



# Flood Risk Modelling Report

**Land East of Lodge Road, Hurst**

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## Acronyms and Abbreviations

|       |                                                                                         |
|-------|-----------------------------------------------------------------------------------------|
| NGR   | National Grid Reference                                                                 |
| CC    | Climate Change                                                                          |
| CCTV  | Closed Circuit Television                                                               |
| HPC   | Heavily Parallelised Compute                                                            |
| RCP   | Reinforced Concrete Pipe (Culvert)                                                      |
| AOD   | Above Ordnance Datum                                                                    |
| AEP   | Annual Exceedance Probability                                                           |
| DEM   | Digital Elevation Model                                                                 |
| LiDAR | Light Detection and Ranging                                                             |
| EA    | Environment Agency                                                                      |
| FEH   | Flood Estimation Handbook                                                               |
| FEH22 | FEH's latest UK-wide statistical model for rainfall depth-duration-frequency estimation |
| ReFH2 | Latest version of the Revitalised Flood Hydrograph model.                               |



## 1.0 Introduction

### 1.1 Background

SLR Consulting (SLR) has been appointed by MacTaggart & Mickel Group Limited to undertake hydraulic modelling of flood risk to the Land East of Lodge Road in Hurst (the “Site”), centred on National Grid Reference (NGR) SU 79440 73648. A hydrological analysis is required to obtain peak flow hydrographs and rainfall hyetographs, which are input into the hydraulic model to simulate both fluvial and surface water flooding in the vicinity of the Site. Specifically, this assessment focuses on Hatchgate ditch, a tributary of the River Loddon that exists to the west of the western site boundary.

The Site has previously been refused planning permission with an objection from the Environment Agency (EA) on flood risk grounds. The objection states that detailed site-specific modelling is to be undertaken to calculate an appropriate and precautionary design flood level for the 1% annual exceedance probability flood with allowance for climate change (1% AEP + CC flood event). According to the most current EA Flood Map for Planning<sup>1</sup> (provided within Figure 1-1 below), the site is mostly located within fluvial Flood Zone 1, however small areas alongside the watercourse to the west of the site boundary (Hatchgate ditch) may be located within Flood Zones 2 and 3. The Environment Agency have acknowledged that there is no site specific modelling data for this location.

As such, a fluvial hydraulic model of Hatchgate ditch is required to quantify the flood risk to the site. To provide a more comprehensive study of potential flood risk, pluvial/rain-on-grid modelling has also been undertaken within this assessment. A hydrological model is required to generate flood flow hydrographs and rainfall hyetographs which are used as an input into the hydraulic model domain.

Peak flow hydrographs and rainfall hyetographs are estimated for the 3.3%, 3.3% + Climate Change (CC), 1%, 1% + CC, 0.1% and 0.1% + CC AEP events.

### 1.2 Site Location

The site is an irregularly shaped greenfield patch of land that covers an area of approximately 10.4 hectares. Situated within Hurst, Wokingham, England, it is surrounded by residential properties to all sides except the west where agricultural land is present. The site is centred on NGR of SU 79440 73648.

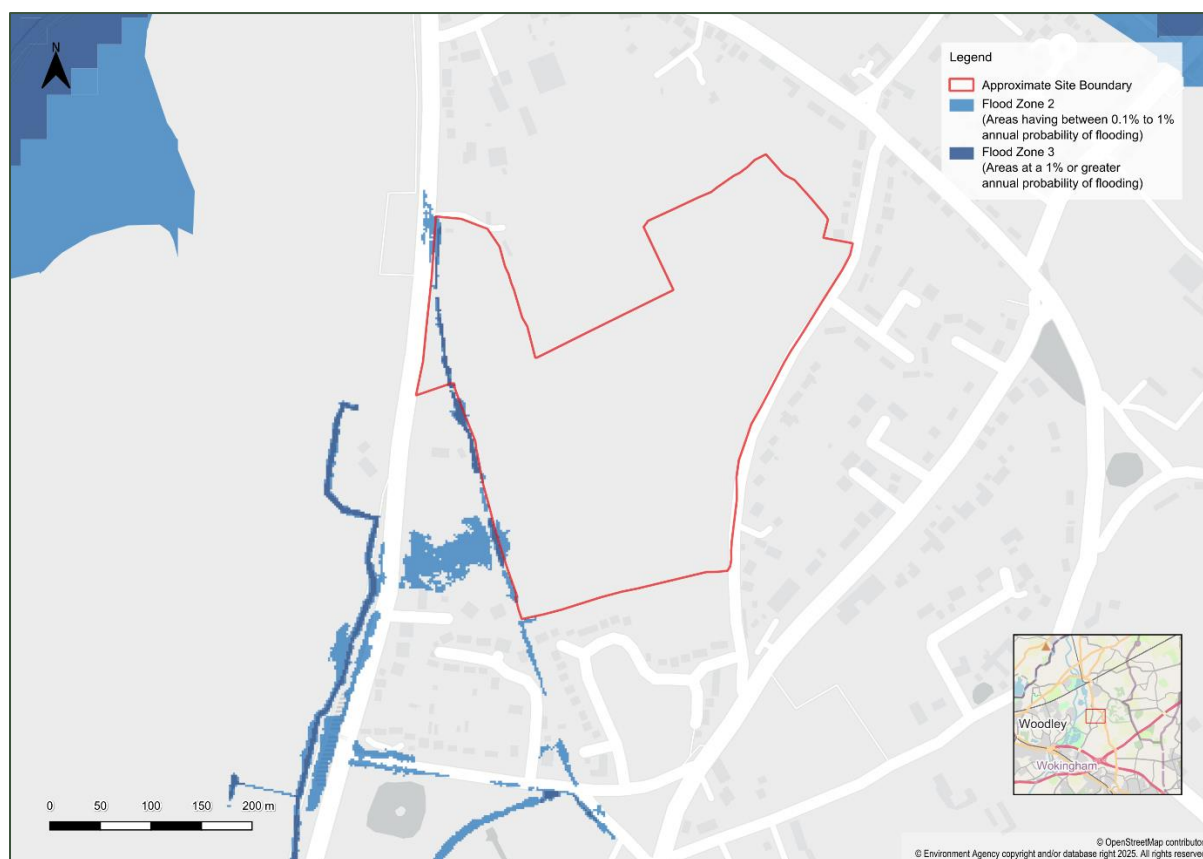
A location plan is provided within Figure 1-2, displaying the site boundary with reference to Ordnance Survey mapping.

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<sup>1</sup> Environment Agency Flood Map for Planning Service (Updated March 2025). Available via: <https://flood-map-for-planning.service.gov.uk/>



**Figure 1-1: Environment Agency Flood Map for Planning**



**Figure 1-2: Site Location Plan**



## 2.0 Methodology

### 2.1 Model Selection

A 1-dimensional / 2-dimensional linked (1D/2D Linked) model was developed for determining flood extents. The modelling approach makes use of the acquired topographic survey of the Hatchgate ditch and associated culverts along the watercourse. The 1D Estry model provides a detailed representation of the Hatchgate ditch, and hydraulic structures whilst the 2D element of the model allows for accurate representation of overland flow paths for any exceedance of the channel capacity simulated in the 1D model. The adopted 1D/2D approach is a recognised industry standard approach to simulating flood risk.

To provide a comprehensive study of flood impacts at the site, both fluvial and pluvial (rain-on-grid) model variants were simulated and assessed. Modelling has been completed in line with Environment Agency's *River Modelling Technical Standards and Assessment* guidelines<sup>2</sup> to ensure overall model suitability in assessing flood risk.

TUFLOW HPC was selected as the numerical solver for the development of the fluvial and pluvial driven 2D flows, dynamically linked with the 1D ESTRY modelling engine. The Heavily Parallelised Compute (HPC) version adopted here solves the full 2D shallow water equations including inertia and turbulence, and is aptly suited to floodplain, open channel and pipe hydraulics. The HPC solver also enables adaptive time-stepping in conjunction with smaller grid resolutions for greater granularity of results and topographic features. This is packaged and distributed by BMT, has been benchmarked by the Environment Agency and is widely used throughout the UK.

### 2.2 Site Inspection

To assist in the construction of the hydraulic model, a site walk over was completed by SLR on 20 March 2025. This site walk over, along with the detailed topographic survey of the main channel, completed on 21 December 2022, assisted in determining appropriate Manning's roughness coefficients, culvert configuration and model topography as discussed in Section 2.4.

Photographs obtained during the site walkover have been provided in Appendix A and are referenced throughout this report. The 1D channel topography survey has been provided in Appendix B.

### 2.3 Hydrology

Fluvial flood estimates have been derived based on the FEH Statistical method, using the small catchment procedures and compared against flood estimates derived by the ReFH2 rainfall-runoff method. In application of the ReFH2 approach, a 75% "winter" storm profile is adopted to derive the fluvial estimates, and further detailed information is provided within the Flood Estimation Report (LIT 65087).

The final fluvial flood estimates are based on the more precautionary i.e., larger estimates produced by the FEH Statistical methodology.

For the fluvial (river) modelling, hydrograph shapes are derived within the ReFH2 model and scaled to the preferred flood estimates derived by the FEH Statistical method. The critical storm duration was determined within the hydraulic model domain. Storm durations ranging between 1.5-hour to 14.5-hour were assessed and a 10.5-hour duration hydrograph adopted as it was shown to produce the greatest flood extents.

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<sup>2</sup> [Environment Agency River Modelling: Technical Standards and Assessment](#).



Design net rainfall has been derived within the ReFH2 software and based on the EA standards<sup>3</sup> set out in “Risk of Surface Water Flooding (RoSWF) Appendix A – Modelling standards” with which surface water modelling practices and model outputs need to comply.

Total net rainfall estimates are derived for the 1, 3, 6 and 12-hour storm. The catchment aerial reduction factor is set as 1.0 and a summer seasonal rainfall profile (50%) adopted with the Seasonal Correction Factor set as 1.0. This aligns with the minimum requirements outlined in the EA standards. Rainfall losses are applied directly within the ReFH2 software at a variable temporal rate which, for the catchment scale, is reported as an acceptable approach within the Environment Agency Flood Estimation Guidelines.

Given the mixed rural and urban components comprising the subject catchment, variable losses are applied due to the need to simplify the methodology of applying the losses over the catchment.

The catchment is located within the Loddon and tributaries Management Catchment basin region. Based on the most recent climate change advice as provided by the Environment Agency<sup>4</sup>; the upper allowance for the 2070s epoch has been selected. This is suitable for development with a lifetime between 2061 and 2125. A +40% uplift in peak rainfall intensity for the 1% and 0.1% AEP rainfall events. This is applied directly within the ReFH2 software. For the fluvial flood estimates, a climate change uplift of +46% is applied to the 3.3%, 1% and 0.1% AEP events derived by either the ReFH2 or FEH Statistical methods.

The hydrological calculations and methodology is further explained in the Flood Estimation Report<sup>5</sup>.

## 2.4 Model Construction

The construction of the 1D/2D linked hydraulic model required several datasets and parameters. These are summarised below:

- A channel and site topographic survey (channel cross-section data - Appendix B);
- Culvert topographic survey (Appendix C);
- Floodplain topography in the form of a Digital Elevation Model (DEM);
- Hydraulic boundaries;
- Roughness across study area (Manning's n); and
- Appropriate model cell size (1m).

All survey data used within the hydraulic model is provided in Appendix B and Appendix C.

### 2.4.1 1D Channel Cross Sections

A total of eight (8) channel cross sections from a site topographic survey carried out in December 2022 were incorporated within the model. These sections informed the 1D open channel network of the watercourse situated directly to the west of the site.

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<sup>3</sup> [River modelling: technical standards and assessment - GOV.UK](#)

<sup>4</sup> [Peak rainfall climate change allowances by management catchment - GOV.UK \(www.gov.uk\)](#)

<sup>5</sup> Flood Estimation Report: Lodge Road, Hurst, prepared by SLR on behalf of MacTaggart & Mickel Group Ltd (20250811\_LIT65087\_Hurst\_Hydrology.pdf).



The 1D representation of the channel was linked to the 2D domain via HX boundary connections running parallel alongside each of the channel banks. To provide maximum compatibility with the 2D element, channel bank crest lines were enforced in the model and applied to the cells lining the edge of the channel by means of a topography modification layer (2d\_zsh) with the elevations of the top of banks within the survey. This was to ensure there was no discrepancy between the 1D and 2D model elevations.

The 1D channel survey has been provided in Appendix B of this report.

## 2.4.2 Hydraulic Structures

All hydraulic structures in the model domain were explicitly represented in the 1D model based on information provided by the site topographic survey. In total, three (3) circular pipe culverts were added into the model from the survey specifications, and a further three (3) culverts assumed based on the site walkover, aerial imagery and available street view. These range in diameter from 0.5m to 0.225m. A Manning's roughness coefficient of 0.013 is adopted as informed by Chow (1959)<sup>6</sup> for all culverts to represent a smooth bored conduit or concrete structure, as indicated by the channel survey, CCTV survey and site photographs.

It should be noted that the culvert under Sawpit Road (Add\_02) has been overestimated to allow conveyance of flow from upstream to downstream ultimately leading to a conservative volume of water reaching the site boundary.

A summary of the culvert specifications and locations are provided within Table 2-1 and Figure 2-1 respectively.

**Table 2-1: Culvert Dimensions**

| Culvert ID     | Culvert Type | Width/Diameter (mm) | Number of Barrels | Surveyed or Assumed |
|----------------|--------------|---------------------|-------------------|---------------------|
| CULVERT_SEC5_3 | C            | 500                 | 1                 | Surveyed            |
| CULVERT_SEC2   | C            | 225                 | 1                 | Surveyed            |
| CULVERT_SEC1   | C            | 300                 | 1                 | Surveyed            |
| Add_01         | C            | 300                 | 1                 | Assumed             |
| Add_02         | R            | 1000x1000           | 1                 | Assumed             |
| Add_03         | C            | 200                 | 1                 | Assumed             |

## 2.4.3 Hydraulic Boundaries

### Upstream Boundaries

The 2D model domain has been based on the topographic catchment extent derived from DEM data. Following preliminary model runs, and due to the flat nature of the site, the pluvial model boundary was further extended to incorporate the area south of the proposed site. The fluvial model boundary was reduced to upstream of Sawpit Road – to coincide with the hydrological assessment point and located sufficiently upstream of the site of interest.

As described in Section 2.3 above, the hydraulic input for the fluvial model was derived from flow vs time hydrographs. Due to the approach of the hydrology and locality of drainage pathways in the catchment the inflow hydrograph has been separated by contributing area and applied to reasonable locations within the model. A flow verse time (QT) boundary was applied at the fluvial model code boundary and applied with 32% of the overall hydrograph to

<sup>6</sup> Chow, V.T. (1959) Open Channel Hydraulics. McGraw-Hill, New York.



represent 32% of the overall catchment contributing to this point. The remaining catchment area of 68% was applied to the start of the 1D channel via a 1d boundary condition node (1d\_bc). This point was selected based on the catchment elevations and is deemed as a reasonable location for the catchment, as both inflow occur upstream of the site of interest.

For the pluvial (rain-on-grid) model, rainfall hyetographs for each AEP were applied across the entire 2D domain via a 2D rainfall polygon (2d\_rf layer). Baseflow was applied via a 2D source area polygon (2d\_sa) within the upstream portion on the tributary, and linked to its respective flow vs time hydrographs. The location of the baseflow inflow location was selected to be a conservative assumption to overall surface water flood risks to the site.

The fluvial and pluvial model boundaries, and inflow locations have been provided in Figure 2-1.

A summary of the flood peak statistics across each AEP event is provided in Table 2-2 and Table 2-3 for the fluvial peaks and pluvial total inputs respectively.

**Table 2-2: Fluvial Model Inflows**

|                | Peak Flow (m <sup>3</sup> /s) |                   |      |                 |      |                   |
|----------------|-------------------------------|-------------------|------|-----------------|------|-------------------|
|                | 3.3%                          | 3.3% + 46%<br>CC* | 1%   | 1% + 46%<br>CC* | 0.1% | 0.1% + 46%<br>CC* |
| Fluvial Inflow | 0.11                          | 0.16              | 0.16 | 0.23            | 0.26 | 0.37              |

\* Climate Change

**Table 2-3: Pluvial Model Inflows**

|      | Total Rainfall Depths (mm) |                   |       |                 |       |                   |
|------|----------------------------|-------------------|-------|-----------------|-------|-------------------|
|      | 3.3%                       | 3.3% + 35%<br>CC* | 1%    | 1% + 40%<br>CC* | 0.1%  | 0.1% + 40%<br>CC* |
| 1h   | 5.31                       | 7.65              | 7.34  | 11.26           | 12.67 | 20.03             |
| 3hr  | 7.61                       | 11.14             | 10.23 | 15.97           | 18.00 | 29.05             |
| 6hr  | 9.13                       | 13.48             | 12.21 | 19.25           | 22.15 | 36.18             |
| 12hr | 10.55                      | 15.70             | 14.08 | 22.39           | 26.07 | 42.99             |

\* Climate Change

## Downstream Boundaries

The hydraulic model has adopted two (2) downstream boundaries. The 2D model boundary was applied using a boundary slope (HQ) of 0.002 m/m and has been calculated using the LIDAR data starting 80m upstream of the edge of the 2D code. It should be noted that the 2d boundary is only required for the fluvial 0.1% AEP event plus CC as all other events are conveyed by the 0.3m discharge pipe. The 2D slope boundary has also been applied down the centre of Sawpit Road to allow water in to overtop Sawpit Road if not conveyed by the channel. Finally, a 2D boundary with the same slope of 0.002 m/m has also been applied across the entire pluvial model boundary to ensure water is not trapped and can leave the model.

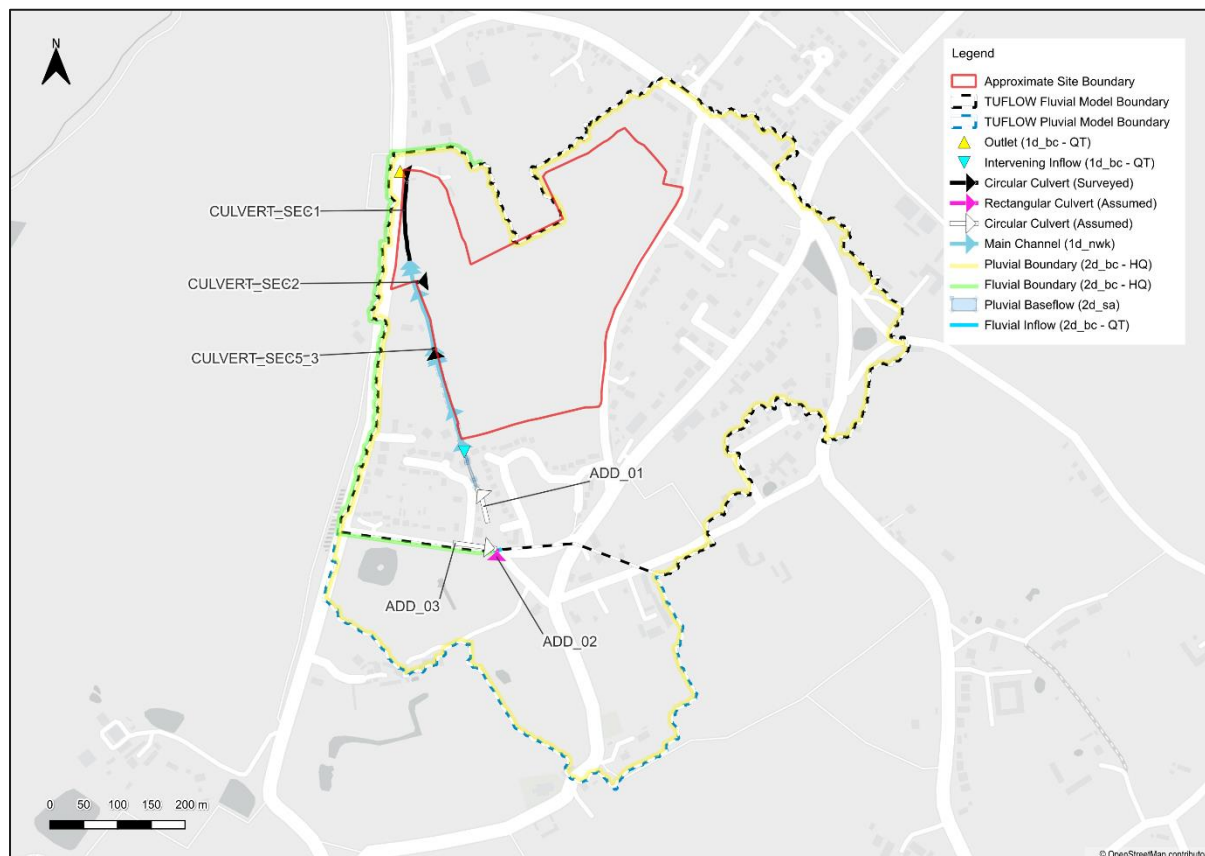
The 1D model boundary has been applied to the manhole at the end of the 0.3m outlet culvert (CULVERT\_SEC1), and is based on the survey information provided for the culvert alignment survey provided in Appendix C. This boundary was applied directly to the 1D



culvert downstream point location and an applied water level boundary (HT) was set to the invert level of 35.88 m AOD.

The 1D and 2D hydraulic model extents and features are shown within Figure 2-1 below.

**Figure 2-1: 1D/2D Hydraulic Model Extent and Features**



#### 2.4.4 Floodplain Topography (DTM)

2D Floodplain topography has been derived from the most up-to-date 1m LiDAR (captured in 2022) data sourced from the Environment Agency National LiDAR programme<sup>7</sup>. This data covers the site and wider catchment area to ensure additional channels are accurately represented within the hydraulic model extent. The LiDAR data reveals the site is predominantly flat with elevations ranging from 37.0m AOD to 40.1m AOD. Topographic survey and aerial imagery displayed numerous artificial channels to the south of the site which were not accurately reflected within the LiDAR data (due to vegetation) leading to the incorporation of numerous channel 'burn-in' areas within the model. These act to reduce the poor representation of topography in these regions, better defining these channels and increasing water conveyance within the model. Where possible, these have been based on the extent of the 1D channel survey extended up the channel, and low spots found in the LiDAR where accurate levels of the channel are assumed.

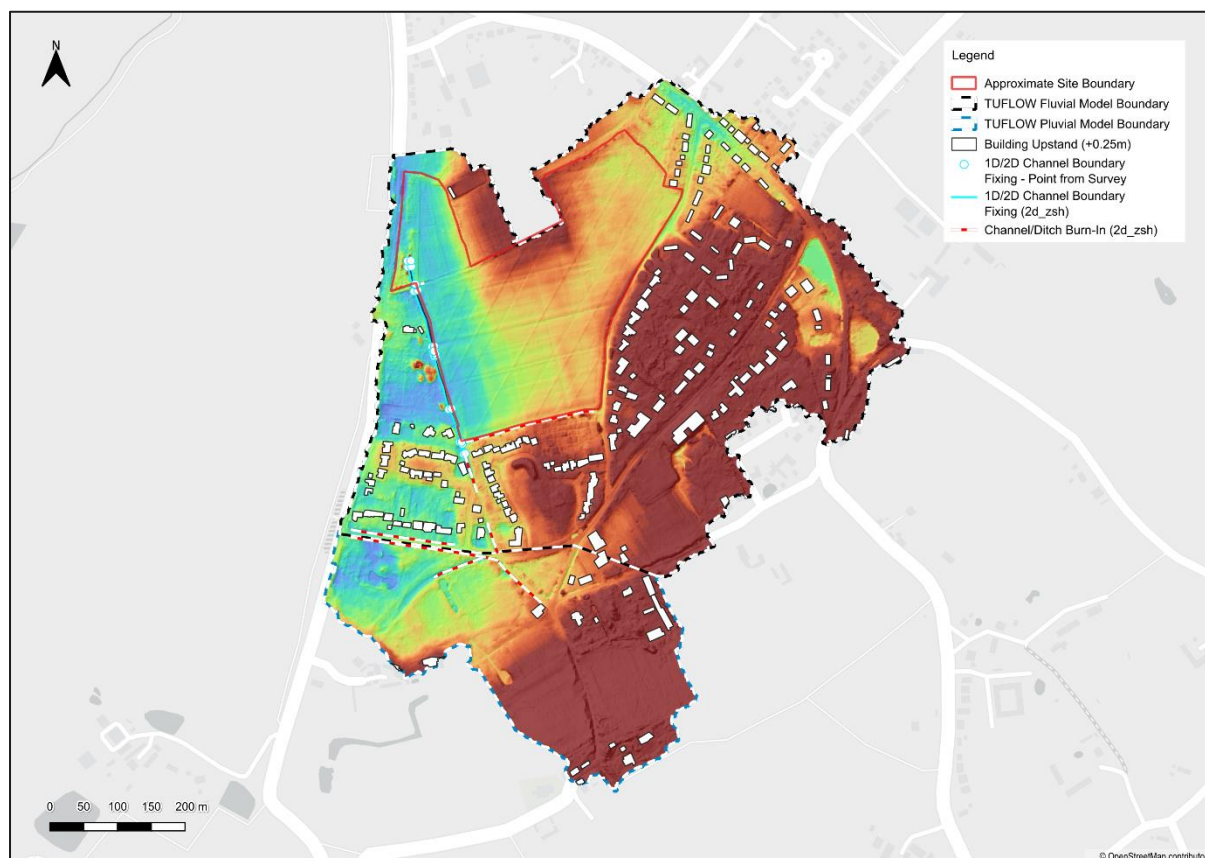
<sup>7</sup> Environment Agency National LiDAR Programme 2024. Available via: <https://environment.data.gov.uk/survey>



Following technical guidance presented by the Environment Agency<sup>8</sup>, building footprints were increased in height by 0.25m (and as shown in Section 2.4.5, also increased in hydraulic roughness).

These changes, alongside their implementation within the model are shown in Figure 2-2 below.

**Figure 2-2: Hydraulic Model Topography Changes**



### 2.4.5 Model Roughness (Manning's n)

The material roughness across the model domain has been read into the hydraulic model using a CSV file, correctly formatted to be read by TUFLOW. Manning's n values for each land classification were derived from texts such as Chow<sup>9</sup>.

Land classification across the model domain were taken from the freely available UK Centre for Ecology and Hydrology land cover maps<sup>10</sup> and further manually processed and annotated to refine land use nearest to the site and incorporate buildings, roads and additional channels.

Additionally, a site visit was completed to provide photographic evidence to justify the Manning's roughness adopted. Based on the site visit observations, the channel bed

<sup>8</sup> Environment Agency River Modelling: Technical Standards and Assessment (representing buildings and infrastructure) Available via: <https://www.gov.uk/government/publications/river-modelling-technical-standards-and-assessment/represent-buildings-and-infrastructure-receptor>

<sup>9</sup> Chow, V.T. (1959) Open Channel Hydraulics. McGraw-Hill, New York.

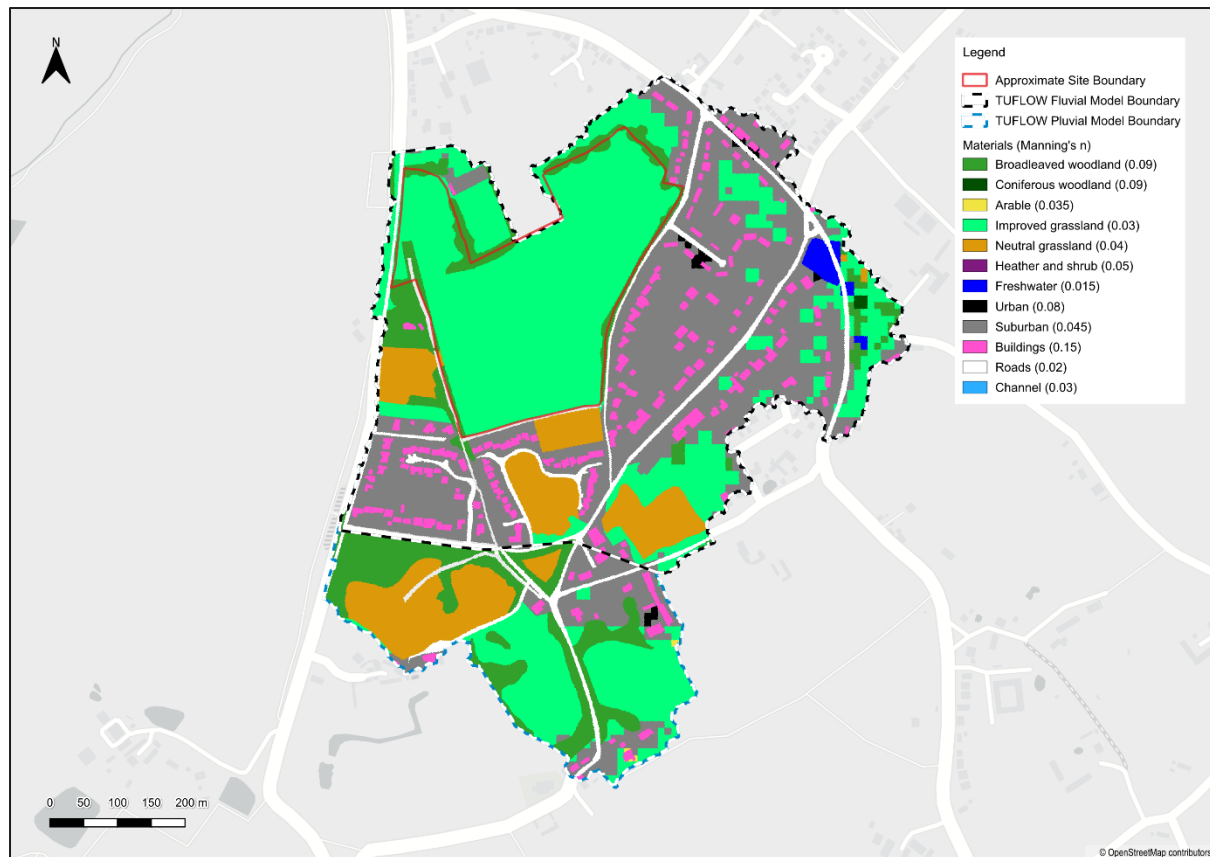
<sup>10</sup> Land Cover Map 2021: <https://www.ceh.ac.uk/data/ukceh-land-cover-maps>



consists of short grass and a value of 0.03 was selected based on this information. These images from the site visit can be seen in Appendix A.

The Manning's Roughness delineation and values have been provided within Figure 2-3 below.

**Figure 2-3: Manning's Roughness**



## 2.4.6 Model Operation

The hydraulic model was simulated using the HPC solver for TUFLOW Build 2025.1.0 single precision (iSP). Initialisation of the TUFLOW model utilised a standard Windows Batch File linking the TUFLOW executable, control files (.tcf) and relevant event, scenario and variant logic. All model runs were performed on high-performance computing facilities using a NVIDIA A10 GPU with an approximate total run time of 12 hours.

A summary of the events and scenarios used within the final model are presented within Table 2-4 below.

**Table 2-4: Model Scenarios Definitions**

| Control File     | HURST_~e1~_~s1~_~s2_023.tcf                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scenarios (~s1~) | BASE (Baseline – Culverts assumed to be completely unblocked)<br>BLOCK1 – 100YCC only - 50% Blockage on all culverts<br>BLOCK2 – 100YCC only - 75% Blockage on all culverts<br>SEN01 – 100YCC only - Mannings +20%<br>SEN02 – 100YCC only - Mannings -20%<br>SEN03 – 100YCC only - Downstream Boundary +20%<br>SEN04 – 100YCC only - Downstream Boundary -20%<br>SEN05 – 100YCC only - Flow Sensitivity +20%<br>SEN06 – 100YCC only - Flow Sensitivity -20%<br>SEN07 – 100YCC only - DS Tailwater = 35.88 + 0.3m<br>SEN08 – 100YCC only - DS Tailwater = 35.88 + 0.6m |
| Variants (~s2~)  | FLU (Fluvial Model), ROG (Pluvial/Rain-on-Grid Model), SD (Storm Duration)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Events (~e1~)    | 30Y (3.3% AEP),<br>30YCC (Fluvial 3.3%+46%CC AEP),<br>30YCC (Pluvial 3.3%+35%CC AEP)<br><br>100Y (1% AEP),<br>100YCC (Fluvial 1%+46%CC AEP),<br>100YCC (Pluvial 1%+40%CC AEP)<br><br>1000Y (0.1% AEP),<br>1000YCC (Fluvial 0.1%+46%CC AEP),<br>1000YCC (Pluvial 0.1%+40%CC AEP)                                                                                                                                                                                                                                                                                       |
| Durations (~e2~) | Pluvial:<br>1hr, 3hr, 6hr, 12hr<br><br>Fluvial:<br>X (dummy duration)<br><br>Fluvial Duration Testing:<br>1.5hr, 2.5hr, 3.5hr, 4.5hr, 5.5hr, 6.5hr, 7.5hr, 8.5hr, 9.5hr, 10.5hr, 11.5hr, 12.5hr, 13.5 hr, 14.5hr                                                                                                                                                                                                                                                                                                                                                      |



## 3.0 Results and Discussion

### 3.1 Model Results

Finalised mapping of all hydraulic modelling results have been provided within the Appendices as follows:

- Appendix D – Model Results (Fluvial)
- Appendix E – Sensitivity Results (Fluvial)
- Appendix F – Model Results (Pluvial)
- Appendix G – Sensitivity results (Pluvial)
- Appendix H – Model Results with Proposed Site Layout (Fluvial/Pluvial)
- Appendix I – EA Flood Mapping
- Appendix J – EA Flood Mapping Comparison

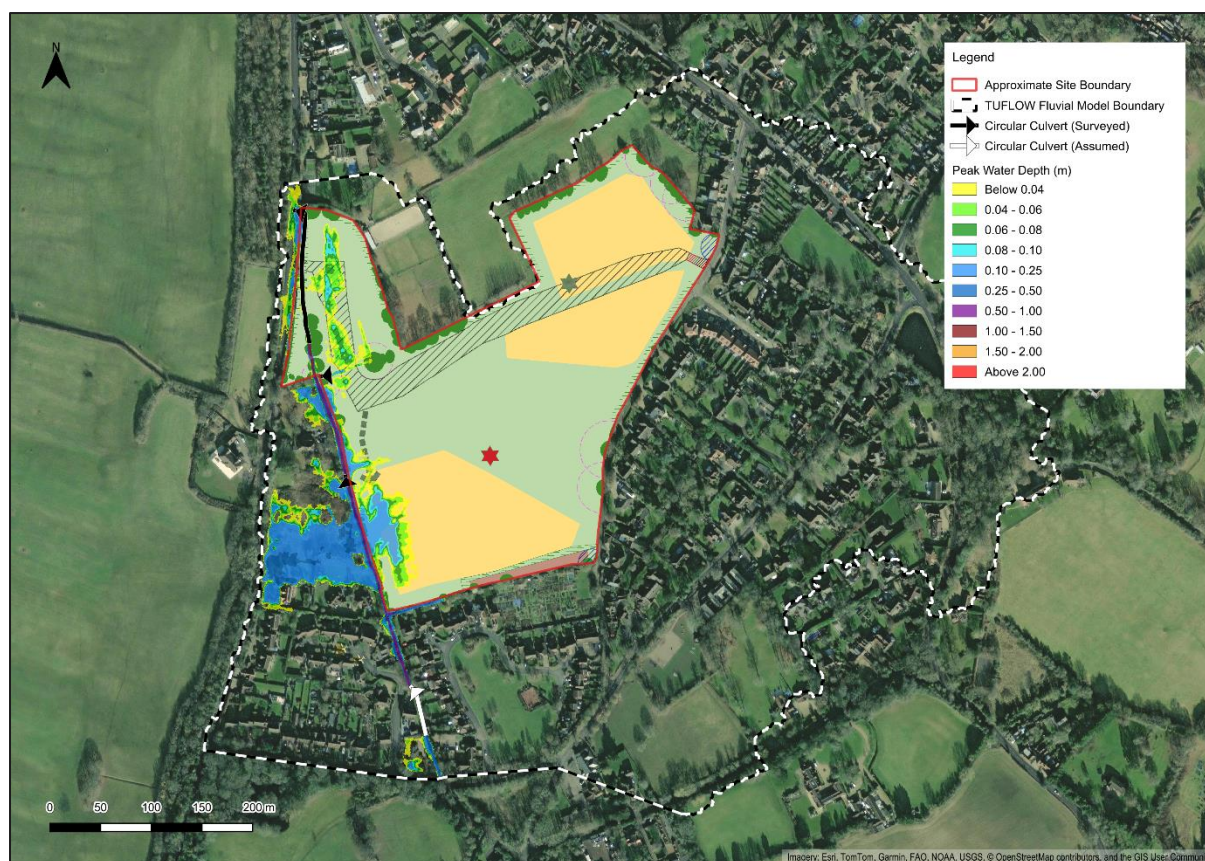
#### 3.1.1 Fluvial

The peak flood extents for the 3.3% and 1% AEP events show no out of bank flow occurring through the site for the baseline (BASE) scenario. Increasing levels of out of bank flooding are associated with the 3.3% + 46% Climate Change, 1% + 46% Climate Change, 0.1% and 0.1% + 46% Climate Change AEP events, with flooding primarily occurring to land immediately to the north of Nursery Close (out of site bounds), and extending minimally within the site up to the 0.1% AEP. In the 0.1% AEP + 46% Climate Change event, significant flooding to the southwest of the site before CULVERT\_SEC5\_3 occurs as well as lower levels of flooding to the northwest.

To illustrate the impacts of flooding to the proposed development, the 1% AEP + 46% Climate Change uplift peak water extent has been shown alongside the development plans in Figure 3-1. Flood risk is shown to only be associated with the southern development area, with low levels, less than 120mm, of flooding extending to the proposed development.



**Figure 3-1: 1% AEP + 46% Climate Change Fluvial Peak Water Extent**



### 3.1.2 Fluvial Flow Reconciliation

Due to the presence of several structures along the watercourse that are having a significant hydraulic effect, which limits the ability to undertake a flow reconciliation - particularly for higher return periods where the hydraulics are controlling flows.

Reviewing the 1% AEP event, there is a close match between the model inflow ( $0.16 \text{ m}^3/\text{s}$ ) and flow in cross section MC02 – immediately upstream of the site of interest. For the 1% AEP plus CC and the 0.1% AEP event the inflow and observed flow at cross section MC02 (upstream end of the proposed site) are within 8%. For the 0.1% plus CC the model flow is 16% lower due to the presence of the hydraulic controls within the watercourse – this demonstrates the impacts of the hydraulic structures as a flow control.

The results of the flow reconciliation are included in Table 3-1.

**Table 3-1: Model Flow Reconciliation**

|                | Peak Flow ( $\text{m}^3/\text{s}$ ) |               |      |              |      |                |
|----------------|-------------------------------------|---------------|------|--------------|------|----------------|
|                | 3.3%                                | 3.3% + 46% CC | 1%   | 1% + 46% CC* | 0.1% | 0.1% + 46% CC* |
| Fluvial Inflow | 0.11                                | 0.16          | 0.16 | 0.23         | 0.26 | 0.37           |
| Model XS       | 0.11                                | 0.16          | 0.15 | 0.22         | 0.24 | 0.32           |



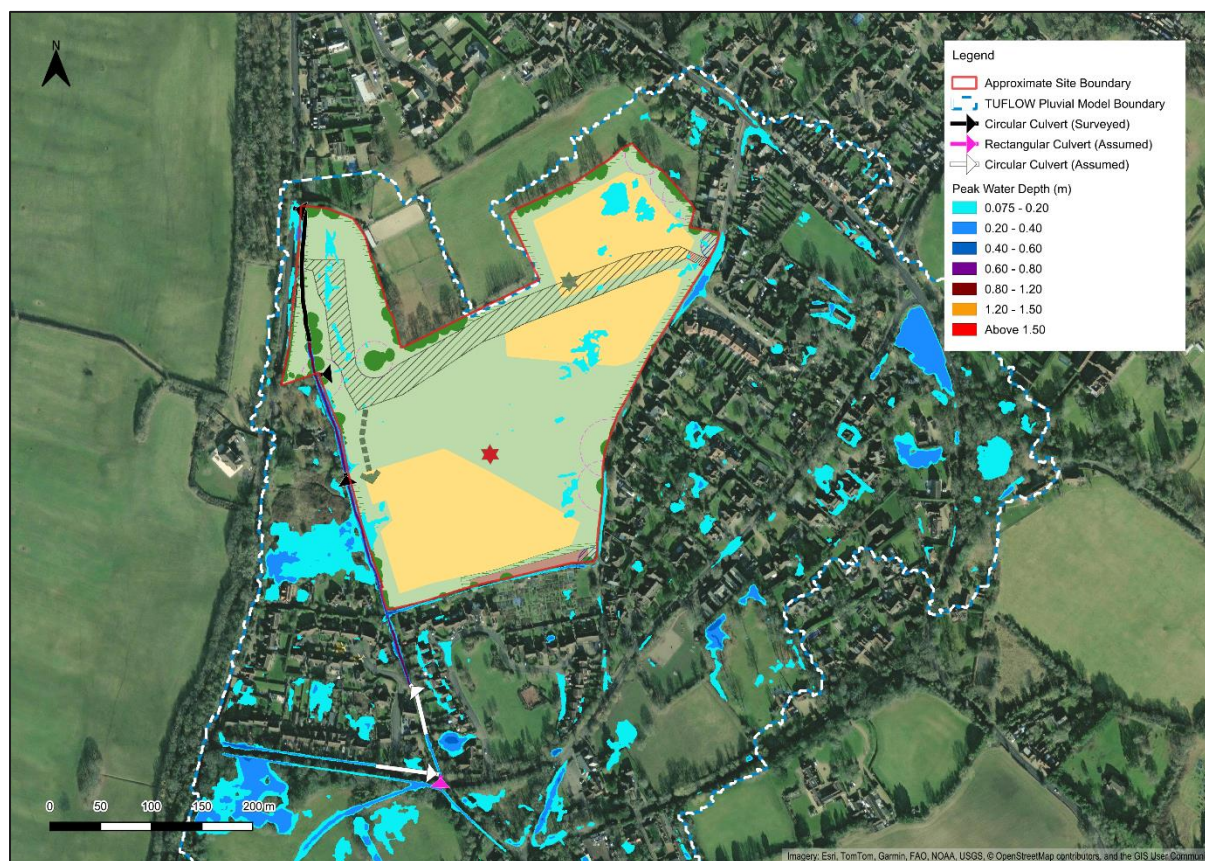
### 3.1.3 Pluvial

Pluvial results for the 3.3% and 1% AEP show minimal levels of flooding (<75mm) in the northwest and across the east/southeast of the site. Greatest water depths are seen directly below Sawpit Road associated with a localised topographic depression. As expected, across the 1% + 40% Climate Change, 0.1% and 0.1% + 40% Climate Change AEP events these flooded areas expand with associated increases in water depth. Comparable with the fluvial results, significant out of bank flooding occurs directly south of *CULVERT\_SEC5\_3* and onto the west of the site.

Overtopping of the Hatchgate ditch within the two (2) blockage scenarios shows flow to escape out of the model domain to the far northwest of the site boundary. A cross-section analysis of LiDAR data in this area confirms that this is expected behaviour due to the location of a local catchment in this area allowing an additional route for water to exit the model. In absence of local survey to confirm drainage paths in this area, this boundary is considered to be representative of current conditions.

Pluvial peak water extent for the 1% AEP + 40% climate change uplift event is shown with reference to the proposed development in Figure 3-2. A depth cutoff of 75mm was used to reduce overall noise in the results – this is consistent with the approach taken to post process the EA Risk of flooding from surface water flood mapping<sup>11</sup>. Both north and south developments show low levels of flooding associated with the watercourse and surface water.

**Figure 3-2: 1% AEP + 40% Climate Change Pluvial Peak Water Extent**



<sup>11</sup> [Risk of flooding from surface water – understanding and using the map - GOV.UK](https://www.gov.uk/guidance/risk-of-flooding-from-surface-water-understanding-and-using-the-map)



## 3.2 Model Sensitivity Testing

### 3.2.1 Sensitivity Parameters

Sensitivity testing has been completed to quantify the level of uncertainty within the model. This has only been completed on the 1% AEP + CC event for each of the fluvial and pluvial models for difference in peak water levels between baseline and the corresponding sensitivity test. A total of ten (10) sensitivity tests were carried out:

- 50% Culvert Blockage (BLOCK1)
- 75% Culvert Blockage (BLOCK2)
- +20% Model Roughness (SEN01)
- -20% Model Roughness (SEN02)
- +20% Boundary 2D Slope Increase (SEN03)
- -20% Boundary 2D Slope Decrease (SEN04)
- +20% Inflow Sensitivity (SEN05)
- -20% Inflow Sensitivity (SEN06)
- Downstream Tailwater Sensitivity – 35.88 m AOD + 0.3m (SEN07)
- Downstream Tailwater Sensitivity – 35.88 m AOD + 0.6m (SEN08)

The sensitivity results for the above sensitivity tests have been provided for the fluvial and pluvial model scenarios in Appendix E and Appendix G respectively.

### 3.2.2 Culvert Blockage

Culvert blockage has been applied uniformly across all structures within the model domain.

Results of the sensitivity testing indicate that the model is moderately sensitive to culvert blockage. As would be expected, increasing levels of blockage (50% to 75%) across all structures results in higher flood levels throughout the model.

For both the fluvial and pluvial model scenarios, this increase is concentrated directly upstream and downstream of CULVERT\_SEC5\_3 within the channel and over an area directly above Nursery Close, located west of the site boundary. The largest differences were found in the 75% blockage scenario (BLOCK2), with increases of +37mm (0.037m) for the fluvial model and increases of +54mm (0.054m) for pluvial variant recorded north of CULVERT\_SEC5\_3.

### 3.2.3 Model Roughness

Results of increasing and decreasing global roughness by  $\pm 20\%$  indicate that the model is moderately sensitive to adjustments in roughness. Across most of the domain, differences in flood levels compared to the baseline model were less than 30mm.

An exception to this was noted in the SEN01 scenario (+20% Roughness) for the fluvial model, where a localised increase in flood level of +240mm (0.240m) was recorded at the intersection between Sawpit Road and Barber Close, far south of the site boundary.

### 3.2.4 2D Downstream Boundary

The downstream boundary sensitivity consisted of adjusting the 2D boundary slope condition  $\pm 20\%$ . Due to the 1D boundary conditions consisting of a water level verse height boundary, only 2D boundaries were assessed in this test to determine 2D boundary sensitivity.



SEN03 depicts an increase 2D slope boundary by +20% and SEN04 depicts a decreased 2D slope boundary by -20%. The results show that the model is not sensitive to the change in 2D boundary slope, showing no discernible difference.

### **3.2.5 Flow Sensitivity**

Sensitivity testing of the model to flow was undertaken by adjusting model inflows by  $\pm 20\%$  for the fluvial model and global rainfall input by  $\pm 20\%$  for the pluvial model variant.

As expected, a 20% increase in inflows resulted in moderate rises in flood levels. Within the vicinity of the site, the fluvial model recorded a maximum increase of +32mm directly east of CULVERT\_SEC2, while the pluvial model showed an increase of +49mm upstream of CULVERT\_SEC5\_3.

Conversely, a 20% reduction in inflows led to lower flood levels across the model domain with the greatest decreases observed upstream and downstream of CULVERT\_SEC5\_3 in both model variants. Reductions of -74mm and -69mm were reported for the fluvial and pluvial models, respectively.

### **3.2.6 1D Downstream Tailwater Sensitivity**

Due to the 1D boundary conditions consisting of a water level verse height boundary, a 1D Tailwater Sensitivity was completed to assess impacts of tailwater to the site. SEN07 tailwater was set 0.3 m above the 1D boundary level of 35.88 m AOD and SEN08 was set to 0.6 m above the 1D boundary level of 35.88 m AOD.

For both fluvial and pluvial model scenarios, SEN07 showed no discernible differences over the baseline model. Larger differences were found in SEN08, with increases of +15mm (0.015m) for the fluvial model and +19mm (0.019m) for pluvial variant directly south of CULVERT\_SEC1 (Outlet).



### 3.3 Model Performance

To give a measure of the hydraulic model stability, the HPC timeseries output was plotted for each control number (Nu, Nc and Nd) as well as the change in timestep (dt). These are discussed further in the following sections.

#### 3.3.1 Fluvial Model

Figure 3-3 below shows the plotted control numbers against the model simulation time for the fluvial 1% AEP + 46% Climate Change baseline event.

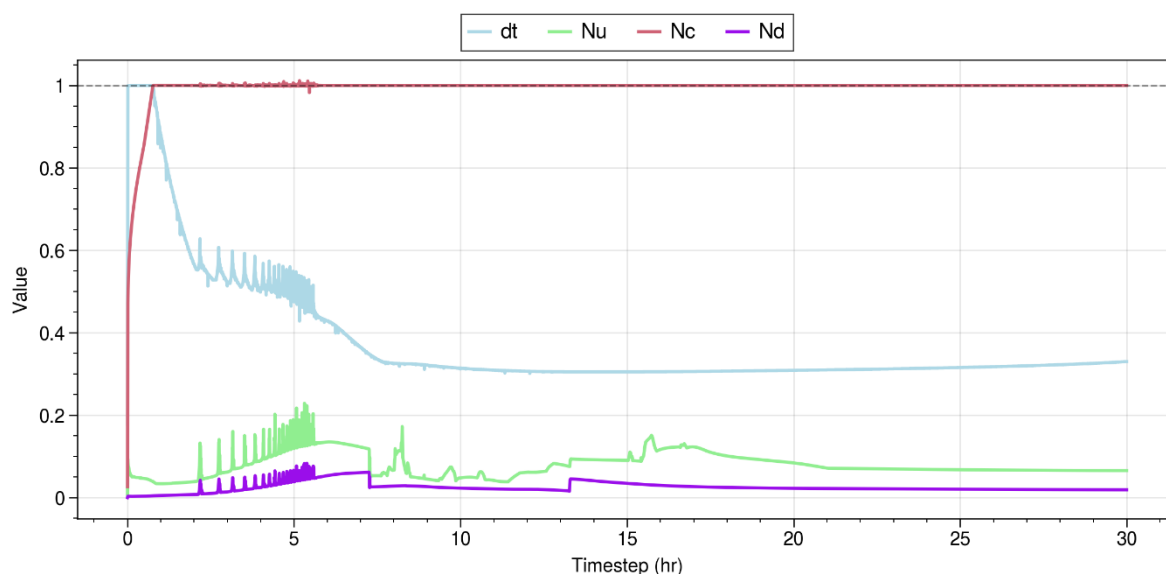
All control numbers are shown to be within their 'standard' range indicated by TUFLOW guidance<sup>12</sup> suggesting the model performs well overall. Small areas of minor instabilities are seen to occur within the control numbers at approximately 2.5 and 7 hours.

This first minor instabilities are related to the wetting of the 1D open channel network and does not impact or relate to the peak water levels or depths, as these are 'drowned out' during the peak of the event. This is evident in the initial 1D channel (to the south of the site) when peak upstream and downstream water levels are plotted with the flow through the open channel, as seen in Figure 3-4.

The second instability at approximately 7 hours is related to the Nc and Nd numbers only. While these values look 'bumpy', both are within modelling tolerances and are shown to be very minor. These values may indicate boundary instabilities within the 1D to 2D boundaries, however after reviewing the timeseries data around this timestep, it is evident that this does not impact peak extent results.

A plot of the change in total model water volume, dVOL (shown in Figure 3-5) suggests that the model is stable for the peak of the flood hydrograph and has been ran for an appropriate length of time. The instability in the dVOL aligns with the minor instability at the start of the 1D open channel wetting as discussed above.

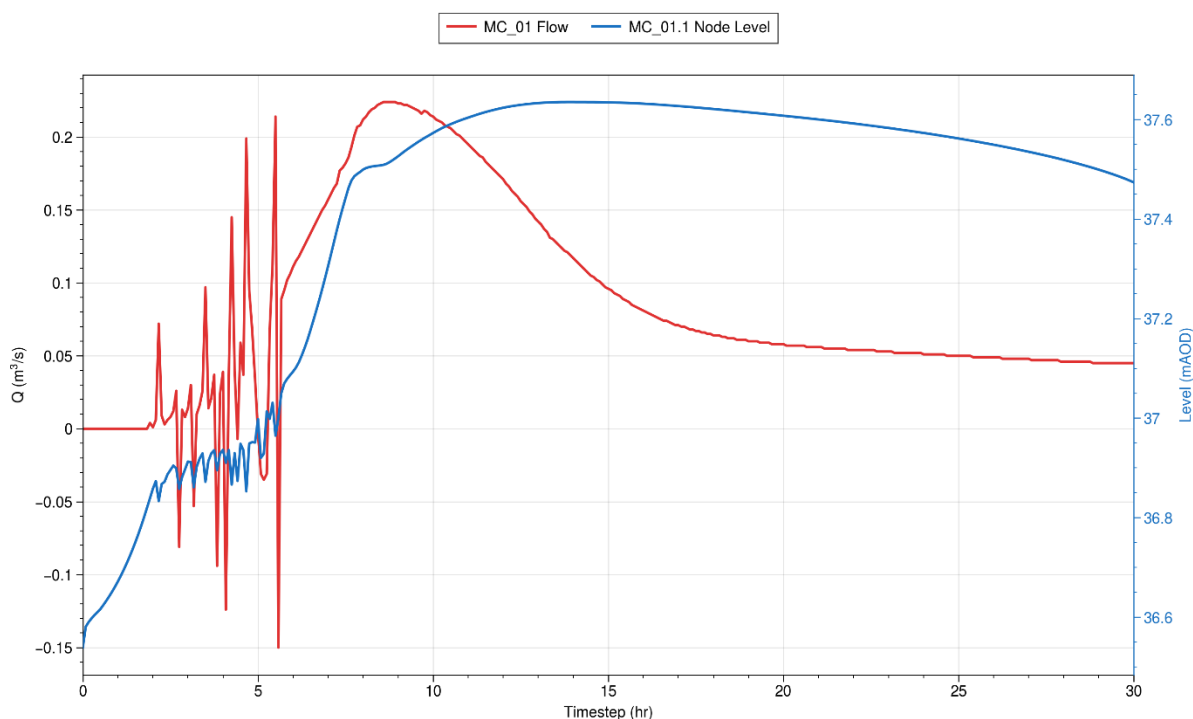
**Figure 3-3: HPC dt Timeseries Output (Baseline 1% + 46% CC Fluvial Model)**



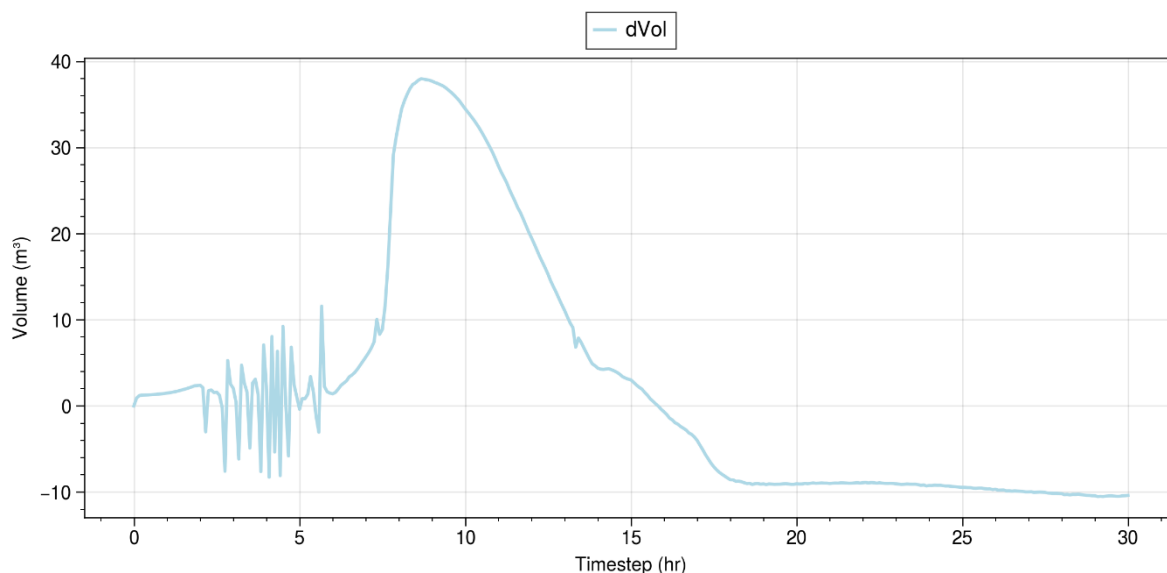
<sup>12</sup> TUFLOW Wiki HPC Model Review. Available at: [https://wiki.tuflow.com/HPC\\_Model\\_Review](https://wiki.tuflow.com/HPC_Model_Review)



**Figure 3-4: Instability in start of 1D Channel (Baseline 1% + 46% CC Fluvial Model)**



**Figure 3-5: dVOL Output (Baseline 1% + 46% CC Fluvial Model)**



### 3.3.2 Pluvial Model

Figure 3-6 below shows the plotted control numbers against the model simulation time for the pluvial 1% AEP + 40% Climate Change baseline event.

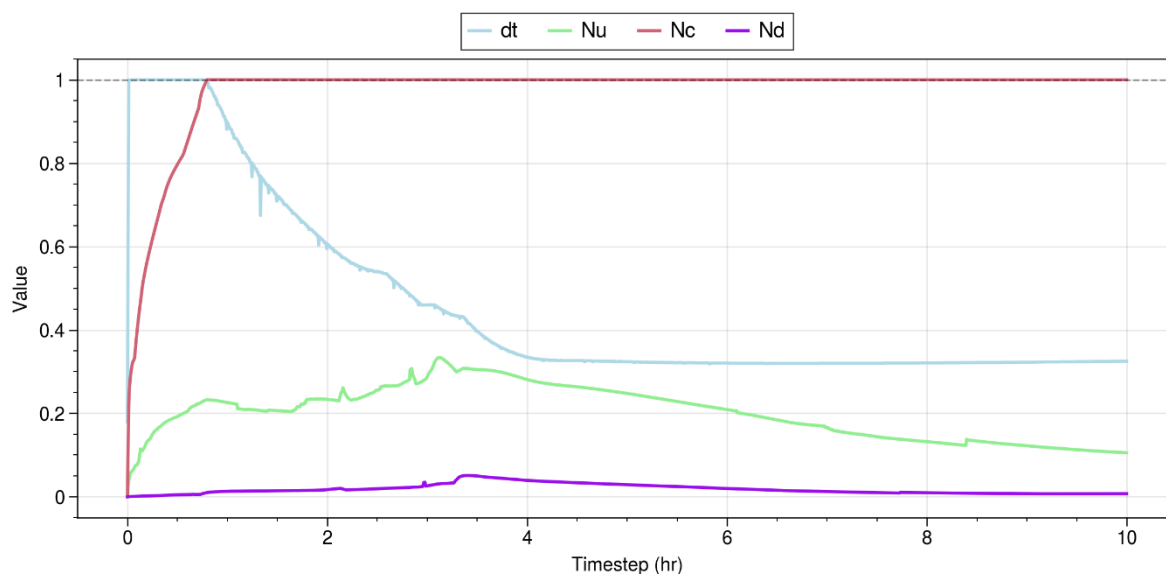
All control numbers are shown to be within their 'standard' range indicated by TUFLOW guidance<sup>13</sup> suggesting the model performs well overall.

<sup>13</sup> TUFLOW Wiki HPC Model Review. Available at: [https://wiki.tuflow.com/HPC\\_Model\\_Review](https://wiki.tuflow.com/HPC_Model_Review)

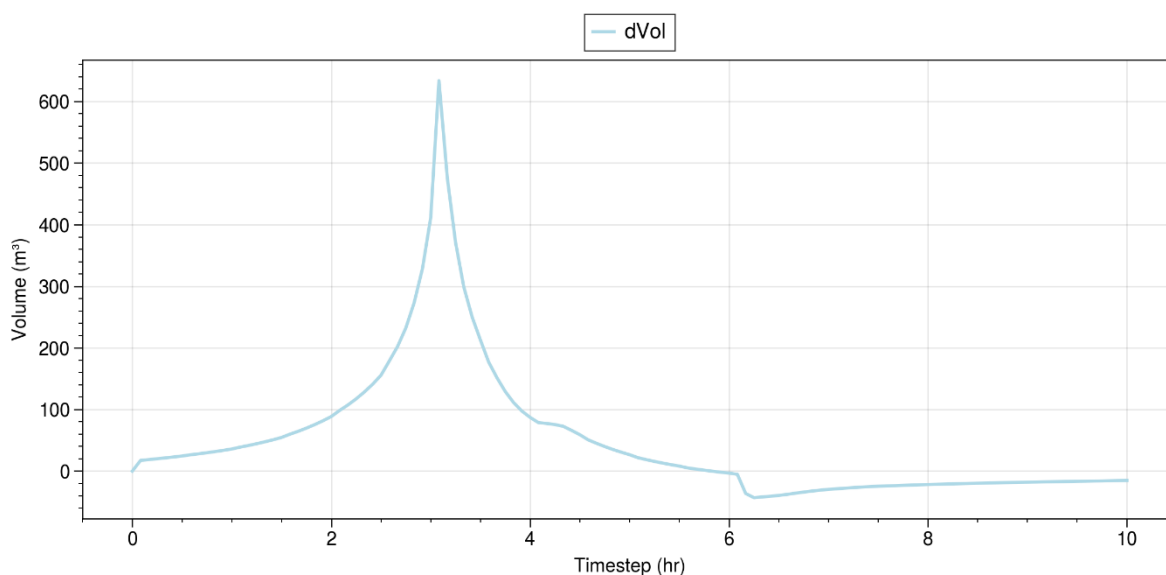


A plot of the change in total model water volume, dVOL (shown in Figure 3-7) suggests that the model is stable and has been ran for an appropriate length of time.

**Figure 3-6: HPC dt Timeseries Output (Baseline 1% + 40% CC Pluvial Model)**



**Figure 3-7: dVol Output (Baseline 1% + 40% CC Pluvial Model)**



### 3.4 Model Validation

A review of the EA's Historical Flood Map dataset identified two recorded flood outlines within the proposed site boundary: 'Recorded\_Flood\_outlines.6979' (dated December 2002) and 'Recorded\_Flood\_outlines.6980' (dated January 2003). The EA commentary associated with both outlines states the flooding "looks more like waterlogging than fluvial in nature". As such, these events have been excluded from use for calibration or verification in this assessment, as they are not considered representative of either fluvial or pluvial flooding – being instead classified by the EA as an 'other' flood source.



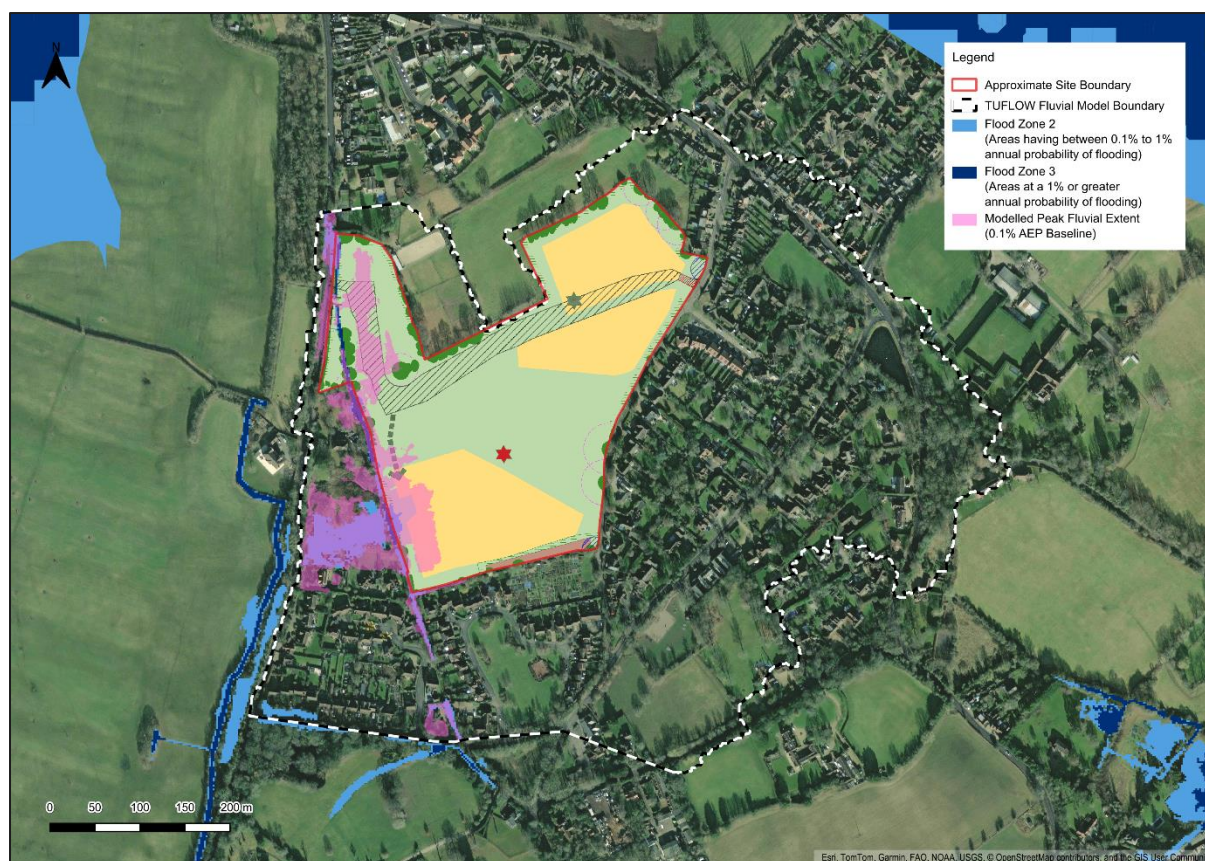
Given the limitations of the Historical Flood Map and the EA acknowledgement of no detailed flood modelling previously undertaken within the site area, the decision was made to compare the hydraulic modelling results to the most recent EA flood mapping (dated March 2025), specifically:

- The Flood Map for Planning (FMFP) for an assessment of fluvial flood risk; and
- The Risk of Flooding from Surface Water map (RoFSW) for pluvial flood risk.

The discrepancies in the flood mapping are related to the additional detail that the site-specific modelling has incorporated in terms of hydraulic structures, watercourse definition and site-specific hydrology. The EA mapping does not appear to show any representation of the existing culvert under Lodge Road. The EA mapping shows the water flowing north to the northern point of the site along Lodge Road, to what could be considered additional storage.

Notwithstanding the discrepancies, there is generally a reasonable representation between the EA flood map for planning with the modelling and Flood Zone 3 are in close agreement. For Flood Zone 2, the site-specific model extent is greater than the EA mapping however, the depth of flooding in the areas outwith the EA flood zone 2 mapping is less than 100mm in depth. The comparison between the fluvial baseline 0.1% AEP modelled results and EA Flood Map for Planning extents is provided in Figure 3-8.

**Figure 3-8: 0.1% AEP Fluvial Peak Water Extent (Baseline Scenario) with reference to EA Flood Map for Planning Flood Zones**



The available EA Risk of Flooding from Surface Water Extent maps<sup>14</sup> allow for direct comparisons between pluvial hydraulic modelling results for the 3.3%, 1% and 0.1% AEP events. For clarity, only the 0.1% AEP event was chosen to compare against the equivalent modelled results and is shown in Figure 3-9. For direct comparison, flood depth less than 75mm (0.075m) have been filtered out of the modelled results.

**Figure 3-9: 0.1% AEP Pluvial Peak Water Extent (Baseline Scenario) with reference to EA Risk of Flooding from Surface Water Mapping**



The results show that modelling is largely in agreement with EA Risk of Flooding from Surface Water mapping. However, our findings present more conservative estimates for flood extent around the site. These differences may be attributed, in part, to the incorporation of higher resolution 1m LiDAR DTM data, the incorporation of the new FEH22 rainfall data and site specific assessment.

### 3.5 Freeboard Uncertainty

EA guidance<sup>15</sup> sets out that the freeboard requirements on modelled flood levels for new developments should be set in accordance with the level of uncertainty in the modelling process.

The magnitude of uncertainties including the score (topic score) are considered below based on ratings provided in the EA guidance document:

<sup>14</sup> Environment Agency Risk of Flooding from Surface Water. Available via: <https://www.data.gov.uk/dataset/d1f31121-0ddc-41e9-9d28-80a4b3e40b7d/risk-of-flooding-from-surface-water-complex-bundle>

<sup>15</sup> EA: Accounting for residual uncertainty. Report – SC120014. Section 3.2.4.



- The model has been created from localised survey, however there are still known deficiencies in some datasets and potential structures not included. *[topic score = 3]*
- Good local representation of floodplain pathways. 1m LiDAR data is available across the entire model domain however lacks detail over few topographical features not picked up in LiDAR survey. *[topic score = 2]*
- Rainfall hyetographs produced following latest FEH Rainfall Runoff methodology, based on catchment descriptors found through FEH webservice. *[topic score = 3]*
- The fluvial threats have been represented within the study area across three different return periods and their subsequent climate change uplift scenarios. Detailed 1D/2D model used incorporating site survey data. *[topic score = 2]*
- No quantified evidence to compare a like-for-like AEP event. Comparison with EA mapping within the vicinity of the site suggests the hydraulic model represents previous flooding behaviour. *[topic score = 3]*

The two worst (highest) scores are then taken and combined using the matrix below (Figure 3-10) to give a star rating. For the Hurst model this provides a 3-star rating.

**Figure 3-10: Scoring Matrix to Derive Confidence Rating**

|                     |    | Worst topic 1 score |        |        |        |        |
|---------------------|----|---------------------|--------|--------|--------|--------|
|                     |    | 10                  | 5      | 3      | 2      | 1      |
| Worst topic 2 score | 10 | 1 star              |        |        | 2 star | 3 star |
|                     | 5  | 1 star              |        | 2 star | 3 star | 4 star |
|                     | 3  | 1 star              | 2 star | 3 star | 4 star |        |
|                     | 2  | 2 star              | 3 star | 4 star |        | 5 star |
|                     | 1  | 3 star              | 4 star |        | 5 star |        |

Based on the confidence rating estimated above, the reliability is then determined using Figure 3-11. A 3-star rating indicates that the hydraulic model is “likely to be locally reliable”.

**Figure 3-11: Residual uncertainty allowance in development planning**

| Confidence rating | Confidence description               | Proportion of design flood depth | Minimum depth (mm) |
|-------------------|--------------------------------------|----------------------------------|--------------------|
| 1 star            | Very unlikely to be locally reliable | 40%                              | 900                |
| 2 star            | Unlikely to be locally reliable      | 30%                              | 750                |
| 3 star            | Likely to be locally reliable        | 20%                              | 600                |
| 4 star            | Very likely to be locally reliable   | 10%                              | 450                |
| 5 star            | Highly likely to be locally reliable | 5%                               | 300                |

## 3.6 Assumptions

The main assumptions made within this hydraulic study are as follows:

- Underlying 1m LiDAR is sufficient in capturing topographic features effectively;



- No structures (in terms of pit, pipe or bridge data) outside of the site have been surveyed.
- Outfall of water from the 1D channel is restricted by the northernmost culvert and not other features further downstream.
- The conveyance of water through additional channels south of the site boundary is enforced with elevation changes within the model based on where it ties into the surveyed data and reasonable slope.
- Rainfall model inputs derived from the ReFH2 model are representative of current conditions.
- Flows leaving the model to the north are assumed to continue travelling downstream and not impact flows in the Hatchgate ditch.

### **3.7 Recommendations**

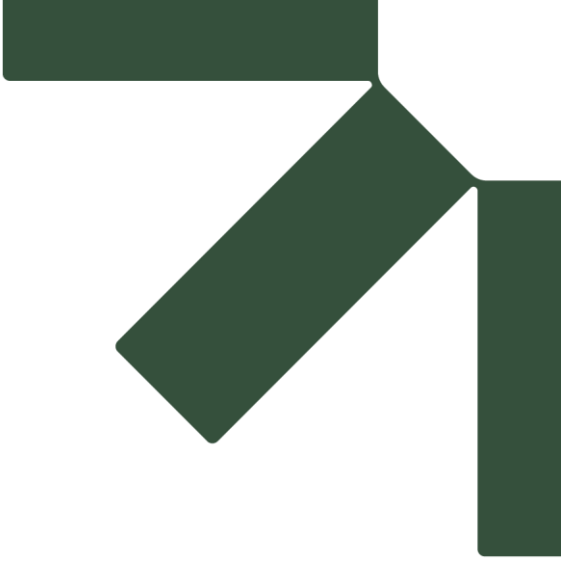
To further refine the flood modelling, additional work may be required to conduct more up-to-date site topographical surveys and incorporate missing hydraulic structures such as culverts and pipes if present. Modelling is assumed to be indicative and based on the available information at the time of completing the assessment. The data presented should only be used to inform potential site layouts acknowledging the modelling uncertainty.



## 4.0 Closure

In conclusion, this report stands as an initial investigation into the potential flooding at the proposed development site (Land East of Lodge Road in Hurst). To inform the client on the potential flood outlines, the decision to map both fluvial and pluvial flooding was taken alongside a series of sensitivity scenarios. A comparison with EA Flood Map for Planning and Risk of Flooding from Surface Water maps show the model is operating as expected. Future model refinement may be needed through an enhanced topographic and site survey depending on the final extent of the development and proximity to the flood outlines.





# Appendix A    Site Walk Over Photos

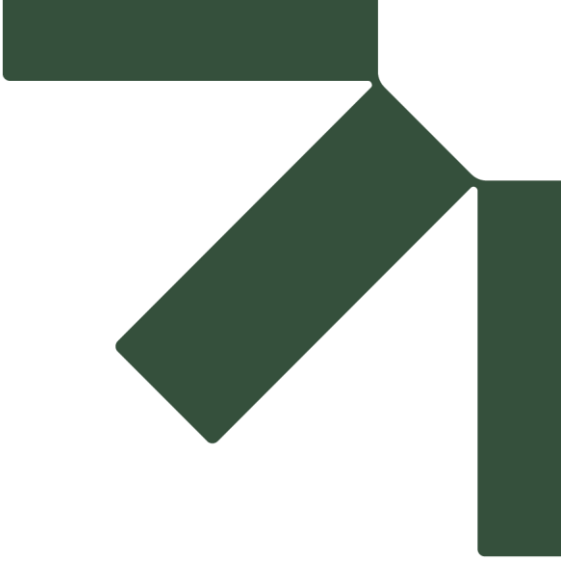
## **Flood Risk Modelling Report**

**Land East of Lodge Road, Hurst**

**MacTaggart & Mickel Group Limited**

SLR Project No.: 432.010035.00002

14 August 2025



# Appendix B 1D Channel Survey

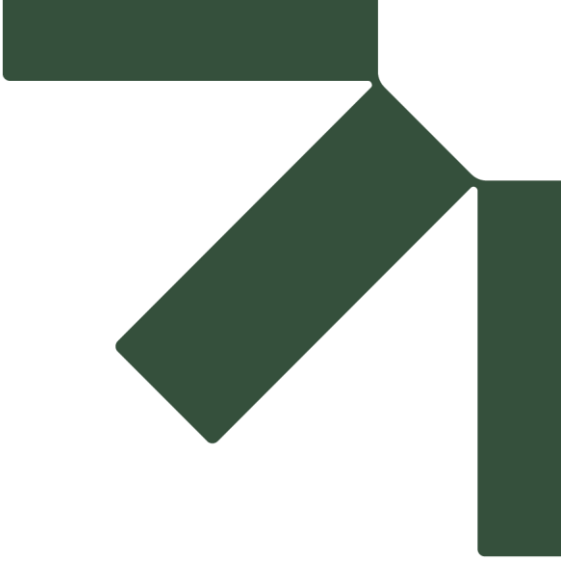
## Flood Risk Modelling Report

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# **Appendix C    Culvert Alignment Survey**

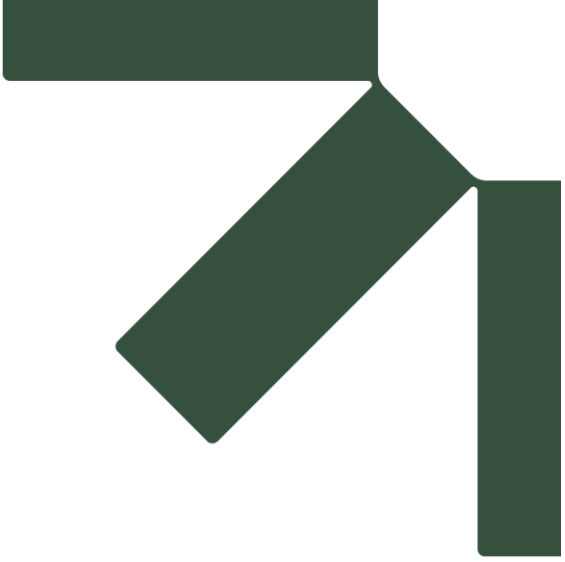
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# **Appendix D    Model Results (Fluvial)**

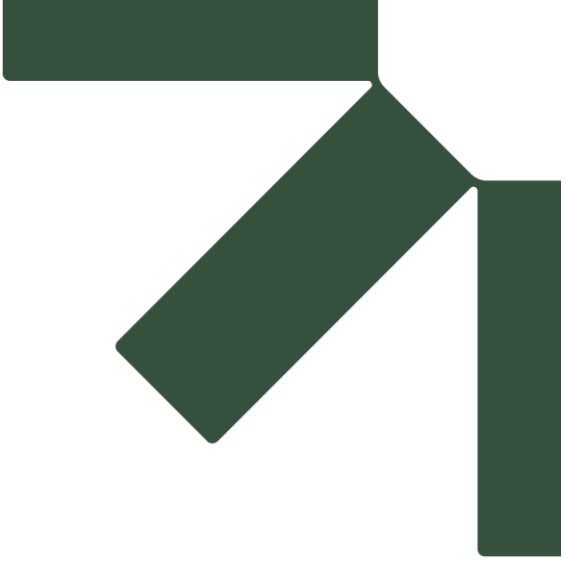
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# **Appendix E    Sensitivity Results (Fluvial)**

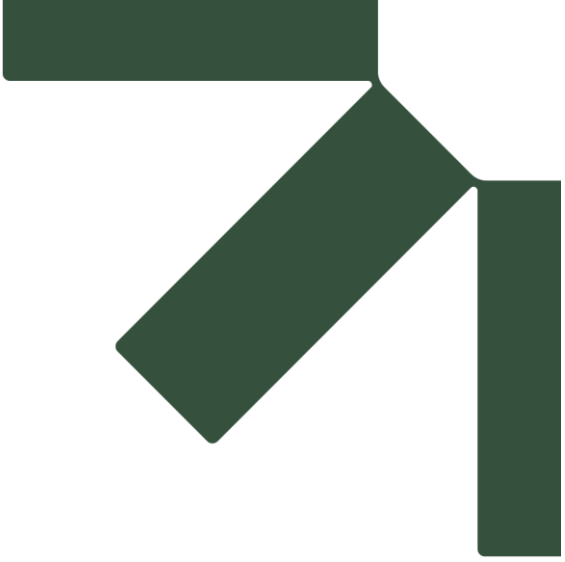
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# **Appendix F    Model Results (Pluvial/Rain-on-Grid)**

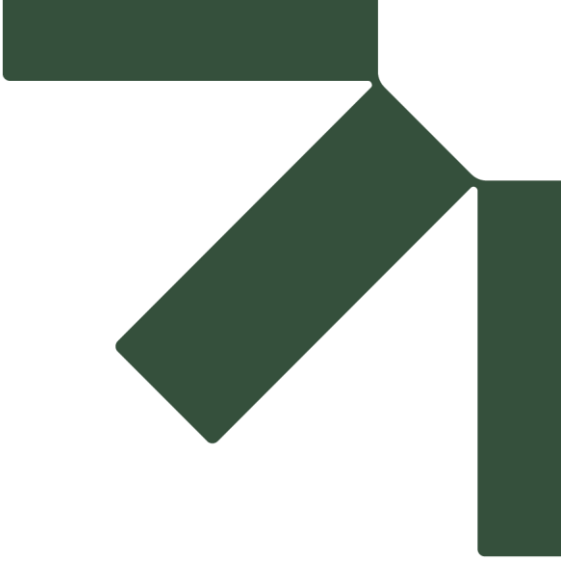
## **Flood Risk Modelling Report**

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# **Appendix G    Sensitivity Results (Pluvial/Rain-on-Grid)**

## **Flood Risk Modelling Report**

**Land East of Lodge Road, Hurst**

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# **Appendix H    Model Results with Proposed Site Layout (Fluvial/Pluvial)**

## **Flood Risk Modelling Report**

**Land East of Lodge Road, Hurst**

**MacTaggart & Mickel Group Limited**

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14 August 2025

# Appendix I      EA Flood Mapping

## **Flood Risk Modelling Report**

**Land East of Lodge Road, Hurst**

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# **Appendix J      Flood Mapping Comparison**

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