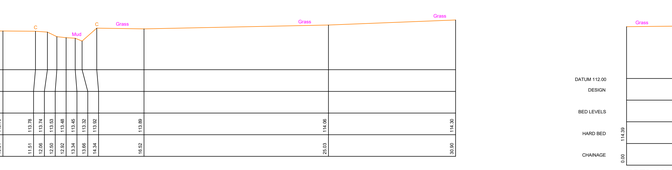


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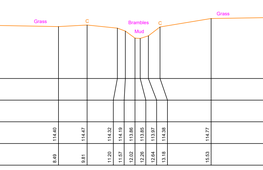


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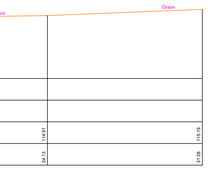


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Open Channel




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588.705 M
Open Channel




GBT2_00663
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Open Channel

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Watercourse
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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 |
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| EP | Electricity Post | IC | Inspection Chamber |
| ER | Earth Rod | IFL | Internal Floor Level |
| FH | Fire Hydrant | IL | Invert Level (as a reduced level) |
| FL | Floodlight | | |

| | | | |
|---|---|---|---|
| LB | Litter Bin | | |
| LP | Lamp Post | | |
| MH | Manhole | | |
| Mkr | Service Marker | | |
| PB | Post Box | | |
| PT | Post | | |
| RE | Rodding Eye | | |
| SP | Sign Post | | |
| ST | Stop Tap | | |
| SV | Stop Valve | | |
| TCB | Telephone Call Box | | |
| THL | Threshold Level | | |
| TL | Traffic Light | | |
| TP | Telegraph Post | | |
| TS | Traffic Signal | | |
| UTS | Unable to Survey | | |
| WL | Water Level | | |
| WM | Water Meter | | |
| 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 2
SHEET 6 OF 13

| | | | | | |
|---|---|---|---|---|---|
| Drawn: | [redacted] | | Reviewed: | [redacted] | |
| 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-06-ZZ-M2-G-0060 | S2 | P1 |

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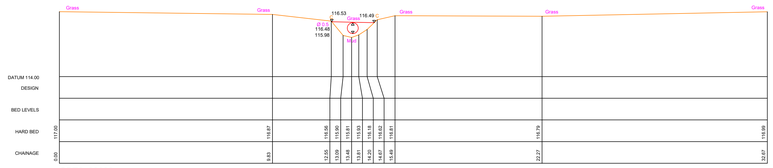


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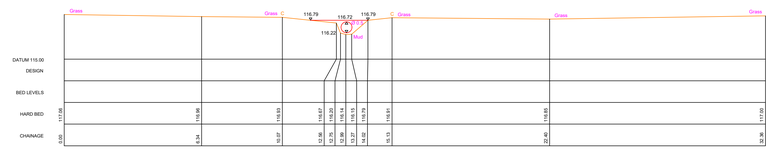


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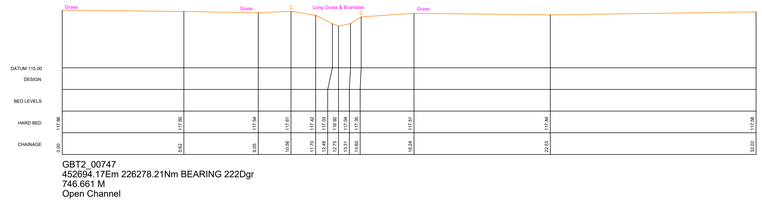


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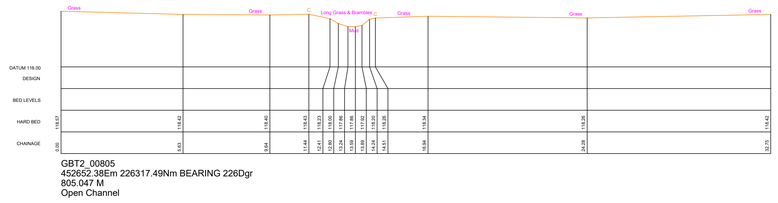


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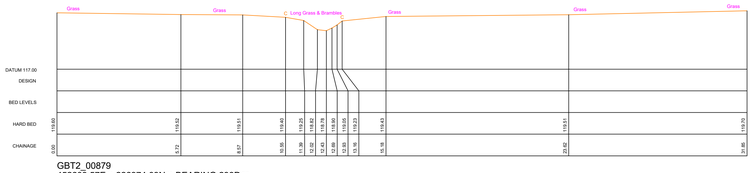


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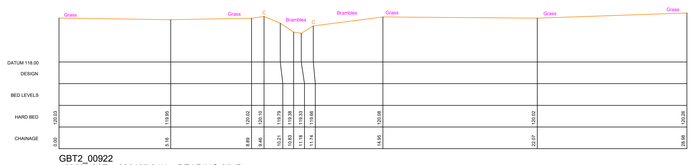


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Open Channel

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## 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.
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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 |
| BG | Back Gully | FCB | Fence Closed Board |
| BO | Bollard | FCL | Fence Chain Link |
| BS | Bus Stop | FEL | Fence Electric |
| BT | British Telecom | FMP | Fence Metal Panel |
| C | Crest | FMR | Fence Metal Railing |
| CL | Cover Level | FOB | Fence Open Board |
| CMP | Cable Marker Post | FPW | Fence Post & Wire |
| | | FSP | Fence Steel Palisade |
| CCTV | Security Camera | FWM | Fence Wire Mesh |
| CTV | Cable TV | FFL | Finished Floor Level |
| DC | Drainage Channel | FP | Flagpole |
| | | Gas | Gas |
| DK | Drop Kerb | GV | Gas Valve |
| DP | Down Pipe | GY | Gully |
| Elec | Electric | Ht | Height |
| EP | Electricity Post | IC | Inspection Chamber |
| ER | Earth Rod | IFL | Internal Floor Level |
| FH | Fire Hydrant | IL | Invert Level (as a reduced level) |
| FL | Floodlight | | |

| | | | |
|---|---|---|---|
| LB | Litter Bin | | |
| LP | Lamp Post | | |
| MH | Manhole | | |
| Mkr | Service Marker | | |
| PB | Post Box | | |
| PT | Post | | |
| RE | Rodding Eye | | |
| SP | Sign Post | | |
| ST | Stop Tap | | |
| SV | Stop Valve | | |
| TCB | Telephone Cell Box | | |
| THL | Threshold Level | | |
| TL | Traffic Light | | |
| TP | Telegraph Post | | |
| TS | Traffic Signal | | |
| UTS | Unable to Survey | | |
| WL | Water Level | | |
| WM | Water Meter | | |
| 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**

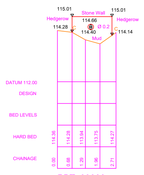
Project Title
**OXFORDSHIRE RFI**

Drawing Title
**WATERCOURSE SURVEY**
**GAGGLE BROOK**
**TRIBUTARY 2**
**SHEET 7 OF 13**

| | | | | | |
|---|---|---|---|---|---|
| Drawn: | [redacted] | | Reviewed: | [redacted] | |
| 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-07-ZZ-M2-G-0060 | S2 | P1 |

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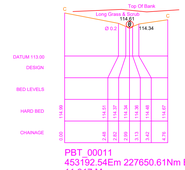


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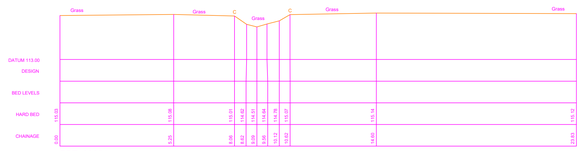
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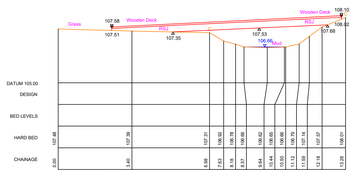


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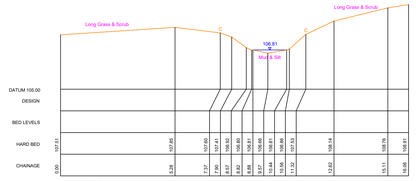


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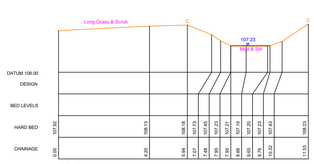


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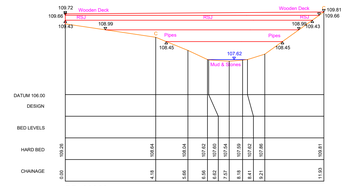


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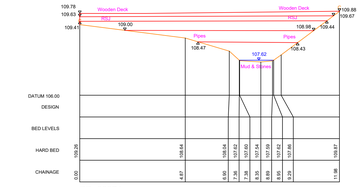


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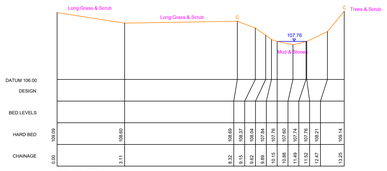


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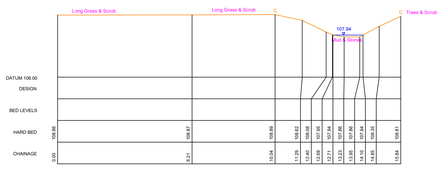


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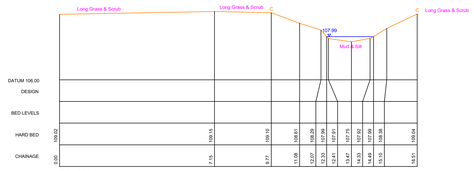


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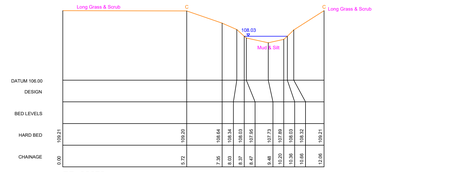


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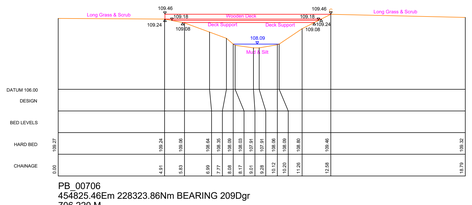


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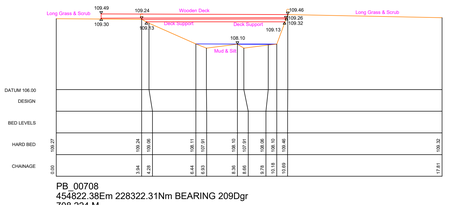


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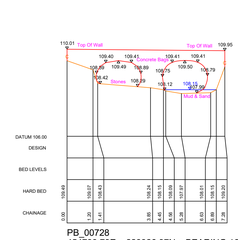


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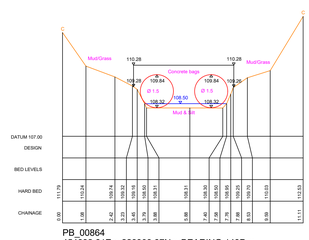


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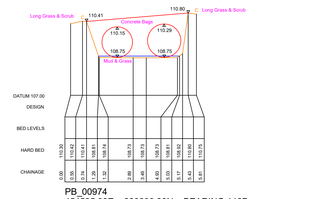


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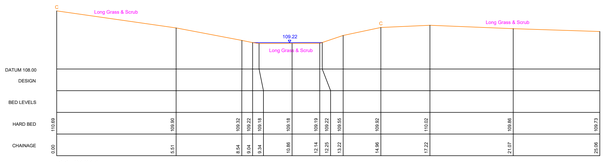


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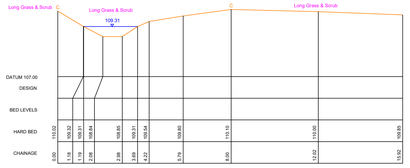


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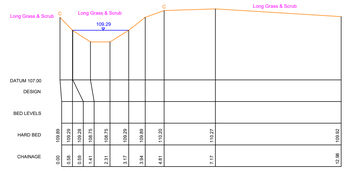


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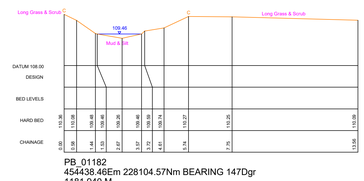


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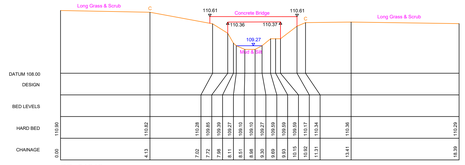


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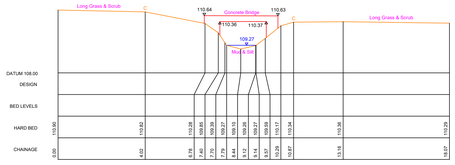


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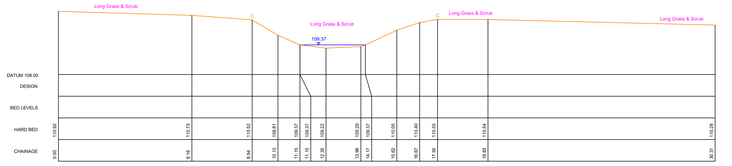
Footbridge

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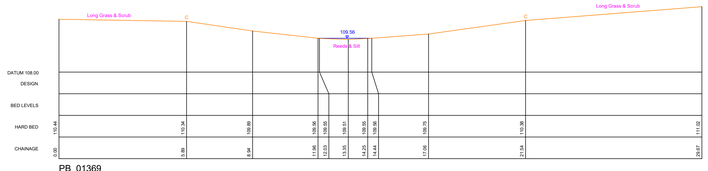
Open Channel

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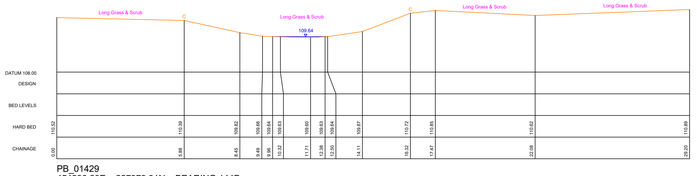


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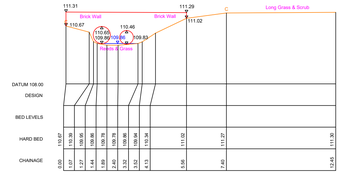


PB_01461
454205.59Em 227963.21Nm BEARING 152Dgr
1460.502 M

## 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 | 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 |
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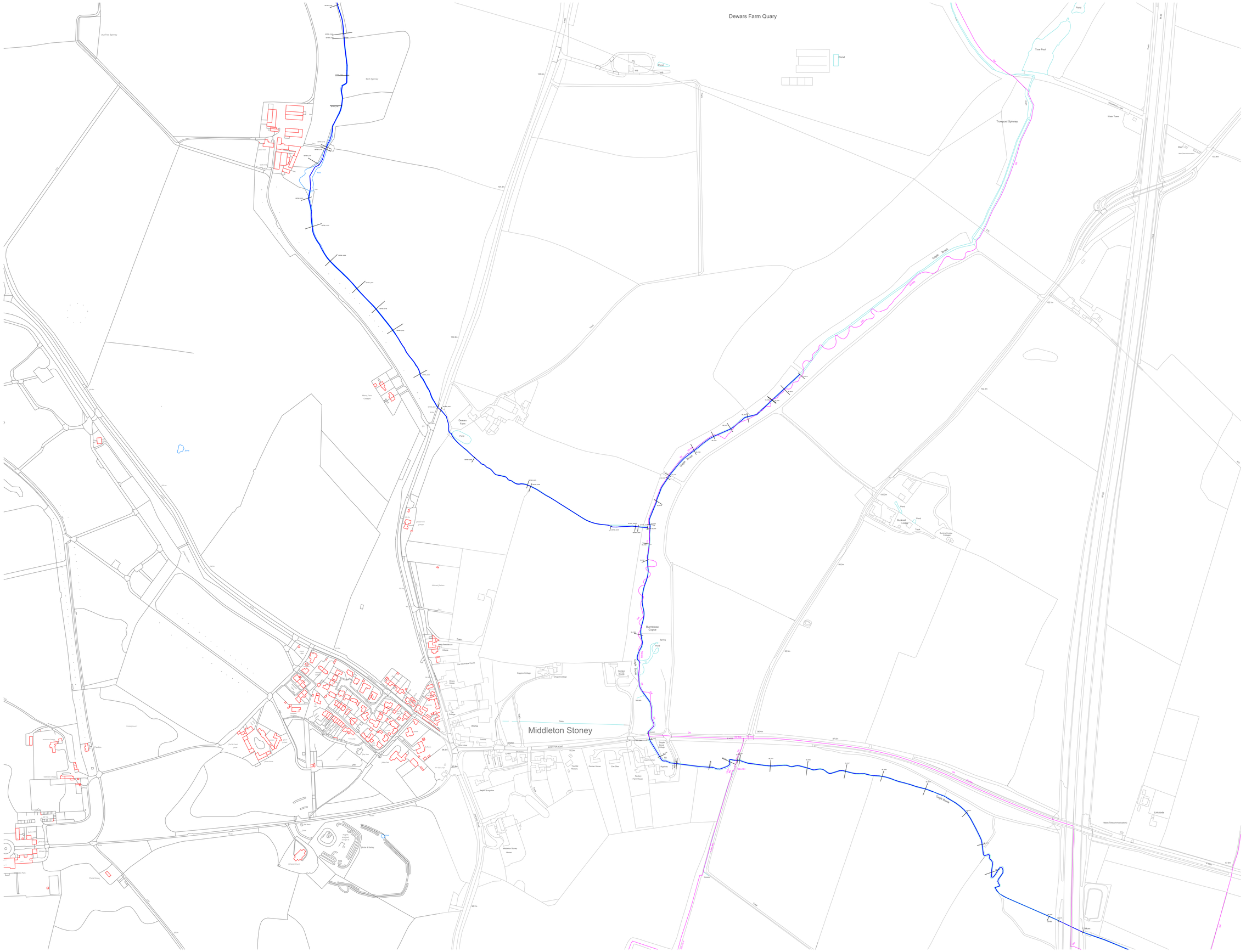
Dewars Farm Quarry
Middleton Stoney
Jack Tree Spinney
Birch Spinney
Trowpool Spinney
Trow Post
Pond
Dewars Farm
Burntclose Copse
Bucknell Lodge
Water Tower
Middleton Park
Cricket Ground
Tennis Courts
Bowling Green
Village Hall
Post Office
Church
Rectory Farm House
Middleton Stoney House
Old Rectory
Manor House
Oak Dale
Chapel Cottage
Corpse Cottage
Village Cottage
Bicester Road
Ditch
Gagle Brook
Gagle Brook Cottages
Linkadale
Wall (Telecommunication)
Mast
Tank
Spring
Works
Quarry
Sewage Works
Pumping Station
Pumping Station (Disused)
Sewage Treatment Works
Sewage Treatment Works (Disused)
Middleton Stoney Primary School
Middleton Park
Middleton Park Stables
Middleton Park Lodge
Middleton Park Farm
Middleton Park Cottages
Middleton Park Offices
Middleton Park Pumping Station
Middleton Park Pump House
Middleton Park Cricket Pavilion
Middleton Park Tennis Courts
Middleton Park Bowling Green
Middleton Park Sewage Treatment Works
Middleton Park Sewage Treatment Works (Disused)
Middleton Park Sewage Pumping Station
Middleton Park Sewage Pumping Station (Disused)
Middleton Park Village Hall
Middleton Park Post Office
Middleton Park Church
Middleton Park Rectory Farm House
Middleton Park Middleton Stoney House
Middleton Park Old Rectory
Middleton Park Manor House
Middleton Park Oak Dale
Middleton Park Chapel Cottage
Middleton Park Corpse Cottage
Middleton Park Village Cottage
Middleton Park Bicester Road
Middleton Park Ditch
Middleton Park Gagle Brook
Middleton Park Gagle Brook Cottages
Middleton Park Linkadale
Middleton Park Wall (Telecommunication)
Middleton Park Mast
Middleton Park Tank
Middleton Park Spring
Middleton Park Works
Middleton Park Quarry
Middleton Park Sewage Works
Middleton Park Pumping Station
Middleton Park Tennis Courts
Middleton Park Bowling Green

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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 | 0.25 |
| Wall | | Station and Name | |
| Kerb Channel Line | | Monitoring Borehole | BH 1 |
| 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 | 50.00 |
| 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 | | |
| | | 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 |
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| FL | Floodlight | | | WO | Wash Out |

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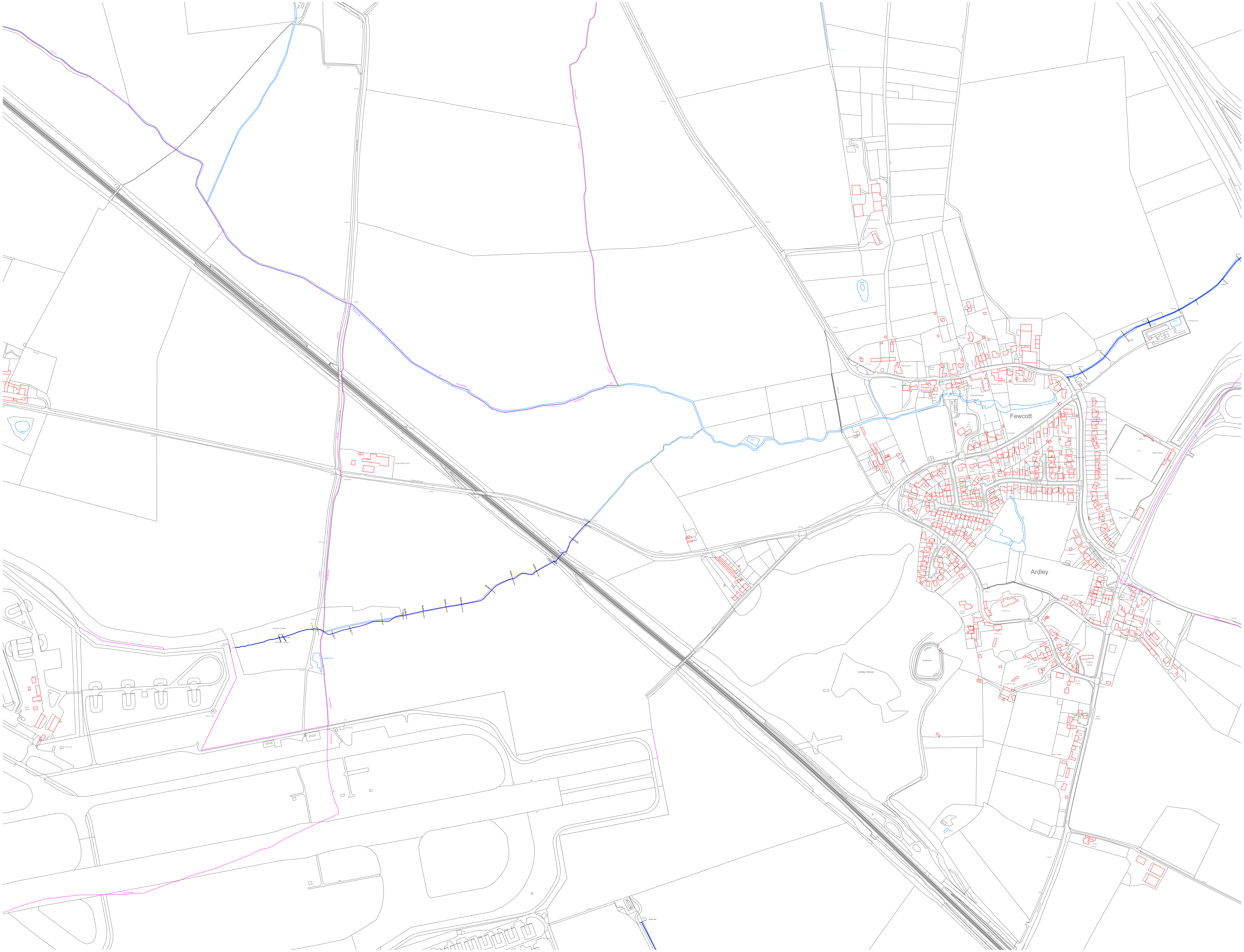


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## Key Plan

## Legend

- OS Buildings
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- Line Marking
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- Watercourse Centre Line
- Barrier
- Fence
- Gate
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- Overhead Utilities
- Contour Lines
- Inspection Chamber
- 0.25 Flow direction and pipe diameter
- 1 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

| | | | | | |
|---|---|---|---|---|---|
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| FL | Floodlight | | | | |

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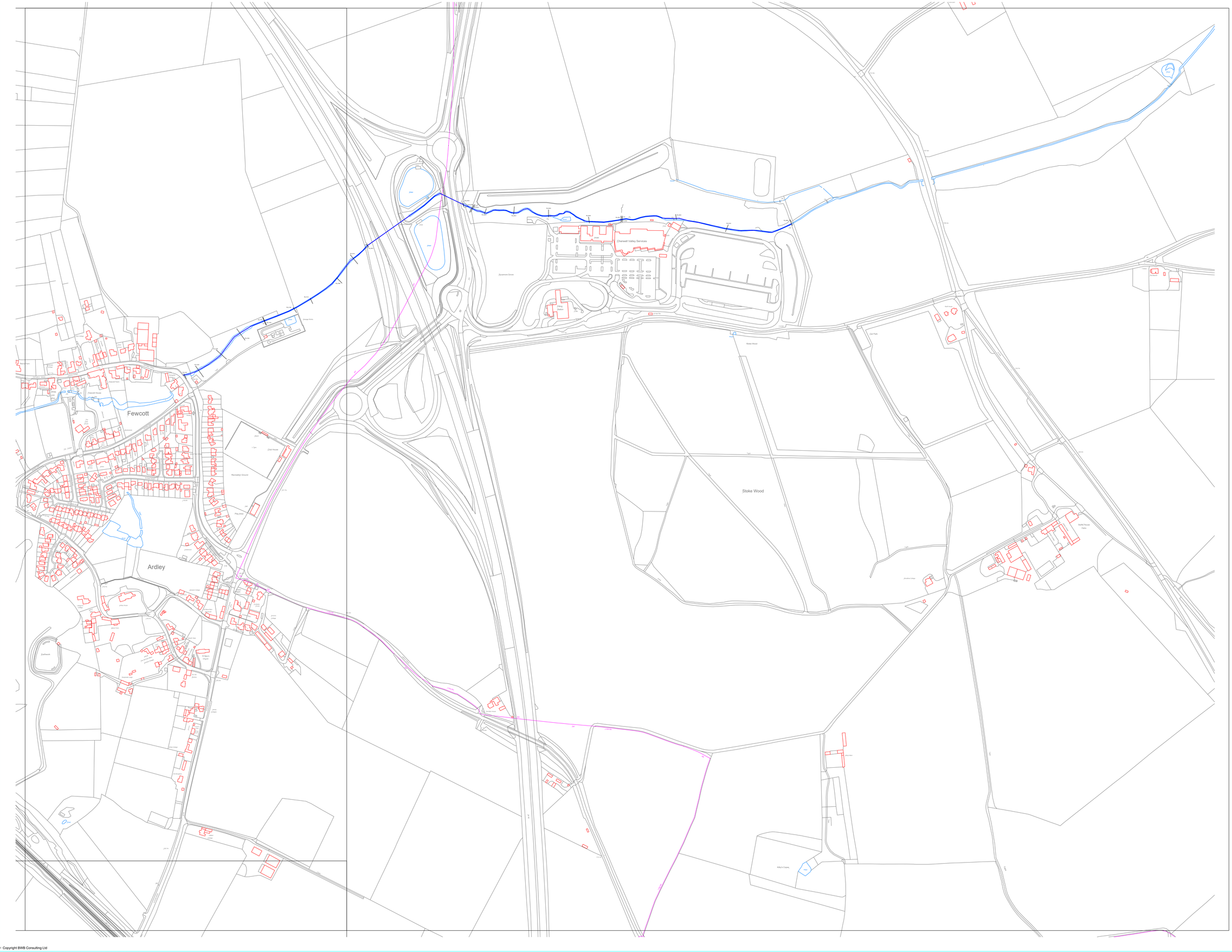
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Ardley
Stoke Wood
Cherwell Valley Services
Hotel
Filling Station
Fewcott House
French Farm
Club House
Recreation Ground
Play Area
Village Hall
Primary School
Church
Old Rectory
Manor Farm
Earthwork
Ardley Cutting
Ardley Tunnel
Ardley Cutting
Ardley Embankment
Stoke Wood
Old Park
Stoke Wood Farm
Stoke Wood Cottages
Stoke Wood Lodge

# Appendix 2: Hydrological Assessment

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# Oxfordshire Rail Freight Limited
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# Flow Estimation Record

Birmingham
Livery Place, 35 Livery Street, Colmore Business District
Birmingham, B3 2PB
T: 0121 233 3322

Leeds
Whitehall Waterfront, 2 Riverside Way
Leeds, LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11 Portland Street
Manchester, M1 3HU
T: 0161 233 4260

**Nottingham**
**5th Floor, Waterfront House, Station Street**
**Nottingham, NG2 3DQ**
**T: 0115 924 1100**

August 2025

# DOCUMENT ISSUE RECORD

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| **BWB Reference:** | NTH-2479-FER |

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|---|---|
| **Author:** | [redacted] |
| **Checked:** | [redacted] |
| **Approved:** | [redacted] |

| Rev | Date | Status | Comment | Author: | Checked: | Approved: |
|---|---|---|---|---|---|---|
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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.**

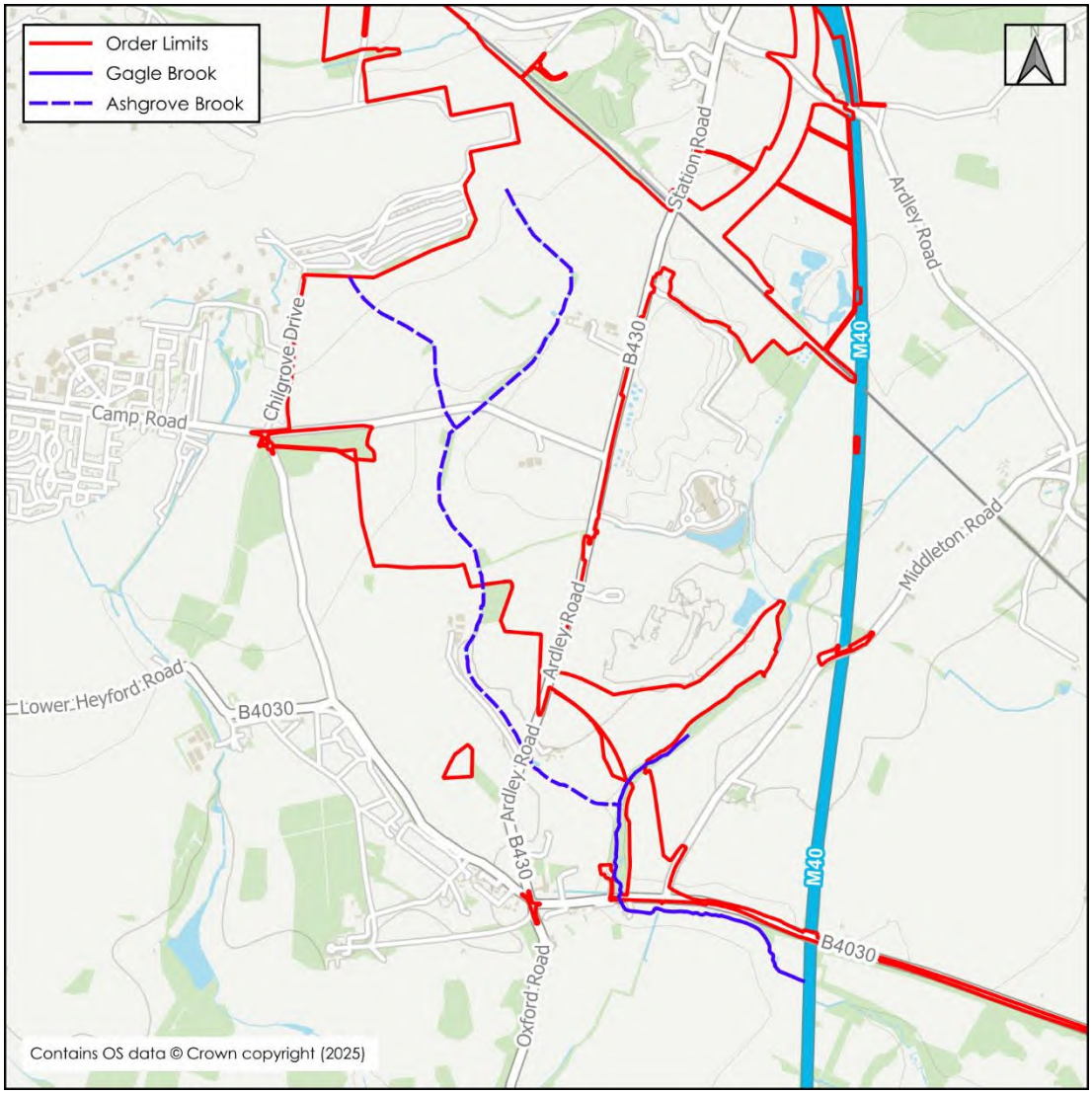


**Figure 1.1: Site Location Plan**

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)

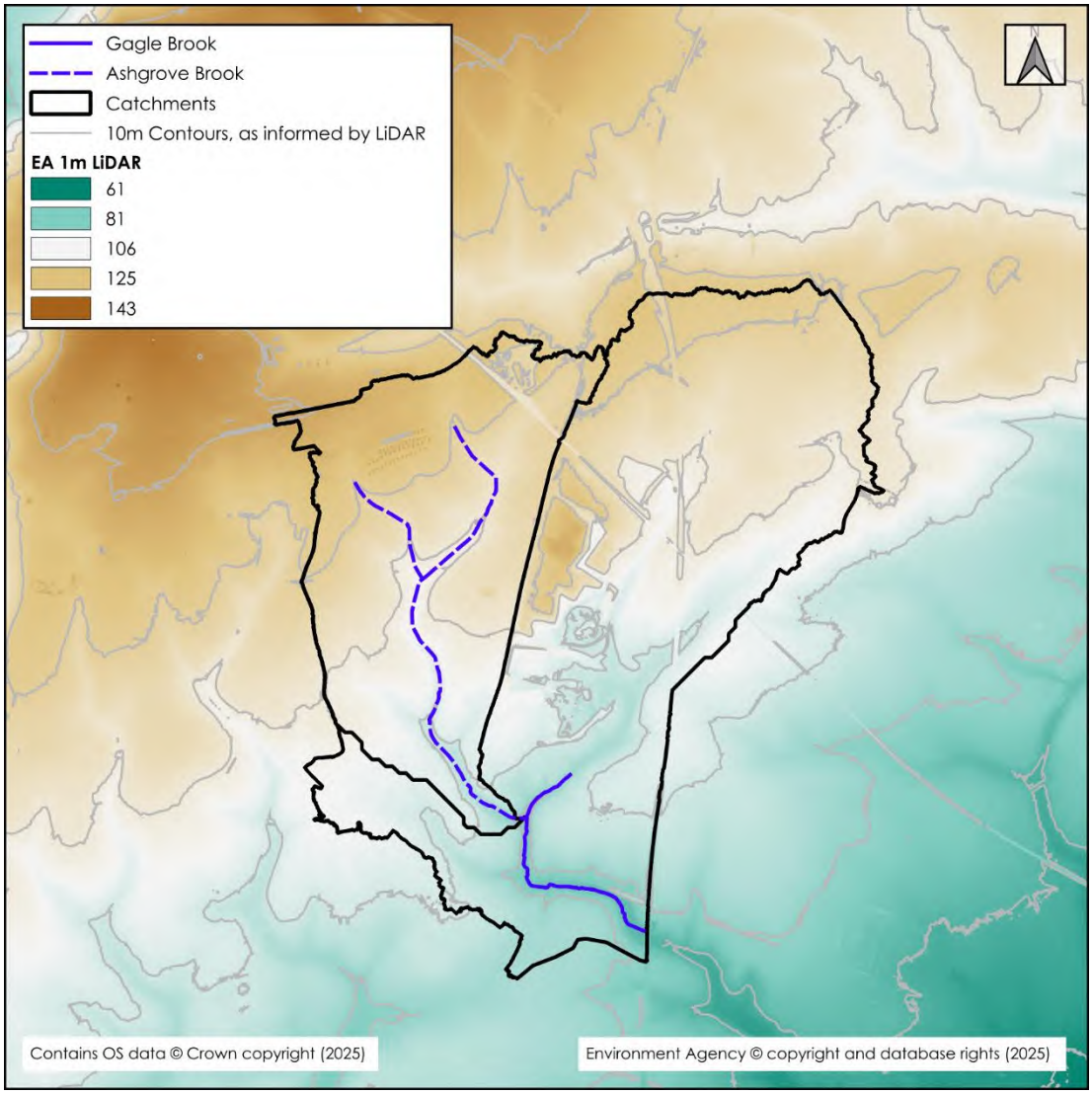


**Figure 1.2: Catchment Topography**

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.<br><br>Both watercourses are culverted in several locations, which means there is the potential for backing up of flows if there is insufficient capacity.<br><br>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.<br><br>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.<br><br>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.<br><br>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. | | | | |

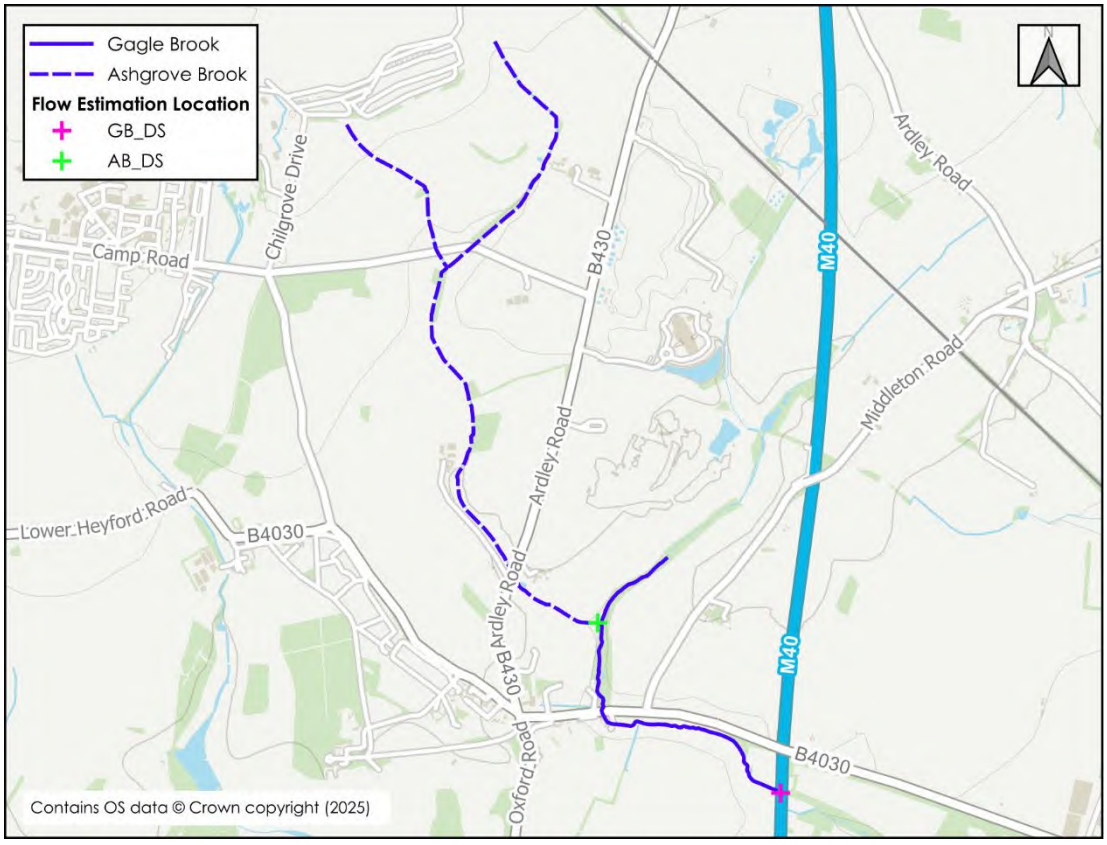


**Figure 2.1: Flow Estimation Locations**

## 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.<br><br>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.<br><br>BFIHOST and SPRHOST values are reasonable based on the geology of the catchment.<br><br>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

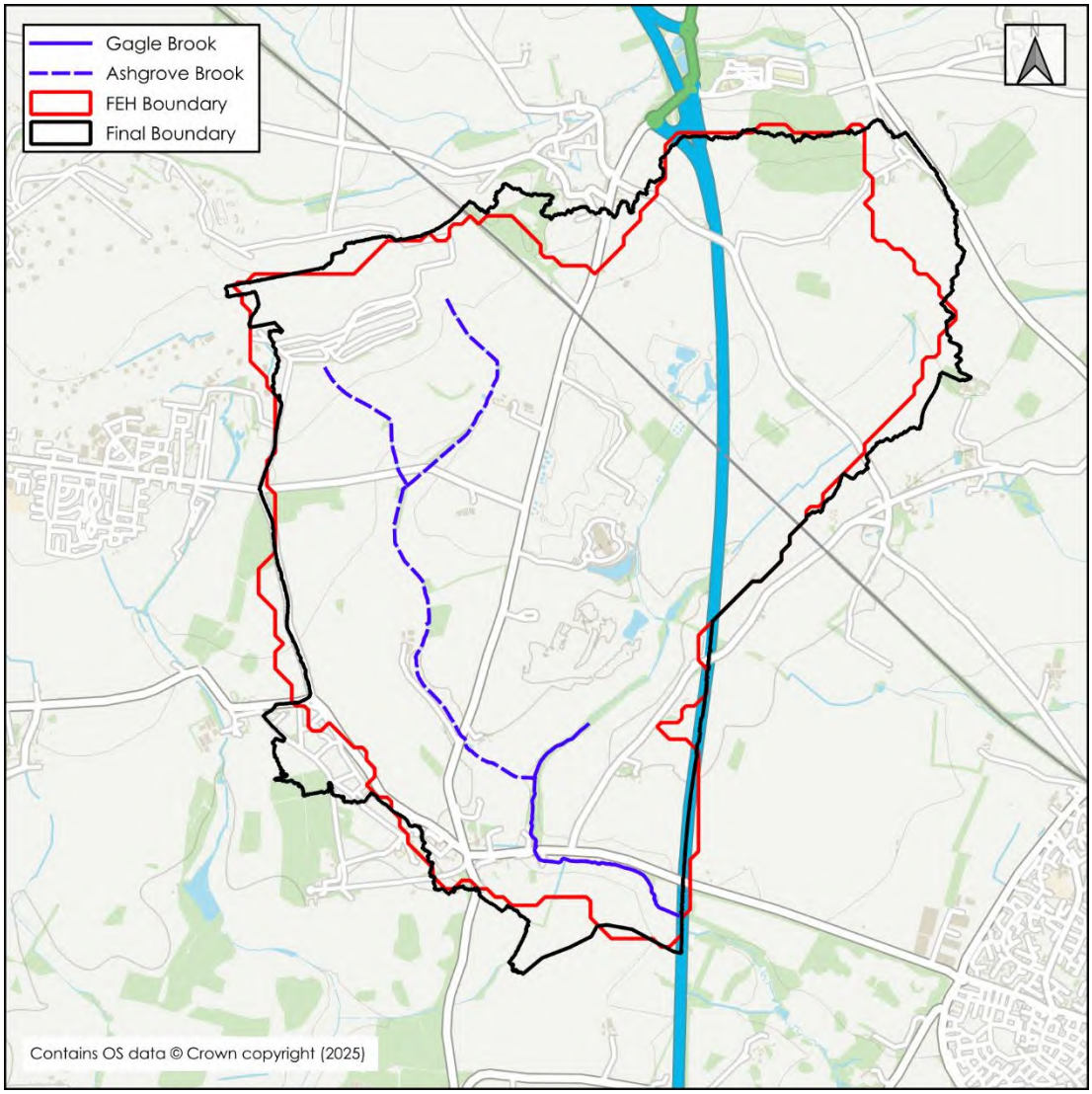


**Figure 2.2: Original and Amended Catchment Boundaries – GB_DS**

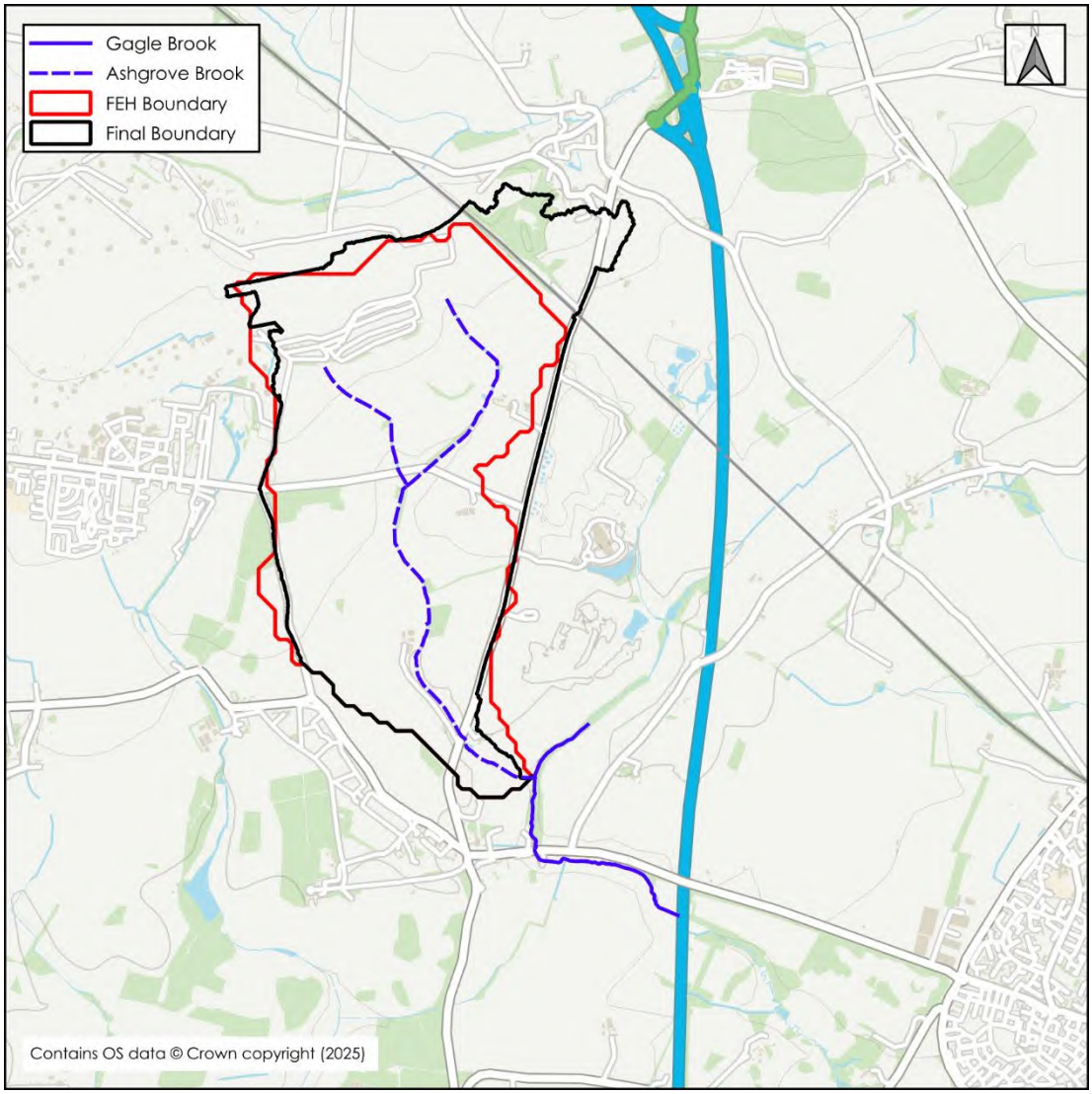


**Figure 2.3: Original and Amended Catchment Boundaries – AB_DS**

# 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:**<br>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.<br><br>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.<br><br>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<br>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.<br><br>**Stations Added:**<br>53017 – added to get pooling group record above 500 years.<br><br>**Comments:**<br>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<br>OPT: Optimisation<br>BR: Baseflow recession fitting<br>CD: Catchment descriptors<br>DT: Data transfer | Tp (hours)<br>Time to peak | $C_{max}$ (mm)<br>Maximum storage capacity | BL (hours)<br>Baseflow lag | BR<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.<br><br>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 |

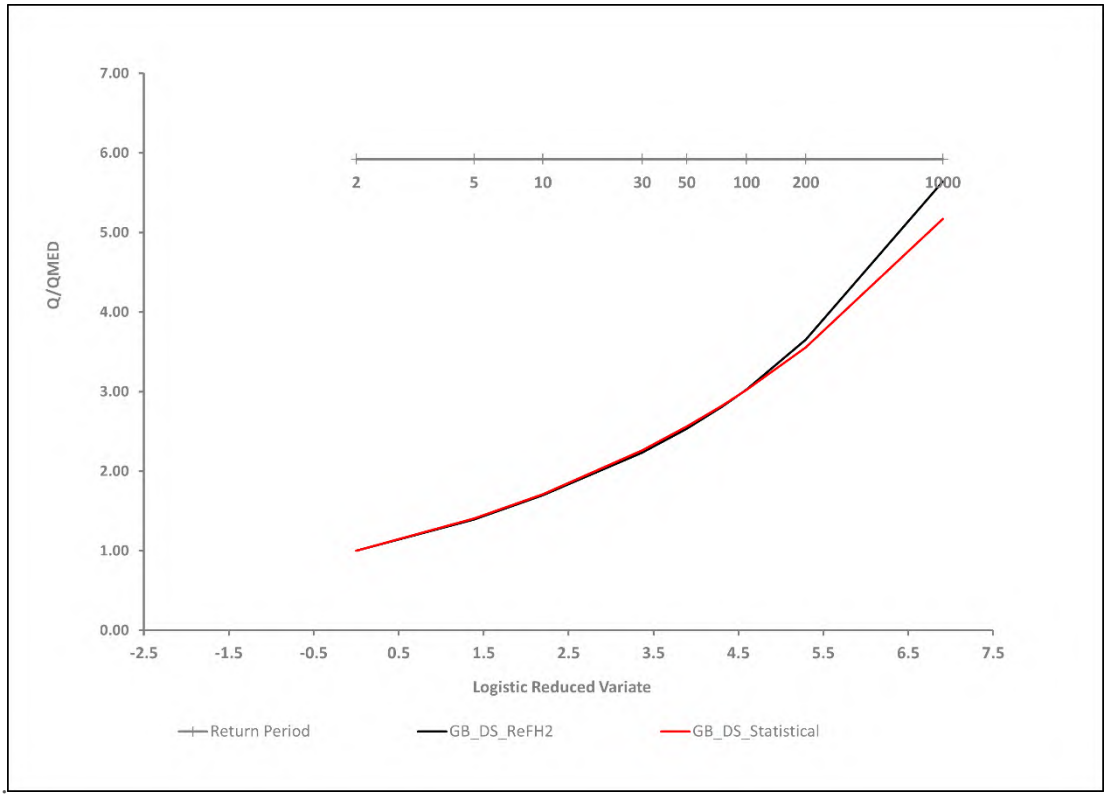


**Figure 5.1: Comparison of Statistical method and ReFH Growth Curves – GB_DS**

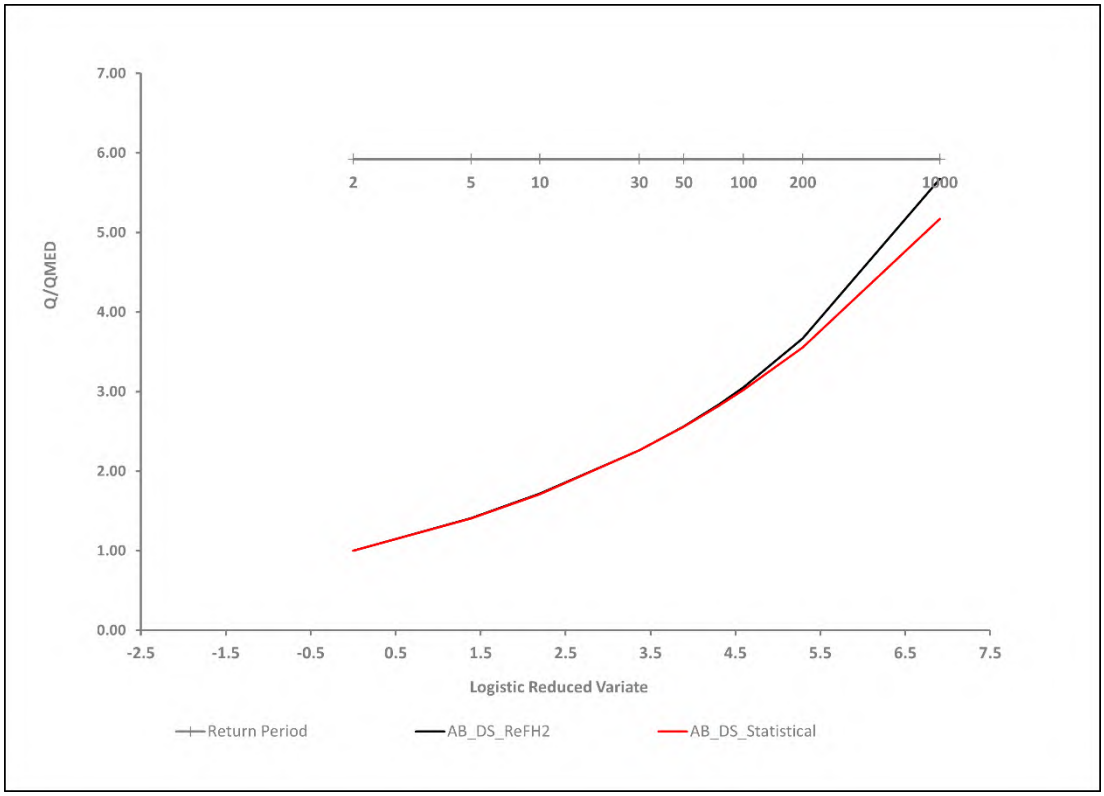


**Figure 5.2: Comparison of Statistical method and ReFH Growth Curves – AB_DS**

## 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.<br><br>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.<br><br>**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.<br>• The ReFH2 hydrograph shape is representative of the catchment response.<br>• Tp and storm duration are representative of the catchment response.<br>• 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.<br>• There are no swallow-holes or springs within the catchment and the groundwater catchment corresponds to the topographical catchment.<br>• 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.<br>• 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.<br>• There is no observed flow data within the catchment with which to verify the flow estimates.<br>• 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.<br>• 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).<br><br>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.<br><br>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.<br>• The 1 in 100-year growth factor for the ReFH2 method is 3.02 for GB_DS and 3.05 for AB_DS.<br><br>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.<br>• 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% |

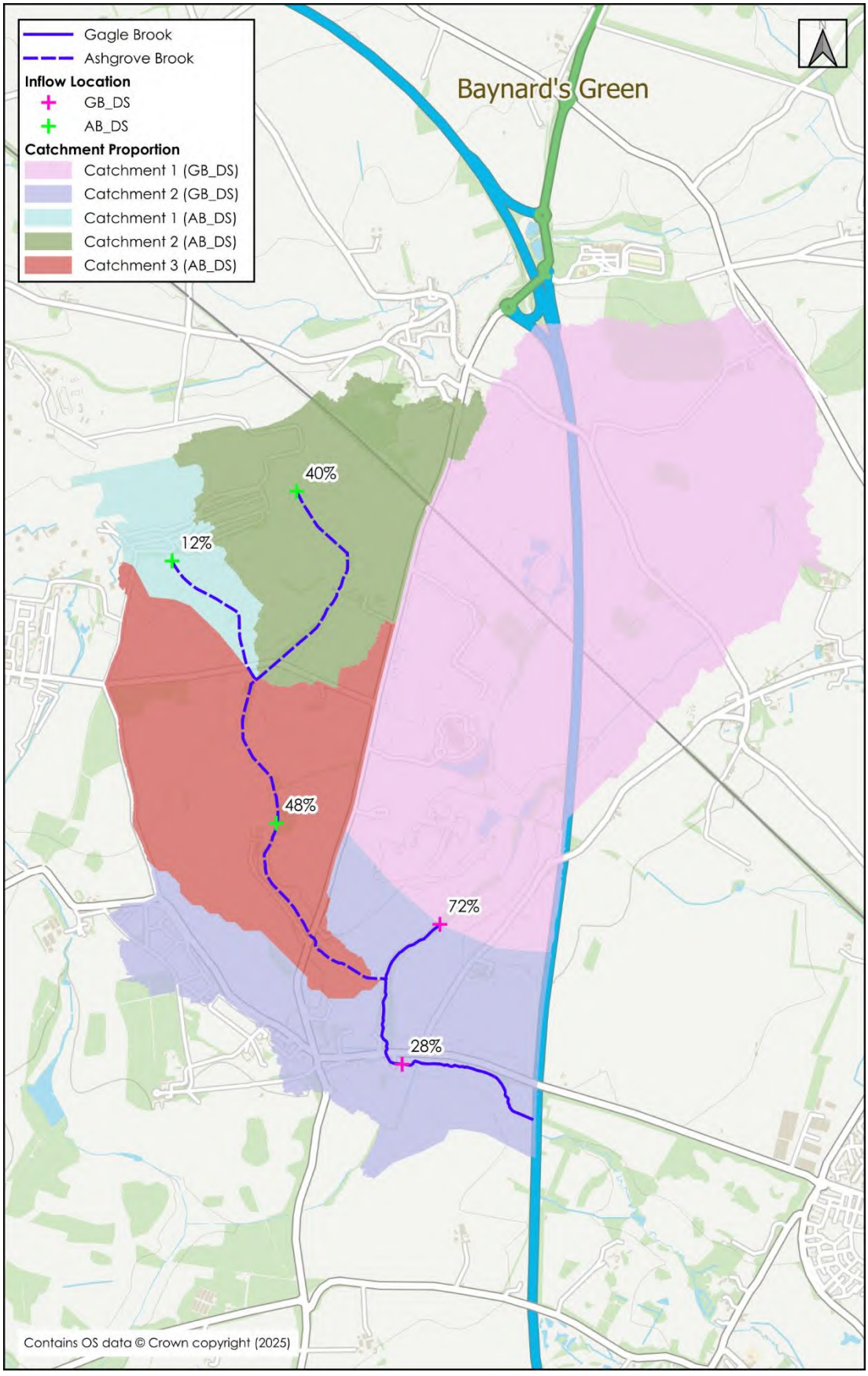


**Figure 6.1: Application of Inflows into Model**

# 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 |

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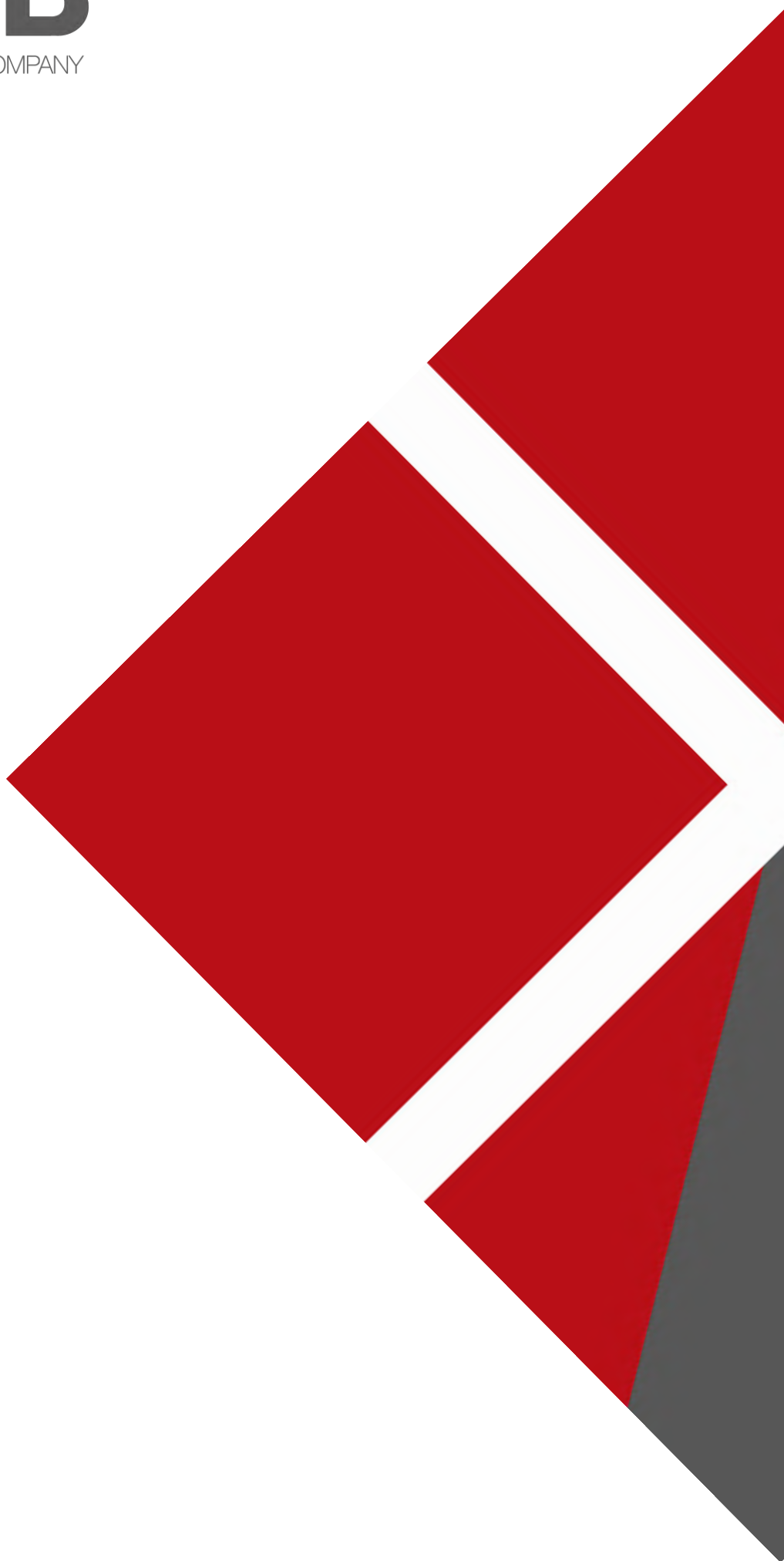

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# Appendix 3: EA Model Review

## Content details

| | |
|---|---|
| Title | Non-real time Hydraulic Model Review Template |
| Audience | Environment Agency, Defra |
| Type | Template |
| Reference | LIT 17617 |
| Version | 9.0 |
| Security marking | OFFICIAL |

## CONTROLLED CONTENT

# NON-REAL TIME HYDRAULIC MODEL REVIEW INTRODUCTION

Below is an overview of what information is required in each sheet. An example has been shown below each description.

A model review process summary is provided below the example. This includes information on the RAG status and how this is decided.

Fill out summary tab first. Here details any stop/go actions. These must be completed before continuing on.

There is a tab titled: *"Reference_info._EA_Staff"*. This tab is for internal Environment Agency staff only and references tools only available within the EA.

For further information or details on this document please contact: MSQA@environment-agency.gov.uk

To provide feedback on this document, please use this form: Quality Assurance Feedback Form

| **Sheet title** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Sub-section title | | | | | | | |
| **Item number** | **Item question** | **Stop/Go item** | **Model developer comments** | **Reviewer comments** | **RAG** | **Actions for model developer** | **Model developer response** |
| Colour code item number if fluvial only (blue) or coastal only (orange) | Questions to be answered as part of the review | Colour coded to allow reviewer to identify if this is a stop/go action as described on the summary sheet | Model developer to provide comments before review is undertaken within EA | Comments provided by the EA reviewer on the item question. This should detail what has and has not been provided. And justification for their review comments | This is based on the colour coding detailed below | The EA reviewer will detail exactly what is required in this space. These are the actions that are required by the model developer. | This is a space for the model developer to provide comments back based on the actions for model developer comments. |
| | | | | | | | |
| 1.4 | Are all model files provided? | Stop/go point | | Model didn't run in 1D and highlighted that these files are missing;.....<br>Stopped review. | Red | All model files to be provided including these:..... | |

## MODEL REVIEW PROCESS

Hydraulic Model reviews are an essential component of the Hydraulic Modelling Quality Assurance (QA) process that provides confidence in a model's suitability for its intended purpose. Evidence that the model has undergone QA may be requested by external parties
and hence all reviews should be written with an expectation that they could be read externally.

To start the review process select the 'Type of review' and 'Level of Assurance' in the top of the Summary Tab. Note, the 'Level of Assurance' option is for Internal reviews only. If you are an external reviewer or model developer select the 'Full / LUP' option. A Lite review involves the removal of some of the review items which will be greyed out if this option is selected. There are also comments for Lite review in the notes to guide how these checks shall be undertaken.

Should any issue(s) be raised during the review process, which require attention, the reviewer should detail the action(s) required in sufficient detail to allow the modeller to complete the changes as appropriate. Completion of this Model Review document does not automatically constitute model approval. Once the suggested changes have been completed, the reviewer may require that the model be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all amendments have
been completed satisfactorily, will the model be considered appropriate for it's intended purpose.

It is recommended that the reviewer makes use of the Fluvial Design Guide (Chapter 7) relevant software manuals and any available modelling standards when completing the review.

Depending on the work being reviewed some questions or entire sections may not be relevant, in which case they can be set to not applicable. On completion of the review the reviewer may choose to use the following colour coding system below to alert the modeller to
the priority of the actions required (if any).

**Colour coding used:**

**OK** – Good practice.
Minimum response: No minimum.
Maximum expected response: No maximum.
Planning: No Objection.

**Green** – Consider for future studies. Negligible impact on the results that is unlikely to change the outcome of the study.
Minimum response: Acknowledge the comment in the spreadsheet and update the limitation section of the report.
Maximum expected response: Actions done to address the issue identified.
Planning: No Objection.

*Note: Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.*

**Amber** – Follow recommendation. Potential impact on the results that may change the outcome of the study.
Minimum response: Comments justifying the approach taken and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Consider objecting to the application based on comments highlighted in this category.

*Note: Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.*

**Red** – Must do. Has an impact on the results that may have a significant impact on the outcome of the study.
Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Objection - Application to be objected if comments are highlighted in this category.
*Note: If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidence. If issues highlighted red are ignored, then submissions should always be sent back.*

# NON-REAL TIME HYDRAULIC MODEL REVIEW

Please select from the drop down the type of review you are doing. This will then open the appropriate tabs.
If an Internal EA reviewer, please select 'Level of Assurance' based on the Quality Assurance Record.
External reviewers and model developers should select 'Full / LUP'.
Please note if you select the wrong type of review from the drop down and the sheets do not refresh when you select another option, you can either:
1. Download and start a new sheet
2. Right-click at the bottom where the sheets are and select '*Unhide*', then select the sheets you require. These should then become visible

| | | | |
|---|---|---|---|
| **Type of review** | Fluvial and/or tidal 1D-2D | **Level of Assurance** | Full / LUP |
| **Project** | Oxfordshire Strategic Rail Freight Interchange (SRFI) project | **Job Number** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Software** | Estry/TUFLOW | **Software version:** | FLOW version 2025.0.2-i | **2nd review** | **3rd review** | **4th review** |
| **Revision** | 1 | **Date** | 09/02/2026 | | | |
| **Area Client** | National | **Reviewer** | [redacted] | | | |

## PROJECT DESCRIPTION & REQUIREMENTS

| | |
|---|---|
| **Please detail what the model is for including project description & requirements** | Hydraulic modelling undertaken using ESTRY-TUFLOW software of the Gagle Brook and Ashgrove brook to support the development of the Oxfordshire Strategic Rail Freight Interchange (SRFI) project. Modelling has been undertaken by BWB Consulting. An accompanying model report dated January 2026 (document reference: OXSRFI-BWB-ZZ-XX-T-W-1001_HMR) describes the model build and input hydrology. The Gagle and Ashgrove Brooks are Ordinary Watercourses. |

At the beginning of your review, if you answer 'no' to any of the items listed below, consider whether the review should continue. If the review will be fundamentally impeded by any of these items, stop the review and place on hold until further information is received.

| Item number | Stop/go actions | Yes or no? | Comments | Stop or go |
|---|---|---|---|---|
| 1.3 | Are all model files provided? | Yes | Yes. All model files have been provided | Go |
| 1.5 | Does the model run? | Yes | _Brook_0100+49_EXG_027 and Gagle_B | Go |
| 1.6 | Have all additional project files been provided to enable a review (i.e. model report, survey etc.)? | Yes | as been provided (document reference: C | Go |
| 10.1 - Coastal | What probability method has been used for the study? Does the approrach conform with best practice? | | Not applicable | |
| 10.4 - Coastal | Has the Coastal Flood Boundary (CFB) data been applied appropriately within the models? | | Not applicable | |
| 11.29 - Coastal | Has emulation been used in the model? If so, is the emulation appropriate to inform the model design runs? | | Not applicable | |

## REVIEW SUMMARY/CONCLUSION

| | |
|---|---|
| **Is the model suitable for intended use?** | The existing and proposed models are well schematised. The results show that flood risk is relatively constrained to the channels for the Ashgrove and Gagle Brooks. There are just a few minor comments for further consideration. These are detailed below for ease. Further details can be found in subsequent sections of this review workbook.<br><br>1. As noted within the model report, please include the proposed diversion and culverting on the upper reaches of the Ashgrove Brook once the design detail is known<br><br>2. What is the rationale for the slightly lower flows applied to AB_1, AB_2, and AB_3 in the proposed scenario when compared to the baseline scenario? The scaling factors for these inflows are reduced in the proposed scenario when compared to the baseline which results in a 28% reduction in flow. For example, for the 1% AEP existing scenario the combined peak flow for AB_1, AB_2, and AB_3 is 0.6m3/s. In the proposed scenario this reduces to 0.43m3/s. Is this due to the incorporation of SUDs within the proposed development site which would limit runoff rates? Please see comment 4.2 within worksheet ***1D_Boundary_Conditions*** for further details<br><br>3. It is noted that there is a potential culverted reach at the outlet to the pond at cross section *GBT1_02793_A* in the existing scenario which is not included. What are the implications of not including this in the baseline scenario? Please see comment 5.1 within worksheet ***1D_Structures*** for further details<br><br>4. What is the rationale for the differing 1d initial water levels applied to the model at coincident cross sections between the existing and proposed scenarios? Please see comment 14.2 within worksheet ***Run_Parameters*** |

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For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## MODEL SUMMARY

| MODEL APPROACH & SUMMARY | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Item No.** | **Item Checked** | **Stop/Go item** | **Model developer comments** | **RAG 1** | **1st Review Comments** | **1st Actions for model developer** | **1st Model developer response (DATE)** | **RAG 2** | **2nd Review Comments** | **2nd Model developer response (DATE)** | **RAG 3** | **3rd Review Comments** | **3rd Model developer response (DATE)** | **RAG 4** | **4th Review Comments** | **4th Model developer response (DATE)** |
| 1.1 | What model approach has been adopted? Is it appropriate? **HEC-RAS:** if it is only a steady state model - is it appropriate or is unsteady flow required? | N/A | | OK | A 1d-2d linked approach has been adopted using ESTRY-TUFLOW software (Tuflow build 2025.0.2). A HPC solution scheme has been adopted. This is considered reasonable. | No further action required | | | | | | | | | | |
| 1.2 | What model version are you reviewing? | N/A | | OK | First submission of detailed hydraulic model including both the existing and proposed scenarios. | No further action required | | | | | | | | | | |
| 1.3 | Are all model files provided? | Yes. Check summary sheet | | OK | Yes. All model files have been provided | No further action required | | | | | | | | | | |
| 1.4 | Does the vertical chainage (upstream to downstream) in the model approximately match chainage based on survey or base mapping? | N/A | | OK | Model chainage is considered reasonable | No further action required | | | | | | | | | | |
| 1.5 | Does the model run? | Yes. Check summary sheet | | OK | Yes. Check runs were undertaken for the existing and proposed 1 in 100 year plus 49% CC scenario (Gagle_Brook_0100+49_EXG_027 and Gagle_Brook_0100+49_PRO_026) using Tuflow build 2025.0.0-iDP. Both scenarios ran to completion with no issues | No further action required | | | | | | | | | | |
| **MODEL MANAGEMENT** | | | | | | | | | | | | | | | | |
| 1.6 | Have all additional project files been provided to enable a review (i.e. model report, survey etc.)? | Yes. Check summary sheet | | OK | An accompanying model report and FEH calculation record has been provided. The model report also includes channel cross section and structure survey. The | No further action required | | | | | | | | | | |
| 1.7 | Was a suitable file naming, structure & management system used? | N/A | | OK | Model file naming convention and folder structure is considered reasonable | No further action required | | | | | | | | | | |
| 1.8 | Have check files been provided to enable a review or can they be generated via a model re-run? | N/A | | OK | Yes. Check files were provided and also generated as part of the existing and proposed scenario check runs | No further action required | | | | | | | | | | |
| 1.9 | Is model reporting sufficient to understand the scope of the project, how the model has been built and the quality of the modelling? | N/A | | OK | Yes. The model report is considered sufficiently detailed to understand the scope of the project and the model build. The model report also includes water level difference mapping across a range of scenarios which shows the impact of the proposed | No further action required | | | | | | | | | | |

## Area comments

**This sections is for any comments that area or senior users have on the model that will be reviewed. Please provide comments below**

| Area comments | | |
|---|---|---|
| Item No. | Initials | |
| 200.1 | | |
| 200.2 | | |
| 200.3 | | |
| 200.4 | | |
| 200.5 | | |
| 200.6 | | |
| 200.7 | | |
| 200.8 | | |
| 200.9 | | |
| 201 | | |

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For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## MODEL SCENARIOS

| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **EVENTS & SCENARIOS** | | | | | | | | | | | | | | |
| 2.1 | Are the simulated events sufficient to meet project requirements? | | OK | Yes. The 1 in 30, 1 in 100), and 1in 1000-year AEP scenarios have been simulated for the existing and proposed scenarios. This is considered reasonable | No further action required | | | | | | | | | | |
| 2.2 | Are climate change runs aligned with current guidance? | | OK | With respect to climate change, the proposed development falls within the Cherwell and Ray management catchment. Climate change uplifts for the 2080s epoch are 15% (central), 25% (higher central), and 49% (upper). The 1% (1 in 100) AEP plus 15%, 25%, and 49% climate change scenarios have been run through the hydraulic model for both the baseline (EXG) and proposed scenarios (PRO). A check of inflow data within Floodflows_005.csv shows that climate change scaling factors have been appropriately applied. Please see worksheet ***Inflow_and_CC_Check*** for further details | No further action required | | | | | | | | | | |
| 2.3 | Are undefended scenarios required (for Flood Zones etc.) and if so have any raised defences and structures been removed in line with guidance? | | N/A | There are no raised defences within the model domain. Undefended modelling for the purposes of updating the Flood Map for Planning is not required. | Not applicable | | | | | | | | | | |
| | **SCHEME PROJECTS** | | | | | | | | | | | | | | |
| 2.4 | Where a scheme is being developed, have appropriate model runs been provided to compare the baseline and with-scheme scenarios? Have the with-scheme scenarios been schematised appropriately? | | N/A | The modelling is not being used for the development of a Flood Alleviation Scheme | Not applicable | | | | | | | | | | |
| 2.5 | Has a study for quantifying uncertainty been undertaken? How was this derived and does it seem sensible? | | N/A | Not applicable. A full residual uncertainty assessment using the 2017 residual uncertainty guidance is not considered necessary for a project of this nature. Sensitivity testing is considered suitable for understanding uncertainties. Please see comment 16.8 within worksheet Model_Performance for further details | Not applicable | | | | | | | | | | |
| | **DEVELOPMENT PROJECTS** | | | | | | | | | | | | | | |
| 2.6 | Where a development is being proposed, have appropriate model runs been provided to compare the baseline and with-development scenarios? | | OK | Yes. Appropriate model runs have been undertaken to compare the baseline and proposed development | No further action required | | | | | | | | | | |
| 2.7 | Where post development modelling is required, has this been considered within the modelling adequately and are the proposals represented in line with design drawings? | | Green | The existing model the 1d network is defined by *1d_nwke_GB_014_L.shp* . For the proposed scenario *1d_nwke_GB_020_L_PRO.shp* is used. In the proposed scenario the Ashgrove Brook which crosses the main site has been removed. There is no representation within the hydraulic model for this diversion. The modelling report notes that 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. It is recommended that the proposed diversions are included within the hydraulic model once the design has been confirmed. Aside from the amendments to the 2d domain of the model which are described and reviewed in later sections of this spreadsheet, a series of new culverts are proposed the location of which are shown in figure 5.1 and the corresponding dimensional detail is presented in table 5.1. These are appropriately represented within the model | As noted within the model report, please include the proposed diversion and culverting on the upper reaches of the Ashgrove Brook once the design detail is known | Noted, once the detailed design is known this can be included. However, at this stage, we are unlikely to have information on this culvert. | | | | | | | | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 1D MODEL BUILD

| 1D NETWORK | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
| 3.1 | Have appropriate distances between sections and/or nodes been used? | | OK | ESTRY Channel cross section spacing is considered reasonable. | No further action required | | | | | | | | | | |
| 3.2 | Is the model geo-referenced? | | OK | Yes. The model is georeferenced. | No further action required | | | | | | | | | | |
| 3.3 | Do the cross sections and bed profiles look reasonable? | | OK | ESTRY channel cross sections look reasonable, and channel cross sections geometry aligns with the detail shown on the survey drawings in Appendix 1 of the model report dated January 2026. Please see worksheet ***ESTRY_Cross_Section_Check*** for further details | No further action required | | | | | | | | | | |
| 3.4 | Does conveyance look appropriate? | | OK | ESTRY 1d cross section conveyance looks reasonable. There are no notable areas of negative conveyance based on a review of *Gagle_Brook_0100+49_EXG_027_1d_ta_tables_check.csv* | No further action required | | | | | | | | | | |
| 3.5 | Bank Markers. Are they used and if so, are they suitably located? | | N/A | Not applicable. Bank Markers are not used in ESTRY | Not applicable | | | | | | | | | | |
| 3.6 | What method has been used to estimate roughness? What values have been used for the floodplain (if 1D only model) and channel? Are these appropriate? | | OK | Mannings roughness values for the bed of generally between 0.035 and 0.04 have been applied (there are some isolated locations where higher values have been used). For the banks values of between 0.05 and 0.1 have been applied. Detail on the application of mannings roughness is described in section 3.8 of the model report and an example reach photograph for the Gagle Brook is shown in table 3.1. Channel cross section roughness is plotted and shown within worksheet ***ESTRY_Cross_Section_Check***. The adopted values appear reasonable | No further action required | | | | | | | | | | |
| 3.7 | **HEC-RAS:** Do the cross sections contain ineffective flow areas. If so, have they been applied correctly? | | N/A | Not applicable. Not a HEC-RAS model | Not applicable | | | | | | | | | | |

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For 'lite' level of assurance, greyed out rows **do not** need to be filled out

| 1D BOUNDARY CONDITIONS | | |
|---|---|---|

**1D BOUNDARY CONDITIONS**

| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.1 | Is there 'glass walling' anywhere in the modelled reaches? Are out of bank flows represented in 1D? If so, how has it been done and is it appropriate? | | N/A | Not applicable. 1d ESTRY cross sections are linked to the 2d domain using Head Exchange boundaries in both the existing and proposed scenarios | Not applicable | | | | | | | | | | |
| 4.2 | How have the inflows boundaries been applied? | | Amber | Inflows are applied to the hydraulic model using inflow points *1d_bc_Inflows_GB_003_P* and lateral distribution polygon *1d_bc_Lateral_Inflows_GB_002_R.shp*. In the proposed scenario *1d_bc_Inflows_GB_005_P_PRO.shp* is used. The placement and naming of inflow points between the existing and proposed scenario is largely the same, however, in the proposed scenario inflow points AB_1 and AB_2 have been moved further south (circa 850 metres and 650 metres respectively) to account for the proposed development and removal of the Upper reaches of the Ashgrove and Gagle Brooks. Input flow hydrograph data is contained within Floodflows_005.csv. This is consistent between both the existing and proposed scenarios although the scaling factors applied to AB_1, AB_2, and AB_3 are reduced when compared to the baseline scenario (please see worksheet ***Inflow_and_CC_Check***). For the existing scenario, inflows applied to the model are consistent with the design flow estimates shown in Table 2.1 of the model report (accounting for the removal of Ashgrove Brook estimates from the Gagle Brook estimates to avoid double counting). There is good reconciliation between the modelled flows at the downstream end of the hydraulic model and the calculated peak flows for GB_DS | What is the rationale for the slightly lower flows applied to AB_1, AB_2, and AB_3 in the proposed scenario when compared to the baseline scenario? The scaling factors for these inflows are reduced in the proposed scenario when compared to the baseline which results in a 28% reduction in flow. For example, for the 1% AEP existing scenario the combined peak flow for AB_1, AB_2, and AB_3 is 0.6m3/s. In the proposed scenario this reduces to 0.43m3/s. Is this due to the incorporation of SUDs within the proposed development site which would limit runoff rates? | Yes, as noted in paragraph 5.5, the hydrology was adjusted to remove the proposed development as this will be served by the proposed drainage infrastructure.<br><br>Additional information has been provided within the Hydraulic Model Report. | | | | | | | | | |
| 4.3 | How is the downstream boundary(s) applied? Have appropriate locations been chosen for the downstream model extents? | | OK | The downstream boundary of the model is located at the M40 at cross section GB_00175 in both the existing and proposed scenarios. A HT boundary is applied at the downstream end of the hydraulic model. A fixed water level of 81.01 mAOD is applied as shown within *Floodflows_005.csv*. This aligns with what is reported in section 3.13 of BWB's model report dated January 2026. The modelling report notes that the downstream boundary is based on the surveyed water level at the downstream cross section GB_00175. A review of the surveyed water level shown at cross section GB_00175 within Appendix 1 of the model report confirms this to be the case. It is noted that there is a culvert underneath the M40 which would result in some potential energy losses at the downstream boundary which could affect water levels upstream. It is noted that a sensitivity test has been undertaken on downstream boundary conditions, this shows limited variation in water levels and not effect at the proposed development site. On this basis the approach to the downstream boundary is considered reasonable. It is not considered necessary to include the M40 culvert | No further action required | | | | | | | | | |
| 4.4 | **If tidal -** how has the boundary been derived? | | N/A | Not applicable. Not a tidal model | Not applicable | | | | | | | | | | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 1D STRUCTURES

| 1D STRUCTURES | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
| 5.1 | Are all structures represented (inc. movable structures)? If not, have explanations for structures not modelled been given in the reporting? | | Green | All key structures appear to be represented although in the existing scenario there is a culvert at the outlet of the pond just to the southwest of Ashgrove Farm which is not included within the model (section *GBT1_02793_A* grid reference: 453465, 226070). Section 3.3 page 17 of the model report notes that a series of cross sections are based on Lidar where survey was unavailable at these ponds so it may be that it was not possible to survey this small, culverted section. The use of an open channel cross section rather than a culverted reach in this location is likely to result in potentially more pass forward flow. It is noted that in the proposed scenario a circular 0.9m diameter culvert is included at this location (*GBT1_02793_A*) which ties in with the dimensional detail presented in table 5.1 of the model report. | It is noted that there is a potential culverted reach at the outlet to the pond at cross section GBT1_02793_A in the existing scenario which is not included. What are the implications of not including this in the baseline scenario? | It is considered more conservative to model the channel as open as this passes more flow downstream. Therefore, this has been retained at this stage. | | | | | | | | | |
| 5.2 | Are invert levels correct compared to survey data? | | OK | Structure representation within the hydraulic model in the existing scenario aligns with the dimensional detail presented in Appendix 3 (table of structures) within the modelling report. The culverts in the proposed scenario align with the dimensional detail presented in table 5.1 of the modelling report when considering the sedimentation allowance. For further details please see worksheet ***Proposed_Structure_Check*** | No further action required | | | | | | | | | | |
| 5.3 | Do bridges surcharge? If so has orifice flow been enabled? | | N/A | Not applicable to ESTRY structures. Relevant only for Flood Modeller Arch and USBPR bridges. | Not applicable | | | | | | | | | | |
| 5.4 | Where structures bypass or overtop, have spills been represented correctly to reflect this? | | OK | In the existing and proposed scenarios spills are represented either in 2d where a Head Exchange Line is placed perpendicular to flow or using 1d ESTRY weirs where bridge decks are narrow with respect to the 2d model grid resolution. Bridge decks are appropriately represented in the model DTM where a 2d representation is used. Where a 1d representation is used, spill width (eN1) and spill depth (eN2) appear reasonable. In the proposed scenario there is no spill over culvert *GBT_01517_P* and *GBT1_02298_P* but the elevation of the bridge decks are sufficiently high that spilling would not occur. | No further action required | | | | | | | | | | |
| 5.5 | Have structure coefficients been changed from default values? If so, are these changes appropriate and justified? | | OK | Default values adopted. | No further action required | | | | | | | | | | |
| 5.6 | Have appropriate roughness values been used? | | OK | Roughness values for culverts and bridges in the existing and proposed scenarios are considered reasonable. | No further action required | | | | | | | | | | |

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For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 2D MODEL BUILD

| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
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| **DIGITAL TERRIAN MODEL** | | | | | | | | | | | | | | | |
| 6.1 | What datasets have been used to define the floodplain (i.e. LiDAR, topographic survey etc.) and have these datasets been correctly represented in the model DTM? | | OK | Several Lidar datasets are "read-in" via the existing (*Gagle_Brook_EXG_016.tgc*) and proposed (*Gagle_Brook_PRO_014.tgc*) Tuflow Geometry Control files. The existing and proposed digital terrain models are largely consistent except for *Proposed_Main Site Finished Levels_P01.asc* and *Proposed_Middleton Stoney Relief Road_P01.asc* which are additional files referenced in the proposed scenario. Initially EA 2 metre resolution Lidar data is used (Merged_LiDAR.asc). This is then "over stamped" with several DTM datasets from *BWB-Middleton-Stoney-DTM-A1.asc* through to *BWB-Middleton-Stoney-DTM-E4.asc* (17 in total) and *Topo_Survey_Rev4_GB.asc*. A review of the respective final model DTMs (DEM_Z files) suggests reasonable topography and no notable cliff edges at the interface between different Lidar datasets. As part of this review a comparison was undertaken comparing the proposed and baseline model DTMs (DEM_Z). This shows topographic adjustments only in the areas which are expected. Please see worksheet ***DTM_Check*** for further details | No further action required | | | | | | | | | | | |
| 6.2 | What grid resolution has been used within the model and is it suitable to capture key flow routes within the model (e.g. between buildings) | | OK | A grid resolution of 2 metres is adopted in both the existing and proposed scenarios. This is considered reasonable | No further action required | | | | | | | | | | |
| 6.3 | Has the DTM been rotated to optimise flow route representation? Is this appropriate? | | OK | DTM orientation as defined by *2d_loc_GB_001_L.shp* is considered reasonable. | No further action required | | | | | | | | | | |
| 6.4 | How have buildings been represented within the DTM? Is this appropriate? | | OK | In the existing scenario buildings are represented in the DTM using *2d_mat_Buildings_GB_001_R.shp*. In the proposed scenario *2d_mat_Buildings_GB_002_R_PRO.shp*. Both use a material value of 10021 which relates to a mannings roughness of 0.5 within *Gagle_Brook_Materials_001.tmf*. Topographic adjustments are not made to building footprints. The representation of buildings appears reasonable. | No further action required | | | | | | | | | | |
| 6.5 | Are bank crests accurately represented? | | OK | In the existing scenario banks are represented using *2d_zln_EA_LiDAR_Banks_GB_008_P.shp*, *2d_zln_Flythru_Banks_GB_008_P.shp*, *2d_zln_Topo_Banks_GB_009_P.shp*, and *2d_zln_XS_Banks_GB_009_P.shp*. In the proposed scenario banks are represented using *2d_zln_Banks_GB_010_L_PRO.shp*, *2d_zln_Flythru_Banks_GB_002_P_PRO.shp*, *2d_zln_Topo_Banks_GB_008_P_PRO.shp*, and *2d_zln_XS_Banks_GB_009_P_PRO.shp*. As part of this review the elevations within the respective existing and proposed 1d_2d check files (lowest ZC_2d) were compared. The differences between bank elevations at coincident elevations points between the existing and proposed models are confined to the area where the main site is proposed and also where culvert GB_01875_P is proposed. A sense check of bank elevations was undertaken by comparing them to 2 metre resolution Lidar data (*Merged_Lidar.asc*). This comparison shows largely good agreement, some differences are to be expected given the placement of bank elevation points with respect to the Lidar data. | No further action required | | | | | | | | | | |
| 6.6 | Are raised defences/embankments accurately represented? | | N/A | There are no formal raised defences along the modelled reach | Not applicable | | | | | | | | | | |
| 6.7 | Are conveyance routes underneath raised embankments accurately represented? | | OK | There are no structures in the 2d domain of the hydraulic model. Key conveyance routes are under the road to Upper Heyford (represented in 1d), underneath Ardley Road (represented in 1d), and underneath the B4030 to Middleton Stoney. Road embankments are appropriately represented in the model DTM. | No further action required | | | | | | | | | | |
| **2D ROUGHNESS** | | | | | | | | | | | | | | | |
| 6.8 | What method has been used to estimate roughness? What values have been used for the floodplain and channel (for a 2D only model)? Are these appropriate? | | OK | Floodplain roughness values are defined within *Gagle_Brook_Materials_001.tmf*. The adopted values based on different land use classifications appear reasonable. The accompanying model report describes how roughness values were determined using aerial imagery, site photographs and Ordnance Survey base mapping data. This is reasonable. A review of the apportionment of roughness across the model domain based on the respective DEM_M check files shows different land use types have been appropriately mapped and included in the existing and proposed scenarios | No further action required | | | | | | | | | | |
| 6.9 | Is the representation of different roughness areas sufficiently accurate and detailed? | | | | | | | | | | | | | | |

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## 2D BOUNDARIES

| 2D BOUNDARY CONDITIONS | | | | | | | | | | | | | | |
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| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
| 7.1 | Have any 2D boundaries been used in the model and if so are these schematised correctly? | | OK | Head Exchange (HX) boundaries are used to link the 1d ESTRY and 2d Tuflow domains of the model. At the downstream boundary with the M40 a slope (HQ boundary) is applied (baseline: *2d_bc_dsb_GB_001_L.shp* and proposed: *2d_bc_dsb_GB_001_L.shp* ). A slope of 0.022 metres/metre is applied. The slope values appears reasonable based on Lidar data but there is no out of bank flooding in this location so the 2d downstream boundary condition does not come into effect. | Not further action required | | | | | | | | | | |
| 7.2 | Is there 'glass walling' anywhere in the modelled reach where outputs reach the model domain boundary? | | OK | The 2d code layer (*2d_code_GB_004_R* ) is large enough to ensure no glass walling occurs. Flood extent is largely contained to the channel. | Not further action required | | | | | | | | | | |
| 7.3 | For direct rainfall modelling how has the input rainfall been applied? | | N/A | Not applicable. Not a direct rainfall model. | Not applicable | | | | | | | | | | |

For 'lite' level of assurance, greyed out rows **do not** need to be filled out

## 2D STRUCTURES

| 2D STRUCTURES | | | | | | | | | | | | | | | |
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| 8.1 | Have any structures been included in the 2D domain (floodplain or channel) and how have they been represented? Are structure details (invert, length etc.) correct compared to survey? | | N/A | Not applicable. There are no structures in the 2d domain of the model | Not applicable | | | | | | | | | | |
| 8.2 | Are values of roughness and loss co-efficient suitable for the type of structure? | | N/A | Not applicable. There are no structures in the 2d domain of the model | Not applicable | | | | | | | | | | |

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## 1D/2D MODEL LINKS

| MODEL LINKS | | | | | | | | | | | | | | | |
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| 13.1 | How have the 1D/2D models been coupled, is it appropriate? Is the digitisation of the links acceptable? | | OK | The 1d and 2d models are coupled using a Head Exchange (HX) boundary. The schematisation of these for the existing and proposed scenarios is considered reasonable. | No further action required | | | | | | | | | | |
| 13.2 | Is the 2D representation of the river channel comparable in width with the 1D model cross sections? | | OK | Cross section widths are comparable to the width of the deactivated 1d area | No further action required | | | | | | | | | | |
| 13.3 | How is the 1D output represented within the 2D domain and is it schematised correctly? | | OK | Yes, flood risk for the 1d deactivated area is mapped. This is achieved through the use of Water Level Lines (*1d_WLL_GB_009_L.shp* and *1d_WLL_GB_011_L_PRO.shp*) | No further action required | | | | | | | | | | |
| 13.4 | Have any default link parameters been changed (i.e. to improve stability) and are these appropriate and justified? | | OK | Link parameters within *2d_bc_GB_011_L_PRO.shp* and *2d_bc_GB_016_L.shp* are set to default values | No further action required | | | | | | | | | | |

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## RUN PARAMETERS

| Item No. | Item Checked | Model developer comments | RAG 1 | 1st Review Comments | 1st Actions for model developer | 1st Model developer response (DATE) | RAG 2 | 2nd Review Comments | 2nd Model developer response (DATE) | RAG 3 | 3rd Review Comments | 3rd Model developer response (DATE) | RAG 4 | 4th Review Comments | 4th Model developer response (DATE) |
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| | **1D RUN PARAMETERS** | | | | | | | | | | | | | | |
| 14.1 | What time step has been used for the 1D model? Is it appropriate? | | OK | A 1d ESTRY timestep of 0.5 seconds has been adopted. This is considered reasonable | No further action required | | | | | | | | | | |
| 14.2 | Are 1D initial conditions appropriate for the start of the model run? | | Green | Initial water levels for ESTRY cross sections are applied via 1d_iwl_GB_004_P.shp (existing -although commented out of the TCF) and 1d_iwl_GB_006_P_PRO.shp. A review of the initial water level check file shows slight differences in initial water levels at coincident cross sections between the existing and proposed scenarios. Generally initial water levels for the proposed scenario are slightly higher than the existing scenario. The discrepancy is not likely to have a notable impact on model results but is worth double checking. | What is the rationale for the differing 1d initial water levels applied to the model at coincident cross sections between the existing and proposed scenarios? | Initial conditions are read in through a baseflow and restart file. Therefore, the initial water levels have been removed from the model. | | | | | | | | | |
| 14.3 | Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified? | | OK | Default values adopted | No further action required | | | | | | | | | | |
| | **2D RUN PARAMETERS** | | | | | | | | | | | | | | |
| 14.4 | What time step has been used for the 2D model? Is it appropriate? | | OK | A 2d time step of 1 second has been adopted. This is half the 2d grid resolution and is considered reasonable | No further action required | | | | | | | | | | |
| 14.5 | Have initial water levels been applied and are these appropriate for the scenario being run? | | OK | Yes, initial water levels are used in the 2d domain of the model. *2d_iwl_Pond_GB_001_R.shp* (existing) and *2d_iwl_Pond_GB_001_R_PRO.shp* (proposed). These are used to represent a series of small water bodies along the length of the Ashgrove and Gagle Brooks. Initial water levels are consistent between the existing and proposed scenarios. Applied levels appear reasonable when compared to 2 metre resolution Lidar data albeit more conservative for the most part. | No further action required | | | | | | | | | |
| 14.6 | Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default? If so, has it been justified? | | OK | Cell Wet/Dry Depth is set to 0.0002. All other values are set to default | No further action required | | | | | | | | | | |

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## MODEL STABILITY

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| **1D MODEL STABILITY** | | | | | | | | | | | | | | | |
| 15.1 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | | OK | Please see comment 15.7 below. | No further action required | | | | | | | | | | |
| 15.2 | Is 1D mass balance from the model run within expected limits? Have they been investigated and resolved where potentially impacting the model results? | | OK | 1d mass error is within acceptable limits (+/-1%) | No further action required | | | | | | | | | | |
| 15.3 | Have any periods of non-convergence within the model run been investigated and resolved where potentially impacting the model results? | | OK | A review of ESTRY stage time series data across multiple events shows reasonable water level change. There are some periods of relatively minor water level oscillation in the existing scenario at section *GBT1_03216* and *GBT1_03264* but this is unlikely to have any notable impact on model results. | No further action required | | | | | | | | | | |
| 15.4 | Under a range of different scenarios do the animations and graphed outputs give an indication of good model stability? | | OK | Yes, as noted above ESTRY stage time series reveals a stable change in water levels for nearly all cross sections. There is progression in flow and level as expected with rarer annual exceedance probability events | No further action required | | | | | | | | | | |
| **2D MODEL STABILITY** | | | | | | | | | | | | | | | |
| 15.5 | Is 2D mass balance from the model run within expected limits? Where outside of expected tolerance, have they been investigated and resolved where potentially impacting the model results? | | OK | A HPC solution scheme has been used which is mass conservative. That being said, mass error starts off slightly elevated for some scenarios but settles down to within acceptable boundary (+/-1%). Mass error is considered reasonable | No further action required | | | | | | | | | | |
| 15.6 | Are CE and dV values relatively stable and remain so once the run has got going? | | OK | Volume exchange is considered reasonable across multiple scenarios. | No further action required | | | | | | | | | | |
| 15.7 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | | OK | The following key warnings are listed. These have been reviewed and are not of concern.<br>WARNING 1100 - Structure GB_01809 crest/invert (87.610) is below bed (87.612) of primary upstream channel GB_01883B. This warning is not of concern. This relates to slight differences between channel and culvert invert levels<br>WARNING 1100 - Structure GB_02082 crest/invert (90.110) is below bed (90.114) of primary downstream channel GB_02081. This warning is not of concern. This relates to slight differences between channel and culvert invert levels<br>WARNING 2073 - Null Shape object ignored. Only Regions, Lines, Polylines & Multiple Polylines used. This warning is not of concern. This sometimes happens when blank rows remain in the respective template GIS files used to build the model. | No further action required | | | | | | | | | | |
| 15.8 | Are negative depths being created during the model run? If so, have these been investigated and resolved where appropriate? | | OK | There a no negative depths within any of the simulations | No further action required | | | | | | | | | | |
| 15.9 | Under a range of different scenarios do the animations and graphed outputs give an indication of good model stability? | | OK | Inspection of model results using Tuflow viewer within QGIS reveals reasonable flood progression and increasing flood extents for rarer AEP scenarios | No further action required | | | | | | | | | | |
| 15.10 | **HPC Models Only** - Do the appropriate HPC output files show any indication of instability? If so, has this been investigated and resolved where appropriate? | | OK | HPC control numbers Nu, Nc, and Nd are within accetable ranges | No further action required | | | | | | | | | | |

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## MODEL PERFORMANCE

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| **CALIBRATION/VERIFICATION** | | | | | | | | | | | | | | | |
| 16.1 | Have calibration/verification runs been completed based on locally gauged and recorded data? | | N/A | There are no level or flow gauges within the model domain and hence a formal model calibration or verification is not possible. | Not applicable | | | | | | | | | | |
| 16.2 | Are the simulated hydrograph peaks reasonably similar to the recorded peaks? Is the shape of the simulated hydrograph and therefore the volume suitably similar? | | N/A | As noted above in comment 16.1, it is not possible to calibrate of verify the hydraulic model against gauge data as there are no level or flow gauges within the modelled reach. | Not applicable | | | | | | | | | | |
| 16.3 | Are simulated floodplain extents similar to recorded extents? Are flow routes similar? | | N/A | The Environment Agency do not hold any recorded flood outlines within the modelled reach or in the vicinity of the proposed development. | Not applicable | | | | | | | | | | |
| 16.4 | Has suitable effort been made to attempt and improve calibration. Have attempted changes been documented with a quantification of impact? | | N/A | As noted in comments 16.1 to 16.3 above, it is not possible to formally calibrate the model | Not applicable | | | | | | | | | | |
| **RECONCILIATION** | | | | | | | | | | | | | | | |
| 16.5 | Is there good reconciliation between estimates at flow estimation points and the model for given exceedance probabilities? | | OK | The 1% (1 in 100) AEP peak flow extracted from the hydraulic model (existing scenario) at the downstream end of the model domain just upstream of the M40 (node GB_00197) is 1.32 m3/s. This compares to the calculated FEH statistical peak flow of 1.4m3/s for the lumped Gagle Brook catchment (GB_DS). There is reasonable agreement between the two which gives confidence to the application of flows to the hydraulic model. | No further action required | | | | | | | | | | |
| **VALIDATION** | | | | | | | | | | | | | | | |
| 16.6 | Where calibration is not possible due to data availability, have checks been made against other recorded data (wrack marks, flood extents, photographs etc.) and how do these compare? | | N/A | Not applicable as noted in comments 16.1 to 16.3 above | Not applicable | | | | | | | | | | |
| 16.7 | If no recorded or historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large difference, does it seem sensible? | | OK | The Environment Agency do not hold any detailed hydraulic models for the Gagle and Ashgrove Brooks. The only available modelling is the New National Modelling (NNM) used to inform the Flood Map for Planning. When comparing the 1% (1 in 100) AEP flood extent from BWB's detailed modelling with Flood Zone 3 (where there is overlap) there is a slight reduction in extent. Both model outputs confirm that the Gagle Brook channel has fairly constrained flood risk. | No further action required | | | | | | | | | | |
| **SENSITIVITY TESTING** | | | | | | | | | | | | | | | |
| 16.8 | Have appropriate model parameters been chosen for sensitivity testing?<br>Typical tests include:<br>☐ Sensitivity to roughness ± 20% ( Manning's "n" both in 1D and 2D)<br>☐Sensitivity to flows ± 20% (From central estimate)<br>☐ Sensitivity to downstream boundary<br>☐ Key structure blockage(s) | | OK | Sensitivity testing has been undertaken on storm duration (7.5hrs), Mannings roughness (+/-20%), and downstream boundary conditions (water level and slope increased and decreased by 20%). Blockage testing has also been undertaken in the model at 5 locations. The downstream boundary increased sensitivity test (*Gagle_Brook_~e1~_PRO_026_DSB+.TCF*) appears to reference *BC_dbase_005_PRO_DSB-.csv* and the downstream boundary minus sensitivity test appears to reflect the BC_dbase_005_PRO_DSB+.csv dataset. Both these scenarios tie in with increased and reduced slope in the 2d domain respectively so have been implemented correctly. The Mannings roughness values have been correctly scaled by 0.8 and 1.2. Blockage scenarios are referenced within *Gagle_Brook_~e1~_PRO_026_BL1.TCF* to *Gagle_Brook_~e1~_PRO_026_BL5.TCF*. Blockages are represented in the following 1d_nwke files by increasing the pBlockage value: *1d_nwke_GB_020_L_PRO_BL1.shp* , *1d_nwke_GB_020_L_PRO_BL2.shp* , *1d_nwke_GB_020_L_PRO_BL3.shp* , *1d_nwke_GB_020_L_PRO_BL4.shp* , and *1d_nwke_GB_020_L_PRO_BL5.shp* . Blockage 1 - *GBT1_02793_A* – pBlockage value set to 75%, Blockage 2 - *GBT1_02298_P* – pBlockage value set to 75%, Blockage 3 - *GBT1_01968_P* – pBlockage value set to 50%, Blockage 4 – *GBT_01517_P* – pBlockage value set to 75%, and Blockage 5 - *GB_01875_Pa* and *GB_01875_Pb* – both pBlockage values set to 50%. This aligns with what is described within the model report. | No further action required | | | | | | | | | | |
| 16.9 | Do the results of the tests show the models to be particularly sensitive to certain parameters? | | OK | The model results are not particularly sensitive to changes in manning's roughness, downstream boundary conditions, storm duration, or blockage. This is not surprising given the relatively constrained nature of the Gagle and Ashford Brooks. | No further action required | | | | | | | | | | |
| **DEVELOPMENT PROJECTS** | | | | | | | | | | | | | | | |
| 16.10 | For development modelling, has the uncertainty of the modelling been quantified and reported, is this reasonable? Does it describe what it means to the conclusions of the assessment (design of the development/mitigation)? | | OK | A full residual uncertainty assessment using the 2017 accounting for residual uncertainty guidance is not considered necessary for a study of this nature. The sensitivity testing undertaken on various model parameters as highlighted in comment 16.8 demonstrates that model results and flood risk to the proposed development site are not particularly sensitive to a number of secondary variables within the hydraulic model. | No further action required | | | | | | | | | | |
| 16.11 | Has an assessment of post scheme/development on third party flood risk been undertaken? Has justification been provided for any off-site change and is this reasonable? | | OK | As part of this review a comparison was undertaken comparing several AEP events for the existing scenario with the proposed scenario. This shows that flood risk is not increased off site because of the proposed development. Flows in the proposed scenario and levels just upstream of the M40 are slightly lower than the same flows in the existing scenario. To be fair this is in part likely to the lower flows applied ay AB_1, AB_2, and AB_3 in the proposed scenario when compared to the existing scenario. Please see worksheets ***Results_Comparison_Time_Series*** and ***Results_Comparison_Maps*** for further details. | No further action required however please see the comments with respect to the different scaling factors applied to AB_1, AB_2 and AB_3 when compared to the baseline scenario | | | | | | | | | | |

## Additional information

**This section is for you to provide and further comments on items within the review. This could include any screenshots or photographs, or further detailed information. Please change the item number to the one you are referencing.**
**Add as many row as you need. This sheet is here to expend on some issues that might have been encountered during the review or/and need more details.**

| Additional information | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 101 | | | | | | | | | | | | | | |

Worksheet detailing checks on input hydrology and climate change scaling factors used in the modelling

| | Scaling factor (existing) | 30 year (m3/s) | 100 year (m3/s) | 1000 year (m3/s) | 100 year +15% CC | 100 year +25% CC | 100 year +49% CC |
|---|---|---|---|---|---|---|---|
| GB_1 | 0.72 | 0.46 | 0.61 | 1.47 | 0.71 | 0.77 | 0.92 |
| GB_2 | 0.28 | 0.18 | 0.24 | 0.42 | 0.27 | 0.30 | 0.36 |
| AB_1 | 0.12 | 0.06 | 0.07 | 0.12 | 0.08 | 0.09 | 0.11 |
| AB_2 | 0.4 | 0.2 | 0.24 | 0.40 | 0.28 | 0.30 | 0.36 |
| AB_3 | 0.48 | 0.24 | 0.29 | 0.48 | 0.33 | 0.36 | 0.42 |
| | Scaling factor (proposed) | 30 year (m3/s) | 100 year (m3/s) | 1000 year (m3/s) | 100 year +15% CC | 100 year +25% CC | 100 year +49% CC |
| AB_1 | 0.08 | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 | 0.07 |
| AB_2 | 0.23 | 0.12 | 0.14 | 0.23 | 0.16 | 0.17 | 0.21 |
| AB_3 | 0.41 | 0.21 | 0.25 | 0.41 | 0.28 | 0.31 | 0.37 |
| | 0.60 | | | | | | |

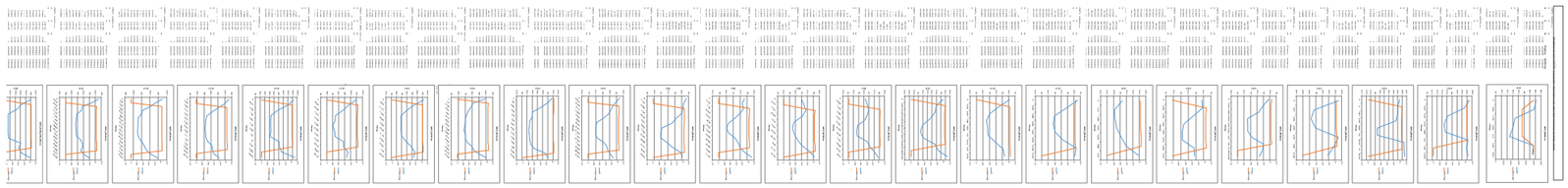
| Climate change scaling factor +15% | Climate change scaling factor +25% | Climate change scaling factor +49% |
|---|---|---|
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |
| 1.15 | 1.25 | 1.49 |

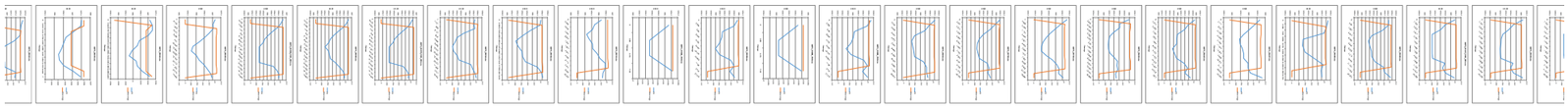
| 0.43 | Existing scenario | | |
|---|---|---|---|
| | 30 year (m3/s) | 100 year (m3/s) | 1000 year (m3/s) |
| GB_DS | 0.64 | 0.85 | 1.49 |
| AB_DS | 0.50 | 0.60 | 1.00 |

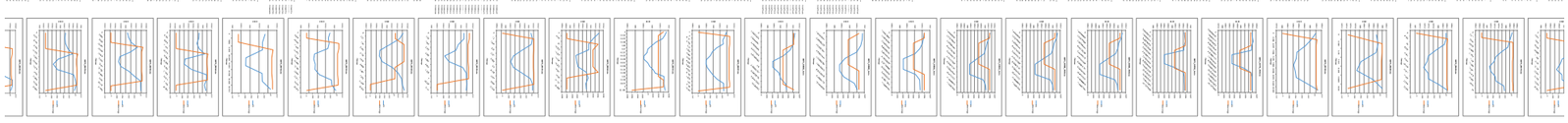
| | Proposed scenario | | |
|---|---|---|---|
| | 30 year (m3/s) | 100 year (m3/s) | 1000 year (m3/s) |
| GB_DS | 0.61 | 0.81 | 0.81 |
| AB_DS | 0.01 | 0.02 | 0.02 |

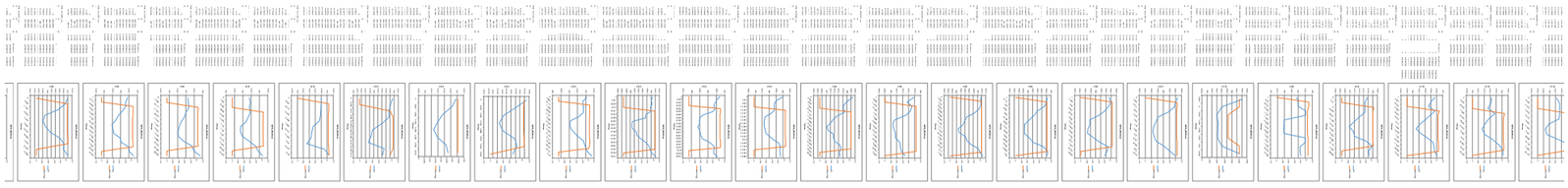


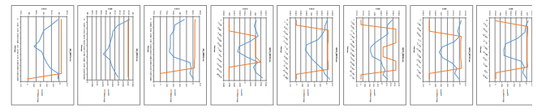
| Peak flow (m3/s) | | 0.64 | 0.85 | 1.49 | | 1.27 | 0.50 | 0.60 | 1.00 | 0.69 | 0.75 | 0.93 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | | GB_DS_Flows_0030 | GB_DS_Flows_0100 | GB_DS_Flows_1000 | GB_D | Flows_0100+49 | AB_DS_Flows_0030 | AB_DS_Flows_0100 | AB_DS_Flows_1000 | AB_DS_Flows_0100+15 | AB_DS_Flows_0100+25 | AB_DS_Flows_0100+49 |
| 0 | | 0.00 | 0.00 | 0.00 | U.U.U | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 3 | | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 4 | | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 |
| 5 | | 0.03 | 0.05 | 0.07 | 0.05 | 0.06 | 0.07 | 0.07 | 0.11 | 0.08 | 0.09 | 0.11 |
| 6 | | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 | 0.13 | 0.12 | 0.14 | 0.21 | 0.16 | 0.17 |
| 7 | | 0.12 | 0.16 | 0.29 | 0.18 | 0.20 | 0.24 | 0.20 | 0.23 | 0.36 | 0.27 | 0.29 |
| 8 | | 0.18 | 0.25 | 0.42 | 0.28 | 0.31 | 0.37 | 0.29 | 0.34 | 0.54 | 0.39 | 0.43 |
| 9 | | 0.26 | 0.35 | 0.60 | 0.41 | 0.44 | 0.53 | 0.41 | 0.48 | 0.73 | 0.52 | 0.62 |
| 10 | | 0.36 | 0.48 | 0.81 | 0.55 | 0.60 | 0.71 | 0.45 | 0.54 | 0.88 | 0.62 | 0.67 |
| 11 | | 0.46 | 0.62 | 1.06 | 0.71 | 0.77 | 0.92 | 0.49 | 0.59 | 0.97 | 0.68 | 0.74 |
| 12 | | 0.56 | 0.74 | 1.28 | 0.85 | 0.93 | 1.11 | 0.50 | 0.60 | 1.00 | 0.69 | 0.75 |
| 13 | | 0.62 | 0.82 | 1.42 | 0.94 | 1.02 | 1.22 | 0.48 | 0.58 | 0.97 | 0.67 | 0.73 |
| 14 | | 0.64 | 0.85 | 1.48 | 0.98 | 1.06 | 1.27 | 0.45 | 0.55 | 0.92 | 0.63 | 0.68 |
| 15 | | 0.64 | 0.85 | 1.49 | 0.98 | 1.07 | 1.27 | 0.42 | 0.50 | 0.85 | 0.58 | 0.63 |
| 16 | | 0.63 | 0.83 | 1.45 | 0.96 | 1.04 | 1.24 | 0.38 | 0.46 | 0.78 | 0.53 | 0.58 |
| 17 | | 0.60 | 0.79 | 1.38 | 0.91 | 0.99 | 1.18 | 0.35 | 0.42 | 0.71 | 0.49 | 0.53 |
| 18 | | 0.57 | 0.75 | 1.31 | 0.86 | 0.94 | 1.11 | 0.32 | 0.39 | 0.65 | 0.45 | 0.48 |
| 19 | | 0.54 | 0.71 | 1.24 | 0.82 | 0.89 | 1.06 | 0.29 | 0.35 | 0.60 | 0.41 | 0.44 |
| 20 | | 0.52 | 0.69 | 1.19 | 0.79 | 0.86 | 1.02 | 0.27 | 0.32 | 0.54 | 0.37 | 0.40 |
| 21 | | 0.50 | 0.66 | 1.15 | 0.76 | 0.82 | 0.98 | 0.24 | 0.29 | 0.49 | 0.34 | 0.36 |
| 22 | | 0.48 | 0.63 | 1.10 | 0.73 | 0.79 | 0.94 | 0.22 | 0.26 | 0.45 | 0.30 | 0.33 |
| 23 | | 0.46 | 0.60 | 1.05 | 0.69 | 0.75 | 0.89 | 0.20 | 0.24 | 0.41 | 0.28 | 0.31 |
| 24 | | 0.43 | 0.56 | 0.98 | 0.64 | 0.70 | 0.84 | 0.19 | 0.23 | 0.39 | 0.27 | 0.29 |
| 25 | | 0.39 | 0.52 | 0.91 | 0.59 | 0.65 | 0.77 | 0.18 | 0.22 | 0.37 | 0.26 | 0.28 |
| 26 | | 0.36 | 0.47 | 0.83 | 0.54 | 0.59 | 0.70 | 0.18 | 0.21 | 0.36 | 0.25 | 0.27 |
| 27 | | 0.32 | 0.43 | 0.75 | 0.49 | 0.53 | 0.64 | 0.17 | 0.21 | 0.35 | 0.24 | 0.26 |
| 28 | | 0.30 | 0.39 | 0.69 | 0.45 | 0.49 | 0.58 | 0.17 | 0.21 | 0.34 | 0.24 | 0.26 |
| 29 | | 0.28 | 0.37 | 0.64 | 0.42 | 0.46 | 0.55 | 0.17 | 0.20 | 0.34 | 0.23 | 0.25 |
| 30 | | 0.26 | 0.35 | 0.61 | 0.40 | 0.44 | 0.52 | 0.17 | 0.20 | 0.33 | 0.23 | 0.25 |
| 31 | | 0.26 | 0.34 | 0.59 | 0.39 | 0.42 | 0.50 | 0.16 | 0.20 | 0.33 | 0.22 | 0.24 |
| 32 | | 0.25 | 0.33 | 0.58 | 0.38 | 0.41 | 0.49 | 0.16 | 0.19 | 0.32 | 0.22 | 0.24 |
| 33 | | 0.25 | 0.32 | 0.57 | 0.37 | 0.41 | 0.48 | 0.16 | 0.19 | 0.31 | 0.22 | 0.24 |
| 34 | | 0.24 | 0.32 | 0.56 | 0.37 | 0.40 | 0.48 | 0.15 | 0.19 | 0.31 | 0.21 | 0.23 |
| 35 | | 0.24 | 0.32 | 0.55 | 0.36 | 0.39 | 0.47 | 0.15 | 0.18 | 0.30 | 0.21 | 0.23 |
| 36 | | 0.23 | 0.31 | 0.54 | 0.36 | 0.39 | 0.46 | 0.15 | 0.18 | 0.30 | 0.21 | 0.22 |
| 37 | | 0.23 | 0.31 | 0.53 | 0.35 | 0.38 | 0.46 | 0.15 | 0.18 | 0.29 | 0.20 | 0.22 |
| 38 | | 0.23 | 0.30 | 0.53 | 0.35 | 0.38 | 0.45 | 0.14 | 0.17 | 0.29 | 0.20 | 0.22 |
| 39 | | 0.22 | 0.30 | 0.52 | 0.34 | 0.37 | 0.44 | 0.14 | 0.17 | 0.28 | 0.20 | 0.21 |
| 40 | | 0.22 | 0.29 | 0.51 | 0.34 | 0.37 | 0.44 | 0.14 | 0.17 | 0.28 | 0.19 | 0.21 |
| 41 | | 0.22 | 0.29 | 0.50 | 0.33 | 0.36 | 0.43 | 0.14 | 0.16 | 0.27 | 0.19 | 0.21 |
| 42 | | 0.22 | 0.28 | 0.50 | 0.33 | 0.36 | 0.42 | 0.13 | 0.16 | 0.27 | 0.19 | 0.20 |
| 43 | | 0.21 | 0.28 | 0.49 | 0.32 | 0.35 | 0.42 | 0.13 | 0.16 | 0.27 | 0.18 | 0.20 |
| 44 | | 0.21 | 0.28 | 0.48 | 0.32 | 0.35 | 0.41 | 0.13 | 0.16 | 0.26 | 0.18 | 0.20 |
| 45 | | 0.21 | 0.27 | 0.48 | 0.31 | 0.34 | 0.41 | 0.13 | 0.15 | 0.26 | 0.18 | 0.19 |
| 46 | | 0.20 | 0.27 | 0.47 | 0.31 | 0.34 | 0.40 | 0.13 | 0.15 | 0.25 | 0.17 | 0.19 |
| 47 | | 0.20 | 0.27 | 0.46 | 0.30 | 0.33 | 0.39 | 0.12 | 0.15 | 0.25 | 0.17 | 0.18 |
| 48 | | 0.20 | 0.26 | 0.46 | 0.30 | 0.33 | 0.39 | 0.12 | 0.15 | 0.24 | 0.17 | 0.18 |
| 49 | | 0.19 | 0.26 | 0.45 | 0.30 | 0.32 | 0.38 | 0.12 | 0.14 | 0.24 | 0.16 | 0.18 |
| 50 | | 0.19 | 0.25 | 0.44 | 0.29 | 0.32 | 0.38 | 0.12 | 0.14 | 0.24 | 0.16 | 0.18 |
| 51 | | 0.19 | 0.25 | 0.44 | 0.29 | 0.31 | 0.37 | 0.12 | 0.14 | 0.23 | 0.16 | 0.17 |
| 52 | | 0.19 | 0.25 | 0.43 | 0.28 | 0.31 | 0.37 | 0.11 | 0.14 | 0.23 | 0.16 | 0.17 |
| 53 | | 0.18 | 0.24 | 0.42 | 0.28 | 0.30 | 0.36 | 0.11 | 0.13 | 0.22 | 0.15 | 0.17 |
| 54 | | 0.18 | 0.24 | 0.42 | 0.28 | 0.30 | 0.36 | 0.11 | 0.13 | 0.22 | 0.15 | 0.16 |
| 55 | | 0.18 | 0.24 | 0.41 | 0.27 | 0.29 | 0.35 | 0.11 | 0.13 | 0.22 | 0.15 | 0.16 |
| 56 | | 0.18 | 0.23 | 0.41 | 0.27 | 0.29 | 0.35 | 0.11 | 0.13 | 0.21 | 0.15 | 0.16 |
| 57 | | 0.17 | 0.23 | 0.40 | 0.26 | 0.29 | 0.34 | 0.10 | 0.12 | 0.21 | 0.14 | 0.16 |
| 58 | | 0.17 | 0.23 | 0.39 | 0.26 | 0.28 | 0.34 | 0.10 | 0.12 | 0.20 | 0.14 | 0.15 |
| 59 | | 0.17 | 0.22 | 0.39 | 0.26 | 0.28 | 0.33 | 0.10 | 0.12 | 0.20 | 0.14 | 0.15 |
| 60 | | 0.17 | 0.22 | 0.38 | 0.25 | 0.27 | 0.33 | 0.10 | 0.12 | 0.20 | 0.14 | 0.15 |
| 61 | | 0.16 | 0.22 | 0.38 | 0.25 | 0.27 | 0.32 | 0.10 | 0.12 | 0.19 | 0.13 | 0.15 |
| 62 | | 0.16 | 0.21 | 0.37 | 0.25 | 0.27 | 0.32 | 0.10 | 0.11 | 0.19 | 0.13 | 0.14 |
| 63 | | 0.16 | 0.21 | 0.37 | 0.24 | 0.26 | 0.31 | 0.09 | 0.11 | 0.19 | 0.13 | 0.14 |
| 64 | | 0.16 | 0.21 | 0.36 | 0.24 | 0.26 | 0.31 | 0.09 | 0.11 | 0.18 | 0.13 | 0.14 |
| 65 | | 0.15 | 0.20 | 0.36 | 0.23 | 0.26 | 0.30 | 0.09 | 0.11 | 0.18 | 0.13 | 0.14 |
| 66 | | 0.15 | 0.20 | 0.35 | 0.23 | 0.25 | 0.30 | 0.09 | 0.11 | 0.18 | 0.12 | 0.13 |
| 67 | | 0.15 | 0.20 | 0.35 | 0.23 | 0.25 | 0.30 | 0.09 | 0.11 | 0.18 | 0.12 | 0.13 |
| 68 | | 0.15 | 0.20 | 0.34 | 0.22 | 0.24 | 0.29 | 0.09 | 0.10 | 0.17 | 0.12 | 0.13 |
| 69 | | 0.15 | 0.19 | 0.34 | 0.22 | 0.24 | 0.29 | 0.08 | 0.10 | 0.17 | 0.12 | 0.13 |
| 70 | | 0.14 | 0.19 | 0.33 | 0.22 | 0.24 | 0.28 | 0.08 | 0.10 | 0.17 | 0.11 | 0.12 |
| 71 | | 0.14 | 0.19 | 0.33 | 0.21 | 0.23 | 0.28 | 0.08 | 0.10 | 0.16 | 0.11 | 0.12 |
| 72 | | 0.14 | 0.18 | 0.32 | 0.21 | 0.23 | 0.27 | 0.08 | 0.10 | 0.16 | 0.11 | 0.12 |
| 73 | | 0.14 | 0.18 | 0.32 | 0.21 | 0.23 | 0.27 | 0.08 | 0.09 | 0.16 | 0.11 | 0.12 |
| 74 | | 0.14 | 0.18 | 0.31 | 0.21 | 0.22 | 0.27 | 0.08 | 0.09 | 0.16 | 0.11 | 0.12 |
| 75 | | 0.13 | 0.18 | 0.31 | 0.20 | 0.22 | 0.26 | 0.08 | 0.09 | 0.15 | 0.11 | 0.11 |
| 76 | | 0.13 | 0.17 | 0.30 | 0.20 | 0.22 | 0.26 | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 |
| 77 | | 0.13 | 0.17 | 0.30 | 0.20 | 0.21 | 0.26 | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 |
| 78 | | 0.13 | 0.17 | 0.29 | 0.19 | 0.21 | 0.25 | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 |
| 79 | | 0.13 | 0.17 | 0.29 | 0.19 | 0.21 | 0.25 | 0.07 | 0.09 | 0.14 | 0.10 | 0.11 |
| 80 | | 0.12 | 0.16 | 0.29 | 0.19 | 0.20 | 0.24 | 0.07 | 0.08 | 0.14 | 0.10 | 0.11 |
| 81 | | 0.12 | 0.16 | 0.28 | 0.19 | 0.20 | 0.24 | 0.07 | 0.08 | 0.14 | 0.09 | 0.10 |
| 82 | | 0.12 | 0.16 | 0.28 | 0.18 | 0.20 | 0.24 | 0.07 | 0.08 | 0.14 | 0.09 | 0.10 |
| 83 | | 0.12 | 0.16 | 0.27 | 0.18 | 0.20 | 0.23 | 0.07 | 0.08 | 0.13 | 0.09 | 0.10 |
| 84 | | 0.12 | 0.15 | 0.27 | 0.18 | 0.19 | 0.23 | 0.07 | 0.08 | 0.13 | 0.09 | 0.10 |
| 85 | | 0.12 | 0.15 | 0.27 | 0.18 | 0.19 | 0.23 | 0.06 | 0.08 | 0.13 | 0.09 | 0.10 |
| 86 | | 0.11 | 0.15 | 0.26 | 0.17 | 0.19 | 0.22 | 0.06 | 0.08 | 0.12 | 0.09 | 0.09 |
| 87 | | 0.11 | 0.15 | 0.26 | 0.17 | 0.18 | 0.22 | 0.06 | 0.07 | 0.12 | 0.09 | 0.09 |
| 88 | | 0.11 | 0.15 | 0.25 | 0.17 | 0.18 | 0.22 | 0.06 | 0.07 | 0.12 | 0.08 | 0.09 |
| 89 | | 0.11 | 0.14 | 0.25 | 0.17 | 0.18 | 0.21 | 0.06 | 0.07 | 0.12 | 0.08 | 0.09 |
| 90 | | 0.11 | 0.14 | 0.25 | 0.16 | 0.18 | 0.21 | 0.06 | 0.07 | 0.12 | 0.08 | 0.09 |
| 91 | | 0.11 | 0.14 | 0.24 | 0.16 | 0.17 | 0.21 | 0.06 | 0.07 | 0.12 | 0.08 | 0.09 |
| 92 | | 0.10 | 0.14 | 0.24 | 0.16 | 0.17 | 0.20 | 0.06 | 0.07 | 0.11 | 0.08 | 0.09 |
| 93 | | 0.10 | 0.14 | 0.24 | 0.16 | 0.17 | 0.20 | 0.06 | 0.07 | 0.11 | 0.08 | 0.08 |
| 94 | | 0.10 | 0.13 | 0.23 | 0.15 | 0.17 | 0.20 | 0.05 | 0.07 | 0.11 | 0.08 | 0.08 |
| 95 | | 0.10 | 0.13 | 0.23 | 0.15 | 0.16 | 0.20 | 0.05 | 0.06 | 0.11 | 0.07 | 0.08 |
| 96 | | 0.10 | 0.13 | 0.23 | 0.15 | 0.16 | 0.19 | 0.05 | 0.06 | 0.10 | 0.07 | 0.08 |
| 97 | | 0.10 | 0.13 | 0.22 | 0.15 | 0.16 | 0.19 | 0.05 | 0.06 | 0.10 | 0.07 | 0.08 |
| 98 | | 0.10 | 0.13 | 0.22 | 0.14 | 0.16 | 0.19 | 0.05 | 0.06 | 0.10 | 0.07 | 0.08 |
| 99 | | 0.09 | 0.12 | 0.22 | 0.14 | 0.15 | 0.18 | 0.05 | 0.06 | 0.10 | 0.07 | 0.07 |
| 100 | | 0.09 | 0.12 | 0.21 | 0.14 | 0.15 | 0.18 | 0.05 | 0.06 | 0.10 | 0.07 | 0.07 |
| 101 | | 0.09 | 0.12 | 0.21 | 0.14 | 0.15 | 0.18 | 0.05 | 0.06 | 0.10 | 0.07 | 0.07 |
| 102 | | 0.09 | 0.12 | 0.21 | 0.14 | 0.15 | 0.18 | 0.05 | 0.06 | 0.10 | 0.07 | 0.07 |
| 103 | | 0.09 | 0.12 | 0.20 | 0.13 | 0.14 | 0.17 | 0.05 | 0.06 | 0.09 | 0.06 | 0.07 |
| 104 | | 0.09 | 0.12 | 0.20 | 0.13 | 0.14 | 0.17 | 0.05 | 0.06 | 0.09 | 0.06 | 0.07 |
| 105 | | 0.09 | 0.11 | 0.20 | 0.13 | 0.14 | 0.17 | 0.05 | 0.05 | 0.09 | 0.06 | 0.07 |
| 106 | | 0.09 | 0.11 | 0.19 | 0.13 | 0.14 | 0.17 | 0.04 | 0.05 | 0.09 | 0.06 | 0.07 |
| 107 | | 0.08 | 0.11 | 0.19 | 0.13 | 0.14 | 0.16 | 0.04 | 0.05 | 0.09 | 0.06 | 0.07 |
| 108 | | 0.08 | 0.11 | 0.19 | 0.13 | 0.14 | 0.16 | 0.04 | 0.05 | 0.09 | 0.06 | 0.06 |
| 109 | | 0.08 | 0.11 | 0.18 | 0.12 | 0.13 | 0.16 | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 |
| 110 | | 0.08 | 0.11 | 0.18 | 0.12 | 0.13 | 0.16 | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 |
| 111 | | 0.08 | 0.10 | 0.18 | 0.12 | 0.13 | 0.15 | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 |
| 112 | | 0.08 | 0.10 | 0.18 | 0.12 | 0.13 | 0.15 | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 |
| 113 | | 0.08 | 0.10 | 0.18 | 0.12 | 0.13 | 0.15 | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 |
| 114 | | 0.08 | 0.10 | 0.17 | 0.11 | 0.12 | 0.15 | 0.04 | 0.05 | 0.08 | 0.05 | 0.06 |
| 115 | | 0.07 | 0.10 | 0.17 | 0.11 | 0.12 | 0.14 | 0.04 | 0.05 | 0.08 | 0.05 | 0.06 |
| 116 | | 0.07 | 0.10 | 0.17 | 0.11 | 0.12 | 0.14 | 0.04 | 0.05 | 0.08 | 0.05 | 0.06 |
| 117 | | 0.07 | 0.09 | 0.16 | 0.11 | 0.12 | 0.14 | 0.04 | 0.04 | 0.07 | 0.05 | 0.06 |
| 118 | | 0.07 | 0.09 | 0.16 | 0.11 | 0.12 | 0.14 | 0.04 | 0.04 | 0.07 | 0.05 | 0.05 |
| 119 | | 0.07 | 0.09 | 0.16 | 0.11 | 0.12 | 0.14 | 0.04 | 0.04 | 0.07 | 0.05 | 0.05 |
| 120 | | 0.07 | 0.09 | 0.16 | 0.10 | 0.11 | 0.14 | 0.04 | 0.04 | 0.07 | 0.05 | 0.05 |
| 121 | | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 | 0.13 | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 |
| 122 | | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 | 0.13 | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 |
| 123 | | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 | 0.13 | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 |
| 124 | | 0.07 | 0.09 | 0.15 | 0.10 | 0.11 | 0.13 | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 |
| 125 | | 0.06 | 0.08 | 0.15 | 0.10 | 0.11 | 0.13 | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 |
| 126 | | 0.06 | 0.08 | 0.15 | 0.10 | 0.10 | 0.12 | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 |
| 127 | | 0.06 | 0.08 | 0.14 | 0.09 | 0.10 | 0.12 | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 |
| 128 | | 0.06 | 0.08 | 0.14 | 0.09 | 0.10 | 0.12 | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 |
| 129 | | 0.06 | 0.08 | 0.14 | 0.09 | 0.10 | 0.12 | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 |
| 130 | | 0.06 | 0.08 | 0.14 | 0.09 | 0.10 | 0.12 | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 |
| 131 | | 0.06 | 0.08 | 0.13 | 0.09 | 0.10 | 0.12 | 0.03 | 0.03 | 0.06 | 0.04 | 0.04 |
| 132 | | 0.06 | 0.08 | 0.13 | 0.09 | 0.10 | 0.11 | 0.03 | 0.03 | 0.06 | 0.04 | 0.04 |
| 133 | | 0.06 | 0.08 | 0.13 | 0.09 | 0.09 | 0.11 | 0.03 | 0.03 | 0.06 | 0.04 | 0.04 |
| 134 | | 0.06 | 0.07 | 0.13 | 0.09 | 0.09 | 0.11 | 0.03 | 0.03 | 0.06 | 0.04 | 0.04 |
| 135 | | 0.06 | 0.07 | 0.13 | 0.08 | 0.09 | 0.11 | 0.03 | 0.03 | 0.05 | 0.04 | 0.04 |
| 136 | | 0.05 | 0.07 | 0.13 | 0.08 | 0.09 | 0.11 | 0.03 | 0.03 | 0.05 | 0.04 | 0.04 |
| 137 | | 0.05 | 0.07 | 0.12 | 0.08 | 0.09 | 0.10 | 0.03 | 0.03 | 0.05 | 0.04 | 0.04 |
| 138 | | 0.05 | 0.07 | 0.12 | 0.08 | 0.09 | 0.10 | 0.03 | 0.03 | 0.05 | 0.04 | 0.04 |
| 139 | | 0.05 | 0.07 | 0.12 | 0.08 | 0.09 | 0.10 | 0.03 | 0.03 | 0.05 | 0.04 | 0.04 |
| 140 | | 0.05 | 0.07 | 0.12 | 0.08 | 0.09 | 0.10 | 0.02 | 0.03 | 0.05 | 0.03 | 0.04 |
| 141 | | 0.05 | 0.07 | 0.12 | 0.08 | 0.08 | 0.10 | 0.02 | 0.03 | 0.05 | 0.03 | 0.04 |
| 142 | | 0.05 | 0.07 | 0.11 | 0.08 | 0.08 | 0.10 | 0.02 | 0.03 | 0.05 | 0.03 | 0.04 |
| 143 | | 0.05 | 0.07 | 0.11 | 0.07 | 0.08 | 0.10 | 0.02 | 0.03 | 0.05 | 0.03 | 0.04 |
| 144 | | 0.05 | 0.06 | 0.11 | 0.07 | 0.08 | 0.10 | 0.02 | 0.03 | 0.05 | 0.03 | 0.03 |
| 145 | | 0.05 | 0.06 | 0.11 | 0.07 | 0.08 | 0.09 | 0.02 | 0.03 | 0.05 | 0.03 | 0.03 |
| 146 | | 0.05 | 0.06 | 0.11 | 0.07 | 0.08 | 0.09 | 0.02 | 0.03 | 0.05 | 0.03 | 0.03 |
| 147 | | 0.05 | 0.06 | 0.11 | 0.07 | 0.08 | 0.09 | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 |
| 148 | | 0.05 | 0.06 | 0.11 | 0.07 | 0.08 | 0.09 | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 |
| 149 | | 0.05 | 0.06 | 0.10 | 0.07 | 0.07 | 0.09 | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 |
| 150 | | 0.04 | 0.06 | 0.10 | 0.07 | 0.07 | 0.09 | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 |
| 151 | | 0.04 | 0.06 | 0.10 | 0.07 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 152 | | 0.04 | 0.06 | 0.10 | 0.07 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 153 | | 0.04 | 0.06 | 0.10 | 0.06 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 154 | | 0.04 | 0.06 | 0.10 | 0.06 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 155 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 156 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 157 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 158 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.07 | 0.08 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 |
| 159 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.06 | 0.08 | 0.02 | 0.02 | 0.04 | 0.02 | 0.03 |
| 160 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.06 | 0.08 | 0.02 | 0.02 | 0.04 | 0.02 | 0.03 |
| 161 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 |
| 162 | | 0.04 | 0.05 | 0.09 | 0.06 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 |
| 163 | | 0.04 | 0.05 | 0.08 | 0.06 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 |
| 164 | | 0.04 | 0.05 | 0.08 | 0.05 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 |
| 165 | | 0.04 | 0.05 | 0.08 | 0.05 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 |
| 166 | | 0.04 | 0.05 | 0.08 | 0.05 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 |
| 167 | | 0.03 | 0.05 | 0.08 | 0.05 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 |
| 168 | | 0.03 | 0.05 | 0.08 | 0.05 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 |
| 169 | | 0.03 | 0.04 | 0.08 | 0.05 | 0.06 | 0.07 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 |
| 170 | | 0.03 | 0.04 | 0.08 | 0.05 | 0.05 | 0.07 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 171 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 172 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 173 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 174 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 175 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 176 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 177 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 178 | | 0.03 | 0.04 | 0.07 | 0.04 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 179 | | 0.03 | 0.04 | 0.07 | 0.04 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 180 | | 0.03 | 0.04 | 0.07 | 0.04 | 0.05 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| 181 | | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 | 0.06 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 182 | | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 | 0.05 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 183 | | 0.03 | 0.04 | 0.06 | 0.04 | 0.05 | 0.05 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 184 | | 0.03 | 0.04 | 0.06 | 0.04 | 0.04 | 0.05 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 185 | | 0.03 | 0.04 | 0.06 | 0.04 | 0.04 | 0.05 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 186 | | 0.03 | 0.03 | 0.06 | 0.04 | 0.04 | 0.05 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 187 | | 0.03 | 0.03 | 0.06 | 0.04 | 0.04 | 0.05 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 188 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 189 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 190 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 191 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 192 | | 0.03 | 0.04 | 0.07 | 0.05 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 193 | | 0.03 | 0.04 | 0.07 | 0.04 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 194 | | 0.03 | 0.04 | 0.07 | 0.04 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |











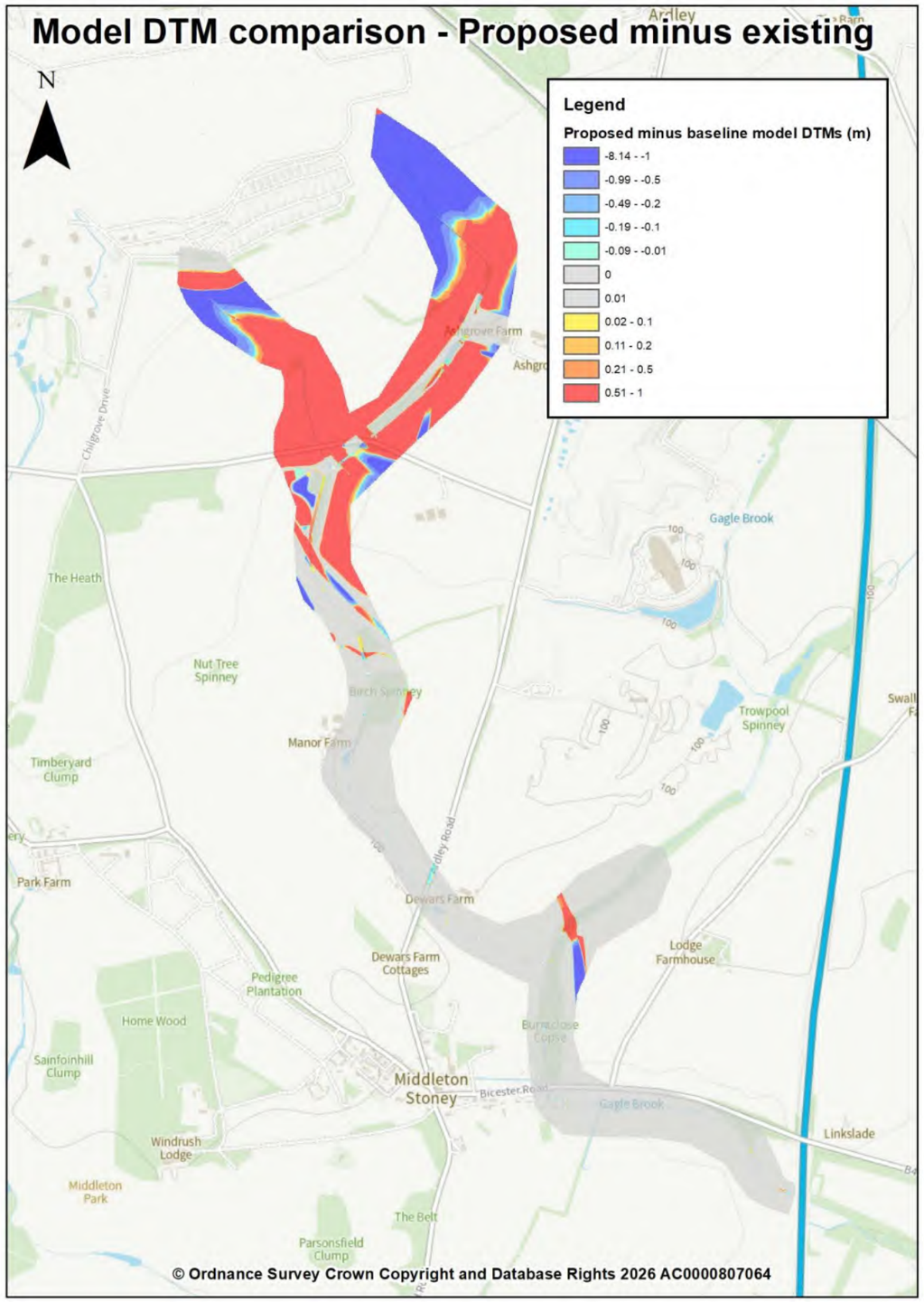
**Proposed culvert dimension check**

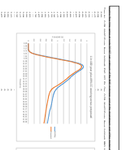
| Name | Type | US invert | DS Invert | N | Width or diamete | Height | pblockage |
|---|---|---|---|---|---|---|---|
| GBT1_02793_A | C | 108.375 | 108.3 | 0.02 | 0.9 | | 25 |
| GBT1_02422 | C | 106.43 | 106.07 | 0.02 | 0.35 | | 0 |
| GBT1_02298_P | R | 105.581 | 105.536 | 0.02 | 1 | 0.75 | 0 |
| GBT1_01968_P | C | 104.32 | 103.88 | 0.02 | 1.2 | | 17 |
| GBT_01517_P | R | 101.285 | 101.125 | 0.02 | 1 | 0.75 | 0 |
| GB_01875_Pa | C | 88.062 | 87.861 | 0.02 | 1.2 | | 17 |
| GB_01875_Pb | C | 88.062 | 87.861 | 0.02 | 1.2 | | 17 |

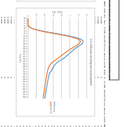
Table 5.1: Proposed Structures to be Modelled

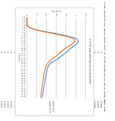
| Structure ID | Culvert Type | Size | Sedimentation Allowance (buried bed) | Freeboard Required |
|---|---|---|---|---|
| GBT1_02909_P | Clear Span Bridge | - | - | - |
| GBT1_02793_A | Circular Culvert | 0.9m | 225mm | 225mm |
| GBT1_02298_P | Rectangular Culvert | 1m x 1m | 250mm | 250mm |
| GBT1_01968_P | 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 |

The map below shows the proposed model digitial terrain model (DEM_Z) minus the baseline model DTM. Adjustments in the proposed scenario are as expected

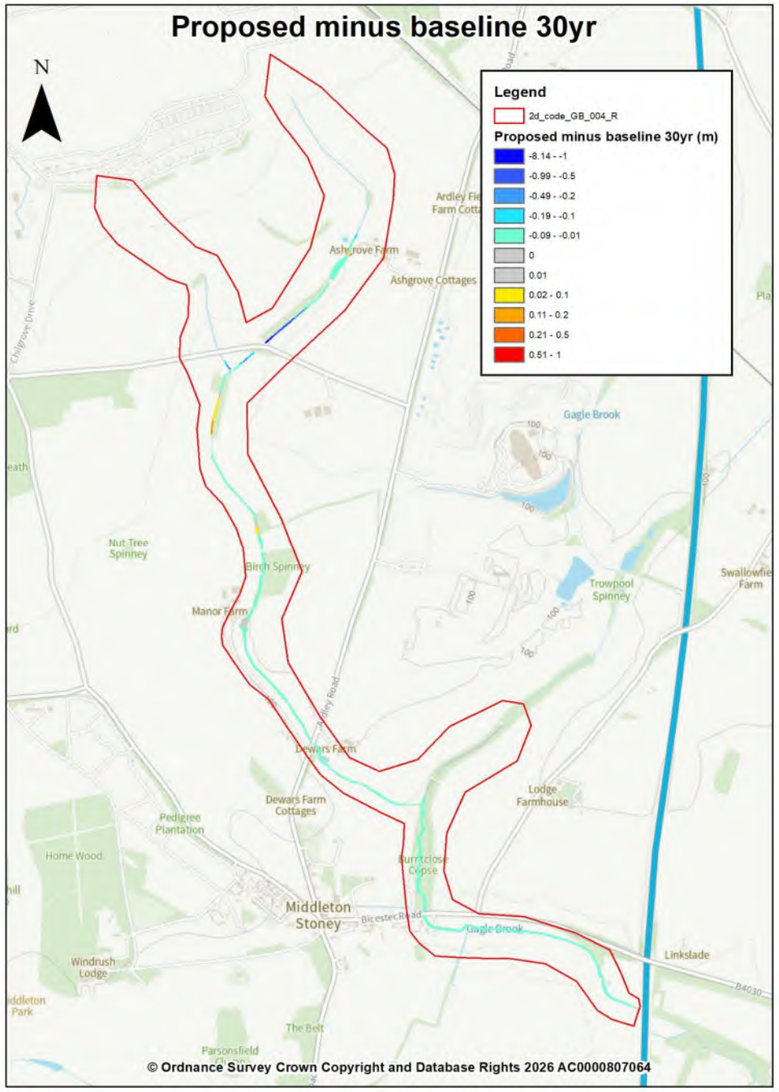


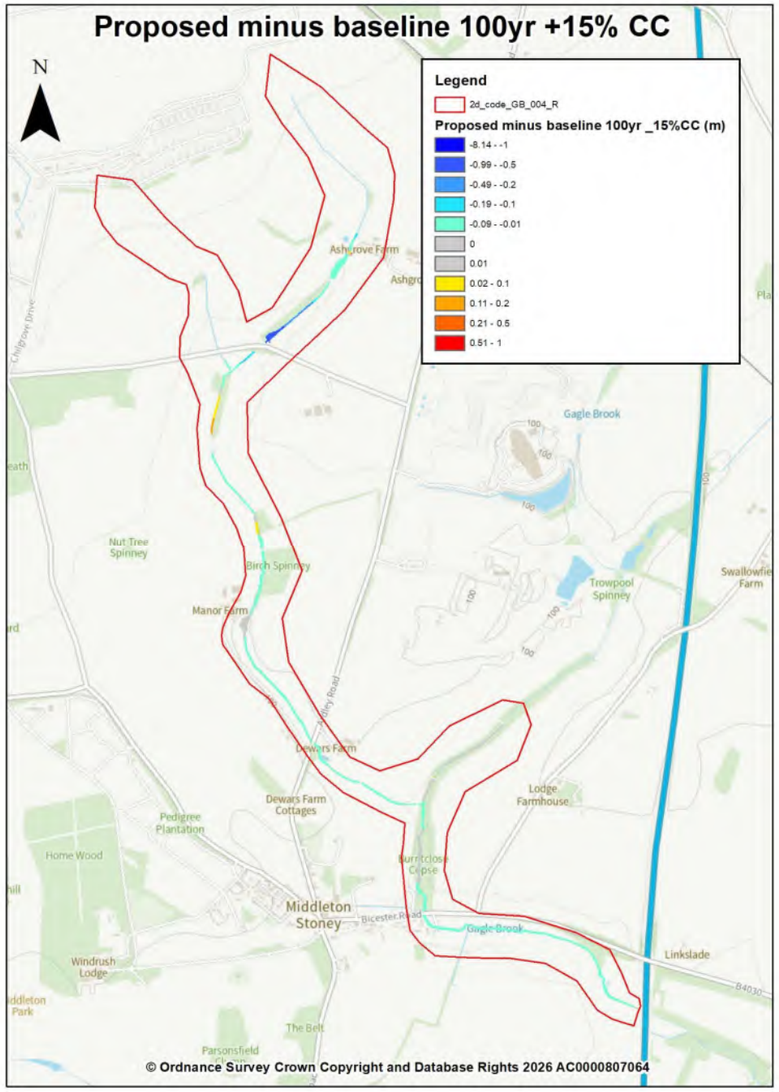


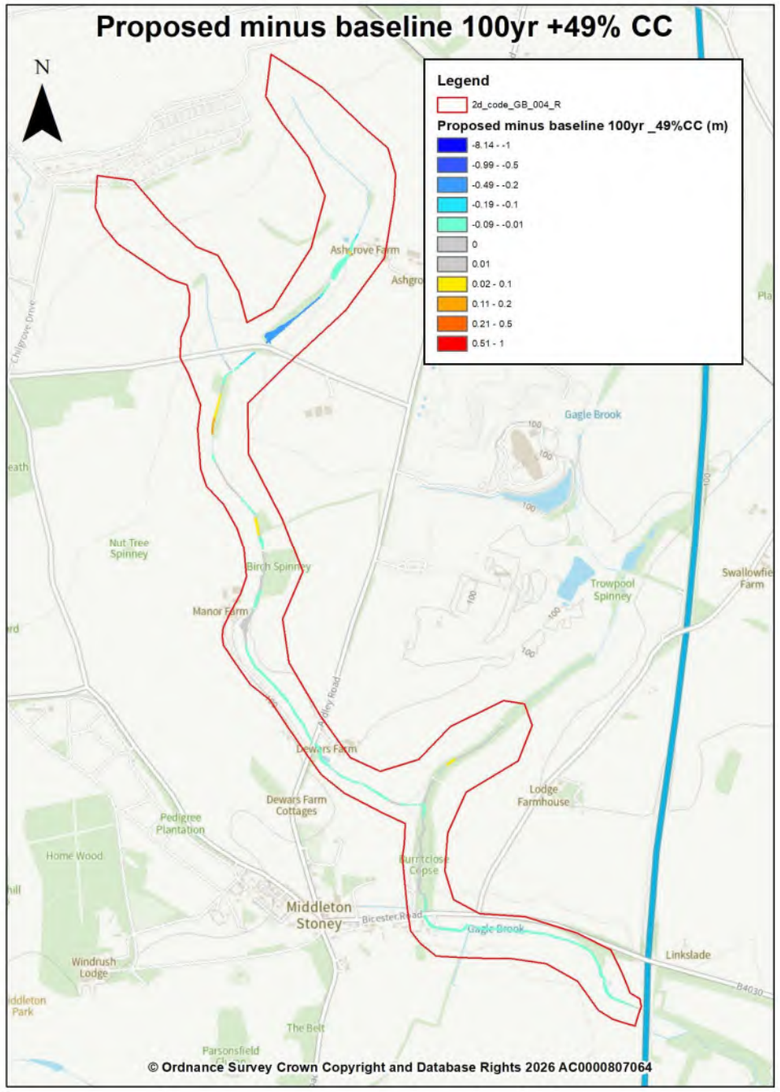




The maps below show the change in water levels when comparing the proposed scenario to the existing scenario (proposed minus existing)



**Manning's n for Channels (Chow, 1959).**

| Type of Channel and Description | Minimum | Normal | Maximum |
|---|---|---|---|
| Natural streams - minor streams (top width at flood stage < 100 ft) | | | |
| **1. Main Channels** | | | |
| a. clean, straight, full stage, no rifts or deep | 0.025 | 0.03 | 0.033 |
| b. same as above, but more stones and | 0.03 | 0.035 | 0.04 |
| c. clean, winding, some pools and shoals | 0.033 | 0.04 | 0.045 |
| d. same as above, but some weeds and | 0.035 | 0.045 | 0.05 |
| e. same as above, lower stages, more slopes and sections | 0.04 | 0.048 | 0.055 |
| f. same as "d" with more stones | 0.045 | 0.05 | 0.06 |
| Chainage – compared to surveyed sections | 0.05 | 0.07 | 0.08 |
| g. very weedy reaches, deep pools, or | 0.075 | 0.1 | 0.15 |
| with heavy stand of timber and underbrush | | | |
| **2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high** | | | |
| a. bottom: gravels, cobbles, and few boulders | 0.03 | 0.04 | 0.05 |
| b. bottom: cobbles with large boulders | 0.04 | 0.05 | 0.07 |
| **3. Floodplains** | | | |
| a. Pasture, no brush | | | |
| 1.short grass | 0.025 | 0.03 | 0.035 |
| 2. high grass | 0.03 | 0.035 | 0.05 |
| b. Cultivated areas | | | |
| 1. no crop | 0.02 | 0.03 | 0.04 |
| 2. mature row | 0.025 | 0.035 | 0.045 |
| 3. mature field | 0.03 | 0.04 | 0.05 |
| c. Brush | | | |
| 1. scattered | 0.035 | 0.05 | 0.07 |
| 2. light brush and | 0.035 | 0.05 | 0.06 |
| 3. light brush and | 0.04 | 0.06 | 0.08 |
| 4. medium to | 0.045 | 0.07 | 0.11 |
| 5. medium to | 0.07 | 0.1 | 0.16 |
| d. Trees | | | |
| 1. dense willows, | 0.11 | 0.15 | 0.2 |
| 2. cleared land | 0.03 | 0.04 | 0.05 |
| 3. Same as above, but with | 0.05 | 0.06 | 0.08 |
| 4. heavy stand of timber, a few down trees, little | 0.08 | 0.1 | 0.12 |
| 5. Same as | | | |
| with flood stage | 0.1 | 0.12 | 0.16 |
| **4. Excavated or Dredged Channels** | | | |
| a. Earth, straight, and uniform | | | |
| 1. clean, recently | 0.016 | 0.018 | 0.02 |
| 2. clean, after | 0.018 | 0.022 | 0.025 |
| 3. gravel, uniform | 0.022 | 0.025 | 0.03 |
| 4. with short | 0.022 | 0.027 | 0.033 |
| b. Earth winding and sluggish | | | |
| 1. no vegetation | 0.023 | 0.025 | 0.03 |
| 2. grass, some | 0.025 | 0.03 | 0.033 |
| 3. dense weeds or aquatic plants in | 0.03 | 0.035 | 0.04 |
| 4. earth bottom | 0.028 | 0.03 | 0.035 |
| 5. stony bottom | 0.025 | 0.035 | 0.04 |
| 6. cobble bottom | 0.03 | 0.04 | 0.05 |
| c. Dragline-excavated or dredged | | | |
| 1. no vegetation | 0.025 | 0.028 | 0.033 |
| 2. light brush on | 0.035 | 0.05 | 0.06 |
| d. Rock cuts | | | |
| 1. smooth and | 0.025 | 0.035 | 0.04 |
| 2. jagged and | 0.035 | 0.04 | 0.05 |
| e. Channels not maintained, weeds and brush | | | |
| 1. dense weeds, | 0.05 | 0.08 | 0.12 |
| 2. clean bottom, | 0.04 | 0.05 | 0.08 |
| 3. Same as | 0.045 | 0.07 | 0.11 |
| 4. Same as | 0.08 | 0.1 | 0.14 |
| **5. Lined or Constructed Channels** | | | |
| a. Cement | | | |
| 1. neat surface | 0.01 | 0.011 | 0.013 |
| 2. mortar | 0.011 | 0.013 | 0.015 |
| b. Wood | | | |
| 1. planed, | 0.01 | 0.012 | 0.014 |
| 2. planed, | 0.011 | 0.012 | 0.015 |
| 3. unplaned | 0.011 | 0.013 | 0.015 |
| 4. plank with | 0.012 | 0.015 | 0.018 |
| 5. lined with | 0.01 | 0.014 | 0.017 |
| c. Concrete | | | |
| 1. trowel finish | 0.011 | 0.013 | 0.015 |
| 2. float finish | 0.013 | 0.015 | 0.016 |
| 3. finished, with | 0.015 | 0.017 | 0.02 |
| 4. unfinished | 0.014 | 0.017 | 0.02 |
| 5. gunite, good | 0.016 | 0.019 | 0.023 |
| 6. gunite, wavy | 0.018 | 0.022 | 0.025 |
| 7. on good | 0.017 | 0.02 | |
| 8. on irregular | 0.022 | 0.027 | |
| d. Concrete bottom float finish with sides of | | | |
| 1. dressed stone | 0.015 | 0.017 | 0.02 |
| 2. random stone | 0.017 | 0.02 | 0.024 |
| 3. cement rubble | 0.016 | 0.02 | 0.024 |
| 4. cement rubble | 0.02 | 0.025 | 0.03 |
| 5. dry rubble or | 0.02 | 0.03 | 0.035 |
| e. Gravel bottom with sides of | | | |
| 1. formed | 0.017 | 0.02 | 0.025 |
| 2. random stone | 0.02 | 0.023 | 0.026 |
| 3. dry rubble or | 0.023 | 0.033 | 0.036 |
| f. Brick | | | |
| 1. glazed | 0.011 | 0.013 | 0.015 |
| 2. in cement | 0.012 | 0.015 | 0.018 |
| g. Masonry | | | |
| 1. cemented | 0.017 | 0.025 | 0.03 |
| 2. dry rubble | 0.023 | 0.032 | 0.035 |
| h. Dressed ashlar/stone paving | 0.013 | 0.015 | 0.017 |
| i. Asphalt | | | |
| 1. smooth | 0.013 | 0.013 | |
| 2. rough | 0.016 | 0.016 | |
| j. Vegetal lining | 0.03 | | 0.5 |

Manning's n for Closed

| Type of Conduit and Description | Minimum | Normal | Maximum |
|---|---|---|---|
| **1. Brass, smooth:** | 0.009 | 0.01 | 0.013 |
| **2. Steel:** | | | |
| Lockbar and | 0.01 | 0.012 | 0.014 |
| Riveted and spiral | 0.013 | 0.016 | 0.017 |
| **3. Cast Iron:** | | | |
| Coated | 0.01 | 0.013 | 0.014 |
| Uncoated | 0.011 | 0.014 | 0.016 |
| **4. Wrought Iron:** | | | |
| Black | 0.012 | 0.014 | 0.015 |
| Galvanized | 0.013 | 0.016 | 0.017 |
| **5. Corrugated Metal:** | | | |
| Subdrain | 0.017 | 0.019 | 0.021 |
| Stormdrain | 0.021 | 0.024 | 0.03 |
| **6. Cement:** | | | |
| Neat Surface | 0.01 | 0.011 | 0.013 |
| Mortar | 0.011 | 0.013 | 0.015 |
| **7. Concrete:** | | | |
| Culvert, straight, | 0.01 | 0.011 | 0.013 |
| Culvert with bends, | 0.011 | 0.013 | 0.014 |
| Finished, | 0.011 | 0.012 | 0.014 |
| Finish, | 0.013 | 0.015 | 0.017 |
| Unfinished, steel | 0.012 | 0.013 | 0.014 |
| Unfinished, smooth | 0.012 | 0.014 | 0.016 |
| Unfinished, rough | 0.015 | 0.017 | 0.02 |
| **8. Wood:** | | | |
| Stave | 0.01 | 0.012 | 0.014 |
| Laminated, treated | 0.015 | 0.017 | 0.02 |
| **9. Clay:** | | | |
| Common drainage | 0.011 | 0.013 | 0.017 |
| Vitrified sewer | 0.011 | 0.014 | 0.017 |
| Vitrified sewer with | 0.013 | 0.015 | 0.017 |
| Vitrified subdrain | 0.014 | 0.016 | 0.018 |
| **10. Brickwork:** | | | |
| Glazed | 0.011 | 0.013 | 0.015 |
| Lined with cement | 0.012 | 0.015 | 0.017 |
| Sanitary sewers | 0.012 | 0.013 | 0.016 |
| Paved invert, | 0.016 | 0.019 | 0.02 |
| Rubble masonry, | 0.018 | 0.025 | 0.03 |

Manning's n for Corrugated

| Type of Pipe, Diameter and Corrugation Dimensions | n |
|---|---|
| **1. Annular 2.67 x 1/2 inch (all diameters)** | 0.024 |
| **2. Helical 1.60 x 1/4 inch** | |
| 8" diameter | 0.012 |
| 10" diameter | 0.014 |
| **3. Helical 2.67 x 1/2 inch** | |
| 12" diameter | 0.011 |
| 18" diameter | 0.014 |
| 24" diameter | 0.016 |
| 36" diameter | 0.019 |
| 48" diameter | 0.02 |
| 60" diameter | 0.021 |
| **4. Annular 3x1 inch (all diameters)** | 0.027 |
| **5. Helical 3x1 inch** | |
| 48" diameter | 0.023 |
| 54" diameter | 0.023 |
| 60" diameter | 0.024 |
| 66" diameter | 0.025 |
| 72" diameter | 0.026 |
| 78" diameter and larger | 0.027 |
| **6. Corrugations 6x2 inches** | |
| 60" diameter | 0.033 |
| 72" diameter | 0.032 |
| 120" diameter | 0.03 |
| 180" diameter | 0.028 |

Updated Nov 24

| **Flood Modeller parameters** | |
|---|---|
| **Default parameters:** | https://help.floodmodeller.com/docs/parameters.tab |
| Lower Froude limit | 0.75 |
| Upper Froude limit | 0.9 |
| Pivotal choice parameter | 0.1 |
| Matrix dummy coefficient | 0 |
| Convergence | 0.001 |
| Minimum depth of water | 0.1 |
| Average water temperature | 10 |
| Global matrix dummy coefficient | 0 |
| Large results check | off |
| Upper flow bound | 1x10^7 |
| Upper stage bound | 1x10^5 |
| | |
| **Advanced parameters** | https://help.floodmodeller.com/docs/advance-parameters.tab |
| dflood | 3 |
| htol | 0.01 |
| qtol | 0.01 |
| nxstr | 3 |
| maxstr | 11 |
| theta | 0.7 |
| alpha | 0.7 |
| sconmx | 100 |
| dlimax | 1 |
| dlimax | 1000 |
| sweip | 0.001 |
| weight | 0.1 |
| Spill threshold | 1.n-6 |
| dfloodb | 10 |
| pcmexd | 2 |
| radint | 1 |
| avtr | 3.5 |
| qawide | 0.1 |
| pideap | 1 |
| Orifice linearization head | 0 |

| **Software help pages or manuals** |
|---|
| Flood Modeller | Knowledge Base |
| Tuflow |
| HEC-RAS User's Manual |
| InfoWorks ICM Online Help - Welcome |
| MIKE Knowledge Base |

| **EA site links for modelling standards & guidance:** |
|---|
| Evidence and Risk: Modelling Standards and Guidance |

| **EA modelling guidance** | LIT# |
|---|---|
| Fluvial Modelling Standards | LIT 56326 |
| Coastal Modelling Standards | LIT 56561 |
| Estuary Modelling Standards | LIT 56527 |
| NEC4 Minimum Technica Requirements for Modelling | LIT 18686 |
| Accounting for Residual uncertainty: updating the freeboard guide | SC120014 |
| Assessment of Residual uncertainty - supplementary Technical guidance | LIT 73536 |
| Assessment of residual uncertainty - RUA tool | LIT 73537 |
| Further RUA case studies | LIT 73530 - 73535 |

**Use the buttons to select the model reference information you require:**

**Flood Modeller**

| | | |
|---|---|---|
| 1.1 | What model approach has been adopted? Is it appropriate? **HEC-RAS:** If it is only a steady state model - is it appropriate or is unsteady | |
| 1.2 | | |
| 1.3 | Are all model files provided? | Output and input files must be checked. Check for outputs files as well as model inputs – list is: • Model input files • Model check files • Model logbook • Model results (raw, 1D and 2D) Model log text file and additional outputs (*.tlfs and *.word files) https://help.floodmodeller.com/docs/en/file-types-within-a-project?highlight=model%20files **Model_checks spreadsheet:** "File availability" button - select root folder of where the model files are stored - press OK - NO to "only report missing files" pop-up message - look into the "File_Check" tab - check the "File |
| 1.4 | Does the vertical chainage (upstream to downstream) in the model approximately match chainage based on survey or base mapping? | Scroll through cross sections and plot. Plot the long section. https://help.floodmodeller.com/docs/cross-section-selection-window |
| 1.5 | Does the model run? | Run a 1D simulation |
| 1.6 | Have all additional project files been provided to enable a review (i.e. | |
| 1.7 | | |
| 1.8 | Have check files been provided to enable a review or can they be | |
| 1.9 | Is model reporting sufficient to understand the scope of the project, how | |
| 2.1 | | |
| 2.2 | | |
| 2.3 | Are undefended scenarios required (for Flood Zones etc.) and if so have any raised defences and structures been removed in line | |
| 2.4 | Where a scheme is being developed, have appropriate model runs been provided to compare the baseline and with-scheme scenarios? Have the | |
| 2.5 | Has a study for quantifying uncertainty been undertaken? How was this | |
| 2.6 | Where a development is being proposed, have appropriate model runs been provided to compare the baseline and with-development scenarios? | |
| 2.7 | Where post development modelling is required, has this been considered within the modelling adequately and are the proposals represented in line | |
| 3.1 | Have appropriate distances between sections and/or nodes been used? | - be no more than 20B apart, where B is the top width of the channel; - generally not be more than 1/(2S) apart, where S is the mean slope (m vertical to m horizontal) of the river; - generally not be more than 0.2D/S apart, where D is the typical depth of flow and S is the mean slope. Where these requirements cannot otherwise be met, interpolated channel sections can be used in the model. Check whether there is erratic node spacing. Also worth checking if the cross section spacing allows suitable detail to be picked up from the channel. Use 1D model summary this will give a table with the node and chainage which details the distance to next node. Alternatively go through each cross section and look at the distance to next section at the bottom left. |
| 3.2 | Is the model geo-referenced? | This is important – FMP - are gxy/iey file available? If not available, then request files and if that isn't an option or only partial x,y data is available then use 'FMP_gxy_editor' (Model_checks folder) to improve the network |
| 3.3 | Do the cross sections and bed profiles look reasonable? | Scroll through cross sections and plot. Plot the long section. https://help.floodmodeller.com/docs/cross-section-selection-window |
| 3.4 | Does conveyance look appropriate? | A conveyance ratio outside of 0.7-1.4 normally indicates a significant change in geometry between cross sections - check survey. To improve the accuracy of the solver it may be appropriate to add interpolates or truncate redundant parts of a cross section. Check several sections (result) at once by selecting sections in the network window, then navigate to the toolbar, expand "model review tools", the "1D models", then open the "tabulate cross section properties" tool. Click the "River section property plots" tab. Ensure conveyance and stage are selected for x and y and then click on the "plot" button. You can zoom in on the graph with a left click, hold and drag to see more detail. Visually check for selected sections by right clicking a section in the network, select "Cross Section" from drop down menu and then "plot" from the box. In the xs plot, right click and select "Add series" then tick "conveyance" option. Proceed to scroll through sections using the arrows, top right of xs plot window. Note - if scrolling through xs, the plots will reset when you reach a structure - Need to repeat the above process to turn conveyance back on when you reach next open channel xs. **Model_checks spreadsheet:** "FMP River model" button - copy the exact location of the .dat file path into cell B2 - click on "Run Check" - are there any Xs highlighted? |
| 3.5 | | |
| 3.6 | What method has been used to estimate roughness? What values have been used for the floodplain (if 1D only model) and channel? Are these | |
| 3.7 | **HEC-RAS:** Do the cross sections contain ineffective flow areas. If so, have | |
| 4.1 | Is there 'glass walling' anywhere in the modelled reaches? Are out of bank flows represented in 1D? If so, how has it been done and is it appropriate? | Plot the cross sections & long section. https://help.floodmodeller.com/docs/how-to-plot-sections-and-customise-a-long-section-of-1d-river-results?highlight=plot%20long%20section |
| 4.2 | | |
| 4.3 | How is the downstream boundary(s) applied? Have appropriate locations | |
| 4.4 | **If tidal** - how has the boundary been derived? | Ensure boundary peak levels are updated to present day and tidal boundary extends for 4-5 tides with peak tide 2nd/3rd tide. For most studies EA data will be used, check location and peak values. Check phasing of astronomical and surge is repeated. |
| 5.1 | Are all structures represented (inc. movable structures)? If not, have explanations for structures not modelled been given in the reporting? | Look at the river network table to identify all structures used. Cross reference this with the survey data. |
| 5.2 | | |
| 5.3 | Are invert levels correct compared to survey data? | Plot the structure through the cross section view. |
| 5.4 | Where structures bypass or overtop, have spills been represented correctly | Check the river network to see if spills have been added in at bridges. |
| 5.5 | Have structure coefficients been changed from default values? If so, are | |
| 5.6 | | |
| 6.1 | What datasets have been used to define the floodplain (i.e. LIDAR, topographic survey etc.) and have these datasets been correctly | |
| 6.2 | What grid resolution has been used within the model and is it suitable to capture key flow routes within the model (e.g. between buildings)? | **.tlf log file:** open the log file and search for Cell Size **Model_checks spreadsheet:** "TUFLOW output summary" button - select the folder that all TUFLOW files - "Output_summary" sheet - what is the cell size used? - is it suitable? |
| 6.3 | Has the DTM been created to optimise flow route representation? Is this | |
| 6.4 | How have buildings been represented within the DTM? Is this | |
| 6.5 | | |
| 6.6 | | |
| 6.7 | Are conveyance routes underneath raised embankments accurately | |
| 6.8 | What method has been used to estimate roughness? What values have been used for the floodplain and channel (for a 2D only model)? Are these | |
| 6.9 | Is the representation of different roughness areas sufficiently accurate and | |
| 7.1 | Have any 2D boundaries been used in the model and if so are these | |
| 7.2 | Is there 'glass walling' anywhere in the modelled reach where outputs | |
| 7.3 | | |
| 8.1 | Have any structures been included in the 2D domain (floodplain or channel) and how have they been represented? Are structure details (invert, length | |
| 8.2 | Are values of roughness and loss coefficient suitable for the type of | |
| 9.1 | Check the geographical coverage of the model relative to the surface water catchment for the study. Is the model coverage sufficient for the | |
| 9.2 | Have contributing areas been applied appropriately? Are the sub catchment boundaries geocoded? Do the impermeable area assumptions | |
| 9.3 | How has the surface water network been represented; is it suitably | |
| 9.4 | Does connectivity between the surface water pipe network and the 1D or | |
| 9.5 | How are receiving watercourses represented in the model? Is this | |
| 9.6 | Has storage compensation for manhole shafts been included (relevant to | |
| 9.7 | Does connectivity between the surface water pipe network and the 1D or | |
| 9.8 | Are all significant storage tanks included in model with appropriate detail? | |
| 9.9 | Are all significant pumping stations included in the model with appropriate | |
| 9.10 | Has any infrastructure been omitted from the model network? If so what is | |
| 9.11 | Is the runoff model appropriate and have the parameters been applied | |
| 9.12 | How has the design rainfall been generated and applied? Is this | |
| 9.13 | Are there any backfalls in the model and do these look realistic where they | |
| 9.14 | Have sediment depths and roughness coefficients been applied | |
| 13.1 | How have the 1D/2D models been coupled, is it appropriate? Is the | |
| 13.2 | Is the 2D representation of the river channel comparable in width with the 1D model cross sections? | Visual check - Load the 2D link lines/boundaries into FMP GIS interface. Then open the FMP .dat file into FMP, click on the .dat file in project window, drag it and drop it into the FMP map window (don't display deactivated parts of the cross section when asked). This will plot the georeferenced 1D sections in the map window where they can be directly compared to the 2D boundary that describes the 1D channel. |
| 13.3 | How is the 1D output represented within the 2D domain and is it | |
| 13.4 | Have any default link parameters been changed (i.e. to improve stability). | |
| 14.1 | What time step has been used for the 1D model? Is it appropriate? | Check the IEF files or simulations sections and timestep tab https://help.floodmodeller.com/docs/en/timestep?highlight=timestep |
| 14.2 | | |
| 14.3 | Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified? | Model-checks 'FMP zzd' summarises all the available .zzd file including modified parameters. Alternatively check individual ZZD model output, which summarises where these have been changed. |
| 14.4 | What time step has been used for the 2D model? Is it appropriate? | **.tlf log file:** open the log file and search for time step **Model_checks spreadsheet:** "TUFLOW output summary" button - select the folder that all TUFLOW files - "Output_summary" sheet - is the time step suitable? **QGIS ModCheck plugin:** Select "Run variable and summary" - select the FMP .ief folder - "Multiple Summary" tab - what is the 2D time step? Is it acceptable? |
| 14.5 | Have initial water levels been applied and are these appropriate for the | |
| 14.6 | Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default? If so, has it been justified? | |
| 15.1 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | **TUFLOW 2D:** open QGIS - "Layer" toolbar - "Add Layer" - "Add Vector Layer..." or Ctrl+Shift+V - add the "_messages_P.shp" file (usually it can be found in the TUFLOW\check\logs folder) **QGIS ModCheck plugin:** Select "Run variable and summary" - "TUFLOW" tab - "Multiple Summary" tab - select the .tlf file - "Warnings" and "Checks" columns - are there any negative depths? Check the output data including detailed output tables which will list all warnings/ errors at all XS, structures, Weirs, special structures etc. Typical errors include: Cross sections end points had to be extended vertically: indicate insufficient 1D cross section (glass walling). It also advised to check the river banks/ lateral links elevations are set correctly. Energy loss was greater than 0.8m between current and previous section: Likely to indicate the need of extra/ interpolated sections. Conveyance ratio outside the range 0.7-1.4: indicating sudden/ large changes in cross section area: possible solutions may include truncating redundant portions of XS or add extra XS. Poor calculations at structures: Query have 4 cross sections plus parameters been set correctly (i.e. Tabs 5.1 – 5.2) to allow matrix to function properly) and/ or the pressure flows been enabled for high flows? |
| 15.2 | Is 1D mass balance from the model run within expected limits? Have they been investigated and resolved where potentially impacting the model | |
| 15.3 | Have any periods of non-convergence within the model run been investigated and resolved where potentially impacting the model results? | **Model_checks spreadsheet:** "FMP zzd" button - select the folder that has all .zzd files - "FMP_zzd" sheet - are there any NM values reported? **QGIS ModCheck plugin:** Select "Run variable and summary" - "FMP" tab - "Diagnostics" tab - select the .zzd file - are there non-convergent timesteps present? Timestep Log Diagnostics : When re-running a simulation with this on for an enhanced, and bigger simulation log file which provides non-convergence information for every timestep. Listed in the log file. |
| 15.4 | Under a range of different scenarios do the animations and graphed | |
| 15.5 | Is 2D mass balance from the model run within expected limits? Where outside of expected tolerance, have they been investigated and resolved | **QGIS ModCheck plugin:** Select "Check TUFLOW MB" - "Summary" tab - load the folder that has all MB files - analyse the graphed outputs |
| 15.6 | Are CE and dV values relatively stable and remain so once the run has got going? | for Tuflow /FMP 2D - multiple model runs can be checked Model_checks ' TuFlow output summary' and time series of MB(W) can be plotted using 'Mass Balance' Alternatively review individual TLF and MB*.csv files **QGIS ModCheck plugin:** Select "Check TUFLOW MB" - "Summary" tab - load the folder that has all MB files - analyse the graphed outputs |
| 15.7 | Have any comments, errors and warnings generated during the model run, | |
| 15.8 | Are negative depths being created during the model run? If so, have these | |
| 15.9 | Under a range of different scenarios do the animations and graphed | |
| #### | **HPC Models Only** - Do the appropriate HPC output files show any indication of instability? If so, has this been investigated and resolved where | |
| 16.1 | Have calibration/verification runs been completed based on locally gauged | |
| 16.2 | Are the simulated hydrograph peaks reasonably similar to the recorded peaks? Is the shape of the simulated hydrograph and therefore the volume | |
| 16.3 | Are simulated floodplain extents similar to recorded extents? Are flow | |
| 16.4 | Has suitable effort been made to attempt and improve calibration. Have | |
| 16.5 | Is there good reconciliation between estimates at flow estimation points | |
| 16.6 | Where calibration is not possible due to data availability, have checks been made against other recorded data (wrack marks, flood events, | |
| 16.7 | If no recorded or historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large | |
| 16.8 | Have appropriate model parameters been chosen for sensitivity testing? Typical tests include: Sensitivity to roughness ± 20% ( Manning's "n" both in 1D and 2D) Sensitivity to flows ± 20% (From central estimate) Sensitivity to downstream boundary | |
| 16.9 | Do the results of the tests show the models to be particularly sensitive to | |
| #### | For development modelling, has the uncertainty of the modelling been quantified and reported, is this reasonable? Does it describe what it means to the conclusions of the assessment (design of the | |
| 16.1 | Has an assessment of post scheme/development on third party flood risk been undertaken? Has justification been provided for any off-site change and is this reasonable? | What do maps look like with no buffer What justification has been provided? Check other metrics such as flow downstream of site, timing, volume pre and post. Is any compensation/mitigation proposed? How big is the difference? Is the difference widespread or isolated? Could the change be hydraulically linked to the site? Are the baseline and post development models setup the same? What is the overall stability of the model? Could this be improved? |
| 11.3 | Does the coastline file represent the coastline to a high enough resolution | |
| 11.5 | Does the model extend far enough offshore that computational error close | |
| 11.6 | Does the model domain extend sufficiently to the boundary source | |
| 11.8 | Is the spectral shape to be applied to the ocean boundary appropriate | |
| 11.9 | Does the model mesh / grid represent the input bathymetry well, and is the input bathymetry of high enough resolution to represent bathymetric features that are expected to alter wave propagation within the model | |
| 11.1 | Has the model water level been set constant across the model domain? If yes, is this a realistic assumption given the tidal behaviour across the | |
| 11.1 | Is the model stationary or non-stationary? For non-stationary models has the underlying tide / surge behaviour been | |
| 11.2 | For non-stationary models has an appropriate data set been identified to | |
| 11.2 | Are the wave boundary conditions from the same model data source as the | |
| 11.2 | For non-stationary models has an appropriate dataset been identified to | |
| 11.2 | Has the wave transformation model been calibrated against appropriate | |
| 11.2 | Do the locations of the calibration data allow calibration close to the | |
| 11.2 | Has the model been validated against appropriate data independent from | |
| 11.2 | Have sensitivity runs been performed in order to test the sensitivity of the model at the output locations to reasonable variations in the model forcing | |
| 11.2 | Have the number of iterations been modified away from the default and is | |
| 11.2 | Has the model achieved the appropriate levels of convergence, in | |
| 11.3 | Is model behaviour suitable when reviewing outputs of Hs,Tp, Mdir fields | |
| 11.3 | Has emulation been used in the model? If so, is the emulation appropriate | |
| 12.5 | Have the correct crest, toe and slope been used in terms of any | |
| 12.6 | Are the defence profiles comparable to beach profile, AIMS, defence | |
| #### | How has wave overtopping been considered when the still water levels | |

**TUFLOW**

| | | |
|---|---|---|
| 1.1 | What model approach has been adopted? Is it appropriate? **HEC-RAS:** If it is only a steady state model - is it appropriate or is unsteady | |
| 1.2 | | |
| 1.3 | Are all model files provided? | Use Model_checks 'File Availability' Run model in 1D only mode. Missing files will be highlighted. Output and input files must be checked. Check for outputs files as well as model inputs – list is: • Model input files • Model check files • Model logbook • Model results (raw, 1D and 2D) |
| 1.4 | Does the vertical chainage (upstream to downstream) in the model | |
| 1.5 | Does the model run? | Run the model. |
| 1.6 | Have all additional project files been provided to enable a review (i.e. | |
| 1.7 | | |
| 1.8 | Have check files been provided to enable a review or can they be | |
| 1.9 | Is model reporting sufficient to understand the scope of the project, how | |
| 2.1 | | |
| 2.2 | | |
| 2.3 | Are undefended scenarios required (for Flood Zones etc.) and if so have any raised defences and structures been removed in line | |
| 2.4 | Where a scheme is being developed, have appropriate model runs been provided to compare the baseline and with-scheme scenarios? Have the | |
| 2.5 | Has a study for quantifying uncertainty been undertaken? How was this | |
| 2.6 | Where a development is being proposed, have appropriate model runs been provided to compare the baseline and with-development scenarios? | |
| 2.7 | Where post development modelling is required, has this been considered within the modelling adequately and are the proposals represented in line | |
| 3.1 | Have appropriate distances between sections and/or nodes been used? | The spacing should aim to satisfy the requirements that channel sections should: - be no more than 20B apart, where B is the top width of the channel; - generally not be more than 1/(2S) apart, where S is the mean slope (m vertical to m horizontal) of the river; - generally not be more than 0.2D/S apart, where D is the typical depth of flow and S is the mean slope. Where these requirements cannot otherwise be met, interpolated channel sections can be used in the model. |
| 3.2 | | |
| 3.3 | | |
| 3.4 | Does conveyance look appropriate? | A conveyance ratio outside of 0.7-1.4 normally indicates a significant change in geometry between cross sections - check survey. To improve the accuracy of the solver it may be appropriate to add interpolates or truncate |
| 3.5 | | |
| 3.6 | What method has been used to estimate roughness? What values have been used for the floodplain (if 1D only model) and channel? Are these | |
| 3.7 | **HEC-RAS:** Do the cross sections contain ineffective flow areas. If so, have | |
| 4.1 | Is there 'glass walling' anywhere in the modelled reaches? Are out of bank flows represented in 1D? If so, how has it been done and is it appropriate? | |
| 4.2 | | |
| 4.3 | How is the downstream boundary(s) applied? Have appropriate locations | |
| 4.4 | **If tidal** - how has the boundary been derived? | Ensure boundary peak levels are updated to present day and tidal boundary extends for 4-5 tides with peak tide 2nd/3rd tide. For most studies EA data will be used, check location and peak values. Check phasing of astronomical and surge is repeated. |
| 5.1 | Are all structures represented (inc. movable structures)? If not, have | |
| 5.2 | | |
| 5.3 | | |
| 5.4 | Where structures bypass or overtop, have spills been represented correctly | |
| 5.5 | Have structure coefficients been changed from default values? If so, are | |
| 5.6 | | |
| 6.1 | What datasets have been used to define the floodplain (i.e. LIDAR, topographic survey etc.) and have these datasets been correctly | |
| 6.2 | What grid resolution has been used within the model and is it suitable to capture key flow routes within the model (e.g. between buildings)? | The cell size for 2D simulations to try and capture key flow routes with a width of 2-3 cells. This can be done by comparing the cell size to known width of flow routes, or by comparing the 2d_grid check file and underlying map check visually. Model_checks 'Tuflow output summary' summarises grid size and time step. |
| 6.3 | Has the DTM been created to optimise flow route representation? Is this | |
| 6.4 | How have buildings been represented within the DTM? Is this | |
| 6.5 | | |
| 6.6 | | |
| 6.7 | Are conveyance routes underneath raised embankments accurately | |
| 6.8 | What method has been used to estimate roughness? What values have been used for the floodplain and channel (for a 2D only model)? Are these | |
| 6.9 | Is the representation of different roughness areas sufficiently accurate and | |
| 7.1 | Have any 2D boundaries been used in the model and if so are these | |
| 7.2 | Is there 'glass walling' anywhere in the modelled reach where outputs | |
| 7.3 | | |
| 8.1 | Have any structures been included in the 2D domain (floodplain or channel) and how have they been represented? Are structure details (invert, length | Significant obstructions to flow in the 2D domain must be represented explicitly in the 2D domain. Check the *.tgc file and check files including 2d_zpts (grid this in Vertical Mapper), 2d_bc_hx_check and 2d_zsh_zpt_check |
| 8.2 | Are values of roughness and loss coefficient suitable for the type of | |
| 9.1 | Check the geographical coverage of the model relative to the surface water catchment for the study. Is the model coverage sufficient for the | |
| 9.2 | Have contributing areas been applied appropriately? Are the sub catchment boundaries geocoded? Do the impermeable area assumptions | |
| 9.3 | How has the surface water network been represented; is it suitably | |
| 9.4 | Does connectivity between the surface water pipe network and the 1D or | |
| 9.5 | How are receiving watercourses represented in the model? Is this | |
| 9.6 | Has storage compensation for manhole shafts been included (relevant to | |
| 9.7 | Does connectivity between the surface water pipe network and the 1D or | |
| 9.8 | Are all significant storage tanks included in model with appropriate detail? | |
| 9.9 | Are all significant pumping stations included in the model with appropriate | |
| 9.10 | Has any infrastructure been omitted from the model network? If so what is | |
| 9.11 | Is the runoff model appropriate and have the parameters been applied | |
| 9.12 | How has the design rainfall been generated and applied? Is this | |
| 9.13 | Are there any backfalls in the model and do these look realistic where they | |
| 9.14 | Have sediment depths and roughness coefficients been applied | |
| 13.1 | How have the 1D/2D models been coupled, is it appropriate? Is the digitisation of the links acceptable? | Use the 1d_2D check file to confirm where linking has been applied and the type of link allocated. Suitable approaches should be taken depending upon the channel and floodplain topography and how stable the link is. Key points to remember are: HX linking: • Topography of cells is important – if bank survey is available then thick Z lines must be applied to these links if survey is not available make sure 2D level is aligned with 1D survey. • Are HX links putting water into the floodplain in unusual locations? Check model outputs in GIS mapper or similar. SX linking: |
| 13.2 | Is the 2D representation of the river channel comparable in width with the | |
| 13.3 | How is the 1D output represented within the 2D domain and is it | |
| 13.4 | Have any default link parameters been changed (i.e. to improve stability). | |
| 14.1 | | |
| 14.3 | Have any of the parameters and advanced parameters been changed from | |
| 14.4 | | |
| 14.5 | Have initial water levels been applied and are these appropriate for the | |

| | | |
|---|---|---|
| 14.6 | Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default? If so, has it been justified? | |
| | | |
| 15.1 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | Check the output data including detailed output tables which will list all warnings/ errors at all XS, structures, weirs, lateral structures etc.<br>Typical errors include:<br>Cross sections end points had to be extended vertically: indicate insufficient 1D cross section (glass walling). It also advised to check the river banks/ lateral links elevations are set correctly<br>Energy loss was greater than 0.3m between current and previous section: Likely to indicate the need of extra/ interpolate(d) sections<br>Conveyance ratio outside the range 0.7-1.4: indicating sudden/ large changes in cross section area: possible solutions may include truncating redundant portions of XS or add extra XS<br>Poor calculations at structures: Query have 4 cross sections plus parameters been set correctly (i.e. Tabs 5.1 - 5.5) (to allow maths to function properly) and/ or has pressure flows been enabled for high flows? |
| 15.2 | Is 1D mass balance from the model run within expected limits? Have they been investigated and resolved where potentially impacting the model | |
| 15.3 | Have any periods of non-convergence within the model run been investigated and resolved where potentially impacting the model results? | Timestep Log Diagnostics . When re-running a simulation witch this on for an enhanced, and bigger simulation log file which provides non-convergence information for every timestep.<br>Listed in the log file. |
| 15.4 | Under a range of different scenarios do the animations and graphed | |
| 15.5 | Is 2D mass balance from the model run within expected limits? Where outside of expected tolerance, have they been investigated and resolved where potentially impacting the model results? | Multiple model runs can be checked Model_checks 'Tuflow output summary' and time series of MB(d)V can be plotted using 'Mass balance'<br>Alternatively, cumulative mass balance can be found near the bottom of the TLF, or you can open the mass balance .csv outputs from the Tuflow results folder and plot graphs (this takes longer than using the above mentioned tool). |
| 15.6 | Are CE and dV values relatively stable and remain so once the run has got | For Tuflow /FMP 2D - multiple model runs can be checked Model_checks 'Tuflow output summary' and time series of MB(d)V can be plotted using 'Mass balance' |
| 15.7 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | Model checks 'Tuflow output summary' display the number of warnings/error messages for multiple model runs. |
| 15.8 | Are negative depths being created during the model run? If so, have these been investigated and resolved where appropriate? | Total numbers of negative depths can be checked for multiple model runs by using Model_checks 'Tuflow output summary' |
| 15.9 | Under a range of different scenarios do the animations and graphed | |
| #### | **HPC Models Only** - Do the appropriate HPC output files show any indication of instability? If so, has this been investigated and resolved where appropriate? | |
| | | |
| 16.1 | Have calibration/verification runs been completed based on locally gauged | |
| 16.2 | Are the simulated hydrograph peaks reasonably similar to the recorded peaks? Is the shape of the simulated hydrograph and therefore the volume | |
| 16.3 | Are simulated floodplain extents similar to recorded extents? Are flow | |
| 16.4 | Has suitable effort been made to attempt and improve calibration. Have | |
| 16.5 | Is there good reconciliation between estimates at flow estimation points | |
| 16.6 | Where calibration is not possible due to data availability, have checks been made against other recorded data (wrack marks, flood extents, | |
| 16.7 | If no recorded or historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large | |
| 16.8 | Have appropriate model parameters been chosen for sensitivity testing?<br>Typical tests include:<br>Sensitivity to roughness ± 20% ( Manning's "n" both in 1D and 2D)<br>Sensitivity to flows ± 20% (From central estimate)<br>Sensitivity to downstream boundary | |
| 16.9 | Do the results of the tests show the models to be particularly sensitive to | |
| #### | For development modelling, has the uncertainty of the modelling been quantified and reported, is this reasonable? Does it describe what it means to the conclusions of the assessment (design of the | |
| 16.1 | Has an assessment of post scheme/development on third party flood risk been undertaken? Has justification been provided for any off-site change and is this reasonable? | What do maps look like with no buffer<br>What justification has been provided?<br>Check other metrics such as flow downstream of site, timing, volume pre and post.<br>Is any compensation/mitigation proposed?<br>How big is the difference?<br>Is the difference widespread or isolated?<br>Could the change be hydraulically linked to the site?<br>Are the baseline and post development models setup the same?<br>What is the overall stability of the model? Could this be improved? |
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| 10.1 | What probability method has been used for the study? | |
| 10.2 | Has up to date data been used as a forcing parameter to drive the wave | |
| 10.4 | Has the Coastal Flood Boundary (CFB) data been applied appropriately | |
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| 11.3 | Does the coastline file represent the coastline to a high enough resolution | |
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| 11.8 | Is the spectral shape to be applied to the ocean boundary appropriate | |
| 11.9 | Does the model mesh / grid represent the input bathymetry well, and is the input bathymetry of high enough resolution to represent bathymetric features that are expected to alter wave propagation within the model | |
| 11.1 | Has the model water level been set constant across the model domain? If yes, is this a realistic assumption given the tidal behaviour across the | |
| 11.1 | Is the model stationary or non-stationary?<br>For non-stationary models has the underlying tide / surge behaviour been | |
| 11.2 | For non-stationary models has an appropriate data set been identified to | |
| 11.2 | Are the wave boundary conditions from the same model data source as the | |
| 11.2 | For non-stationary models has an appropriate data set been identified to | |
| 11.3 | Has the wave transformation model been calibrated against appropriate | |
| #### | Do the locations of the calibration data allow calibration close to the | |
| 11.3 | Has the model been validated against appropriate data independent from | |
| 11.2 | Have sensitivity runs been performed in order to test the sensitivity of the model at the output locations to reasonable variations in the model forcing | |
| 11.2 | Have the number of iterations been modified away from the default and is | |
| 11.3 | Has the model achieved the appropriate levels of convergence, in | |
| 11.3 | Is model behaviour suitable when reviewing outputs of Hs,Tp, MWD fields | |
| 11.3 | Has emulation been used in the model? If so, is the emulation appropriate | |
| | | |
| 12.5 | Have the correct crest, toe and slope been used in terms of any | |
| 12.6 | Are the defence profiles comparable to As-built profile, NGMS, defence | |
| #### | Has the wave overtopping been considered at the still water levels | |

| | | |
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| 1.1 | What model approach has been adopted? Is it appropriate?<br>**HEC-RAS:** If it is only a steady state model - is it appropriate or is unsteady | |
| 1.2 | What model version are you reviewing? | In the simulation toolbar, there is a drop down selection box listing all of the saved versions of the model. Select the latest version e.g. the one at the bottom of the list.<br>To compare model versions (or scenarios) right click on the model network. Scroll on the left of the screen, under the master database) it will have a yellow icon next to it. Select the compare option and then choose the two |
| 1.3 | Are all model files provided? | Run model in 1D only mode. Missing files will be highlighted.<br>Output and input files must be checked.<br>Check for outputs files as well as model inputs – list is:<br>• Model input files<br>• Model check files<br>• Model logbook<br>• Model results (raw, 1D and 2D)<br>Model log text file and additional outputs (*.tlf and * event files) |
| 1.4 | Does the vertical chainage (upstream to downstream) in the model appropriately match chainages based on survey or base mapping? | After selecting the network, in the simulation toolbar, there is a drop down selection box listing all of the saved versions of the model. Select the latest version e.g. the one at the bottom of the list. Select the version of the model you are reviewing.<br>Click on the Network menu in the top left of the screen, select overview. This will summarise the properties of the model version (or scenario) you have selected.<br>Right click in GeoPlan, through properties and themes select the cross section layer and turn it on to be visible.<br>Use the selection tool to choose a cross section and double left click, choose cross section line in the pop up box. The properties menu will open up, giving you the length (width) of the cross section, click on the .... icon next to the section data option. This will bring up the detailed cross section properties including roughness values.<br>Or: GeoPlan menu, GeoPlan tools, cross section graph. Left click on the cross section you wish to inspect and a cross section is produced. Less detailed than the method above. |
| 1.5 | Does the model run? | Expand the model runs / simulations folder, drag the scenario you wish to re-run in to the gureplane or double click on the scenario. This will open the run form, click on run simulations.<br>Blue diamond means that the model is running. |
| 1.6 | Have all additional project files been provided to enable a review (i.e. model report, survey etc)? | To create a log file in Infoworks takes quite a bit of time. |
| 1.8 | Have check files been provided to enable a review or can they be | |
| 1.9 | Is model reporting sufficient to understand the scope of the project, how | |
| | | |
| 2.1 | Are the simulated events sufficient to meet project requirements? | Events are listed in the master database window, in the simulations group.<br>These are likely to be saved as separate model scenarios or versions. This should be detailed in the modelling log. |
| 2.3 | Are undefended scenarios required (for Flood Zones etc.) and if so have any raised defences and structures been removed in line | |
| 2.4 | Where a scheme is being developed, have appropriate model runs been provided to compare the baseline and with-scheme scenarios? Have the | Events are listed in the master Database window, in the simulation group. |
| 2.5 | Has a study for quantifying uncertainty been undertaken? How was this | |
| 2.6 | Where a development is being proposed, have appropriate model runs been provided to compare the baseline and with-development scenarios? | |
| 2.7 | Where post development modelling is required, has this been considered within the modelling adequately and are the proposals represented in line | |
| | | |
| 3.1 | Have appropriate distances between sections and/or nodes been used? | - be no more than 20W apart, where W is the top width of the channel;<br>- generally not be more than L/(20) apart, where L is the length of the channel;<br>- generally not be more than 0.2D/S apart, where D is the typical depth of flow and S is the mean slope.<br>Where these requirements cannot otherwise be met, interpolated channel sections can be used in the model.<br>Check whether there is erratic node spacing. Also worth checking if the cross section spacing allows suitable detail to be picked up from the channel<br>Make sure that you have selected the correct network version.<br>If a theme has been created for the river cross sections, drag that in to the GeoPlan and use the measure distance tool (icon looks like a ruler).<br>If a theme has not been created, right click in the GeoPlan window, select properties and themes and scroll to the cross section layer and select it to make it visible. press OK |
| 3.3 | Do the cross sections and bed profiles look reasonable? | Right click in GeoPlan, through properties and themes select the cross section layer and turn it on to be visible.<br>Use the selection tool to choose a cross section and double left click, choose cross section line in the pop up box. The properties menu will open up, giving you the length (width) of the cross section, click on the .... icon next to the section data option. This will bring up the detailed cross section properties including roughness values. |
| 3.4 | Does conveyance look appropriate? | A conveyance ratio outside of 0.7-1.4 normally indicates a significant change in geometry between cross sections - check survey. To improve the accuracy of the solver it may be appropriate to add interpolates or truncate |
| 3.6 | What method has been used to estimate roughness? What values have been used for the floodplain (if 1D only model) and channel? Are these appropriate? | Specified in the 1D cross section.<br>Make sure that you have selected the correct network version.<br>If a theme has been created for the river cross sections, drag that in to the GeoPlan and use the measure distance tool (icon looks like a ruler).<br>If a theme has not been created, right click in the GeoPlan window, select properties and themes and scroll to the cross section layer and select it to make it visible. press OK |
| 3.7 | **HEC-RAS:** Do the cross sections contain ineffective flow areas. If so, have | |
| | | |
| 4.1 | Is there 'glass walling' anywhere in the modelled reaches? Are out of bank flows represented in 1D? If so, how has it been done and is it appropriate? | Use the selection tool to choose a cross section and double left click, choose cross section line in the pop up box. The properties menu will open up, giving you the length (width) of the cross section, click on the .... icon next to the section data option. This will bring up the detailed cross section properties including roughness values.<br>Or: GeoPlan menu, GeoPlan tools, cross section graph. Left click on the cross section you wish to inspect and a cross section is produced. Less detailed than the method above.<br>Left double click on a cross section with the selection tool or use the information tool to open the cross section data.<br>Make sure that you have selected the correct network version.<br>If a theme has been created for the river cross sections, drag that in to the GeoPlan and use the measure distance tool (icon looks like a ruler).<br>If a theme has not been created, right click in the GeoPlan window, select properties and themes and scroll to the cross section layer and select it to make it visible. press OK |
| 4.2 | How have the inflows boundaries been applied? | Double click on a simulation to open the run form, check the inflow section, this will tell you which event file is being used. |
| 4.3 | How is the downstream boundary(s) applied? Have appropriate locations | |
| 4.4 | **If tidal** - how has the boundary been derived? | Ensure boundary peak levels are updated to present day and tidal boundary extends for 3-5 tides with peak tide 2nd/3rd tide. For most studies CFB data will be used, check location and peak values. Check phasing of astronomical and surge is reported. |
| | | |
| 5.1 | Are all structures represented (inc. movable structures)? If not, have explanations for structures not modelled been given in the reporting? | Select "new lines window" and navigate to the 2D boundary tab, this will give you the information regarding any 2D boundaries.<br>You can them add the boundary lines ri to the GeoPlan using properties and themes. |
| 5.4 | Where structures bypass or overtop, have spills been represented correctly to reflect this? | Right click in the GeoPlan window, select properties and themes and scroll to the inline banks layer and select it to make it visible. press OK<br>Inline banks have been digitised at the end of channels to represent spills. |
| 5.5 | Have structure coefficients been changed from default values? If so, are | |
| | | |
| 6.1 | What datasets have been used to define the floodplain (i.e. LiDAR, topographic survey etc.) and have these datasets been correctly | |
| 6.2 | What grid resolution has been used within the model and is it suitable to | |
| 6.3 | Has the DTM been rotated to optimise flow route representation? Is this | |
| 6.4 | How have buildings been represented within the DTM? Is this | |
| 6.7 | Are conveyance routes underneath raised embankments accurately | |
| 6.8 | What method has been used to estimate roughness? What values have been used for the floodplain and channel (for a 2D only model)? Are these | Select new polygons window icon, along the bottom of the bottom there are a set of tabs, select roughness zone. This will list all of the roughness zone polygons and the associated roughness values. |
| 6.9 | Is the representation of different roughness areas sufficiently accurate and | |
| | | |
| 7.1 | Have any 2D boundaries been used in the model and if so are these schematised correctly? | Select "new lines window" and navigate to the 2D boundary tab, this will give you the information regarding any 2D boundaries. |
| 7.2 | Is there 'glass walling' anywhere in the modelled reach where outputs | |
| 7.3 | For direct rainfall modelling how has the input rainfall been applied? | Select "new polygons window" and choose the infiltration zone tab, this lists the land use types (you can select one of the entries and zoom to it by right clicking and selecting select and find in GeoPlan). |
| | | |
| 8.1 | Have any structures been included in the 2D domain (floodplain or channel) and how have they been represented? Are structure details (invert, length etc.) correct compared to survey? | Mesh level zones are utilised to increase or lower topographic levels.<br>Right click on the GeoPlan and select properties and themes, look for Mesh Zone in the layers and themes tab and select it to be visible.<br>If there are mesh level zones present, double click on it using the selection tool. to open the polygon properties. In the properties window, click on "vertices...." to view the height data associated with the polygon.<br>To view the impact of the mesh level zone, zoom in to the area where it is located and click on "new 3D network window" icon to see a 3D image of the change. See screenshot in the comment. |
| 8.2 | Are values of roughness and loss co-efficient suitable for the type of structure? | Use the selection tool or the properties tool to select the link line. In the section menu choose River reach and press OK. |
| | | |
| 9.1 | Check the geographical coverage of the model relative to the surface water catchment for the study. Is the model coverage sufficient for the study or project? | Check the coverage of sub catchments.<br>Right click, properties and themes, sub catchment. |
| 9.2 | Have contributing areas been applied appropriately? Are the sub catchment boundaries geocoded? Do the impermeable area assumptions | |
| 9.3 | How has the surface water network been represented, is it suitably detailed? | Open a "new links window" and view the data in the various types. The conduits tab included pipe data. |
| 9.4 | Does connectivity between the surface water pipe network and the 1D or | |
| 9.5 | How are receiving watercourses represented in the model? Is this | |
| 9.6 | Has storage compensation for manhole shafts been included (relevant to | |
| 9.7 | Does connectivity between the surface water pipe network and the 1D or | |
| 9.8 | Are all significant storage tanks included in model with appropriate detail? | Types:<br>Manhole<br>Storage<br>Break<br>Outfall<br>Pond |
| 9.9 | Are all significant pumping stations included in the model with appropriate | |
| 9.10 | Has any infrastructure been omitted from the model network? If so what is | |
| 9.11 | Is the runoff model appropriate and have the parameters been applied | |
| 9.12 | How has the design rainfall been generated and applied? Is this | |
| 9.13 | Are there any backfalls in the model and do these look realistic where they | |
| 9.14 | Have sediment depths and roughness coefficients been applied | |
| | | |
| 13.1 | How have the 1D/2D models been coupled, is it appropriate? Is the digitisation of the links acceptable? | River reach lines connect the 1D and 2D domains.<br>Inline banks can also be used to link the 1D and 2D domains.<br>Left click on the lines with the selection tool or information tool to open properties. |
| 13.2 | Is the 2D representation of the river channel comparable in width with the | |
| 13.3 | How is the 1D output represented within the 2D domain and is it | |
| 13.4 | Have any default link parameters been changed (i.e. to improve stability) | |
| | | |
| 14.1 | What time step has been used for the 1D model? Is it appropriate? | The Start Timestep is the initial timestep during the initialisation process.<br>The Maximum Timestep is the maximum allowed timestep during the initialisation process.<br>The Phase-in Time is the time over which the boundary conditions (initial inflows and tide levels) are linearly phased in during initialisation. |
| 14.3 | Have any of the parameters and advanced parameters been changed from | |
| 14.4 | What time step has been used for the 2D model? Is it appropriate? | Check in simulation run form by double clicking on a simulation saved in the simulations theme<br>Click on 2D parameters button<br>Depth: default value: 0.001m<br>Momentum: default value: 0.005m<br>Velocity: default value 0 m/s<br>Ignore rain falling on dry elements: default: unchecked<br>Adjust bank levels based on adjacent element ground levels: default is checked.<br>Link 1D and 2D calculations at minor timestep. A minor timestep is a timestep inserted between run timesteps as a result of timestep halving carried out to allow convergence. Using this option may help in reducing the occurrence of oscillations at banks for some networks. |
| 14.5 | Have initial water levels been applied and are these appropriate for the | |
| 14.6 | Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default? If so, has it been justified? | |
| | | |
| 15.1 | Have any comments, errors and warnings generated during the model run, been assessed and resolved as required? | Typical errors include:<br>Cross sections end points had to be extended vertically: indicate insufficient 1D cross section (glass walling). It also advised to check the river banks/ lateral links elevations are set correctly<br>Energy loss was greater than 0.3m between current and previous section: Likely to indicate the need of extra/ interpolate(d) sections<br>Conveyance ratio outside the range 0.7-1.4: indicating sudden/ large changes in cross section area: possible solutions may include truncating redundant portions of XS or add extra XS<br>Poor calculations at structures: Query have 4 cross sections plus parameters been set correctly (i.e. Tabs 5.1 - 5.5) (to allow maths to function properly) and/ or has pressure flows been enabled for high flows? |
| 15.2 | Is 1D mass balance from the model run within expected limits? Have they been investigated and resolved where potentially impacting the model | |
| 15.3 | Have any periods of non-convergence within the model run been investigated and resolved where potentially impacting the model results? | Right click on a completed simulation, not the colour of the diamond, amber indicates that the simulation has completed with errors. And select properties. In the pop up window, note the ID number e.g. 145, this is the ID of the results log file. Close the pop up, and choose Tools- options, click on local folder tab and in the first drop down box change the option from working folder to results folder then click "open the folder....." you can then search for the log folder with the ID you noted e.g. sim145.log and open this in text pad or other.<br>Timestep Log Diagnostics . When re-running a simulation witch this on for an enhanced, and bigger simulation log file which provides non-convergence information for every timestep.<br>Listed in the log file. |
| 15.4 | Under a range of different scenarios do the animations and graphed outputs give an indication of good model stability? | Drag results in to GeoPlan then, GeoPlan Menu, GeoPlan Tools, cross section graph or long section pick tool. |
| 15.5 | Is 2D mass balance from the model run within expected limits? Where outside of expected tolerance, have they been investigated and resolved where potentially impacting the model results? | Timestep Log Diagnostics . When re-running a simulation witch this on for an enhanced, and bigger simulation log file which provides convergence information for every timestep.<br>Listed in the log file. |
| 15.6 | Are CE and dV values relatively stable and remain so once the run has got | |
| 15.7 | Have any comments, errors and warnings generated during the model run, | |
| 15.8 | Are negative depths being created during the model run? If so, have these | |
| 15.9 | Under a range of different scenarios do the animations and graphed | |
| #### | **HPC Models Only** - Do the appropriate HPC output files show any indication of instability? If so, has this been investigated and resolved where appropriate? | Drag in results and animate.<br>Also you can plot flow across 1D-2D links as follows. Geoplan menu, Geoplan tools, graph results tool. |
| | | |
| 16.1 | Have calibration/verification runs been completed based on locally gauged | |
| 16.2 | Are the simulated hydrograph peaks reasonably similar to the recorded peaks? Is the shape of the simulated hydrograph and therefore the volume | |
| 16.3 | Are simulated floodplain extents similar to recorded extents? Are flow | |
| 16.4 | Has suitable effort been made to attempt and improve calibration. Have | |
| 16.5 | Is there good reconciliation between estimates at flow estimation points | |
| 16.6 | Where calibration is not possible due to data availability, have checks been made against other recorded data (wrack marks, flood extents, | |
| 16.7 | If no recorded or historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large | |
| 16.8 | Have appropriate model parameters been chosen for sensitivity testing?<br>Typical tests include:<br>Sensitivity to roughness ± 20% ( Manning's "n" both in 1D and 2D)<br>Sensitivity to flows ± 20% (From central estimate)<br>Sensitivity to downstream boundary | |
| 16.9 | Do the results of the tests show the models to be particularly sensitive to | |
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| 16.1 | Has an assessment of post scheme/development on third party flood risk been undertaken? Has justification been provided for any off-site change and is this reasonable? | What do maps look like with no buffer<br>What justification has been provided?<br>Check other metrics such as flow downstream of site, timing, volume pre and post.<br>Is any compensation/mitigation proposed?<br>How big is the difference?<br>Is the difference widespread or isolated?<br>Could the change be hydraulically linked to the site?<br>Are the baseline and post development models setup the same?<br>What is the overall stability of the model? Could this be improved? |
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| 10.4 | Has the Coastal Flood Boundary (CFB) data been applied appropriately | |
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| 11.2 | Are the wave boundary conditions from the same model data source as the | |

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# Appendix 4: Table of Hydraulic Structures

| Network ID, Cross Section ID | Model Details | Photograph/Survey Section |
|---|---|---|
| GB_02082 | **Description:** Footbridge<br>**NGR:** 454106, 224205<br>**Domain:** 1D ESTRY<br>**Unit Type:** Bridge Weir<br>**Upstream Invert Level:** 90.08m AOD<br>**Downstream Invert Level:** 90.11 mAOD<br>**Length:** 1m<br>**Manning's N:** 0.035<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GB_01809 | **Description:** Access Bridge<br>**NGR:** 453885, 224049<br>**Domain:** 1D ESTRY<br>**Unit Type:** Irregular Culvert<br>**Upstream Invert Level:** 87.61m AOD<br>**Downstream Invert Level:** 87.77m AOD<br>**Length:** 7m<br>**Manning's N:** 0.035<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 2D domain |  |
| GB_01237 | **Description:** Bicester Road Culvert<br>**NGR:** 453839, 223510<br>**Domain:** 1D ESTRY<br>**Unit Type:** Irregular Culvert<br>**Upstream Invert Level:** 85.23m AOD<br>**Downstream Invert Level:** 84.98m AOD<br>**Length:** 14m<br>**Manning's N:** 0.035<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 2D domain |  |

| Network ID, Cross Section ID | Model Details | Photograph/Survey Section |
|---|---|---|
| GB_01144 | **Description:** Access Bridge<br>**NGR:** 453894, 223454<br>**Domain:** 1D ESTRY<br>**Unit Type:** Bridge Weir<br>**Upstream Invert Level:** 84.73m AOD<br>**Downstream Invert Level:** 84.96m AOD<br>**Length:** 4m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GB_01081 | **Description:** Farm Track<br>**NGR:** 454026, 223461<br>**Domain:** 1D ESTRY<br>**Unit Type:** Bridge Weir<br>**Upstream Invert Level:** 84.27m AOD<br>**Downstream Invert Level:** 84.37m AOD<br>**Length:** 4m<br>**Manning's N:** 0.02<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_03216 | **Description:** Culvert<br>**NGR:** 453614, 226461<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.45m (assumed as no pipe visible)<br>**Upstream Invert Level:** 110.90m AOD<br>**Downstream Invert Level:** 110.90m AOD (invert levels assumed)<br>**Length:** 4m<br>**Manning's N:** 0.02<br>**Spill/Bypass:** Modelled in 1D domain |  |

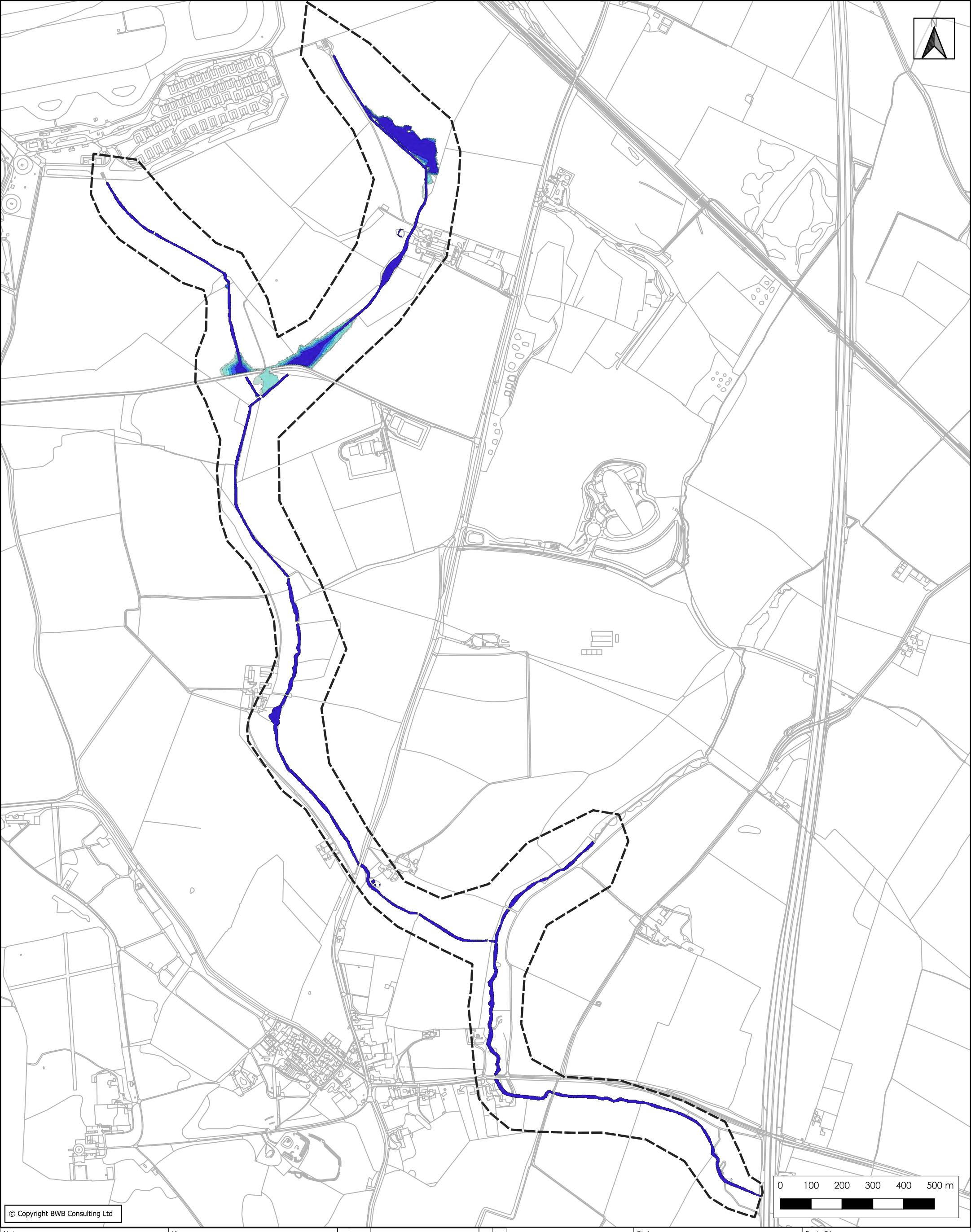
| Network ID, Cross Section ID | Model Details | Photograph/Survey Section |
|---|---|---|
| GBT1_03125 | **Description**: Farm Track Culvert<br>**NGR:** 453614, 226371<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.45m<br>**Upstream Invert Level:** 110.52m AOD<br>**Downstream Invert Level:** 110.44m AOD<br>**Length:** 4m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_03011 | **Description:** Cattle Grid Culvert<br>**NGR:** 453581, 226262<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.5m<br>**Upstream Invert Level:** 109.57m AOD<br>**Downstream Invert Level:** 109.51m AOD<br>**Length:** 4m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_02990 | **Description:** Farm Access Culvert<br>**NGR:** 453564, 226241<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert<br>**Dimensions:** 0.5m<br>**Upstream Invert Level:** 109.40m AOD<br>**Downstream Invert Level:** 109.36m AOD<br>**Length:** 10m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 2D domain | *No image available* |
| GBT1_02422 | **Description:** Camp Road Culvert<br>**NGR:** 453211, 225813<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert<br>**Dimensions:** 0.35m<br>**Upstream Invert Level:** 106.43m AOD<br>**Downstream Invert Level:** 106.07m AOD<br>**Length:** 57m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 2D domain |  |

| Network ID, Cross Section ID | Model Details | Photograph/Survey Section |
|---|---|---|
| GBT1_02254 | **Description:** Grass Crossing Culvert<br>**NGR:** 453086, 225701<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert<br>**Dimensions:** 2 x 0.31m<br>**Upstream Invert Level:** 105.55m AOD<br>**Downstream Invert Level:** 105.50m AOD<br>**Length:** 8m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_01589 | **Description:** Farm Access Culvert<br>**NGR:** 453173, 225124<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.6m<br>**Upstream Invert Level:** 101.52m AOD<br>**Downstream Invert Level:** 101.52m AOD<br>**Length:** 5m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_01443 | **Description:** Farm Track<br>**NGR:** 453215, 224983<br>**Domain:** 1D ESTRY<br>**Unit Type:** Bridge Weir<br>**Upstream Invert Level:** 100.85m AOD<br>**Downstream Invert Level:** 100.76m AOD<br>**Length:** 10m<br>**Manning's N:**<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_01192 | **Description:** Farm Crossing Culvert<br>**NGR:** 453172, 224738<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.7m<br>**Upstream Invert Level:** 99.02m AOD<br>**Downstream Invert Level:** 98.97m AOD<br>**Length:** 5m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |

| Network ID, Cross Section ID | Model Details | Photograph/Survey Section |
|---|---|---|
| GBT1_00543 | **Description:** Ardley Road Bridge<br>**NGR:** 453397, 224201<br>**Domain:** 1D ESTRY<br>**Unit Type:** Irregular Culvert<br>**Upstream Invert Level:** 94.77m AOD<br>**Downstream Invert Level:** 94.89m AOD<br>**Length:** 8m<br>**Manning's N:** 0.035<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 2D domain |  |
| GBT1_00276 | **Description:** Wooden Bridge Culvert<br>**NGR:** 453586, 224039<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.45m<br>**Upstream Invert Level:** 92.09m AOD<br>**Downstream Invert Level:** 92.98m AOD<br>**Length:** 8m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT1_00026 | **Description:** Culvert<br>**NGR:** 453812, 223951<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.5<br>**Upstream Invert Level:** 88.06m AOD<br>**Downstream Invert Level:** 87.77m AOD<br>**Length:** 6m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT2_00694 | **Description:** Culvert<br>**NGR:** 452734, 226250<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.5m<br>**Upstream Invert Level:** 116.22m AOD<br>**Downstream Invert Level:** 115.98m AOD<br>**Length:** 5.m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |

| Network ID, Cross Section ID | Model Details | Photograph/Survey Section |
|---|---|---|
| GBT2_00388 | **Description:** Culvert<br>**NGR:** 452975, 226074<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions**: 0.15m<br>**Upstream Invert Level:** 111.37m AOD<br>**Downstream Invert Level:** 111.27 mAOD (Updated to reflect partial blockage)<br>**Length:** 3m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |
| GBT2_00103 | **Description:** Camp Road Culvert<br>**NGR:** 453030, 225795<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert<br>**Dimensions:** 0.21m<br>**Upstream Invert Level:** 107.09m AOD<br>**Downstream Invert Level:** 106.41m AOD<br>**Length:** 23m<br>**Manning's N:** 0.02<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 2D domain |  |
| GBT2_0005 | **Description:** Culvert<br>**NGR**: 453073, 225713<br>**Domain:** 1D ESTRY<br>**Unit Type:** Circular Culvert Weir<br>**Dimensions:** 0.2m<br>**Upstream Invert Level:** 105.70m AOD<br>**Downstream Invert Level:** 105.61m AOD<br>**Length:** 5m<br>**Manning's N:**<br>**Blockage:** 0%<br>**Spill/Bypass:** Modelled in 1D domain |  |

# Appendix 5: Baseline Floodplain Maps

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5. Model not yet peer reviewed.

5. Contains OS data © Licence no. 100019980.

## 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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Drawing Title

**Baseline Model Floodplain Extents**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| BWB Ref: | NTH2479 | Date: | 06.04.23 | Scale@A3: | 1:11,000 |

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**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 |
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Drawing Title

**Baseline Modelled Flood Depths: 1 in 30-Year**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| BWB Ref: | NTH2479 | Date: | 06.04.23 | Scale@A3: | 1:11,000 |

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**PRELIMINARY**

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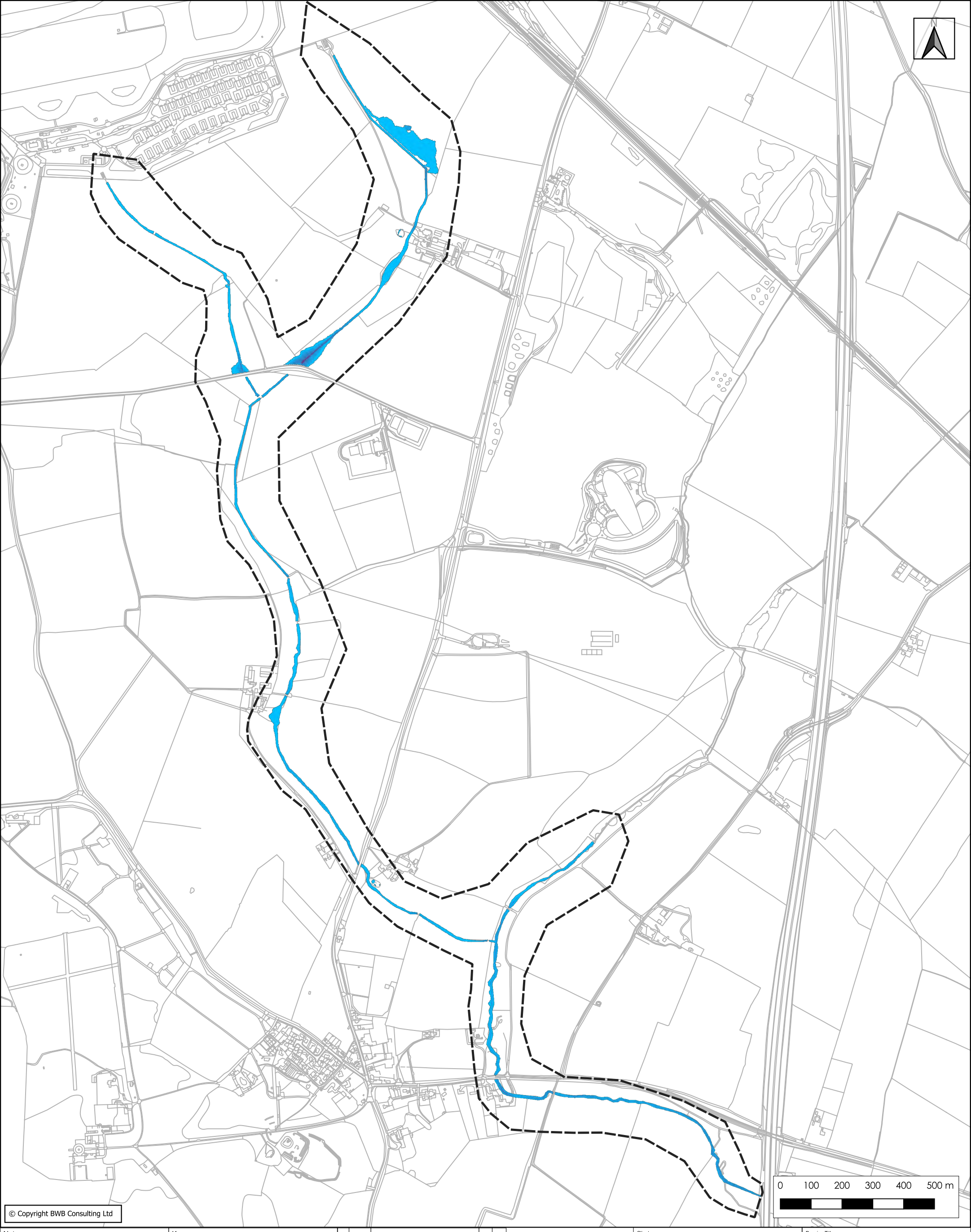


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4. Any discrepancies noted on site are to be reported to the engineer immediately.

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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 |
|---|---|---|---|---|
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**Baseline Modelled Flood Depths: 1 in 100-Year**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
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|---|---|---|
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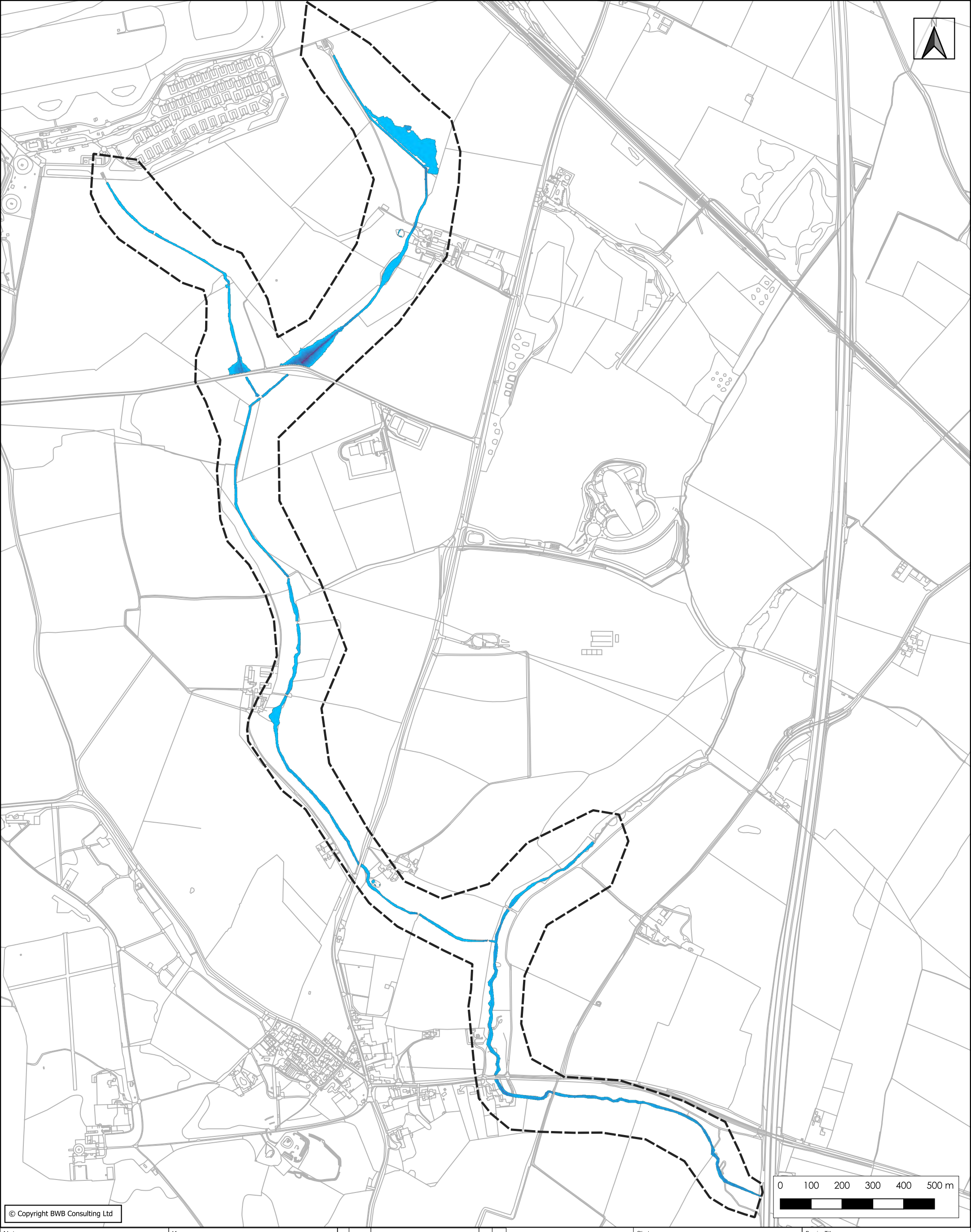


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## Key

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 |
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**Baseline Modelled Flood Depths: 1 in 100-Year + 15%CC**

Drawn: [redacted]

| BWB Ref: | NTH2479 | Date: | 06.04.23 | Scale@A3: | 1:11,000 |
|---|---|---|---|---|---|

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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 |
|---|---|---|---|---|
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| P01 | 06.04.23 | PRELIMINARY ISSUE | LR | MB |

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**Baseline Modelled Flood Depths: 1 in 100-Year + 25%CC**

| Drawn: | | | | | |
|---|---|---|---|---|---|
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Drawing Status

**PRELIMINARY**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
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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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|---|---|---|---|---|---|
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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 |
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Drawn: [redacted]

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|---|---|---|---|---|---|

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**PRELIMINARY**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
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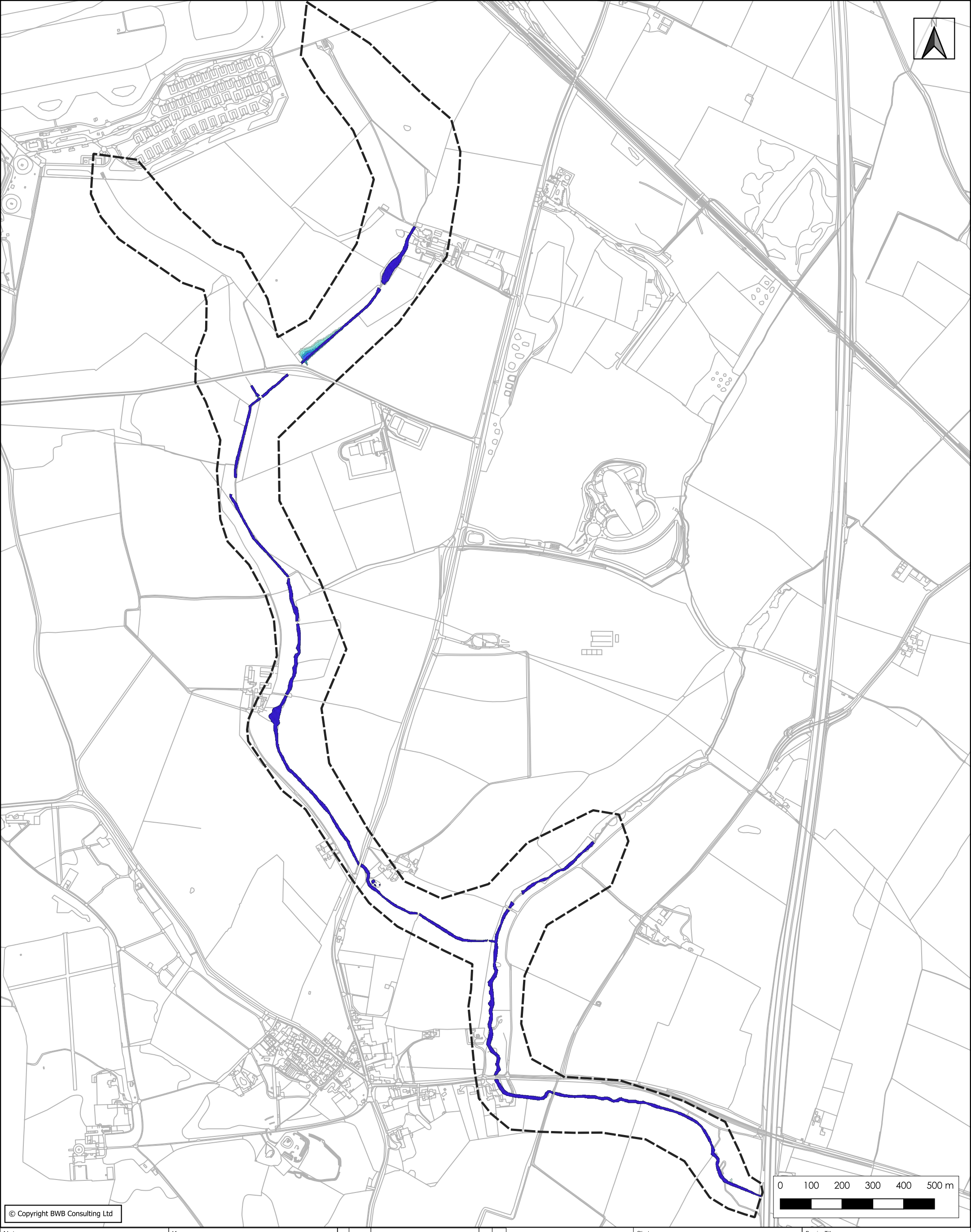
| OXSRFI-BWB-ZZ-XX-D-W-1007 | S2 | P02 |

# Appendix 6: Proposed Floodplain Maps

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5. Model not yet peer reviewed.

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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 |
|---|---|---|---|---|
| P03 | 25.03.26 | Updated following EA comments | 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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Drawing Title

**Proposed Model Floodplain Extents**

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|---|---|---|---|---|---|
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Drawing Status

**PRELIMINARY**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| OXSRFI-BWB-ZZ-XX-D-W-1021 | S2 | P03 |

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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 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 |
|---|---|---|---|---|
| P03 | 26.03.26 | Updated following EA comments | MN | LR |
| P02 | 30.07.25 | Updated to include latest hydrology | MN | LR |
| P01 | 06.04.23 | PRELIMINARY ISSUE | LR | MB |

Issues & Revisions

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□ Manchester | 0161 233 4260
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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: | | | | | |
|---|---|---|---|---|---|
| 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 | P03 |

0 100 200 300 400 500 m

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## Notes

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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 |
|---|---|---|---|---|
| P03 | 26.03.26 | Updated following EA comments | MN | LR |
| P02 | 30.07.25 | Updated to include latest hydrology | MN | LR |
| P01 | 06.04.23 | PRELIMINARY ISSUE | LR | MB |

Issues & Revisions

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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**

| Drawn: | [redacted] | | | | |
|---|---|---|---|---|---|
| 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 | P03 |