

Technical Note

Job Ref:	01C500376	Client:	Jelson Homes Limited
Site:	Sherborne Road, Burbage, Leicestershire	Site Visit:	Not applicable
Prepared by:	David Hoppe BSc MCIWEM C.WEM FRGS MEPS - Director – Flood Risk	Date of Note:	Version 1: 30/06/2025 Version 2: 08/10/2026 - Updated following independent third-party review of the hydraulic modelling, incorporating revised hydrology, updated model outputs and associated revisions to the Flood Storage Area and embankment design.
Reviewed and Authorised by:	Catriona Woods PhD, MSc, BSc(Hons), CSci, MEnvSc – Director Reviewed: 6/10/26		

INTRODUCTION

This Technical Note has been prepared to support the discharge of Condition 19 attached to planning permission ref. 23/00673/OUT at Sherborne Road, Burbage. The note provides a summary of the updated hydraulic modelling undertaken by JBA Consulting, including revisions arising from a subsequent third-party review of the hydrological and hydraulic model inputs and the incorporation of updated flood estimation guidance and methodologies.

The purpose of this note is to demonstrate that the requirements of Condition 19 continue to be satisfied and to provide a concise summary of the findings presented within the updated modelling documentation prepared by JBA Consulting.

CONDITION 19

Condition 19 (Flood Risk Modelling) – No approval of reserved matters shall take place until such time as the following details have been submitted to, and approved in writing by the Local Planning Authority. Any subsequent design must be carried out in accordance with these approved details:

- *Modelling updated to reflect upper end climate change allowance for both the proposed and existing scenarios.*
- *Full details of flood compensation areas supported by revised modelling, unless modelling/layout demonstrates that compensation is not required*
- *Details demonstrating finished floor levels are set at least 300mm above the modelled 1 in 100 year plus upper end climate change allowance.*
- *Full consideration of source control SuDS*

BACKGROUND

Avison Young prepared a Flood Risk Assessment and Drainage Strategy (01C201896) in support of outline planning application ref. 23/00673/OUT in June 2023. The assessment was supported by hydraulic modelling undertaken by JBA Consulting, which formed the basis of the flood risk strategy approved as part of the outline permission.

To satisfy the requirements of Condition 19, JBA Consulting were subsequently commissioned to update the hydraulic modelling and assess the proposed development against the upper end climate change allowance. A technical note Version 1.0 (dated 30/06/2025), was prepared by Avison Young in support of the Condition 19 discharge application, demonstrating compliance with the requirements of the condition.

Following submission of the original Condition 19 information, the Lead Local Flood Authority, within its consultation response (Ref. 2025/0197/04/R2, dated 23 December 2025) relating to Reserved Matters application ref. 25/00197/REM, advised that it did not appear that an independent review and sign-off of the fluvial hydraulic modelling had been completed and requested that this be undertaken in support of the Condition 19 discharge application.

In response, an independent third-party review of the hydrological assessment and hydraulic model was commissioned. The review identified a number of recommendations, including updates to hydrological inputs, incorporation of updated industry-standard methodologies and additional hydraulic sensitivity testing. Following completion of the review, JBA Consulting updated the hydrology and hydraulic model in accordance with the review findings.

The updated hydrological assessment resulted in a modest increase in peak flows and corresponding increases in modelled flood levels and flood extents when compared to the previous Condition 19 submission. Whilst the increase was relatively small, the revised modelling indicated higher flood levels within the Flood Storage Area (FSA), requiring revisions to the FSA and associated embankment design to maintain the intended level of flood protection.

The revised modelling increased the peak water level within the Flood Storage Area from approximately 99.35mAOD to 99.85mAOD. In response, the Flood Storage Area and associated embankments were redesigned, with embankment crest levels increased from 99.5mAOD to 100.0mAOD to maintain appropriate freeboard and ensure containment of flood flows during the 1% AEP plus 60% climate change event. Review of the updated modelling confirms that the proposed residential finished floor levels continue to provide the required 300mm freeboard above the modelled flood levels and therefore do not require amendment.

Please refer to Appendix I for JBA Consulting's revised Technical Note which includes the revised technical drawings.

This updated submission therefore supersedes the previous Condition 19 response submission and should be read in conjunction with the updated technical documentation prepared by JBA Consulting.

CONDITION 19 COMPLIANCE

JBA Consulting has undertaken the flood modelling which confirms that Condition 19 has been satisfied.

CONDITION 19	RESPONSE
<i>Modelling updated to reflect upper end climate change allowance for both the proposed and existing scenarios.</i>	Following an independent third-party review of the hydrological assessment and hydraulic modelling, the hydrological inputs and hydraulic model were updated to reflect current flood estimation methodologies, revised catchment descriptors, updated urbanisation parameters and revised design flow calculations. Baseline and post-development modelling have subsequently been undertaken for events up to and including the 1% AEP plus 60% climate change event.

	The updated modelling confirms that, with the proposed mitigation measures comprising raised watercourse embankments and a Flood Storage Area (FSA), flood risk to the proposed development parcels has been removed. The 60% climate change allowance represents the upper-end allowance required by the condition
<i>Full details of flood compensation areas supported by revised modelling, unless modelling/layout demonstrates that compensation is not required</i>	The updated hydrological assessment resulted in a modest increase in peak flows and associated flood levels when compared to the previously approved Condition 19 submission. Consequently, the Flood Storage Area (FSA) and associated embankment design were revised, including an increase in embankment crest levels, to accommodate the higher modelled flood levels whilst maintaining the required flood storage capacity and freeboard. A detailed engineering design has therefore been prepared for the revised embankments and Flood Storage Area to support the updated hydraulic modelling. The revised post-development modelling demonstrates that flood flows generated during the 1% AEP plus 60% climate change event are contained within the watercourse corridor and Flood Storage Area. The modelling confirms that there is no loss of floodplain storage and no increase in flood risk elsewhere. Additional flood compensation is not required, as there is no loss in floodplain capacity, with the updated modelling continuing to demonstrate a betterment to third-party flood risk when compared to the baseline scenario.
<i>Details demonstrating finished floor levels (ffl) are set at least 300mm above the modelled 1 in 100 year plus upper end climate change allowance</i>	Maximum modelled water levels for the post-development 1% AEP plus 60% climate change event are presented within the updated hydraulic modelling documentation. The revised modelling confirms that the proposed finished floor levels continue to provide the required freeboard above modelled flood levels. Finished floor levels shall be set a minimum of 300mm above the adjacent modelled flood level in accordance with the requirements of the condition. Please see JBA's Technical Note, Appendix A, Post Developed Engineering Drawings.
<i>Full consideration of source control</i>	Introduction of permeable paving to all private roadways and shared driveways. Proposals already in place for Hydrobrake, flow control units to be installed downstream of all detention basins and

attenuation ponds. These measures combined will provide source control of surface water runoff from the proposed development.

A copy of JBA Consulting's technical note with a full engineering design for the raised banks and flood storage area is provided in **Appendix I**. A copy of the third-party model review can be found in **Appendix II**.

CONCLUSION

To satisfy Condition 19 of planning permission ref. 23/00673/OUT, JBA Consulting were commissioned by Jelson Homes Limited to update the hydraulic modelling and assess the proposed development against the upper-end climate change allowance. Following comments from the Lead Local Flood Authority, an independent third-party review of the hydrological assessment and hydraulic modelling was undertaken. The review recommendations were subsequently incorporated into an updated hydrological assessment and hydraulic model by JBA Consulting.

The updated assessment resulted in a modest increase in peak flows and flood levels compared to the previous Condition 19 submission. Consequently, the Flood Storage Area and associated embankment design were revised, including increases to embankment crest levels, to reflect the updated model outputs and maintain the required level of flood protection. The revised modelling confirms that flood flows remain contained within the Flood Storage Area during the 1% AEP plus 60% climate change event, with no increase in flood risk elsewhere and no changes required to the proposed residential finished floor levels.

We consider that the information submitted demonstrates compliance with the requirements of Condition 19 and that the condition can be discharged.

Appendix I

JBA Consulting FEH Calculations, Technical Note and
Supporting Drawings

Flood estimation report: Sherborne Road, Burbage

Introduction

This report template is based on a supporting document to the Environment Agency's flood estimation guidelines. It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

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Approval

	Name and qualifications	Date
Method statement prepared by:	Sam Cogan BSc MSc	24/07/2023
Method statement reviewed by:	Eva Kordomenidi BSc MSc MCIWEM CWEM CSci	03/08/2023
Calculations prepared by:	Sam Cogan BSc MSc	26/07/2023
Calculations reviewed by:	Eva Kordomenidi BSc MSc MCIWEM CWEM CSci	03/08/2023
FEH25 Calculations prepared by:	Sam Cogan MCIWEM BSc MSc	10/08/2026

Revision History

Revision reference	Date issued	Amendments	Issued to
S2.P1	10/08/2026	FEH25 and sewer loss updates	

Abbreviations

AMAX	Annual Maximum
AREA	Catchment area (km ²)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CPRE.....	Council for the Protection of Rural England
FARL.....	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED.....	Median Annual Flood (with return period 2 years)
ReFH.....	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
Tp(0)	Time to peak of the instantaneous unit hydrograph
URBEXT1990.....	FEH index of fractional urban extent
URBEXT2000.....	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

Note on flood probability

This document quotes the probability of a flood magnitude in terms of a return period based on analysis of annual maximum (AMAX) floods. The return period of a flood on the AMAX scale is the average interval between AMAX floods of that magnitude or greater. The inverse of the AMAX return period is the annual exceedance probability (AEP).

Return periods are output by the Flood Estimation Handbook (FEH) software and can be expressed more succinctly than AEP. AEP can be helpful when presenting results to non-specialists who may associate the concept of return period with a regular rather than an average interval.

Return period can also be measured on the peaks-over-threshold (POT) scale as the average interval between floods of that magnitude or greater. The difference between AMAX and POT return periods is only important for short return periods (under 10 years).

The table below is provided to enable quick conversion between these different measures.

AMAX return period (years)	n/a	2	5	10	20	30	50	75	100	200	1,000
AEP (%)	n/a	50	20	10	5	3.33	2	1.33	1	0.5	0.1
POT return period (years)	1	1.5	4.5	9.5	20	30	50	75	100	200	1,000

1 Method statement

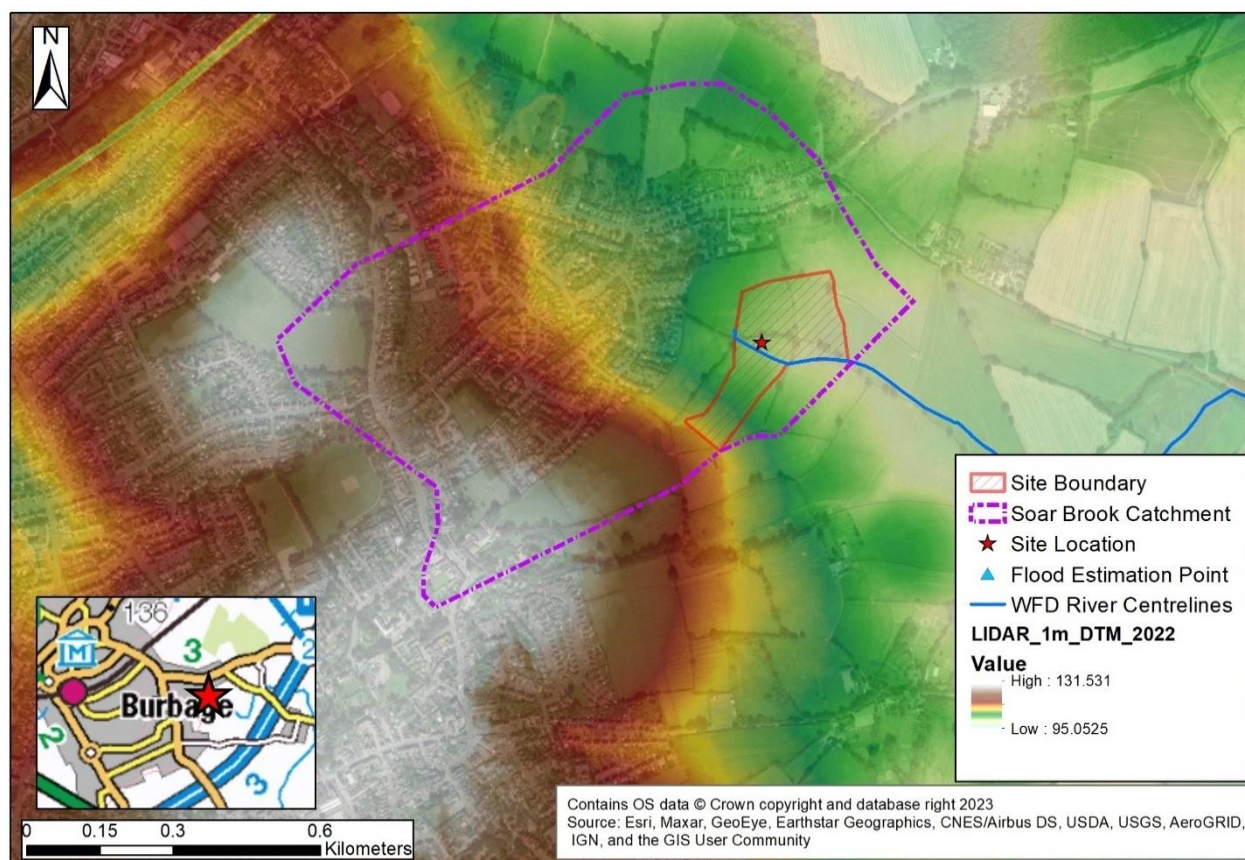
1.1 Requirements for flood estimates

Overview • Purpose of study • Peak flows or hydrographs? • Range of return periods and locations	The proposed development site is located adjacent to Sherborne Road, Burbage (NGR: SP448932). Development proposals for the site is for a residential led development. An unnamed ordinary watercourse flows from northwest to southeast along the southern boundary of the site with an additional tributary crossing from the northwest boundary of the site through the centre to meet the main channel at the southern boundary. JBA Consulting have been commissioned by Avison Young to undertake a hydraulic modelling study to develop an understanding of the flood risk posed from the ordinary watercourse. Hydraulic inputs for a 1D-2D hydraulic model are required in order to assess the changing depth, velocity and hazard at the site during modelled flood events. Peak flows were provided for the model in 2020 however, following an peer review and with consideration to advances in hydrological methodologies and datasets since the undertaking of the 2020 hydrological study, updated hydrology estimates are considered necessary. Objectives: This study seeks to provide a hydrological assessment to quantify fluvial flood risk from Soar Brook. Peak flow estimates and hydrographs are required for four Flood Estimation Points (FEP) which have been informed by the existing hydraulic model for Soar Brook: • Three Inflow for Soar Brook which represents the presence of three small drains which combine to create Soar Brook • Model downstream checkpoint along Soar Brook. Peak flow estimates and hydrographs have been derived for the following annual exceedance probabilities (AEPs): • 2-year flood event; • 30-year flood event; • 100-year flood event; • 100-year plus climate change flood event; and • 1000-year flood event. Based on July 2021 EA climate change allowance guidance¹, the proposed development site is located within the Soar Management Catchment. For the '2080' scenario, the climate change uplift is 28%. Peak flows for the Higher allowance (37% uplift) have also been calculated. Flow estimates and hydrographs derived from the hydrological analysis will subsequently be incorporated into a 1D-2D hydraulic model capable of simulating flood extents, levels and flows through time in relation to the development site.
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¹ Environment Agency (2023). Guidance: Flood risk assessments: climate change allowances. Accessed 17/07/2023. [Source: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#Select-the-peak-river-flow-allowances-to-use-for-your-assessment>].

1.2 The catchment

Map (Include river network, catchment boundary and gauging stations)



Description

Include topography, climate, geology, soils, land use and any unusual features that may affect the flood hydrology.

Soar Brook, including contributing watercourses and urban drainage, drains an area of c.0.74 km², up to the downstream model boundary. The general elevation trend of the Soar Brook catchment is a decline from west to east as land falls from c.131 mAOD to c.99 mAOD.

Underlying bedrock geology of the wider Soar Brook catchment consists of Mercia mudstone group – mudstone. The superficial deposits geology of the catchment consists of Oadby member – diamicton, Dunsmore gravel - sand and gravel, Wolston sand and gravel - sand and gravel and Bosworth clay member - clay and silt².

Typical soils across the study catchment consists of Slightly acid loamy and clayey soils with impeded drainage to the west and Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils to the east³.

The varying nature of the underlying bedrock and superficial geology and soil types would indicate that the fluvial response to rainfall based on soil properties would likely be rapid due to the slowly permeable due to the underlying loamy and clayey soils of the catchment. Generally, the catchment may be considered to be relatively impermeable due to the underlying bedrock geology.

The FEH SPRHOST value at the catchment is moderate at 45%. The PROPWET value of the study catchment is 0.30. The annual rainfall (SAAR) for the period 1961 – 1990, is 649mm, below average compared to the UK average rainfall (1080mm). The catchment is located within the Midlands regional climate. Rainfall is generally well-distributed through the year, but the wettest

² British Geological Society (2021). Geotitles onshore. Accessed: 25/07/2023. [Source: Geotitles - British Geological Survey (bgs.ac.uk)].

³ British Geological Society (2021). UK Soil Observatory Map Viewer. Accessed: 25/07/2023. [Source: mapapps2.bgs.ac.uk/ukso/home.html].

month varies across the region. In the wetter upland areas of the north and west, there is a pronounced winter maximum when the Atlantic depressions are at their most vigorous. In contrast, the East and South Midlands tend to have a more even distribution through the year, with summer amounts there associated with showery, convective rainfall⁴.

The primary areas of flood risk within the catchment are located along the channel of Soar Brook where fluvial flood risk due to channel capacity exceedance would be considered to be the driving mechanism. Based on the Environment Agency Asset Management website⁵, there are no formal, structural flood defences along the bank of Soar Brook.

The catchment is generally comprised of the urban development of Burbage with small areas of grassland and agricultural land use to the lower reaches of the catchment. As the catchment has a relatively significant urban component (updated URBEXT2000 value = 0.37) that is likely to affect the choice of methodology used within this study.

1.3 Source of flood peak data

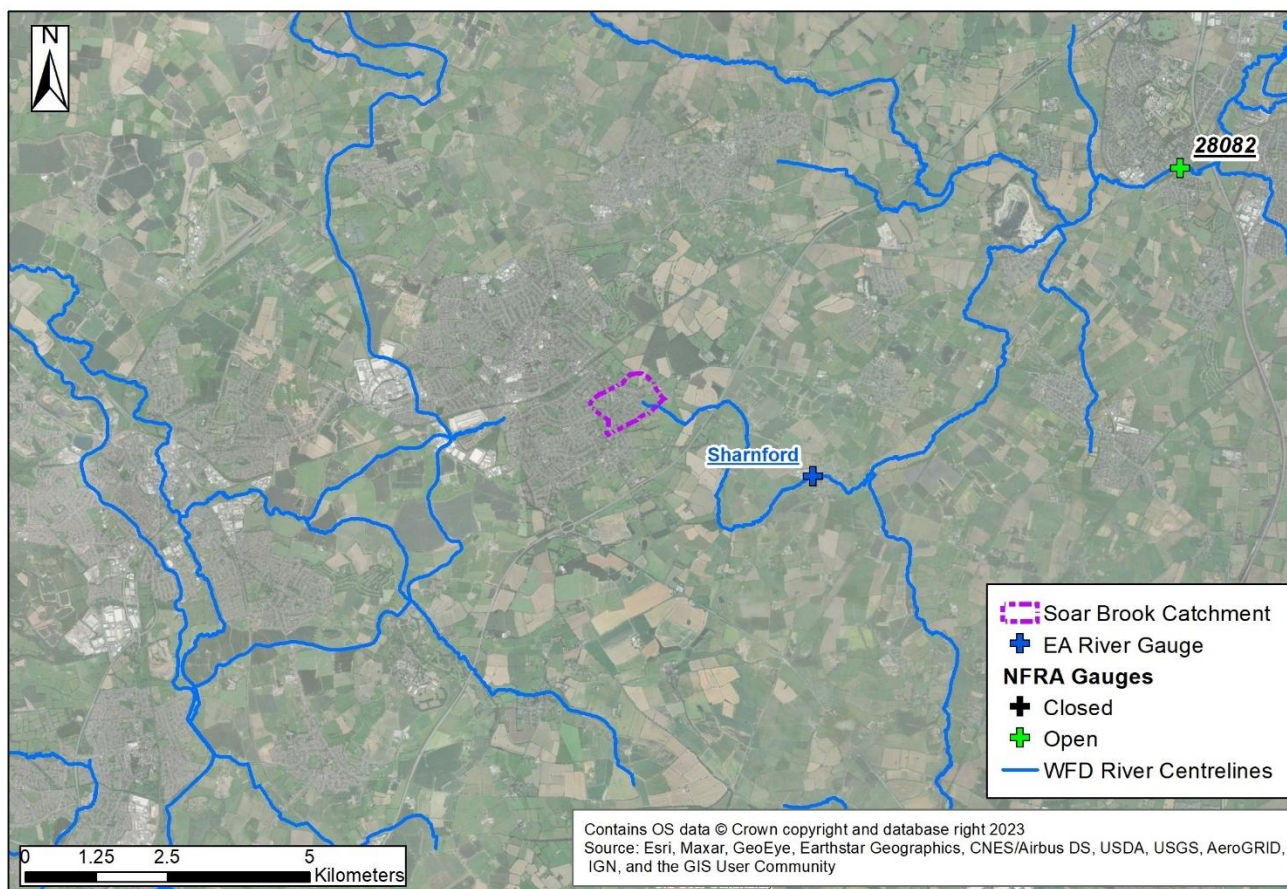
Source	Version 11.1 of the NRFA Peak Flow Dataset files represents a minor update to version 11 of the database (see release note below). This update sees the addition of FEH2022 DDF data, one suitability change and one station number change. Released on 6th March 2023.
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1.4 Gauging stations (flow or level)

Catchment is ungauged

⁴ https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/midlands_-_climate---met-office.pdf

⁵ Environment Agency (2002) Asset Information and Maintenance Programme (data.gov.uk)



(at or very near to the sites of flood estimates)

Water-course	Station name	Gauging authority number	NRFA number	Catchment area (km ²)	Type (rated / ultrasonic / level...)	Start of record and end if station closed
Soar Brook	Sharnford	L4145	-	21.93	Level Only	05/2000 – Present day

1.5 Data available at each flow gauging station in Table 1.4

Station name	Start and end of NRFA flood peak record	Update for this study?	OK for QMED?	OK for pooling?	Data quality check needed ?	Other comments on station and flow data quality														
Sharnford	Gauge peak flow is not on NRFA	N	Unknown - gauge peak flow is not on NRFA which is why its suitability for QMED is unknown.	Unknown - gauge peak flow is not on NRFA which is why its suitability for pooling is unknown.	Y	No comments of gauge available on NRFA. Gauge is a level gauge located along Soar Brook. An assessment of the stage record on the EA Hydrology Data Explorer states that stage readings up to July 2022 is considered to be good. Readings post July 2022 are either unchecked, missing or estimated. A rating review is not within the scope of this study. <u>Gauge Catchment Descriptors from FEH Webservice</u> <table><tr><td>Gauge</td><td>L4145</td></tr><tr><td>Distance</td><td>3.03km SE</td></tr><tr><td>Area (km2)</td><td>21.93</td></tr><tr><td>BFIHOST19</td><td>0.558</td></tr><tr><td>SAAR</td><td>645</td></tr><tr><td>URBEXT2000</td><td>0.040</td></tr><tr><td>FARL</td><td>0.986</td></tr></table>	Gauge	L4145	Distance	3.03km SE	Area (km2)	21.93	BFIHOST19	0.558	SAAR	645	URBEXT2000	0.040	FARL	0.986
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FARL	0.986																			
Tabulate any updated or revised flood peak series in the Annex. Give link/reference to any further data quality checks carried out.					Annex A															

1.6 Other data available and how it has been obtained

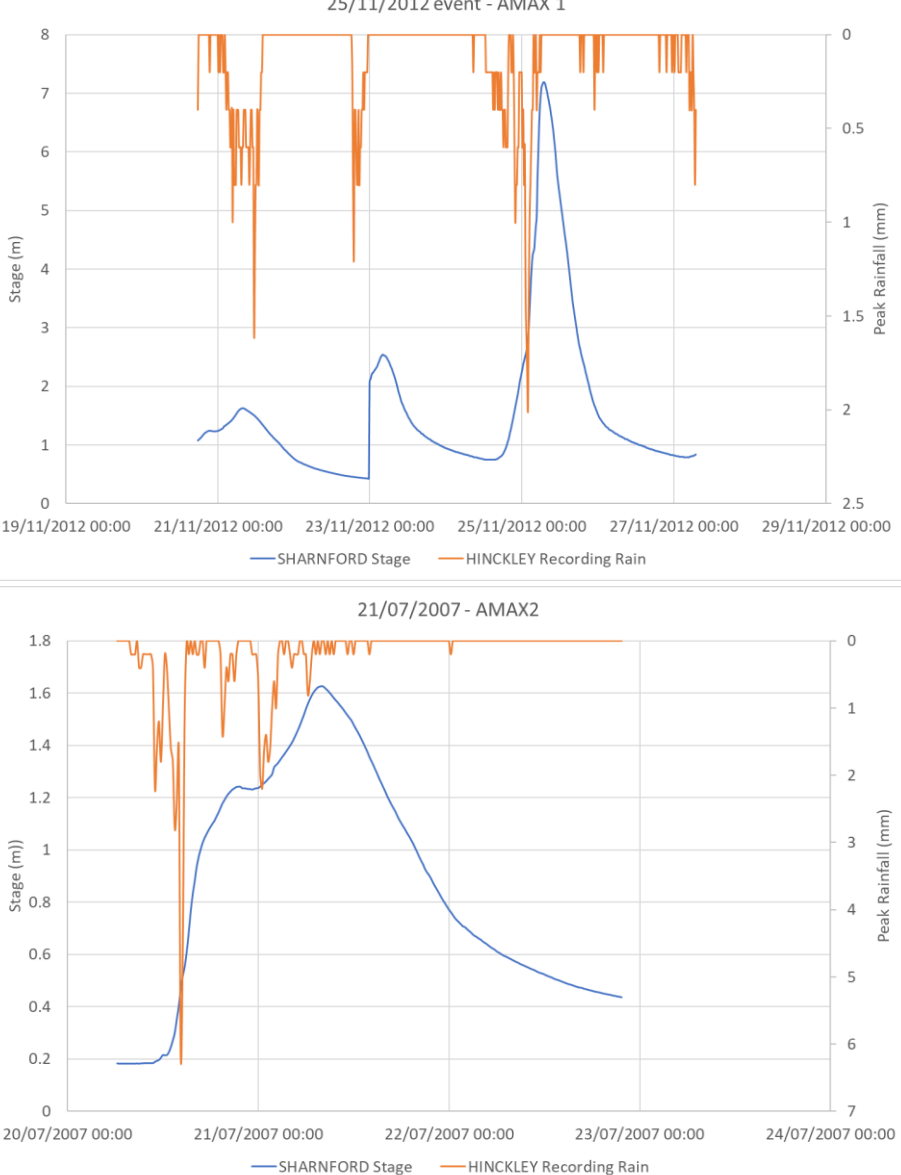
Type of data	Data relevant to this study?	Data available?	Source of data	Details
Check flow gaugings (if planned to review ratings)	N/A	N/A	-	Catchment is ungauged
Historic flood data Include chronology and interpretation of flood history in Annex or separate report.	Yes	Yes	Environment Agency WMS	No record of historical flooding either at the site or within the study catchment.
			BHS Chronology of British Hydrological Events	No record of historical flooding either within Burbage or along Soar Brook.

			LLFA	FOI request submitted to Leicestershire County Council - They do not hold any records of any flooding affecting Sherborne Road, Burbage.
Flow or river level data for events	Yes	Yes	-	Catchment is ungauged however 15-minute stage data for EA level gauge for Sharnford gauge available from Hydrology Data Explorer – data to be used for understanding catchment hydrology only and potentially for model validation. EA level gauges not suitable for use within this study.
Rainfall data for events	No	No	Shoothill Gauge map	No raingauges are located within the study catchment. No flood event analysis is included within the scope
Potential evaporation data	No	No	-	No flood event analysis in scope.
Results from previous studies	Yes	Yes	BWB Consulting (2013) Sherborne Road, Burbage Technical note: hydraulic modelling	Flows derived in 2013 for study catchment used a mixture of ReFH and the modified rational method. Critical Storm duration of 1.2hrs derived. ReFH spreadsheet calculations and calculations of the modified rational method included within Technical note.
			JBA Consulting (2020) Flood Estimation Report: Sherborne Road, Burbage	FEH Calculation Record available for flows derived for the hydraulic model in 2020. This study will make as much use of the initial 2020 study as is feasibly possible.

1.7 Hydrological understanding of catchment

The Sharnford gauge is level only. Further analysis was undertaken on the gauge in order to assess its suitability for this study.

Plots of flow data e.g. annual flow hydrograph, example flood events	There are no raingauges located within the Sharnford gauge catchment. Hinckley rain gauge is located approximately 1.3km north west of the catchment.
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	 The figure consists of two line graphs. The top graph, titled '25/11/2012 event - AMAX 1', plots Stage (m) on the left y-axis (0 to 8) and Peak Rainfall (mm) on the right y-axis (0 to 2.5) against time from 19/11/2012 00:00 to 29/11/2012 00:00. The blue line (SHARNFORD Stage) shows three distinct peaks, with the highest reaching approximately 7.5m on 26/11/2012. The orange line (HINCKLEY Recording Rain) shows multiple sharp peaks, with the highest reaching 2.5mm on 26/11/2012. The bottom graph, titled '21/07/2007 - AMAX2', plots Stage (m) on the left y-axis (0 to 1.8) and Peak Rainfall (mm) on the right y-axis (0 to 7) against time from 20/07/2007 00:00 to 24/07/2007 00:00. The blue line (SHARNFORD Stage) shows a single peak reaching approximately 1.6m on 21/07/2007. The orange line (HINCKLEY Recording Rain) shows multiple sharp peaks, with the highest reaching 7mm on 21/07/2007.
Hydrological interpretation Catchment processes, response time, propagation of flood, contributions from tributaries	The November 2012 event was the largest AMAX stage event at Sharnford. In November 2012 four periods of rainfall brought widespread flooding to many parts of the UK⁶. A fourth period of flooding occurred on the 25 and 26 November with a further 30-50 mm falling across South West England, Wales and Northern England. This week brought four significant rainfall events in the space of a week with already saturated ground given no chance to recover. Based on a comparison of the Sharnford gauge and the Hinkley Raingauge, the record correlates well with the rainfall peaks recorded within the neighbouring catchment. The three stage peaks of the November 2012 event occur approximately 1-8 hours after the rainfall peaks which is considered sensible for the Sharnford gauge if the Hinkley gauge is considered representative of the rainfall of the gauge catchment. For the AMAX2 event, response time to the rainfall event is much longer (c. 17hours). The study site is urban in nature, and it is expected that the response to rainfall in the study catchment would be far quicker for smaller events than what is shown by the Sharnford gauge.
Hydrological interpretation Discuss outliers, non-	23 years is not a sufficient record for non-stationarity analysis to assess if there may be a trend within the stage data. Due to the urban extent within the study catchment, local data should be used

stationarity.	as much as is feasibly possible however the Sharnford gauge is level only, not within the NRFA Peak Flow dataset and is not considered representative of the study catchment. The gauge will not be considered further as a potential donor catchment as rating reviews are not within the scope of this project.
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Outline the conceptual model, addressing questions such as: - Where are the main sites of interest? - What is likely to cause flooding at those locations? (peak flows, flood volumes, backwater effects, combinations of peaks, groundwater, snowmelt, tides...) - Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? - Is there a need to consider temporary debris dams or NFM features that could collapse?	The proposed development site is located adjacent to Sherborne Road, Burbage (NGR: SP448932). An unnamed ordinary watercourse flows from northwest to southeast along the southern boundary of the site with an additional tributary crossing from the northwest boundary of the site through the centre to meet the main channel at the southern boundary. To the upper reaches of the catchment the primary flood mechanism is likely to be due to increased run-off from impermeable urban areas and urban drainage, especially during times of flash rainfall events during the summer months. Three upstream FEPs are required for the proposed model. The catchments for the three inflow points are too small for the FEH web service. The upstream FEPs are located at the urban/rural boundary and for A & C at the onset of the watercourse. The watercourse at FEP C is not being explicitly modelled however the inflow will be used as a point inflow to the main channel. The downstream FEP is only located on Soar Brook.
Any unusual catchment features to take into account? e.g. - highly permeable – avoid ReFH if BFIHOST>0.65, consider permeable catchment adjustment for statistical method if SPRHOST<20% - highly urbanised – seek local flow data; consider method that can account for differing sewer and topographic catchments - pumped watercourse – consider lowland catchment version of rainfall-runoff method - major reservoir influence (FARL<0.90) – consider flood routing, extensive floodplain storage – consider choice of method carefully	The Soar Brook catchment is both small and highly urbanised, which will be a limiting factor within this study. As part of the 2020 hydrological study, sewer maps were consulted to confirm drainage patterns for the combined sewers. This requires the use of ReFH2 method which accounts for runoff over paved surfaces.

1.8 Initial choice of approach

Is FEH appropriate? (it may not be for extremely heavily urbanised or complex catchments) If not, describe other methods to be used.	The study catchments are small and will likely be moderately-highly urbanised. The FEH Statistical method or ReFH2 method can be applied to urbanised catchments with an URBEXT2000 value up to 0.6. The Statistical method is often preferred to derive peak flow estimates as it is based on a much larger dataset of flood events and has been more directly calibrated to reproduce flood frequency on UK catchments than rainfall-runoff approaches. Where good peak flow data is available at or near the site of interest, the Statistical method will generally be preferred. However, there are no fluvial hydrometric gauges on the study watercourses therefore it is not possible to improve or verify modelled flows and levels.
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	Based on relevant guidance the catchment characteristics suggest the ReFH2 methodology, as an urban extension has been widely implemented and is incorporated in ReFH2, may be the more favourable approach for this study.
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	Peak flows Peak flow estimates will be derived from application of FEH methods. ReFH2 methodology will be compared with FEH Statistical for estimating peak flows. The favoured peak flow estimates are provided alongside justification for their adoption in subsequent sections. Urbanised Catchments EA Flood Estimation Guidelines LIT 11832 (2022) that the FEH Statistical method or ReFH2 methods can be applied to urbanised catchments with an URBEXT2000 value up to 0.6⁷. A winter storm rainfall depth, Cini and initial baseflow values and storm profile should be used for all catchments, unless: • URBEXT2000 $\geq$ 0.30; • or URBEXT2000 $\geq$ 0.15 and BFIHOST19 $\geq$ 0.65 Small Catchments Guidance on choice of method for flood estimation on small catchments (defined within the guidance as catchments under 25km²) was developed in Science Project SC090031: Estimating flood peaks and hydrographs for small catchments. In accordance with the report on Phase 1 (Faulkner and others, 2012) we recommend that the flood estimates on small catchments are derived from FEH methods (Statistical or ReFH2) and not from older methods. In addition, Phase 2 of the small catchments research, SC090031 (Stewart and others, 2019) found that on average the ReFH2 method gave a slightly reduced bias and lower factorial standard error than FEH Statistical when estimating QMED on small catchments. Based on relevant guidance, the catchment characteristics would lend itself to the use of ReFH2 methodology for final peak flows. Hydrographs As the inflows for the Soar Brook model are ungauged, hydrographs for the model will be derived using the ReFH2 model. ReFH2 hydrographs will be scaled to the favoured peak flow estimates explored within this study. The representative design storm duration will be determined based on the critical storm durations determined within ReFH2.
Software to be used (with version numbers)	FEH Web Service ⁸ / WINFAP v5 ⁹ / ReFH2.4

⁷ Environment Agency (2012) Estimating flood peaks and hydrographs for small catchments: Phase 1 and Phase 2.

⁸ CEH 2015. The Flood Estimation Handbook (FEH) Online Service, Centre for Ecology & Hydrology, Wallingford, Oxon, UK.

⁹ WINFAP-FEH v5 © Wallingford HydroSolutions Limited 2018.

2 Locations where flood estimates required

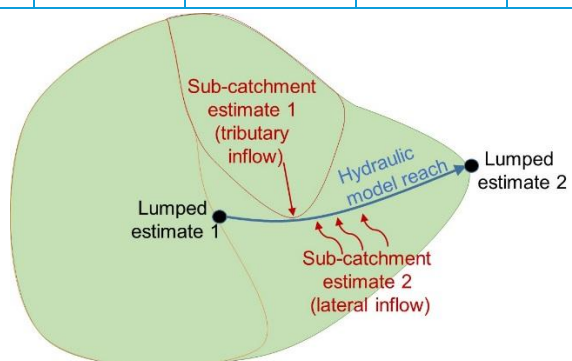
The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

2.1 Summary of subject sites

Figure 2.1



Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA on FEH CD-ROM (km ²)	Revised AREA if altered
A	S	Soar Brook tributary	One of the upstream model extents for flow estimate	444954	293312	N/A	0.27
B	S	Soar Brook tributary	One of the upstream model extents for flow estimate	444761	293177	N/A	0.29
C*	S	Soar Brook tributary	One of the upstream model extents for flow estimate	444730	292945	N/A	0.06
SR_DS	L	Soar Brook	Downstream check point and location of	445000	293150	0.55	0.74

		FEH catchment		
Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required. Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced. The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.				
* EA Operational instruction Doc No 197_08 [page 103] states “For catchments smaller than 0.5 km², derive flow estimates by applying FEH methods to the nearest suitable catchment”. As Site Codes A, B and C are under 0.5 km², flows will be scaled using the derived flows from the closest available catchment using an area ratio (See Section 2.3).				

2.2 Important catchment descriptors at each subject site (incorporating any changes made)

Site code	FARL	PROPWET	BFIHOST 19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2000 ¹⁰	FPEXT
A	1.000	0.30	0.440	0.35	31.5	649	0.365	0.091
B	1.000	0.30	0.440	0.38	31.5	649	0.523	0.091
C	1.000	0.30	0.440	0.07	31.5	649	0.257	0.091
SR_DS	1.000	0.30	0.440	0.96	31.5	649	0.369	0.091

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (add maps if needed)	During the 2020 study the catchment boundary was checked against the 1m Lidar DTM. It was altered to the north to include an area that appeared it would drain into the catchment. Slight alterations were made elsewhere based on the DTM. A check was made against EA 1m 2022 LiDAR data and the extent derived in the 2020 was retained.		
	For FEP points A, B and C the sub-catchments are too small for the FEH web service to pick up. The extent derived in the 2020 was retained for these FEP points which were area-weighted as detailed in FEH Volume 5 using the downstream catchment. Sub-catchment boundaries were created based on the 1m LIDAR DTM and the streamline shapefile. Catchment descriptors were derived by adopting those from SR_DS and adjusted.		
	Site code	AREA	Adjustment ratio
	SR_DS	0.74	-
	A	0.27	0.36
	B	0.29	0.40
C	0.06	0.08	

¹⁰ Updated to present year.

Record how other catchment descriptors were checked and describe any changes. Include before/after table if necessary.

A qualitative sense check was carried out for BFIHOST19 and FARL. Due to the size of the study catchments the DPLBAR value was modified on an area ratio basis as the standard modification equation is known to produce suspect values for smaller catchments.



Catchment descriptors checked against Cranfield University (2021). Cranfield Soil and Agrifood Institute: Soilscales and British Geological Society (2021). Geology of Britain viewer. Underlying bedrock geology of the catchment is mudstone with extensive superficial deposit cover. Typical soils across the study catchment are slightly acid loamy and clayey soils with impeded drainage to the west and slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils to the east ¹¹. The BFIHOST19 value is considered representative of the variable nature of the catchment.

URBEXT2000 was recalculated for all FEP's based on the OS 50k mapping of the area during the 2020 study and was adopted for this study and updated to present year. The remaining descriptors for FEP A, B and C were based on the DS catchment descriptors.

Version of URBEXT

URBEXT2000

Method for updating of URBEXT	CPRE formula from FEH Volume 4
Source of BFIHOST	BFIHOST19 was used in the ReFH2 calculations, since the current release (ReFH2.4) was calibrated using BFIHOST19, and also in the FEH Statistical method, since this has been found to improve the results ¹² .

11 British Geological Society (2021). UK Soil Observatory Map Viewer. Accessed: 16/11/2022. [Source: mapapps2.bgs.ac.uk/ukso/home.html].

12 Griffin, A., Young, A. and Stewart, E. (2019). Revising the BFIHOST catchment descriptor to improve UK flood frequency estimates. Hydrology Research.

3 Statistical method

3.1 Overview of estimation of QMED at each subject site

As stated within Section 1, the Sharnford gauge is level only, not within the NRFA Peak Flow dataset and is not considered representative of the study catchment, a rating review is not within the scope of this project and the final methodology will be ReFH2. The donor gauges used within the previous study have been adopted for use within this update.

Site code	Initial QMED rural (m ³ /s) (from catchment descriptors)	Final method	Data transfer				Urban adjustment factor (UAF)	Final QMED estimate (m ³ /s)	
			NRFA numbers for donor sites used (see 3.3)	Distance between centroids d _{ij} (km)	Moderated QMED adjustment factor, (A/B) ^a	If more than one donor			
						Weight			Weighted ave. adjustment
SR_DS	0.2	CD	54102	22.781	1.005	0.25	1.08	1.432	0.31
			32029	37.851	1.047	0.25			
			31010	44.236	1.065	0.25			
			31026	45.635	1.257	0.25			
Are the values of QMED spatially consistent?					Yes – when donor applied to FEP A, B, C and SR_DS QMED increases sensibly moving downstream				
Method used for urban adjustment for subject and donor sites					WINFAP v4 ¹³				
Parameters used for WINFAP v4 urban adjustment if applicable									
Impervious fraction for built-up areas, IF			Percentage runoff for impervious surfaces, PR _{imp}			Method for calculating fractional urban cover, URBAN			
0.3			70%			From updated URBEXT2000			
Notes									
Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer (with urban adjustment); CD – Catchment descriptors alone (with urban adjustment); BCW – Catchment descriptors and bankfull channel width (add details); LF – Low flow statistics (add details).									
The QMED adjustment factor A/B for each donor site is given in Table 3.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is: (A/B) ^a x QMED _{initial} x UAF									
Important note on urban adjustment									
The method used to adjust QMED for urbanisation published in Kjeldsen (2010) ¹⁴ in which PRUAF is calculated from BFIHOST is not correctly applied in WINFAP-FEH v3.0.003. Significant differences occur only on urban catchments that are highly permeable.									

¹³ Wallingford HydroSolutions (2016). WINFAP 4 Urban adjustment procedures.

¹⁴ Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. **41**. 391-405.

3.2 Search for donor sites for QMED (if applicable)

Comment on potential donor sites Include a map if necessary. Note that donor catchments should usually be rural.	The 2020 study considered four NRFA Peak flow dataset gauging stations as potential donor catchments. The first catchment was chosen based on smallest distance from SR_DS. The further 3 catchments were chosen based on similarity of catchment descriptors and low level of urbanisation. As the EA Sharnford gauge is level only and a rating review is not within the scope of this project, the 2020 donor sites were adopted for this study with the most recent descriptors and QMED estimation available on the NRFA website. The donor sites chosen were: • 54105: Avon @ Lilbourne • 32029: Flore @ Experimental Catchment • 39026: Cherwell @ Banbury • 31010: Charter @ Fosters Bridge The donors were applied using an evenly weighted adjustment.
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3.3 Donor sites chosen and QMED adjustment factors

Gauge no.	Reasons for choosing	Method (AM or POT)	Adjustment for climatic variation ?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjustment ratio (A/B) *
54105	See above	AM	No	13.6	13.3	1.02
32029	See above	AM	No	1.9	1.6	1.24
39026	See above	AM	No	1.1	0.3	3.46
31010	See above	AM	No	10.0	7.2	1.39
* After application of separate 'de-urbanisation' factor to the observed QMED value.						

3.4 Derivation of pooling groups

Several subject sites may use the same pooling group.

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged? (enhanced single site analysis)	Changes made to default pooling group, with reasons	Weighted average L-moments, L-CV and L-skew, (before urban adjustment)
SR_DS 'Small Catchment' Pooling ¹⁵	SR_DS	No	<u>Removed</u> 7011 (Black Burn @ Pluscarden Abbey) – Removed in line with EA Flood Estimation Guidelines LIT 11832 (2022) as record length was 9 years. <u>Added</u> None added *Within the 2020 study, 49005: Bolingey Stream @ Bolingey Cocks Bridge gauge was removed from the default pooling group as record length was 8 years. Within the 2023 study the gauge record is long enough to warrant inclusion within this study and was retained.	L-CV: 0.269, L-SKEW: 0.235.
Note: Pooling groups were derived using the procedures from Science Report SC050050 (2008).				

3.5 Derivation of flood growth curves at subject sites

Site code	Method (SS, P, ESS, J)	If P, ESS or J, name of pooling group (Error! Reference source not found.)	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Parameters of distribution (location, scale and shape after adjustments)	Growth factor for 100-year return period
SR_DS	P	SR_DS 'Small Catchment' Pooling	GL Distribution recommended by WINFAP software	WINFAP-FEHV4	Location: 1.000 Scale: 0.207 Shape: -0.302	3.06
Notes Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters. Urban adjustments are all carried out using the method of Kjeldsen (2010). Growth curves were derived using the procedures from Science Report SC050050 (2008).						

¹⁵ Small Catchment pooling method applied via WINFAP v5.
CUX_JBAU_XX_00_RP_HO_0001_S2_P1_JBA FEH calculation record_Sherborne.docx

3.6 Flood estimates from the statistical method

Site code	Flood peak (m ³ /s) for the following return periods (in years)					
	50% AEP	3.3% AEP	1% AEP	1% AEP + 28% Climate change allowance Central	1% AEP + 37% Climate change allowance Higher	0.1% AEP
A	0.11	0.24	0.34	0.43	0.46	0.64
B	0.12	0.27	0.37	0.47	0.51	0.70
C	0.02	0.05	0.08	0.10	0.10	0.14
SR_DS	0.31	0.68	0.93	1.20	1.28	1.78

4 Revitalised flood hydrograph 2 (ReFH2) method

4.1 Catchment sub-divisions for ReFH2 model

Site code	Area (km ²)			
			Only relevant if significant transfers of water via sewers crossing catchment boundaries...	
	Rural or un-developed	Paved	Paved with sewers draining out of topographic catchment	Paved outside topographic catchment with sewers draining into catchment
A	0.12	0.15	0.012	0.014
B	0.06	0.23	0.091	0.017
SR_DS	0.33	0.41	0.101	0.007
Sources of information for creating sub-divisions	JBA Consulting 2020 FEH Calculation Report: Sherborne Road – assessed via sewer maps		Sewer capacity (return period / rainfall intensity / flow rate) and source of information	5-year return period rainfall [†]

† In the absence of detailed information about sewer drainage in the catchment, a conservative assumption was applied with a 5-year return period set as the sewer capacity as per the 2020 study. A comparison was undertaken between FEH13 rainfall statistics and FEH22 rainfall statistics for the 5-year event in which the FEH22 statistics were the more conservative. However, during a comparison for the 100 year event, FEH13 was the most conservative approach.

In line with the EA (2022) Position statement on FEH22: Evidence & Risk – National Flood Hydrology Team document which states “Once ReFH2.3 has been recalibrated, this new model should be used together with FEH22 in preference to the earlier FEH13 DDF model for any new design flood calculations.” The latest calibration of the ReFH2.3 model was released in 2023 to utilise the FEH22 design rainfall therefore FEH22 rainfall statistics were taken forward within this study.

4.2 Parameters for ReFH2 model

As the study catchments have an URBEXT2000 value of over 0.3, a Summer Profile was used in line with Pg 109 in Environment Agency (2020) Flood estimation guidelines: Technical guidance 197_08 (Version 5). Site A was calculated using plot scale equations due to the lack of watercourse within the sub-catchment. Site C was calculated based on scaling the SR-DS peak flows by area scaling factor.

Site code	Method	T _{prural} (hours)	T _{purban} (hours)	C _{max} (mm)	PR _{imp} % runoff for impermeable surfaces	BL (hours)	BR	Sewer capacity (m ³ /s) ¹⁶
A	CD	1.95	1.46	358.86	70	36.59	2.66	0.35
B	CD	1.45	1.09	358.86	70	26.46	2.66	0.56
C	Area scaling factor	-	-	-	-	-	-	-
SR_DS	CD	2.47	1.85	358.86	70	32.39	2.58	0.74
Brief description of any flood event analysis carried out (further details should be given in the annex)					The catchment is ungauged hence no flood event analysis was undertaken here.			

¹⁶ FEH22 Rainfall Statistics for the Critical Storm Durations listed within Section 4.3.
CUX_JBAU_XX_00_RP_HO_0001_S2_P1_JBA FEH calculation record_Sherborne.docx

Version of the ReFH2 model applied	ReFH2.4 using the water balance option. This treats BR (baseflow recharge) as a state variable rather than a parameter, setting it automatically in order to conserve volume. The values of BR vary with return period and so are not reported here.
Parameters for urban runoff model	The impervious fraction of urban areas, IF, was kept at its default of 0.4. The impervious runoff factor, IRF, (which can also be interpreted as the fraction of the impervious surface that is positively drained) was kept at its default of 0.7. The depression storage was kept at its default of 0.5mm. Tp for runoff from areas modelled as positively drained was calculated as 0.75 times Tp_{rural}.
Methods: OPT: Optimisation, BR: Baseflow recession fitting, CD: Catchment descriptors, DT: Data transfer (give details)	

4.3 Design events for ReFH2 method: Lumped catchments

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)
SR_DS	Urban	Summer	04:45:00

4.4 Design events for ReFH2 method: Sub-catchments and intervening areas

Site code	Season of design event	Storm duration (hours)	Storm area for ARF (if not catchment area)
A	Summer	03:15:00	-
B	Summer	03:15:00	-
Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?			Storm Duration stated in Sections 4.3 and 4.4 are the Critical Storm Duration's for each individual Flood Estimation Point for the 1% AEP event, determined through sensitivity testing of a range of durations within ReFH2 to determine the duration that produced the highest flow. The storm duration is used here to undertake 'worst case' scenario flow comparisons between ReFH2 and FEH Statistical for each individual flow point. For modelling purposes, model peak flows and hydrographs for all FEP's will be derived to the Critical Storm Duration of 03:45:00, the average storm duration for the FEP point CSD's.

4.5 Flood estimates from the ReFH2 method

FEP Critical Storm Duration

Site code	Flood peak (m ³ /s) for the following return periods (in years)					
	50% AEP	3.3% AEP	1% AEP	1% AEP + 28% Climate change allowance Central	1% AEP + 37% Climate change allowance Higher	0.1% AEP
A	0.17	0.37	0.48	0.61	0.65	0.82
B	0.18	0.39	0.49	0.63	0.67	0.89
C	0.03	0.06	0.08	0.10	0.10	0.13
SR_DS	0.36	0.74	0.94	1.20	1.28	1.64

3.75hr Storm Duration for final model

Site code	Flood peak (m ³ /s) for the following return periods (in years)					
	50% AEP	3.3% AEP	1% AEP	1% AEP + 28% Climate change allowance Central	1% AEP + 37% Climate change allowance Higher	0.1% AEP
A	0.18	0.38	0.48	0.61	0.66	0.83
B	0.18	0.39	0.49	0.63	0.67	0.90
C	0.03	0.06	0.08	0.10	0.10	0.13
SR_DS	0.35	0.73	0.93	1.19	1.27	1.62

5 Discussion and summary of results

5.1 Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method at example sites for two key return periods. Blank cells indicate that results for a particular site were not calculated using that method.

Site code	Ratio of peak flow to FEH Statistical peak	
	Return period 2 years	Return period 100 years
	ReFH2	ReFH2
A	1.55	1.41
B	1.51	1.33
C	1.15	1.00
SR_DS	1.15	1.00

5.2 Final choice of method

Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	Flows derived through the application of the ReFH2 model were compared with those derived from the FEH statistical method. Flows derived from the ReFH2 methodology are generally higher than flows derived from FEH Statistical methodology, with a percentage increase above the flow derived from FEH methodology between 7%-55%. Peak flows derived through FEH Statistical methods are only greater than the flows derived through ReFH2 for the 1% and 0.1% AEP event for SR_DS. The catchments considered within this study are small, ungauged catchments and as such, all estimated design flows carry appreciable uncertainty. Urbanised Catchments EA Flood Estimation Guidelines LIT 11832 (2022) that the FEH Statistical method or ReFH2 methods can be applied to urbanised catchments with an URBEXT2000 value up to 0.6¹⁷. A winter storm rainfall depth, Cini and initial baseflow values and storm profile should be used for all catchments, unless: • URBEXT2000 $\geq$ 0.30; • or URBEXT2000 $\geq$ 0.15 and BFIHOST19 $\geq$ 0.65 Small Catchments Guidance on choice of method for flood estimation on small catchments (defined within the guidance as catchments under 25km²) was developed in Science Project SC090031: Estimating flood peaks and hydrographs for small catchments. In accordance with the report on Phase 1 (Faulkner and others, 2012) we recommend that the flood estimates on small catchments are derived from FEH methods (Statistical or ReFH2) and not from older methods. In addition, Phase 2 of the small catchments research, SC090031 (Stewart and others, 2019) found that on average the ReFH2 method gave a slightly reduced bias and lower factorial standard error than FEH Statistical when estimating QMED on small catchments. Based on relevant guidance, the catchment characteristics would lend itself to the use of the ReFH2 methodology therefore peak flows derived using the ReFH2 method will be taken forward.
How will the flows be applied to a hydraulic model?	Catchment flows will be distributed along the model reach, using a flow-time boundary, at locations where flow points have been identified in Figure 2.1. Hydrographs and peak flows obtained using the ReFH2 method will be taken

¹⁷ Environment Agency (2012) Estimating flood peaks and hydrographs for small catchments: Phase 1 and Phase 2.
CUX_JBAU_XX_00_RP_HO_0001_S2_P1_JBA FEH calculation record_Sherborne.docx

If relevant. Will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	forward for modelling purposes. For modelling purposes, hydrographs for all FEP's will be derived to the Storm Duration of 03:45:00 (Average Critical Storm Duration of the FEP's A, B and SR_DS). For FEP C design hydrographs derived from FEP SR_DS will be scaled to match the peak flows derived based on an area ratio. If lateral flows are required for the model, they will be derived on an area ratio from the downstream check point.
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5.3 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	The main assumptions are: -The data used for the derivation of local design flow estimates are accurate. -The design peak flows derived are representative of those that would be observed during flood events; -The catchment boundaries and descriptors have been assumed to be representative; -Design hydrographs generated using the ReFH2 model are representative of those that would be observed during typical flood events. - Peak flows, rather than hydrograph volumes, are assumed to be the main control on flood risk at the site. - Urban area for ReFH2 method taken from URBEXT2000 which is based on the OS 50k mapping, rather than based on detailed mapping (e.g. OS MasterMap). - Data adopted from 2020 study is still relevant,											
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.	The lack of gauged flow records forces a greater reliance on catchment descriptor methods in this study. Even a level-only record on the catchment would greatly aid calibration of hydrological parameters, such as TP in the Urban ReFH method for example. As the catchments are considered to be small relative to the overall database of gauging station data used for calibration, the use of FEH / ReFH is considered to be a primary limitation of the study. Urbanisation of the catchments is also a limitation.											
Give what information you can on uncertainty in the results, e.g. confidence limits from Kjeldsen (2014).	There are no published methods for quantifying uncertainty for the Urban ReFH2 method, apart from carrying out sensitivity tests on key model parameters. <table><tr><td>AEP</td><td>No donor</td><td>1 donor</td></tr><tr><td>50%</td><td>0.48 – 2.10</td><td>0.50 – 2.02</td></tr><tr><td>1%</td><td>0.45 – 2.23</td><td>0.47 – 2.12</td></tr></table>			AEP	No donor	1 donor	50%	0.48 – 2.10	0.50 – 2.02	1%	0.45 – 2.23	0.47 – 2.12
AEP	No donor	1 donor										
50%	0.48 – 2.10	0.50 – 2.02										
1%	0.45 – 2.23	0.47 – 2.12										
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	These flow estimates were derived specifically for this study. They should not be used elsewhere without at least being reviewed for suitability.											
Give any other comments on the study, e.g. suggestions for additional work.	Confidence could be improved through installation of hydrometric monitoring and event hydrometric data.											

5.4 Checks

Are the results consistent, for example at confluences?	Yes, results are considered sensible in that they increase with catchment area.
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What do the results imply regarding the return periods of floods during the period of record?	No data is available in regards to flood events applicable to the site. No flow gauges or active raingauges are available within the study catchment, therefore no comparison with previous events can be undertaken at this stage.																													
What is the range of 100-year growth factors? Is this realistic?	The 1% AEP growth factor for each of the methods are: - FEH Statistical: 2.71-3.06 - ReFH2: 2.62-2.73 The typical range is 2.1 to 4.0 (based on FSR regional growth curves) therefore the 1% AEP growth factor for all FEP's are inside the typical range for both flow estimation methodologies.																													
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	The 0.1%/ 1% AEP event growth factor for each of the methods are: - FEH Statistical: 1.91 - ReFH2: 1.73-1.82																													
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	The flows derived for the BWB Consulting (2013) Sherborne Road, Burbage Technical note: hydraulic modelling are considered out of date and are not comparable to the flows derived in 2020 and 2023. Peak flows were obtained from the JBA Consulting (2020) Flood Estimation Report: Sherborne Road, Burbage and were compared against the 4.75hour ReFH2 flows derived within this study. <table><tr><th rowspan="2">Site code</th><th colspan="4">ReFH2 Flood peak (m³/s) (in years)</th></tr><tr><th>2</th><th>30</th><th>100</th><th>1000</th></tr><tr><td>Site Code A (2023)</td><td>0.18</td><td>0.38</td><td>0.48</td><td>0.83</td></tr><tr><td>Site Code A (2020)</td><td>0.18</td><td>-</td><td>0.53</td><td>0.99</td></tr><tr><td>SR_DS (2023)</td><td>0.35</td><td>0.73</td><td>0.93</td><td>1.62</td></tr><tr><td>SR_DS (2020)</td><td>0.36</td><td>-</td><td>1.09</td><td>2.12</td></tr></table> Flows obtained from ReFH2 are lower than the flows derived from ReFH in 2020. The difference in flows between this study and the 2020 study is likely due the difference in rainfall statistics. As this study utilises 2023 methodologies and FEH22 statistics, flows derived within this study are the preferred flows.	Site code	ReFH2 Flood peak (m ³ /s) (in years)				2	30	100	1000	Site Code A (2023)	0.18	0.38	0.48	0.83	Site Code A (2020)	0.18	-	0.53	0.99	SR_DS (2023)	0.35	0.73	0.93	1.62	SR_DS (2020)	0.36	-	1.09	2.12
Site code	ReFH2 Flood peak (m ³ /s) (in years)																													
	2	30	100	1000																										
Site Code A (2023)	0.18	0.38	0.48	0.83																										
Site Code A (2020)	0.18	-	0.53	0.99																										
SR_DS (2023)	0.35	0.73	0.93	1.62																										
SR_DS (2020)	0.36	-	1.09	2.12																										
Are the results compatible with the longer-term flood history?																														
Describe any other checks on the results	-																													

5.5 Final results

3.75hr Storm Duration for final model

Site code	Flood peak (m ³ /s) for the following return periods (in years)					
	50% AEP	3.3% AEP	1% AEP	1% AEP + 28% Climate change allowance Central	1% AEP + 37% Climate change allowance Higher	0.1% AEP
A	0.18	0.38	0.48	0.61	0.66	0.83
B	0.18	0.39	0.49	0.63	0.67	0.90
C	0.03	0.06	0.08	0.10	0.10	0.13
SR_DS	0.35	0.73	0.93	1.19	1.27	1.62

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, hydraulic model, or reference to table below)

Annex B

6 Annex A – FEH25 and 2026 flow updates

Following the FEP calculations for Sherborne, FEH25 was released. FEH25 is an updated set of procedures, released in Autumn 2025, which has replaced most of the original 1999 and improved FEH08 statistical methods for ungauged sites. New versions of some of the key catchment descriptors (FARL, SAAR, BFIHOST, URBEXT) and an updated Statistical method were released in September 2025, alongside the release of the latest version of the NRFA peak flow dataset

As a result of the release of FEH25, FEH Statistical flows for SD_DR were recalculated using FEH25 as a flow check to understand the impact FEH25 has on FEH Statistical. A reassessment of the ReFH2 inputs and methodology, specifically the sewer losses, has also been undertaken alongside an update to some catchment descriptors, in line with and Flood Estimation Guidelines (2025) v10. The FEP's which were taken forward in the previous iteration of these calculations have been retained.

The ReFH2 model has not been recalibrated with updated catchment descriptors and will use the existing catchment descriptors until such time. This means that there will be inconsistencies in catchment descriptors used between FEH Statistical and ReFH2 methods during this time.

6.1 Preferred approach and methodologies

Are FEH methods appropriate?: Yes.

The study catchments are small and moderately-highly urbanised. URBEXT2000/2015 values are <0.6, the recommended limit for FEH methods, and on this basis both the FEH Statistical and ReFH2 methods are appropriate for application.

6.1.1 Initial choice of method(s)

The study catchments are small and will likely be moderately-highly urbanised. Flood Estimation Guidelines (2025) v10 states that the FEH Statistical method or ReFH2 method can be applied to urbanised catchments with an URBEXT2000 value up to 0.6. The Statistical method is often preferred to derive peak flow estimates as it is based on a much larger dataset of flood events and has been more directly calibrated to reproduce flood frequency on UK catchments than rainfall-runoff approaches. Where good peak flow data is available at or near the site of interest, the Statistical method will generally be preferred. However, there are no fluvial hydrometric gauges on the study watercourses therefore it is not possible to improve or verify modelled flows and levels.

Based on relevant guidance the catchment characteristics suggest the ReFH2 methodology, as an urban extension has been widely implemented and is incorporated in ReFH2, may be the more favourable approach for this study.

6.1.2 Model calibration discussion

There are no level or flow gauges within the modelled reaches with which to supply a gauged flood event inflow hydrograph to the model or compare modelled levels against. Where there is a lack of confidence in the inflows being applied to the hydraulic model for calibration events, there will be an associated lack of confidence in the hydraulic model results. Adjusting model parameters / schematisation to achieve a better fit to observed levels will be implying a false sense of confidence in model performance if the issues are due to the inflows. In this case, nothing is gained from the calibration exercise.

Where calibration is not appropriate, it is sometimes possible to carry out a model validation exercise for design events, using available flood event information, however this information is not available and there is little information regarding the timing of flooding so this is not possible.

6.1.3 Model hydrographs

Hydrographs for the model will be derived using the ReFH2 model. ReFH2 hydrographs will be scaled to the favoured peak flow estimates explored within this study.

Source of flood peak data & software to be used:

- NRFA peak flow dataset, v14.1 (August 2025)
- FEH Web Service^[18]
- WINFAP 5.2^[19]
- ReFH 2.3-FEH22 Calibrated

6.2 Locations where flood estimates are required

The FEPs locations used within the previous iterations of this study have been retained with no changes. For FEP points A, B and C the sub-catchments are still too small for the FEH web service to pick up. Catchment descriptors were derived for these FEP points by adopting those from SR_DS and adjusted (detailed further in sections below).

As it is likely that ReFH2 will be the favoured approach, peak flows and hydrographs for FEP's A and B will be calculated in ReFH2 software via plot-scale equation.

Peak flows for FEP C will be scaled from the peak flow generated from FEP A as the catchment is too small to undertake any peak flow analysis on ReFH2.

6.2.1 Topographic Boundary check

The catchment extents derived within the 2023 study were assessed. Minor modification to SD_SR was required. The extents for FEP's A, B and C were checked and retained.

6.2.2 Sewer Boundary check

Sewer network data was obtained to confirm the sewer network extents that discharge into the study watercourse. There are a number of identifiable areas where the sewer catchments cross over topographic boundaries, often into the topographic boundary of the neighbouring catchments but, importantly, not outside the wider topographic catchment of the downstream FEP.

It is likely that sewers within the catchment would only have capacity for a 10 to 30-year event and it is recognised that the previous iteration of this study, in the absence of detailed information about sewer drainage in the catchment, applied a conservative approach of setting the 5-year return period as the sewer capacity as per the 2020 study.

Alongside application of a 5-year sewer capacity return period the 2020 iteration of this study divided FEP A, B and C into sub-divisions, which was then taken forward for the 2023 update. The sub-divisions were classed as '*Paved with sewers draining out of topographic catchment*' and '*Paved outside topographic catchment with sewers draining into catchment*' - sub-divisions which were required for the Revitalised Flood Hydrograph (ReFH) method within Flood Modeller. FM-ReFH methods have been superseded by ReFH2 therefore these specific sub-divisions are no longer relevant. ReFH2 allows the user to specify both a sewer flow capacity (m³/s) and an Exported Drained area. ReFH2 does not consider paved areas outside topographic catchment with sewers draining into catchment. Assessment of the '*Paved with sewers draining out of topographic catchment*' division was considered for use within this update for use within the ReFH2 Exported Drained area, however the sub-divisions used within the 2020 study could not be reproduced based on the available sewer maps obtained within the study.

Further consideration was given to the appropriateness of the use of the Exported Drained area method available within ReFH2. ReFH2 diverts the nett rainfall generated from the specified urban area to the exporting sewer up to the specified sewer capacity, removing the runoff from the simulation of the event hydrograph. Urban runoff in excess of this flow rate is retained within the catchment. However this method does not allow for the incorporation of that removed runoff back into a neighbouring catchment, potentially underestimating flows.

The ReFH2 technical guidance states in relation to the Exported Drained area method²⁰:

[18] CEH 2015. The Flood Estimation Handbook (FEH) Online Service, Centre for Ecology & Hydrology, Wallingford, UK.

[19] WINFAP 5.2 © Wallingford HydroSolutions Limited 2023.

[20] Wallingford HydroSolutions 2026

“It is important that the drainage systems for which intercepted nett rainfall is retained within the catchment (those that collect and discharge within the catchment) are not modelled using this functionality.”

While the exported drained areas do extend outwith the individual inflow catchments, they are still draining within the watercourse downstream catchment.

Calculations for sewers in can be undertaken externally outside of ReFH2 software. While application of sewers in/sewers out during the assessment stage would address the catchments where sewers do not drain topographically, there is uncertainty as to the realistic benefit such a measure would provide. The study catchments are moderate-highly urbanised and ungauged which is a key limitation of this study and carries with it several assumptions. It is felt that consideration of sewers in/sewers out may further increase the limitations and assumptions made within this study and that any potential benefits will not outweigh the time considerations required to undertake such substantial work. It may also be considered that additional calculations to assess sewers in/sewers out will add no substantial gain in accuracy or confidence to the study flows as there are no flow gauges within the study catchment in which to validate the flows along the study tributaries. As application of sewers in/sewers out is considered to be ineffective, as a conservative measure exporting drained areas within the ReFH2 software will be kept at 0.

Consideration was also given to taking forward the sewer catchments over the topographic catchments however a range of assumptions would be required in order to take forward the sewer catchments which counter the topographic profile of the land:

- Sewer catchments are representative of the flow catchment when sewers are surcharged, and that overflow would follow the sewer network and not the topographic decline of the land.
- Sewers across the study catchments will all have a consistent capacity.

Therefore for return periods which exceeded these events, if the sewer catchments are taken forward, it will be under the assumption that flow for the higher magnitude events would follow the sewer network and not the topographic decline, which is not considered to be realistic. The sewer extent will only contribute flow into the sub-catchments for smaller events, whereas the topographic catchment will take precedence for the larger events, including the 1% and 0.1% AEP events as anything above the sewer capacity will drain topographically to the watercourse for the catchment that the sewers are located in.

Flood Estimation Guidelines (2025) v10 states: "You will need to strike a balance between the potential gain in accuracy and the time needed to gather the extra information". Therefore, in the instances where sewer catchments cross over topographic boundaries, the topographic catchments have taken forward.

6.2.3 Catchment descriptor checks

All descriptors which are not included/updated within the FEH25 method have been retained bar URBEXT2000 and DPLBAR.

BFIHOST19scaled:

Catchment descriptors were checked against the BGS Geology of Britain viewer. The BFIHOST19Scaled exported values are considered representative of the underlying nature of the catchment.

FARL2015:

Catchment descriptors were checked against OS mapping and the FEH Webservice 'Lakes and Waterways' layer and the FEH25 'Lake 2015' layer. The FARL2015 exported value is considered representative of the underlying nature of the catchment.

DPLBAR:

SR_DS – due to the increase in change in area of 40% from exported areas to manually updated area, DPLBAR was recalculated for SR_DS using the standard modification equation ($\text{Area}^{0.548}$).

FEP's A and B - DLPBAR and DPSBAR was not modified as plot-scale equations will be used in ReFH2 for both FEP's.

URBEXT2000:

A check was undertaken on URBEXT as there is a significant difference for SD_DS between the exported value for URBEXT2000 (0.60) and URBEXT2015 (0.36). It is likely that this difference stems from the fact that URBEXT2000 is defined differently from URBEXT1990 and URBEXT2015 and typically has a higher value for the same degree of urbanisation as it is based on 3 land cover types:

- urban
- suburban
- inland bare ground

Flood Estimation Guidelines (2025) v10 states that URBEXT2000 should only be used in equations developed specifically for URBEXT2000. Similarly, only use URBEXT2015 in the updated FEH25 statistical method.

URBEXT2000 was updated correctly within the previous iteration of the study using the relevant guidance at the time (LIT-11832 Flood estimation guidelines 2023) using the OS50k mapping and Bayliss et al.'s (2006)²¹ mapping relationship between URBAN50k and URBEXT2000

$$\text{Equation: } \text{URBEXT2000} = 0.629 * \text{URBAN}$$

However following the release of Flood Estimation Guidelines (2025) v10, the OS50k mapping and Bayliss et al.'s (2007) mapping relationship equation has been updated and it is recommended that the updated equation is used for consistency with WINFAP implementation.

$$\text{Equation: } \text{URBEXT2000} = \text{URBAN} / 1.567$$

URBEXT2015:

URBEXT2015 was updated using the OS50k mapping and Wallingford HydroSolutions mapping relationship between URBAN50k and URBEXT2000

$$\text{Equation: } \text{URBEXT2015} = 0.7806 * \text{URBAN}$$

Site code	Area from drawn 50k (m2) (sum)	Area of catchment (m2)	URBAN50k from drawn	URBEXT 2000	URBEXT 2025
A	179,354	266,700	0.67	0.43	0.27
B	217,910	292,164	0.75	0.48	0.30
C	15,709	60,000	0.26	0.17	0.11
SR_DS	417,868	770,000	0.54	0.35	0.42

Version of URBEXT:

URBEXT2000 for ReFH2 calculations. URBEXT2015 for FEH Statistical method calculations.

[²¹] Bayliss, A.C., Black, K.B., Fava-Verde, A., Kjeldsen, T. R. (2007). URBEXT2000 – A new FEH catchment descriptor. EA/Defra RandD Technical Report FD1919/TR.

6.3 Catchment descriptors

Final catchment descriptors at each subject site:

Site code	AREA on FEH Web Service (km ²)	Revised AREA (km ²)	BFIHOST19	BFIHOST19scaled	DPLBAR (km)	DPSBAR (m/km)	FARL2015	FPEXT	PROPWET	SAAR6190 (mm)	SAAR9120 (mm)	URBEXT 2000	URBEXT2015
A	-	0.74	0.44	0.44	-*	-*	1.00	0.09	0.30	649	669	0.03 [-]	0.03 [-]
B	-	0.29	0.44	0.44	-*	-*	1.00	0.09	0.30	649	669	0.04 [-]	0.04 [-]
C	-	0.06	**-	**-	**-	**-	**-	**-	**-	**-	**-	**-	**-
SR_DS	0.55	0.77	0.44	0.44	0.87	31.5	1.00	0.09	0.30	649	669	0.35 [0.60]	0.42 [0.36]
Red values indicate values updated. [Blue] values indicate original values from the FEH Web Service. Orange values indicate values adopted directly from SR_DS *Note: ReFH2 model will be used to estimate flows for intervening areas. Plotscale option in ReFH2 will be used to estimate flows – this does not use DPLBAR or DPSBAR so values not given for IA in the above table. FARL not used by ReFH2. **Note: no catchment descriptors adopted as flows will be scaled via area ratio form FEP A													

7 FEH25 - Estimating QMED

7.1.1 Search for potential donor sites / rejected donor sites

The previous iteration of this study utilised four donors for QMED adjustment, applied using an evenly weighted adjustment:

- 54102: Avon @ Lilbourne
- 32029: Flore @ Experimental Catchment
- 39026: Cherwell @ Banbury
- 31010: Charter @ Fosters Bridge

Following issue of the report and release of updated NRFA peak flow datasets, 32029: Flore @ Experimental Catchment is no longer deemed to be suitable for QMED. In addition, the 2025 FEH Statistical Method recommends that, in most cases, using multiple donors reduces the bias towards the catchment descriptor equation error at a single site. The 2025 update (Vesuviano and Griffin, 2025) tested using zero to twenty donors selected on distance. There was a clear improvement in model performance as the numbers of donors increased to eight. Flood Estimation Guidelines (2025) v10 states that all new studies should use the 2025 8 donor transfer unless a gauge is located close to the subject site on the same watercourse or the catchment has unusual features that may not be well represented by other donors.

Therefore the use of eight donor catchments was considered alongside the use of the original donors, minus 32029: Flore @ Experimental Catchment, undertaken in WINFAP software. WINFAP v5.3 software was applied for donor catchment selection and adjustment. The software selected the top eight stations with the lowest geographic distance (using catchment centroids).

SD_DS 8 donor QMED ratio

QMED rural estimation. Method: 2025

Method Donor Adjustment Flow Variability

Target Info QMED Catchment Descriptors: 0.215 QMED Adjustment Ratio: 0.893 Donor Adjusted F.S.E.: 1.411

QMED Donor Adjusted: 0.192 No. Donors: 8

Show ☐ All Sites ☒ Only sites suitable for QMED URBEXT2015 < 0.0300 Apply

QMED Data Suitability Catchment Descriptors

	Station	Distance	Use QMED Obs Deurbanised	QMED Obs	QMED Deurbanised	QMED CD's Urban	QMED CD's Rural
1	FEH_Catchment_Descriptors_SR_DS_v5_1_0 @						
2	☒ 54102 (Avon @ Lilbourne)	22.78	☒	13.593	13.430	15.756	15.567
3	☒ 31005 (Welland @ Tixover)	33.24	☒	37.420	36.532	57.821	56.449
4	☒ 31004 (Welland @ Tallington Total)	39.56	☒	34.980	33.671	59.180	56.966
5	☒ 28024 (Wreake @ Syston Mill)	39.76	☒	34.366	33.141	49.229	47.473
6	☒ 31025 (Gwash South Arm @ Manton)	40.47	☒	10.069	9.983	7.257	7.196
7	☒ 39026 (Cherwell @ Banbury)	43.65	☒	17.100	16.620	29.926	29.086
8	☒ 31010 (Charter @ Fosters Bridge)	44.24	☒	10.134	9.813	8.563	8.292
9	☒ 31026 (Eggleton Brook @ Eggleton)	45.63	☒	1.135	1.104	0.514	0.500
10	☐ 33018 (Tove @ Cappenham Bridge)	48.87	☒	17.040	16.485	25.386	24.560
11	☐ 30005 (Witham @ Saltersford Total)	56.16	☒	6.901	6.450	5.359	5.008

Site of Interest Selected Donor

OK Cancel Apply

SD_DS 3 donor QMED ratio

QMED rural estimation, Method: 2025

Method Donor Adjustment Flow Variability

Target Info QMED Catchment Descriptors: 0.215 QMED Adjustment Ratio: 0.943 Donor Adjusted F.S.E.: 1.415

QMED Donor Adjusted: 0.202 No. Donors: 3

Show ☒ All Sites ☐ Only sites suitable for QMED URBEXT2015 < 0.0300 Apply

QMED Data Suitability Catchment Descriptors

	Station	Distance	Use QMED Obs Deurbanised	QMED Obs	QMED Deurbanised	QMED CD's Urban	QMED CD's Rural
1	FEH_Catchment_Descriptors_SR_DS_v5_1_0 @						
2	☒ 54102 (Avon @ Lilbourne)	22.78	☒	13.593	13.430	15.756	15.567
3	☐ 31005 (Welland @ Tixover)	33.24	☒	37.420	36.532	57.821	56.449
4	☐ 31004 (Welland @ Tallington Total)	39.56	☒	34.980	33.671	59.180	56.966
5	☐ 28024 (Wreake @ Syston Mill)	39.76	☒	34.366	33.141	49.229	47.473
6	☐ 31025 (Gwash South Arm @ Manton)	40.47	☒	10.069	9.983	7.257	7.196
7	☒ 39026 (Cherwell @ Banbury)	43.65	☒	17.100	16.620	29.926	29.086
8	☒ 31010 (Chater @ Fosters Bridge)	44.24	☒	10.134	9.813	8.563	8.292
9	☐ 31026 (Egleton Brook @ Egleton)	45.63	☒	1.135	1.104	0.514	0.500
10	☐ 33018 (Tove @ Cappenham Bridge)	48.87	☒	17.040	16.485	25.386	24.560
11	☐ 30005 (Witham @ Saltersford Total)	56.16	☒	6.901	6.450	5.359	5.008

Site of Interest Selected Donor

OK Cancel Apply

A brief assessment of the eight selected donor provided no justification for the removal of any of the default stations. It should be noted that there are some potential limitations to this method in relation to these study catchments: the donor selection method is pulling in some relatively large catchments compared to the study site however it is considered these drawbacks are an acceptable limit.

Due to the moderate-highly urbanised nature of some of the study catchments, a QMED adjustment ratio was also obtained with an URBEXT2025 threshold set to 0.3 (urban) for the 8DT method.

SD_DS 8 donor QMED ratio (urban)

QMED rural estimation, Method: 2025

Method Donor Adjustment Flow Variability

Target Info QMED Catchment Descriptors: 0.215 QMED Adjustment Ratio: 0.806 Donor Adjusted F.S.E.: 1.346

QMED Donor Adjusted: 0.173 No. Donors: 8

Show ☐ All Sites ☒ Only sites suitable for QMED URBEXT2015 < 0.300 Apply

QMED Data Suitability Catchment Descriptors

	Station	Distance	Use QMED Obs Deurbanised	QMED Obs	QMED Deurbanised	QMED CDs Urban	QMED CDs Rural
1	FEH_Catchment_Descriptors_SR_DS_v5_1_0 @						
2	☒ 28082 (Soar @ Littlethorpe)	4.65	☒	16.320	14.994	23.036	21.164
3	☒ 28026 (Anker @ Polesworth)	9.40	☒	48.152	42.156	46.553	40.756
4	☒ 28056 (Rothley Brook @ Rothley)	15.31	☒	12.062	10.643	18.365	16.205
5	☒ 54004 (Sowe @ Stoneleigh)	16.86	☒	30.669	22.798	38.569	28.670
6	☒ 54019 (Avon @ Stareton)	17.38	☒	29.950	27.150	42.849	38.843
7	☒ 54114 (Avon @ Warwick)	19.86	☒	77.219	68.452	115.386	102.286
8	☒ 28086 (Sence @ South Wigston)	20.62	☒	21.388	20.192	23.191	21.894
9	☒ 54102 (Avon @ Lilbourne)	22.78	☒	13.593	13.430	15.756	15.567
10	☐ 28095 (Tame @ Hopwas Bridge)	25.90	☒	134.762	89.642	115.616	76.906
11	☐ 31005 (Welland @ Tixover)	33.24	☒	37.420	36.532	57.821	56.449

Site of Interest Selected Donor

OK Cancel Apply

7.1.2 QMED at ungauged subject sites

Site code	Method	Initial QMED (rural) from CDs (m3/s)	Donors used (NRFA numbers)	Final donor adjustment factor	Urban adjustment factor	Final QMED (m3/s)
SR_DS	DT	0.2	54102, 32026 and 31010	0.94	1.75	0.4
SR_DS	DT8 - rural	0.2	See section above	0.89	1.75	0.3
SR_DS	DT8 - urban	0.2	See section above	0.81	1.75	0.3

QMED estimation methods: DT - catchment descriptors with custom donor transfer; DT8 – catchment descriptors with default WINFAP eight catchment donor transfer

- Donor distance weighting method:
FEH25 moderation term applied
- Multiple donors:
Details of the WINFAP multi-donor approach are reproduced in the appendix. Calculation files are also supplied digitally alongside this report.
- Parameters used for WINFAP v5 urban adjustment:
WINFAP v5.3 **Error! Bookmark not defined.** method applied (subject site and donors). Impervious fraction (IF) and percentage runoff for impervious surfaces (PRimp) set to default 0.30 and 0.70, respectively.

As a precautionary approach, the three donors (54102: Avon @ Lilbourne, 39026: Cherwell @ Banbury and 31010: Charter @ Fosters Bridge) have been taken forward for QMED adjustment.

7.2 FEH25 - Estimating growth curves

As with QMED adjustment, due to the moderate-highly urbanised nature of the study catchment, both a rural pooling group (URBEXT2025 threshold set to 0.03) and an urban pooling group (URBEXT2025 threshold set to 0.3) will be assessed. Flood Estimation Guidelines (2025) v10 states that a concern over including heavily urbanised catchments in pooling groups is that their flood growth curves may be strongly influenced by local hydraulic characteristics, such as culverts that restrict conveyance during large floods which could have a large effect on the flood growth curve and are not transferrable to other catchments however it is often worth including urban catchments as long as they are similar in size to the target catchment and not too heavily urbanised.

7.2.1 Derivation of pooling groups

Name of group	Pooling group target site	Changes made to default pooling group and / or further investigations	Default as-rural pooled L-moment ratios	As-rural pooled L-moment ratios, after any membership changes	As-rural pooled L-moment ratios, after further non-flood-year adjustment
SR_DS - Rural	SR_DS	Removed: None Investigated but retained: 49005 (Bolingey Stream @ Bolingey Cocks Bridge) due to discordancy. Retained as discordancy is not a reason for removal. Added: None -Years of data: 849	L-CV: 0.286 L-Skew: 0.222	N/A	L-CV: 0.273 L-Skew: 0.242
SR_DS - Urban	SR_DS	Removed: None Investigated but retained: 49005 (Bolingey Stream @ Bolingey Cocks Bridge) due to discordancy. Retained as discordancy is not a reason for removal. Added: None -Years of data: 807	L-CV: 0.278 L-Skew: 0.240	N/A	L-CV: 0.261 L-Skew: 0.276

Unless otherwise stated, pooling groups are derived using the procedures from the FEH25 Statistical Method [Error! Bookmark not defined.](#), with a default 800 station-years target for pooling group size.

Catchment selection for pooling group members was filtered to sites with URBEXT2015 values < 0.03 by default.

Pooling group composition is provided in digital deliverables.

7.2.2 Derivation of growth curves at subject sites

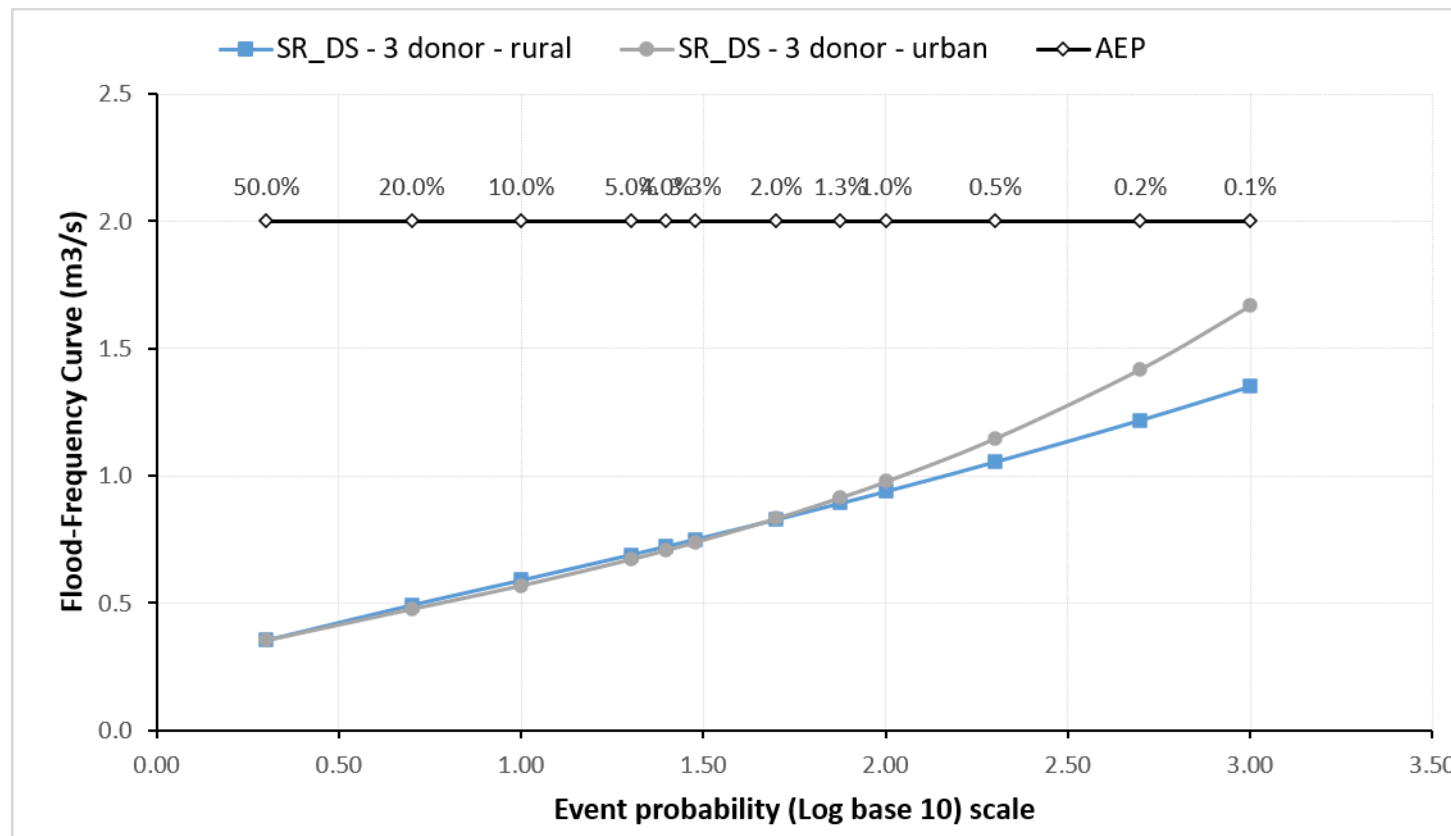
Site code	Method	If P, name of pooling group	Distribution used and reason for choice	Urban adjustment applied and adjusted LCV	Parameters of distribution (location, scale, and shape after adjustments)	Growth factor for 1% AEP
SR_DS	P	SR_DS	GEV GEV and KAP3 were shown to be an acceptable fit to the data. GEV has the lowest absolute z-value indicating the best fit. GEV was therefore selected.	Yes – applied outside WINFAP software UAF = 1.75 LCVurban = 0.218	Location = 1.000 Scale = 0.317 Shape = -0.080	2.65
	P	SR_DS	GL GL, GL NFY and KAP3 were shown to be an acceptable fit to the data. GL has the lowest absolute z-value indicating the best fit. GL was therefore selected	Yes – applied outside WINFAP software UAF = 1.75 LCVurban = 0.212.	Location = 1.000 Scale = 0.209 Shape = -0.240	2.76

Methods: **P** - Pooled

Pooled growth curves are derived using the procedures from the FEH25 Statistical Method [Error! Bookmark not defined.](#) Urban adjustments are carried out using FEH25 methods using URBEXT2015. The resultant peak flows using a rural URBEXT2025 threshold and an urban threshold were assessed. The pooling group with an urban (0.3) threshold produced higher peak flows for the 1% AEP event. As a precautionary approach, the urban pooling group was taken forward over the rural pooling group.

Site code	Pooling Group	Distribution used	1%
SR_DS	SR_DS - rural	GEV	0.9
SR_DS	SR_DS - urban	GL	1.0

7.2.3 FEH25 Flood frequency curve plots



7.3 FEH25 - Final choice of QMED and growth curves

Site code	Final choice of QMED and reasons	Final choice of flood growth curve method and reasons
SR_DS	QMED adjusted using data transfer from three donors (54102: Avon @ Lilbourne, 39026: Cherwell @ Banbury and 31010: Charter @ Fosters Bridge).	Standard urban pooling procedure using GL distribution. Non-flood years adjustment not applied to pooling group.

7.4 Final flood estimates from stationary statistical methods

Site code	50%	3.3%	1%	0.1%
SR_DS - FEH25	0.4	0.7	1.0	1.7
SR_DS - FEH08	0.3	0.7	0.9	1.8

Flood peak in m³/s for the AEP (%) events

8 Revitalised Flood Hydrograph 2 (ReFH2) method

8.1 Rural and urban catchment sub-divisions

As detailed within Section 6, there is uncertainty as to the realistic benefit application of sewers in/sewers out would provide. The study catchments are moderate-highly urbanised and ungauged which is a key limitation of this study and carries with it several assumptions. It is felt that consideration of sewers in/sewers out may further increase the limitations and assumptions made within this study and that any potential benefits will not outweigh the time considerations required to undertake such substantial work. It may also be considered that additional calculations to assess sewers in/sewers out will add no substantial gain in accuracy or confidence to the study flows as there are no flow gauges within the study catchment in which to validate the flows along the study tributaries. As application of sewers in/sewers out is considered to be ineffective, as a conservative measure exporting drained areas within the ReFH2 software will be kept at 0 and no further assessment of rural and urban catchment sub-division's will be undertaken

8.2 ReH2 model parameters

8.2.1 Summary of rural model parameters and initial conditions:

Site code	Method	Cini (mm)	Cmax (mm)	Tp rural (hours)	BF(0) (m3/s)	BL (hours)
A	CD	72.39	358.86	1.91	0	36.39
B		72.39	358.86	1.95	0	36.59
SR_DS		72.39	358.86	2.33	0	31.7

Methods: OPT: Optimisation from event analysis, BR: Baseflow recession fitting, LAG: TP from lag analysis, CD: Catchment descriptors, DT: Data transfer, CAL: model calibration.

Unit Hydrograph shape parameters UP and UK are 0.65 and 0.80, respectively.

The Baseflow Recharge value (BR) is not reported above. BR is no longer a fixed parameter in the ReFH2.3 model²². It is now allowed to vary, changing with event severity to address overall mass-balance issues identified in earlier implementations. Initial values for BR can be viewed in the digital ReFH2 files provided alongside this report.

Is the catchment groundwater-dominated?

No

Plot scale has been used to calculate FEP's A and B

8.2.2 Summary of urban model parameters:

Default ReFH2 model parameters are applied across all flow estimation points as follows:

- Total urban area estimated from the approximate $1.567 * \text{URBEXT2000} * \text{AREA}$ relationship Error! Bookmark not defined.
- No modifications for urban drainage out of the topographic areas applied.
- IF (Impervious Fraction), IRF (Impervious Runoff Factor) and DS (Depression Storage) set to 0.30, 0.70 and 0.5mm, respectively.

Flood Estimation Guidelines v10 states that for very heavily urbanised catchments (URBEXT2000 > 0.3):

Treat the catchment as urban:

²² Wallingford HydroSolutions (2019), ReFH2 Science Report – Closing a Water Balance.
CUX_JBAU_XX_00_RP_HO_0001_S2_P1_JBA FEH calculation record_Sherborne.docx

- Estimate the urban parameters *IF*, *IRF*, *DS* and *TpFactor* where possible using local data, or use default values where no local data is available.
- Use a summer rainfall depth and initial soil moisture, *Cini*, along with the 50% “summer” storm profile.

In line with Flood Estimation Guidelines (2025) v10, in a distributed application it is vital to apply an identical design storm (in terms of storm season, duration and areal reduction factor) to each sub-catchment. Using an individual design storm for each sub-catchment, with a duration set to the critical duration of the sub-catchment, is physically unrealistic and could overestimate the combined flood peak.

8.3 Design event ReFH2 model inputs

8.3.1 Design events for individual lumped catchments

This section provides information for **individual site-specific** design event model inputs, for initial comparison purposes. These may be revised for final flows to be applied to a hydraulic model.

Which rainfall DDF model is used?

FEH22

Site code	Default storm duration (hrs)	Default design event seasonality	Areal Reduction Factor (ARF)	Seasonal Correction Factor (SCF)
A	3.25	Summer	0.98	0.99
B	3.25	Summer	0.98	0.99
SR_DS	3.5	Summer	0.98	0.99

8.3.2 Design events optimised for distributed modelling

Design events for hydraulic model testing:

This section provides information for catchment-wide design storm settings to be assessed. These are applied consistently across all model inputs.

In accordance with research findings, summer storms are selected by default in catchments with URBEXT2000 greater than 0.30.

Design event seasonality	Storm duration (hrs)	ARF	SCF	Details and reasons for selection / testing	Used in final modelling?
Summer	3.75	0.98	Default	Storm duration that provided highest peak flow at FEP B within ReFH2 software	Yes
Summer	4.75	0.98	Default	Storm duration that provided highest peak flow at FEP SR_DS within ReFH2 software	No
Summer	5.75	0.99	Default	Additional duration to test	No

Design storm testing results:

The durations above were tested within the hydraulic model. The difference in flood depths at the site between all three durations was minimal (+/- mm). The 3.75hour duration yielded the greatest depths for most of the study area. As the difference between the three durations was minimal, no further testing was undertaken.

8.4 Final choice of ReFH2 flow estimates

8.4.1 Method choice and reasons:

Site code	Final choice of design inputs and model parameters
All	Urban design inputs, summer season design event. Catchment descriptors (CDs) used for model parameters. No changes to initial conditions (Cini and BF0). 3.75hour duration

Details for distributed modelling using a hydraulic model are provided in Section **Error! Reference source not found.**

8.4.2 Final flood estimates from ReFH2 method

Results for individual catchment settings:

Site code	50%	4%	1%	0.1%
A	0.2	0.4	0.5	0.9
B	0.2	0.5	0.6	1.0
C ²³	0.04	0.1	0.1	0.2
SR_DS	0.5	1.0	1.2	2.1

Flood peak in m³/s for the AEP (%) events.

²³ Scaled via 2.1.1 area ratio from FEP A ReFH23 peak flows
CUX_JBAU_XX_00_RP_HO_0001_S2_P1_JBA FEH calculation record_Sherborne.docx

9 Discussion and summary of results

9.1 Final choice of method

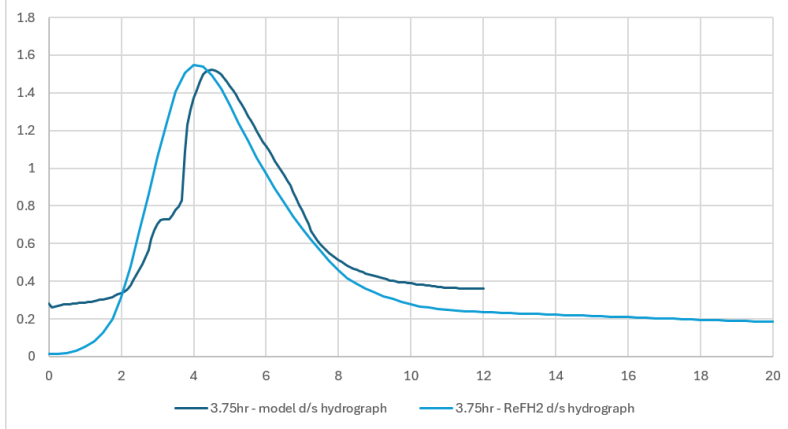
Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	Peak flows derived via ReFH2 are still greater than the peak flows derived via FEH Statistical (FEH25). While the Small catchment guidance has been superseded by FEG v10, it is still considered that ReFH2 is the most suitable method for peak flow generation in this study due to the urbanisation of the catchment.
How will the flows be applied to a hydraulic model? If relevant. Will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	Catchment flows will be distributed along the model reach, using a flow-time boundary, at locations where flow points have been identified in Figure 2.1. Hydrographs and peak flows obtained using the ReFH2 method will be taken forward for modelling purposes. For modelling purposes, hydrographs for all FEP's will be derived to the Storm Duration of 3.75 (See Section 8.3.2). For FEP C, design hydrographs derived from FEP A will be scaled to match the peak flows derived based on an area ratio. The design hydrographs of the model inflow and lateral flow (lateral flow derived via area ratio from SR_DS) have been aligned so as to peak together as a conservative approach.

9.2 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	Same as previous report
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.	Same as previous report
Give what information you can on uncertainty in the results, e.g. confidence limits from Kjeldsen (2014).	Factorial Standard Error (FSE) can inform typical uncertainty bands in design flood calculations. Upper and lower Confidence Interval bounds around a calculated peak flow (QT) apply FSE as follows: 68% Confidence Interval: [QT / FSE] to [QT * FSE] 95% Confidence Interval: [QT / FSE2] to [QT * FSE2] These errors are log-normally distributed around the "central" QT estimate (in other words, the distribution is not uniform; it is more likely that the true value of QT is closer to the centre of the quoted interval, rather than the extremes). WHS24 provide indicative FSE values for the ReFH2 model for rural catchments (Table 6 of that report). There is currently no guidance for how urbanisation affects the FSE of ReFH2 results. The uncertainty tables in Section 9.4 apply the as-rural FSE estimates from the WHS report in these cases, giving an indicative uncertainty. However, the true uncertainty band is likely wider than that given here.
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	These flow estimates were derived specifically for this study. They should not be used elsewhere without at least being reviewed for suitability.
Give any other comments on the study, e.g. suggestions for additional work.	Confidence could be improved through installation of hydrometric monitoring and event hydrometric data.

²⁴ Wallingford HydroSolutions (2023), ReFH2 Science Report – Calibration and Evaluation of the ReFH2.3-FEH22 Design Event Model

9.3 Checks

Are the results consistent, for example at confluences?	Yes, results are considered sensible in that they increase with catchment area.																				
What do the results imply regarding the return periods of floods during the period of record?	No data is available in regards to flood events applicable to the site. No flow gauges or active raingauges are available within the study catchment, therefore no comparison with previous events can be undertaken at this stage.																				
What is the range of 100-year growth factors? Is this realistic?	The 1% AEP growth factors are: ReFH2: 2.66-2.67 The typical range is 2.1 to 4.0 (based on FSR regional growth curves) therefore the 1% AEP growth factor for all FEP's are inside the typical range for both flow estimation methodologies.																				
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	The 0.1%/ 1% AEP event growth factors are: ReFH2: 1.72-1.73																				
Specific discharge checks	<table><tr><th colspan="3">Flood peak in m³/s/km² for the AEP (%) events:</th></tr><tr><th>Site code</th><th>50%</th><th>1%</th></tr><tr><td>A</td><td>0.7</td><td>2.0</td></tr><tr><td>B</td><td>0.8</td><td>2.0</td></tr><tr><td>C</td><td>0.7</td><td>2.0</td></tr><tr><td>SR_DS</td><td>0.6</td><td>1.6</td></tr></table>			Flood peak in m ³ /s/km ² for the AEP (%) events:			Site code	50%	1%	A	0.7	2.0	B	0.8	2.0	C	0.7	2.0	SR_DS	0.6	1.6
Flood peak in m ³ /s/km ² for the AEP (%) events:																					
Site code	50%	1%																			
A	0.7	2.0																			
B	0.8	2.0																			
C	0.7	2.0																			
SR_DS	0.6	1.6																			
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	Flows obtained from ReFH2 are higher than the flows derived from ReFH in 2020. The difference in flows between this study and the 2020 study is due the application of sewer losses within the previous study, which has not been applied within this study. As this study utilises 2026 methodologies, flows derived within this study are the preferred flows.																				
Describe any other checks on the results	Combined hydrographs  The downstream boundary model hydrograph for the 1% AEP + 28% CC event was obtained and compared to the design hydrograph from ReFH2 for SR_DS. Peak flow between the two are comparable (less than a 0.1 m³/s between the design and the model peak flow) which is considered a tolerable difference. The model hydrograph peaks slightly later then the ReFH2 design hydrograph which is likely due to attenuating affect s within the hydraulic model.																				

9.4 Final results

3.75hr Storm Duration for final model

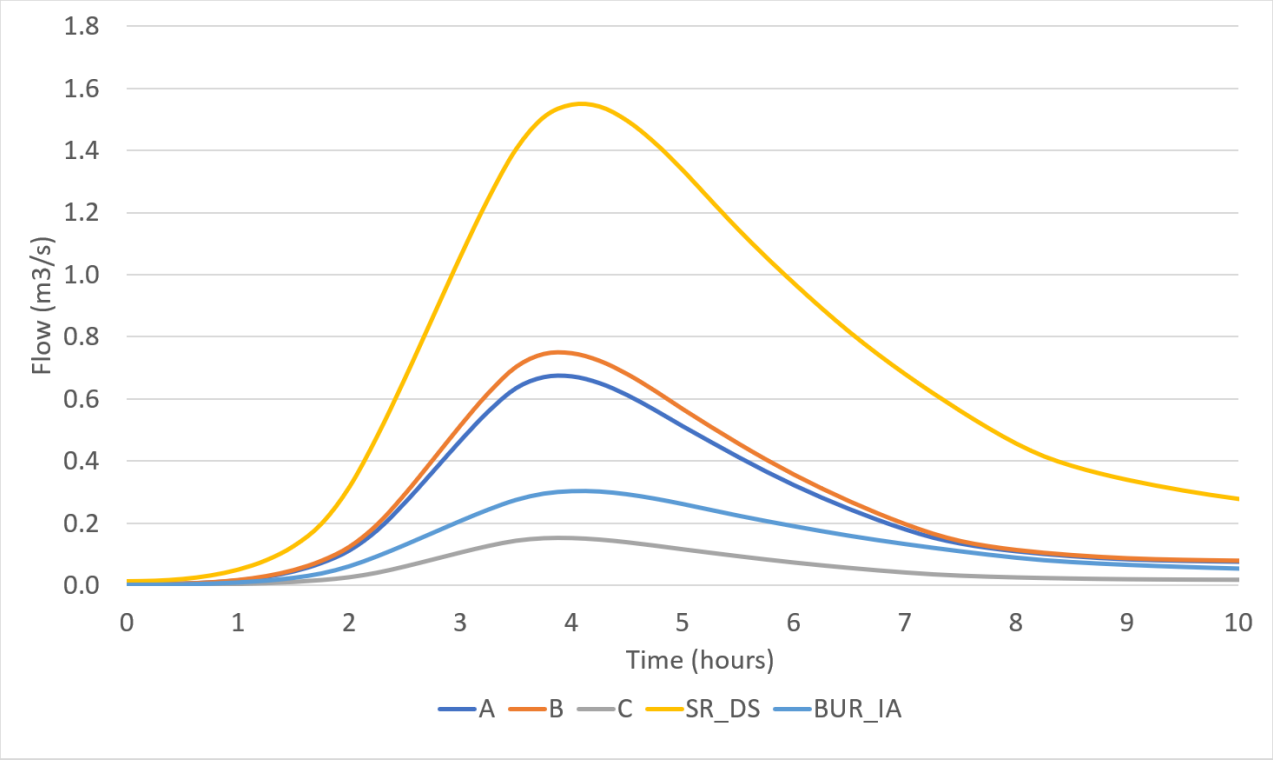
Site code	Flood peak (m ³ /s) for the following return periods (in years)					
	50% AEP	3.3% AEP	1% AEP	1% AEP + 28% Climate change allowance Central	1% AEP + 60% Climate change allowance* Upper	0.1% AEP
A	0.2	0.4	0.5	0.7	0.8	0.9
B	0.2	0.5	0.6	0.7	0.9	1.0
C	0.04	0.1	0.1	0.2	0.2	0.2
SR_DS	0.5	1.0	1.2	1.5	1.9	2.1

*60% climate change included to comply with Condition 19 (Flood Risk Modelling) request

Site code	50% AEP Lower 95%	50% AEP Upper 95%	1% AEP Lower 95%	1% AEP Upper 95%
A	0.1	0.4	0.3	1.1
B	0.1	0.4	0.3	1.2
C	0.02	0.1	0.1	0.2
SR_DS	0.2	0.9	0.2	0.9

10 Annex B – Model design hydrographs

1% AEP + 28% CC event



Offices at

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Peterborough
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

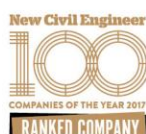
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JBA Project Code	2025s0355
Contract	Sherborne Rd Burbage Condition 19
Client	Jelson Homes Ltd
Day, Date and Time	24 th August 2026
Updated report	7 th October 2026
Author	Gwyn Jones & Sam Cogan
Reviewer / Sign off	John Panesar BEng (Hons) CEng MICE
Subject	Hydraulic Modelling Technical Note

1 Terms of Reference

JBA Consulting (JBA) were commissioned by Jelson Homes Ltd to provide flood risk support in relation to the discharge of planning Condition 19 at Sherborne Road, Burbage, Leicestershire (hereafter referred to as 'the site').

JBA provided hydraulic modelling support to the original planning application for the site in 2021, in which Option 4 was taken forward and supported the planning application submission (ref: 23/00673/OUT). The modelling was approved in July 2023 and planning approval was granted by Hinckley and Bosworth Borough Council.

The following planning condition was attached to the planning approval and this document provides further information to discharge this condition:

Condition 19 (Flood Risk Modelling) – No approval of reserved matters shall take place until such time as the following details have been submitted to, and approved in writing by the Local Planning Authority. Any subsequent design must be carried out in accordance with these approved details:

- a) Modelling updated to reflect upper end climate change allowance for both the proposed and existing scenarios.
- b) Full details of flood compensation areas supported by revised modelling, unless modelling/layout demonstrates that compensation is not required
- c) Details demonstrating finished floor levels are set at least 300mm above the modelled 1 in 100 year plus upper end climate change allowance.
- d) Full consideration of source control SuDS

This technical note has been prepared to demonstrate that the revised post-development layout complies with the above requirements.

An engineering design has been completed to support the modelling with full details of the proposed embankments and flood storage area works, which should be reviewed in conjunction with this technical note.

TECHNICAL NOTE



In addition, following a third-party review undertaken in August 2026, updates and revisions were undertaken on the hydrological inputs to the model. Updates to the baseline flood extents based on the revised hydrology (detailed in Sections 7 to 10 of the CUX_JBAU_XX_00_RP_HO_0001_S2_P1_JBA FEH calculation record_Sherborne calculation record)

2 Site Overview

2.1 Site Description

The site is located on current agricultural land on the south-eastern outskirts of Burbage, Leicestershire. An unnamed ordinary watercourse, which is a headwater of the Soar Brook, itself a tributary of the River Soar, flows along the southern boundary of the site. An additional tributary crosses from the northwest boundary of the site through the centre to meet the main channel at the southern boundary. A drainage ditch runs parallel to and 100m to the north of the main watercourse and confluences with the unnamed tributary. This ditch is modelled in the 2D only. An overview of the site, along with the watercourses and extents included within the supporting hydraulic modelling, is provided in Figure 2-1.

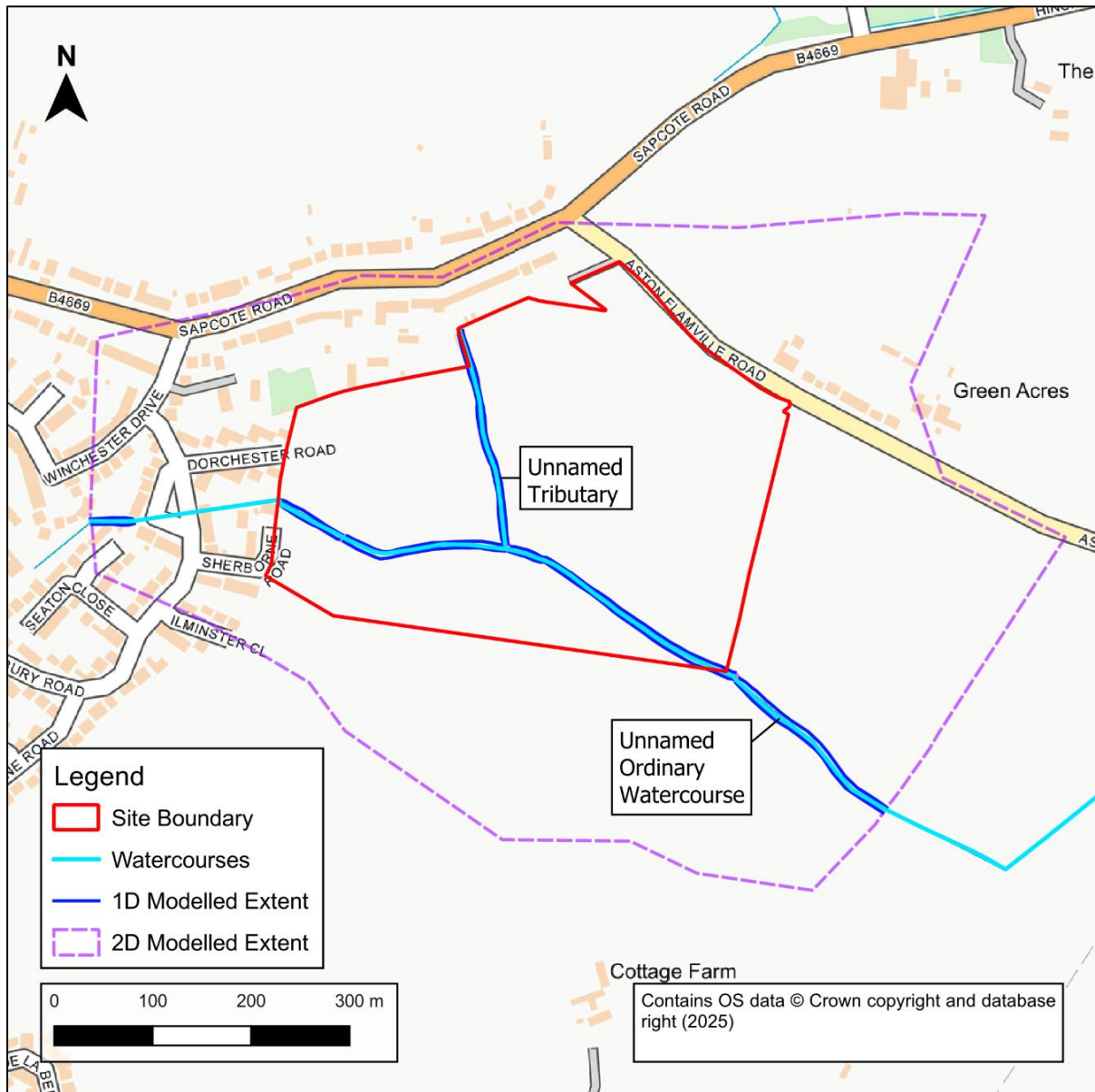


Figure 2-1: Site overview with model extents

3 Hydraulic Modelling

3.1 Previous model

The Sherborne Road hydraulic model is a 1D-2D Flood Modeller-TUFLOW hydraulic model initially developed by JBA in 2021 to develop an understanding of the flood risk posed to the site from the ordinary watercourses. The model includes an approximately 1km reach of the main unnamed ordinary watercourse adjacent to the site along with an approximately 200m reach of the unnamed tributary.

Several post-development options were tested using the previous model – of these, Option 4 was taken forward for the planning application. This option included:

- The removal of three undersized culverts on the tributary and main watercourse
- Raising the banks of the two modelled watercourses
- The creation of a flood storage area (FSA) with flow control structure at the southern end of the site
 - The flow control structure from the FSA was modelled with a pipe diameter of 700mm
- A 1m deep low flow channel running alongside the FSA with a lowered left-hand bank to allow excess water to spill directly into the FSA

The above combination of flood mitigation features was found to prevent flood water from overtopping the river channel (and thus prevent wide-spread flooding across the site) without increasing flood risk elsewhere.

The hydraulic modelling was detailed within the submitted reporting and Leicestershire County Council as Lead Local Flood Authority (LLFA) advised the Local Planning Authority (LPA) that the proposals were considered acceptable subject to required conditions such as that which is the subject of this technical note.

A number of updates were made to the Option 4 post development model to reflect changes made to the development plans. These updates are listed below and are further detailed in Figure 3-1. A detail of the differences between the previous and updated layouts is presented in Figure 3-2.

- An updated layout of the FSA to accommodate a SuDS basin on the proposed development site (note that the SuDS basin itself was not modelled as it is not within the flooded extent of any modelled post-development scenario)
- The retaining embankments of the FSA were set to 100.0m AOD
- Updated configuration of the raised banks upstream of the FSA to tie into paths and the FSA embankment

TECHNICAL NOTE

- Changes were made to the naming convention of the TUFLOW files to include an Event Name term (~e1~), to avoid producing a large number of virtually identical .tcf files for each modelled event

The rest of the modelling approach was retained from the 2021 Option 4 model.

The model was then run for the full suite of events, including the 1% AEP plus climate change (60%) event.

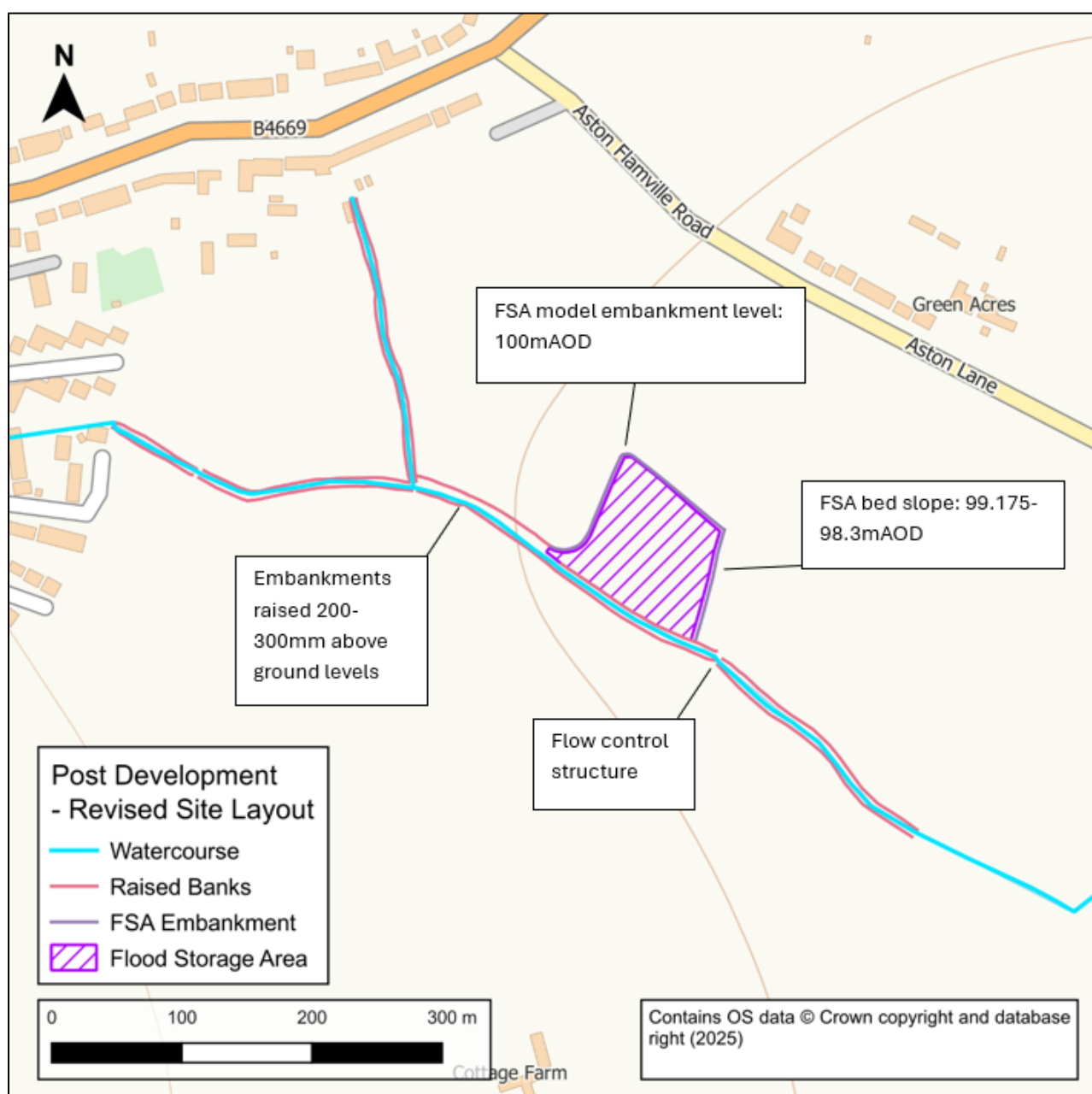


Figure 3-1: Revised Post-developed layout, with levels shown in mAOD

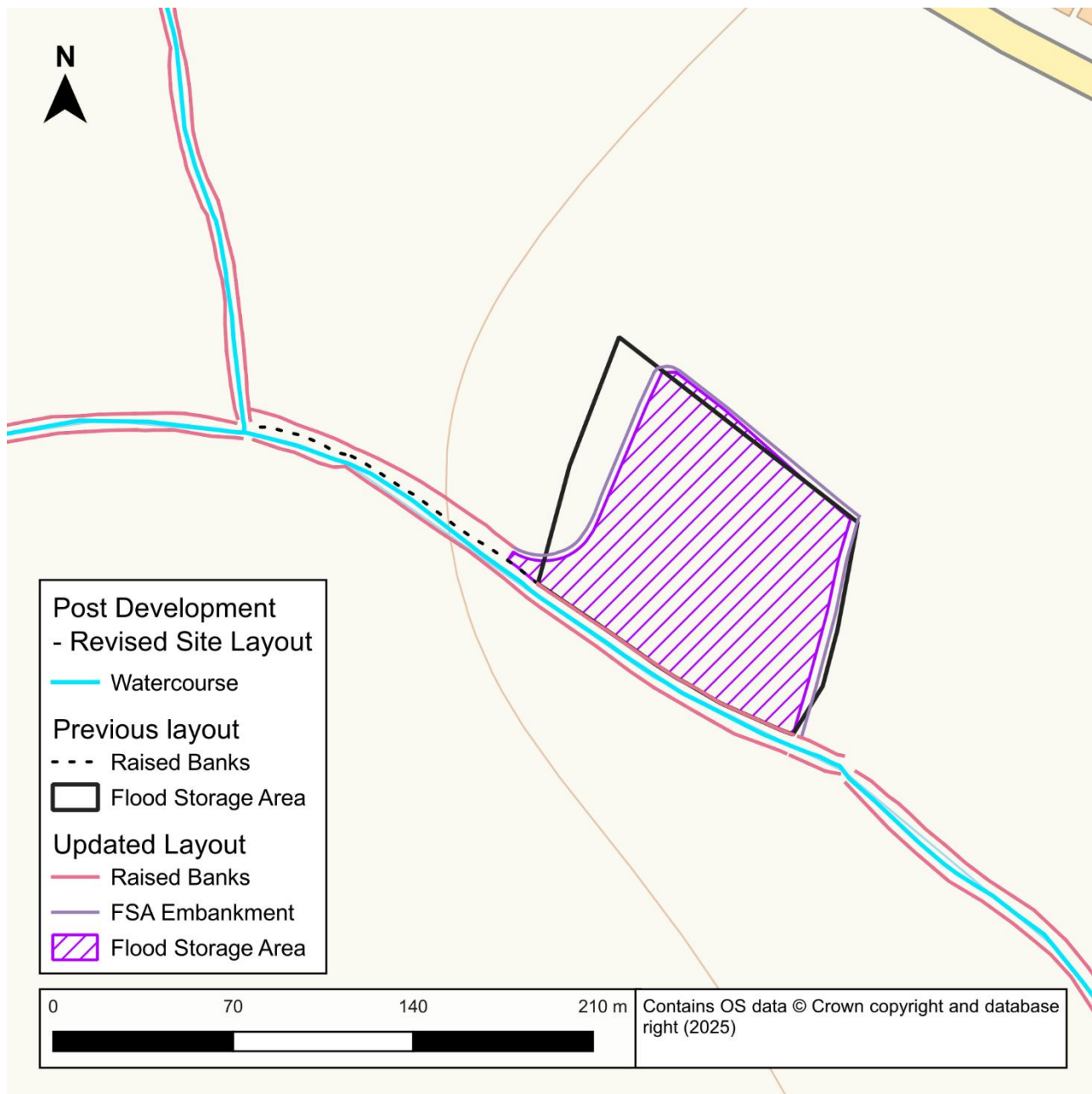


Figure 3-2: Detail of the changes between the previous and updated Option 4 model scenario

4 Hydraulic Modelling Results

4.1 Updated Baseline

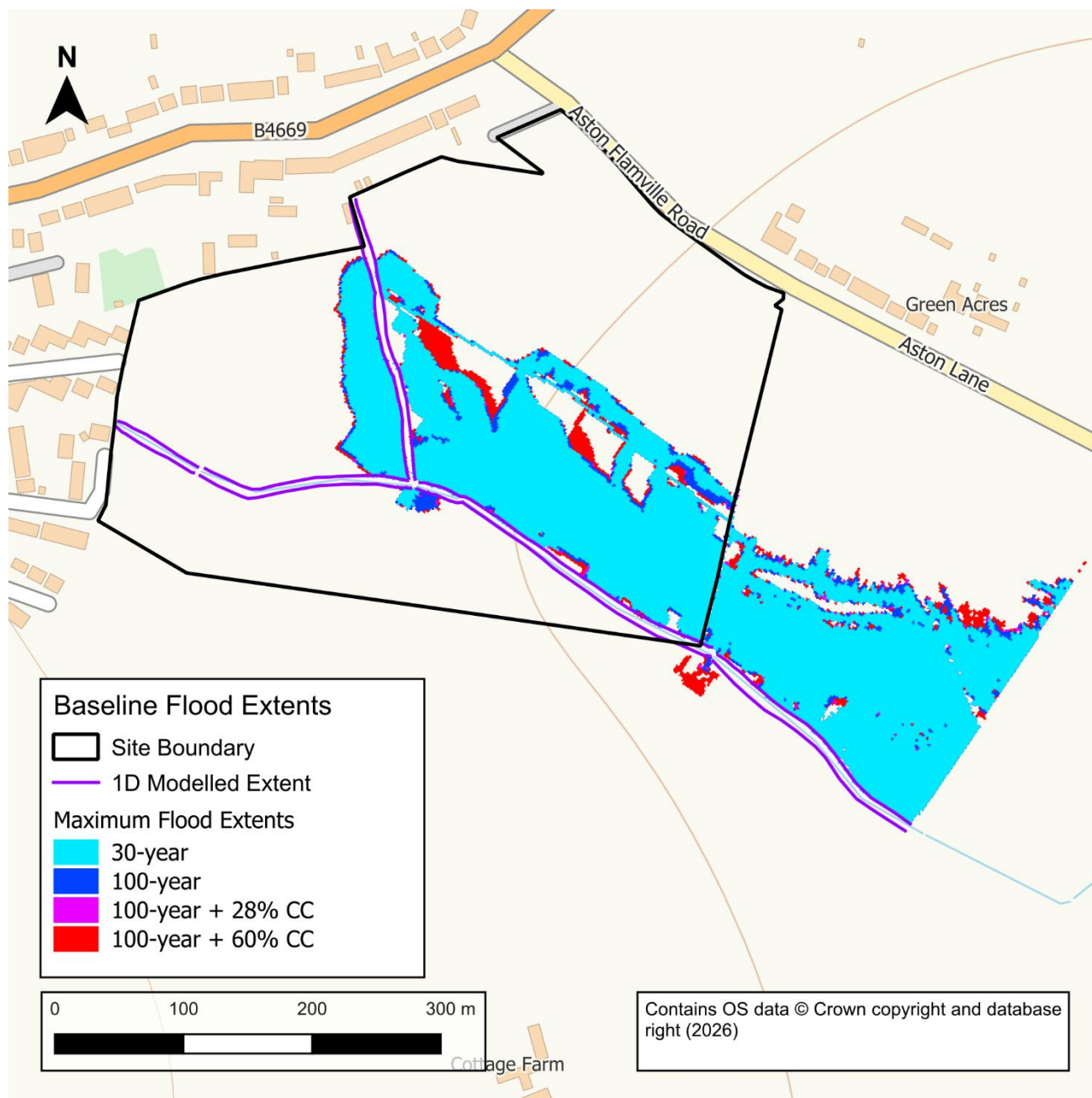


Figure 4-1: Baseline Flood Extents

Figure 4-1 shows the baseline flood extents for the 30-year, 100-year and the 100-year plus 28% and 60% climate change events. LiDAR data indicates that there is a narrow, shallow, unmodelled drainage ditch mid-way down the small tributary, crossing from approximately west to east in the centre of the site. The modelled flood extents suggest that this drainage

ditch overtops its banks approximately 130m to the southwest of where it splits from the modelled tributary in the 30-year event, contributing to a flow path through the site on the northern bank of the modelled ordinary watercourse. This flow path is more extensive in the 100-year and 100-year climate change events, with the unmodelled drainage ditch overtopping in additional locations to add to this. As the catchment area of the modelled watercourse is less than 3km², flood risk from the watercourse is not represented in the Environment Agency (EA) Flood map for Planning. As a result, a direct comparison between the modelled 1,000-year and 100-year flood outlines with the EAs' Zone 2 and 3 extents was not possible. The extent of flooding does not significantly increase when applying the climate change allowances to the 100-year event. This suggests that flooding to the site is mainly driven by the local topography.

4.1.1 Baseline - 100-year + 28% CC scenario

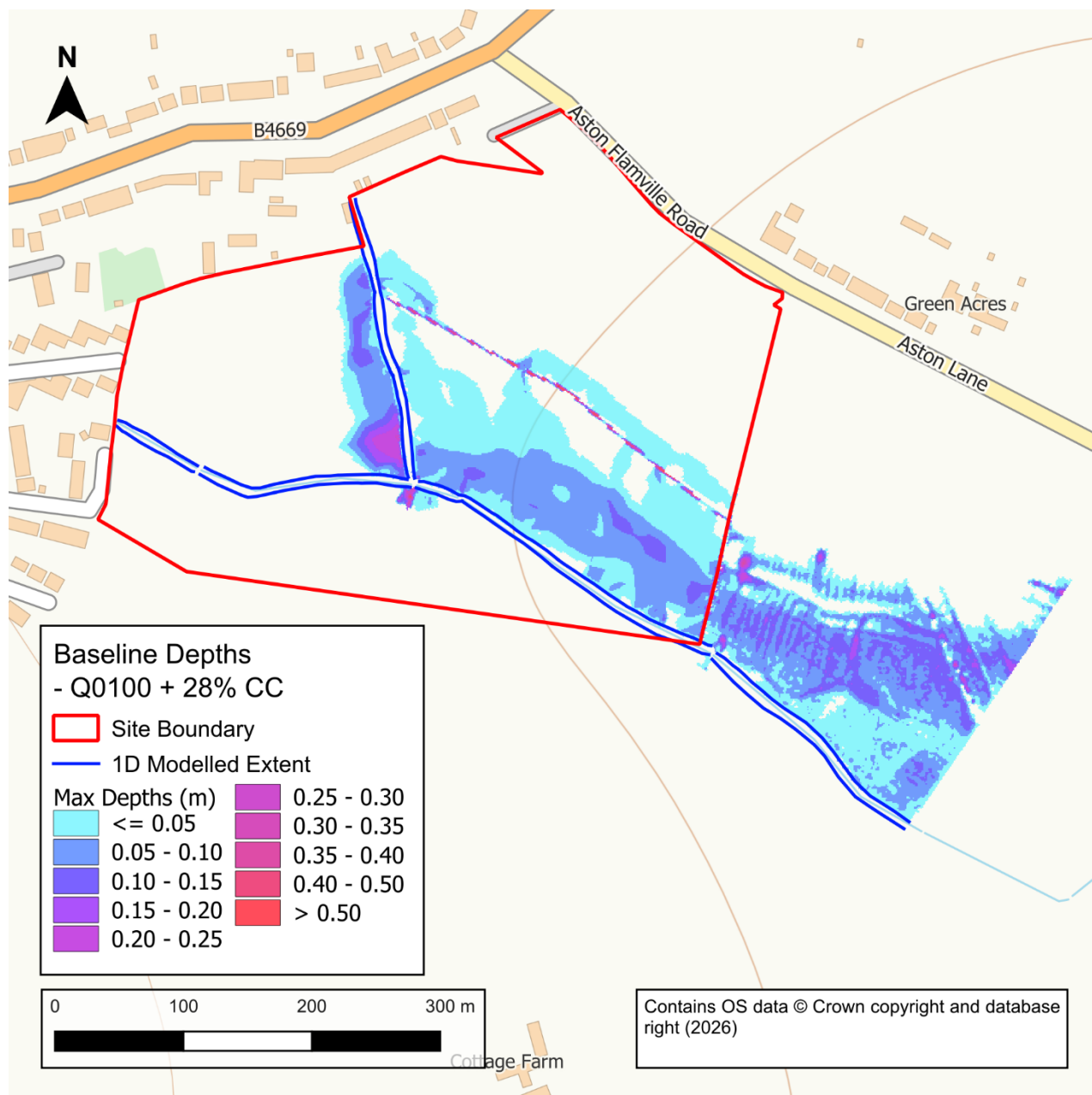


Figure 4-2: Peak flood depths in the baseline 1% AEP plus climate change (28%) event

The maximum flood depth within the site during the 100-year with 28% climate change scenario is approximately 0.43m (at the confluence within the site to the right bank/south of the watercourse) and generally 0.45m within the small drainage ditch crossing the site and running parallel to the unnamed watercourse. However it should be noted that maximum flood depths are located either within the small drainage ditch or within areas adjacent to the modelled watercourses.

TECHNICAL NOTE

The wider site exhibits shallow depths of typically $<0.1\text{m}$ but with pockets of deeper flooding particularly on the confluence of the tributary and the drainage ditch running parallel to the main watercourse across the site.

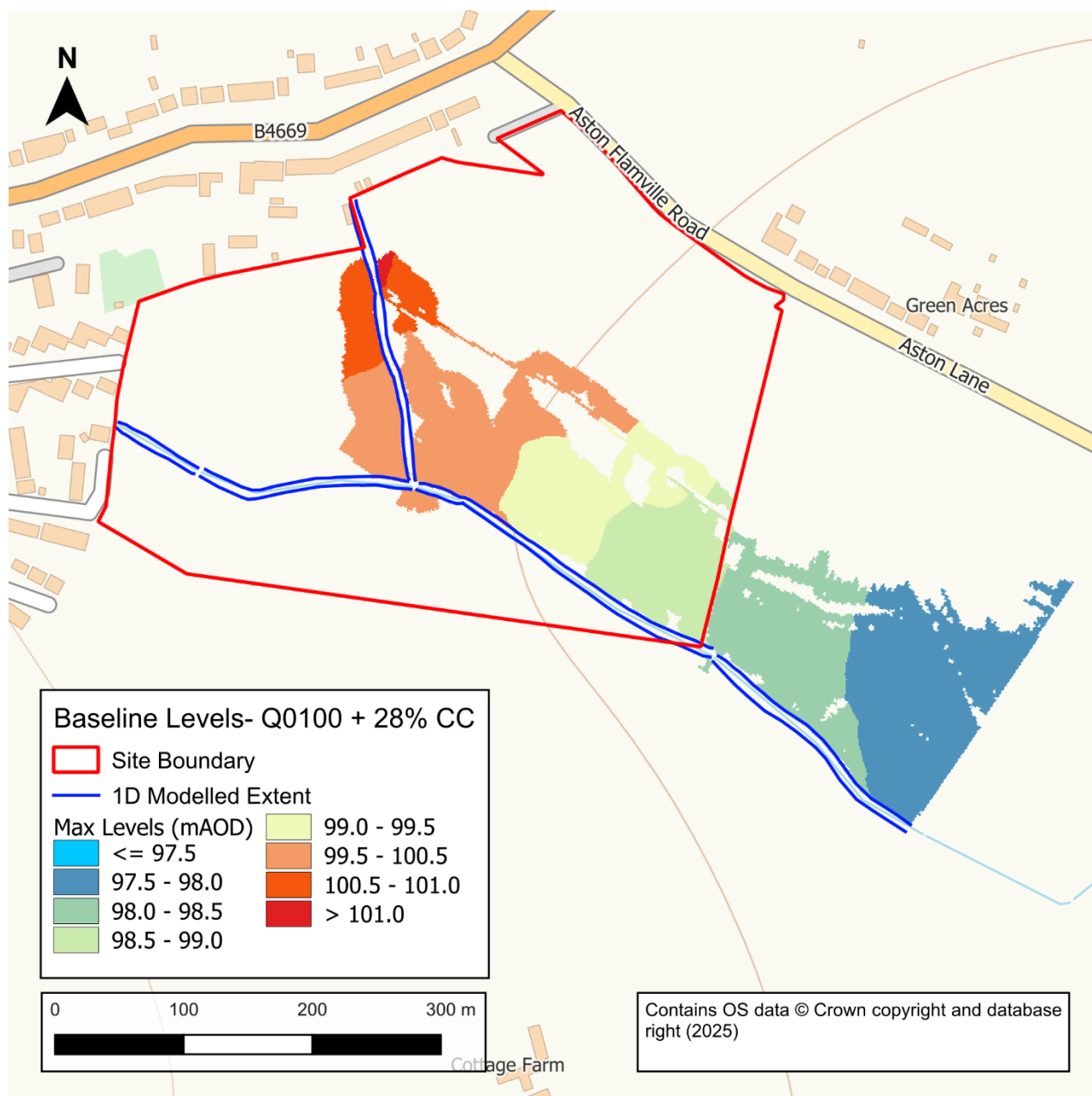


Figure 4-3: Peak water levels modelled in the baseline 1% AEP plus climate change (28%) event

Figure 4-3 shows peak water levels. Water levels vary from approximately 101mAOD at the upstream extent of the tributary to 97.6m AOD at the downstream model extent. Within the site, the lowest water level is 98.5mAOD.

4.1.2 Baseline - 100-year + 60% CC scenario

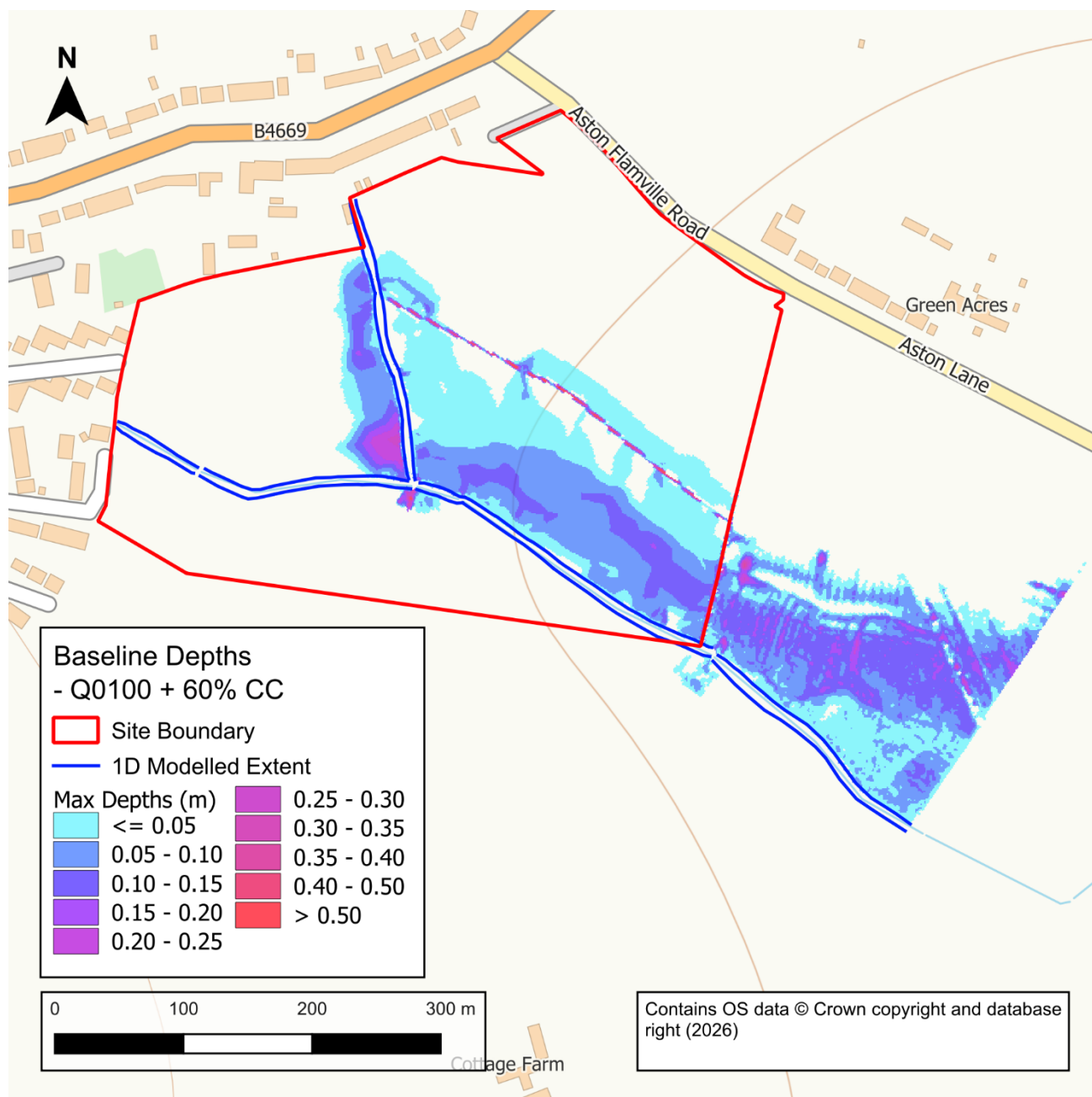


Figure 4-4: Peak flood depths in the baseline 1% AEP plus climate change (60%) event

The maximum depths for the baseline 1% AEP plus climate change (60%) event can be seen in Figure 4-4. The site again exhibits shallow depths of typically <0.1m but with pockets of deeper flooding particularly on the confluence of the tributary and the drainage ditch running parallel to the main watercourse across the site, where there are peak depths of >0.5m.

TECHNICAL NOTE



The maximum flood depth within the site during the 100-year with 60% climate change scenario is approximately 0.56m (at the confluence within the site to the right bank/south of the watercourse) and generally 0.50m within the small drainage ditch crossing the site and running parallel to the unnamed watercourse. As with the 28% climate change event, maximum flood depths are located either within the small drainage ditch or within areas adjacent to the modelled watercourses. The wider site exhibits shallow depths of typically <0.1m. In general, the revised hydrology inputs have increased flood depth on site by approximately 2-4cm when compared to the previous hydrology inputs.

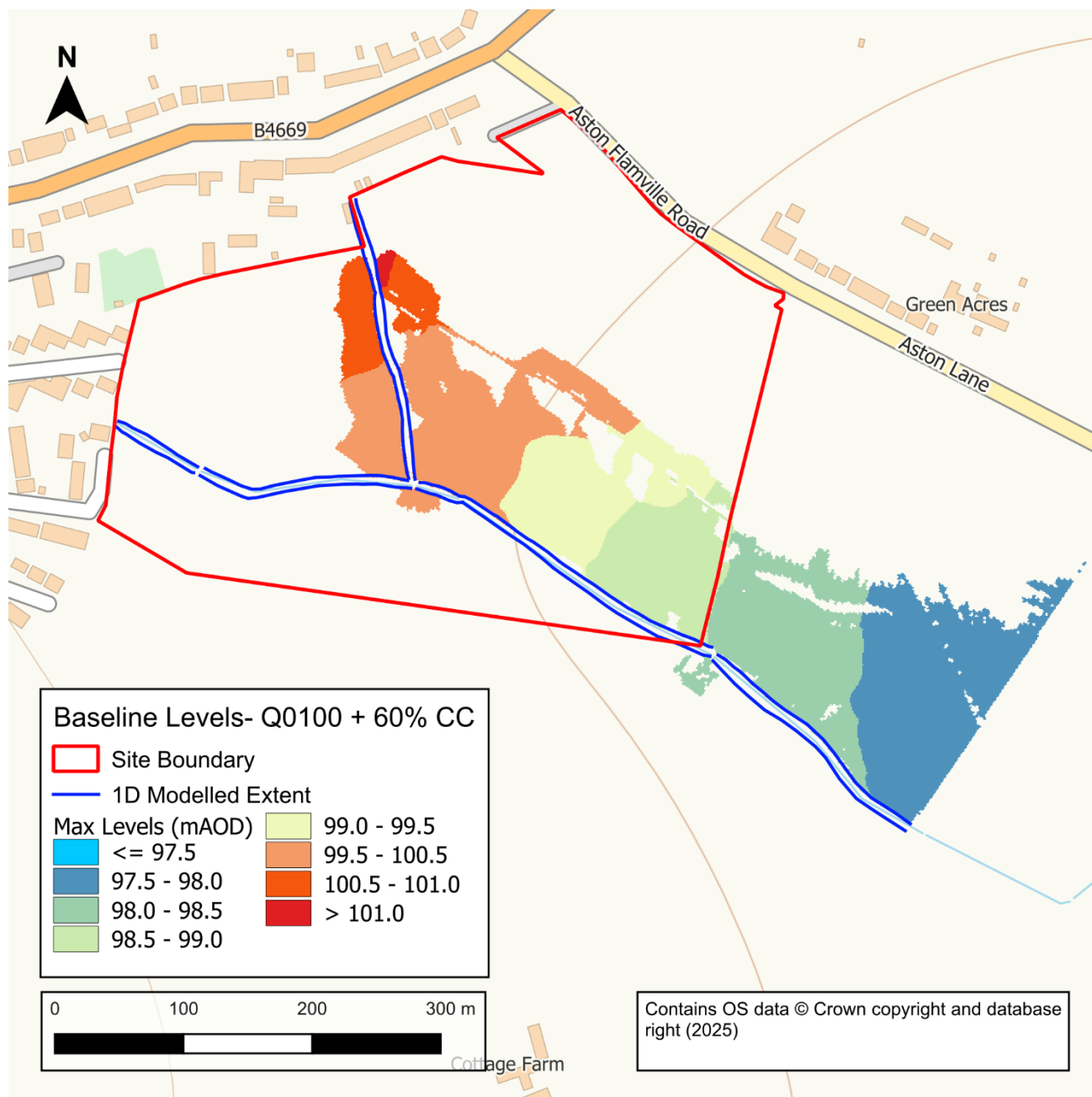


Figure 4-5: Peak water levels in the baseline 1% AEP plus climate change (60%) event

Figure 4-5 shows peak water levels. Water levels vary from approximately 101mAOD at the upstream extent of the tributary to 97.6m AOD at the downstream model extent. Within the site, the lowest water level is 98.5mAOD - a negligible difference from the level obtained for the 28% climate change event and from the initial 60% climate change runs undertaken in 2025.

4.2 Post Development

Figure 4-6 below shows the peak flood depths for the 1% AEP plus climate change (60%) event for the revised Option 4 post development scenario. Flood extents on the site are now wholly contained in-bank or in the Flood Storage Area, where depths reach a maximum of 1m along the downstream boundary. There is shallow flooding downstream of the site of typically 0.01m-0.1m, with some minor isolated areas of depths of 0.2m-0.25m, although to a lesser extent than the baseline.

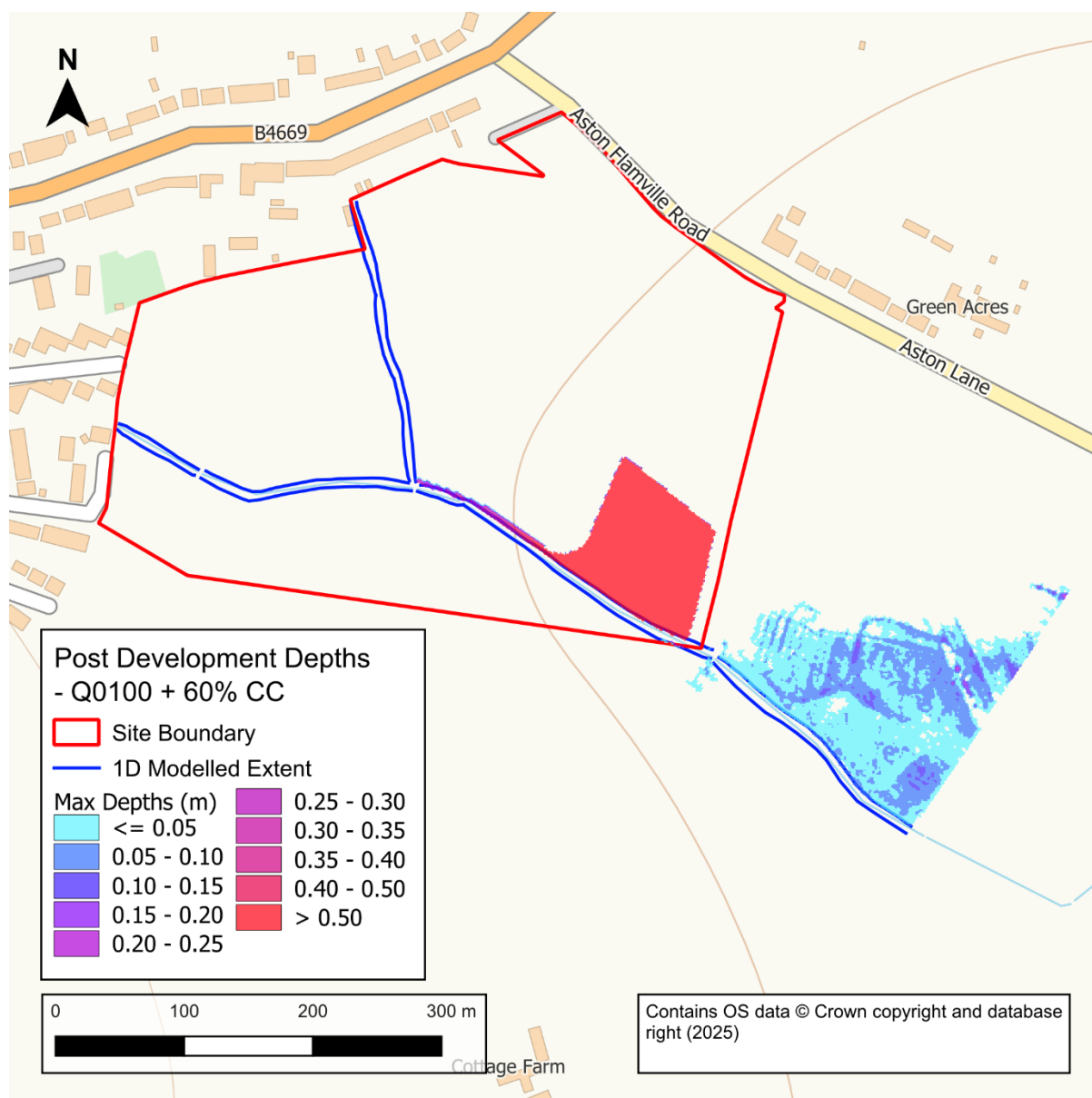


Figure 4-6 - peak flood depths in the post development 1% AEP plus climate change (60%) event

TECHNICAL NOTE

Figure 4-7 shows the peak water levels for the same event. The peak water level within the FSA is 99.85m AOD and in-channel levels are shown as annotations on the figure. It is understood that the final FSA design will be set 100m AOD to provide 150mm freeboard. Finished floor levels should be set at least 300mm above the adjacent peak water level.

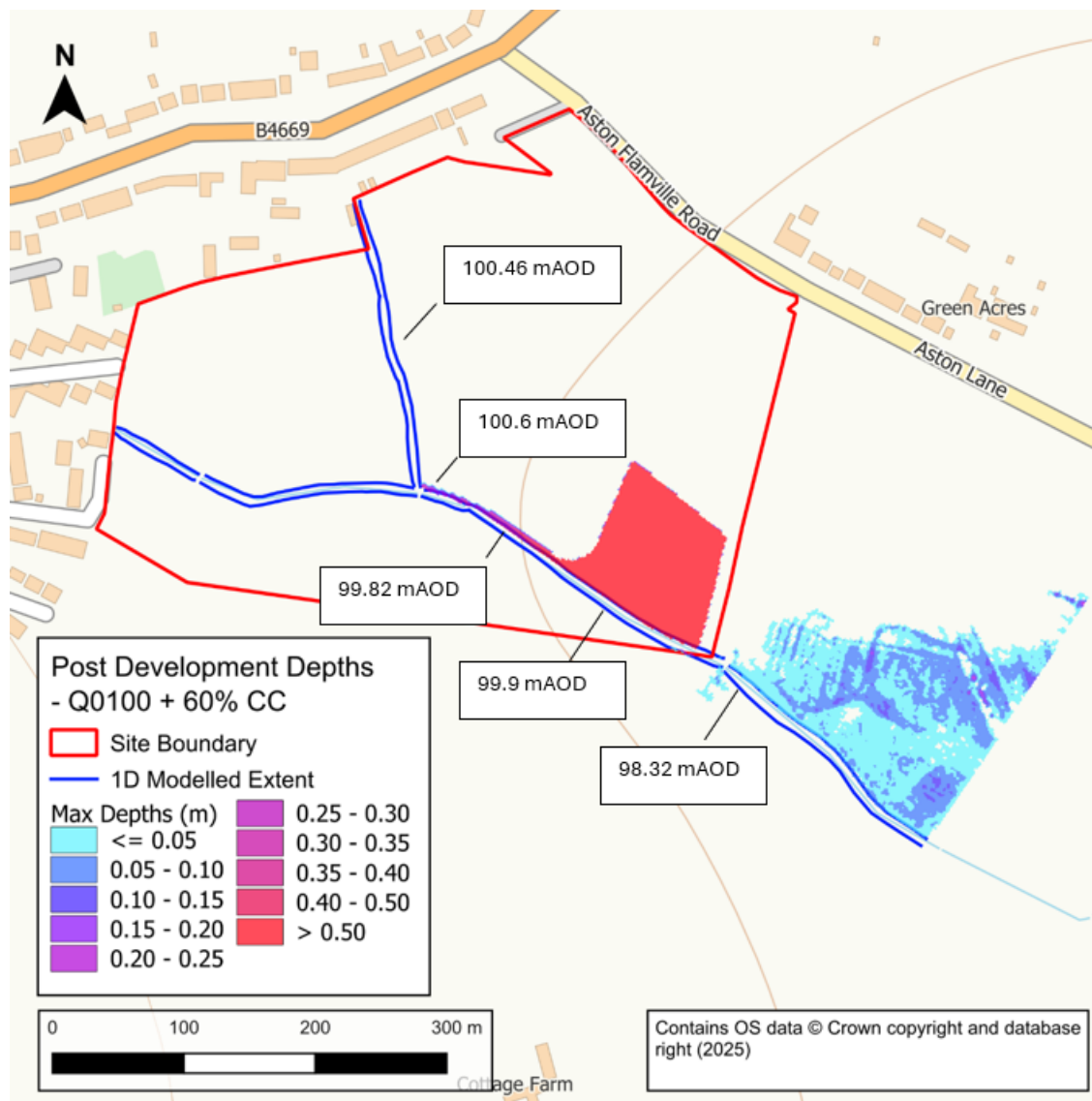


Figure 4-7 - peak water levels in the post development 1% AEP plus climate change (60%) event. In-channel levels in mAOD at key points are shown as annotations.

4.2.1 Depth comparison

Figure 4-8 below shows a depth comparison between the baseline and the post development for the 1% AEP plus climate change (60%) event. Outside of the FSA, flood depths have widely decreased or otherwise have shown no significant difference when compared to the baseline. Within the site, flooding has been wholly prevented. There is no flood detriment on the third-party land downstream of the site.

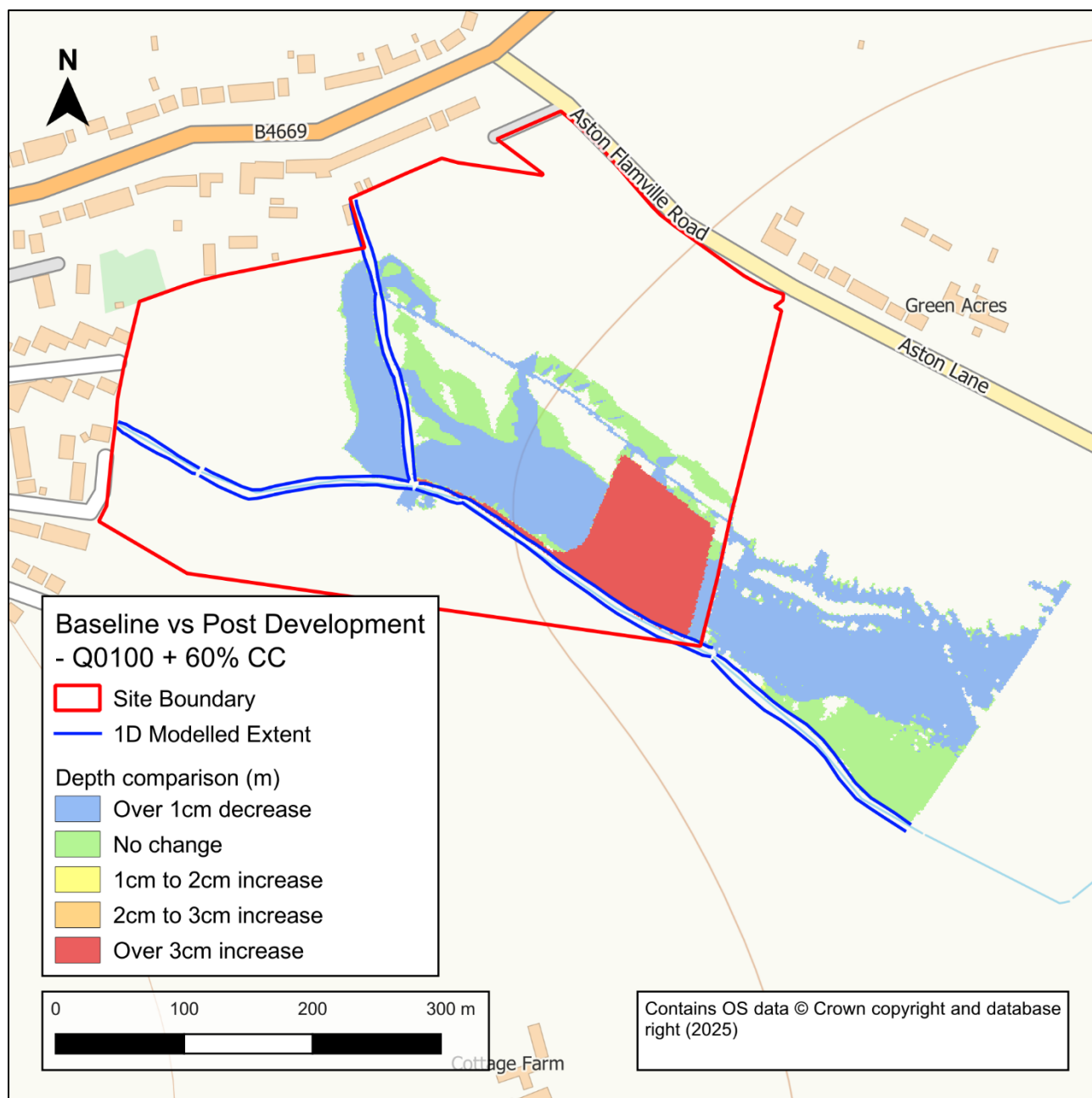


Figure 4-8 - Depths comparison between the baseline and post-development scenarios for the 1% AEP plus climate change (60%) event

5 Conclusion

The purposes of this technical note was to demonstrate that the revised post-development layout complies with requirements needed in order to discharge the following planning condition for the proposed Sherborne Road development site. Where the conditions are addressed within this technical note, these are detailed in green below.

Condition 19 (Flood Risk Modelling) – No approval of reserved matters shall take place until such time as the following details have been submitted to, and approved in writing by the Local Planning Authority. Any subsequent design must be carried out in accordance with these approved details:

- a) Modelling updated to reflect upper end climate change allowance for both the proposed and existing scenarios.
- b) Full details of flood compensation areas supported by revised modelling, unless modelling/layout demonstrates that compensation is not required.
- c) Details demonstrating finished floor levels (FFL) are set at least 300mm above the modelled 1 in 100 year plus upper end climate change allowance.
- d) Full consideration of source control SuDS.

Compliance with the Planning Condition 19 has been set out below, demonstrating how each element of the condition is met.

- a) Baseline and post development modelling up to and including the 1% AEP plus climate change (60%) event has been set out in the previous sections and concludes that, with additional proposed measures of raised banks to the existing watercourse and a flood storage area, the flood risk to the proposed development area where dwellings are proposed has been removed. The 60% climate change figure reflects the upper end allowance as required by the condition.
- b) A full engineering design for the raised banks and flood storage area has been completed to support the hydraulic modelling for the site and these drawings are provided in Appendix B. The post development modelling shows that the water is now contained within the flood storage area during the 1% AEP plus climate change (60%) event. Further compensation is not required as there is no loss in floodplain capacity and the impact assessment shows betterment to third-party flood risk.
- c) Maximum water levels during the 1% AEP plus climate change (60%) event for the post-developed scenario are detailed within this technical note. Finished floor levels should be set 300mm above these levels.
- d) Addressing this comment is outside of the scope of this technical note.

In summary, as noted in this report and associated modelling:

- The hydrological assessment from the previous JBA study was reviewed and found to be acceptable for use in this study.
- The Sherborne Road hydraulic model, developed by JBA in 2021 was simulated with the Soar Management Catchment upper end climate change allowance (60%) for the 1% AEP event for the baseline scenario.
- The Option 4 post development layout, which was taken forward from the previous JBA study, was adjusted with changes to the Flood Storage Area (FSA) and embankment layout. This was simulated in the model with the 1% AEP plus climate change (60%) event
- Hydraulic modelling demonstrated that in the revised Option 4 post development layout, the raised banks, FSA and flow control structure fully contain peak flows from the proposed development site, and cause no flood risk detriment to the third party land downstream

TECHNICAL NOTE



A Post-developed engineering drawings



GENERAL NOTES

- ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
- ALL COORDINATES ARE IN METRES RELATIVE TO ORDNANCE SURVEY NATIONAL GRID.
- DO NOT SCALE FROM THIS DRAWING. ALL DIMENSIONS MUST BE CHECKED/VERIFIED ON SITE.
- ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE SUPERVISOR IMMEDIATELY.
- THIS DRAWING IS BASED ON TOPOGRAPHIC SURVEY REFERENCE 'S3396' BY PHOENIX SURVEY SERVICES LTD DATED APRIL 2013 AND PROPOSED SITE LAYOUT DRAWING NUMBER 'BURB.001' REVISION B, BY JELSON HOMES LTD DATED JANUARY 2025.

DRAWING NOTES

- PROPOSED EMBANKMENT TO BE CONSTRUCTED FROM AS-DUG MATERIAL ONSITE. TOP-SOILED AND SEEDED IN ACCORDANCE WITH LANDSCAPE ARCHITECTS SPECIFICATION.
- GROUND DATA MISSING FOR SECTIONS F-L. SPOT LEVELS TAKEN FROM TOPOGRAPHIC SURVEY TO DERIVE CHANNEL DATA AND SOUTHERN MOST EMBANKMENT.
- EXISTING GROUND LEVELS WITHIN PROPOSED FLOOD STORAGE AREA ARE TO BE ADJUSTED TO SMOOTH PROFILE OF EXISTING GROUND IN ACCORDANCE WITH THE HYDRAULIC MODELLING. SEE SETTING OUT INFORMATION FOR PROPOSED LEVELS.

REFERENCE DRAWING SCHEDULE:

- PIB-JBA-XX-XX-DR-C-0009-General Arrangement (Sheet 1 of 3)
- PIB-JBA-XX-XX-DR-C-0002-General Arrangement (Sheet 2 of 3)
- PIB-JBA-XX-XX-DR-C-0003-General Arrangement (Sheet 3 of 3)
- PIB-JBA-XX-XX-DR-C-0004-Construction Details
- PIB-JBA-XX-XX-DR-C-0006-Embankment, Sections, Sheet_1_of_3
- PIB-JBA-XX-XX-DR-C-0007-Embankment, Sections, Sheet_2_of_3
- PIB-JBA-XX-XX-DR-C-0008-Embankment, Sections, Sheet_3_of_3

Hazards Summary

Construction and maintenance :

- Working in watercourses. Contractor its to prepare a method statement to ensure operatives are familiar and competent with the dangers of working in watercourses.
- Excavations within existing tree root zones. Contractor is to seek advice from an Arboriculturalist and work to the methodology and requirements set out in the Arboriculturalist's report.
- High groundwater levels. Contractor to undertake necessary work to mitigate against groundwater ingress into excavations.

Public Risks:

- Unauthorised access

Environmental Risks:

- Pollution to watercourse and groundwater
- Damage to existing trees and hedgerows

UTILITY SERVICES INVESTIGATION GAUGE TO PAS 128

TYPE D	TYPE C	TYPE B	TYPE A
TYPE D: DESK STUDY	TYPE C: DESK STUDY WITH SITE RECONNAISSANCE	TYPE B: DESK STUDY, SITE RECONNAISSANCE AND DETECTION SURVEY	TYPE A: DESK STUDY, SITE RECON, DETECTION SURVEY AND TRIAL HOLES
<XX/XX/XX>	-	-	-

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Rev.	Description	Date	Author	Designer	Checker	Approver
P03	UPDATED FOR REVISED MODELING LEVELS	29/09/26	LG	LG	JP	JP
P02	DRAWING LAYOUTS UPDATED	26/06/25	LG	LG	LG	JP
P01	PRELIMINARY ISSUE	06/03/25	ES	LG	LG	JP

Document Control

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E: info@jbaconsulting.com
www.jbaconsulting.com
Twitter @JBAConsulting

JBA
consulting

Project Title

Sherborne Road, Burbage

Drawing Title

**General Arrangement
(Overall Layout)**

Parent Model

PIB-JBA-XX-XX-DR-C-0001-GENERAL ARRANGEMENT

Security Classification

OFFICIAL USE ONLY

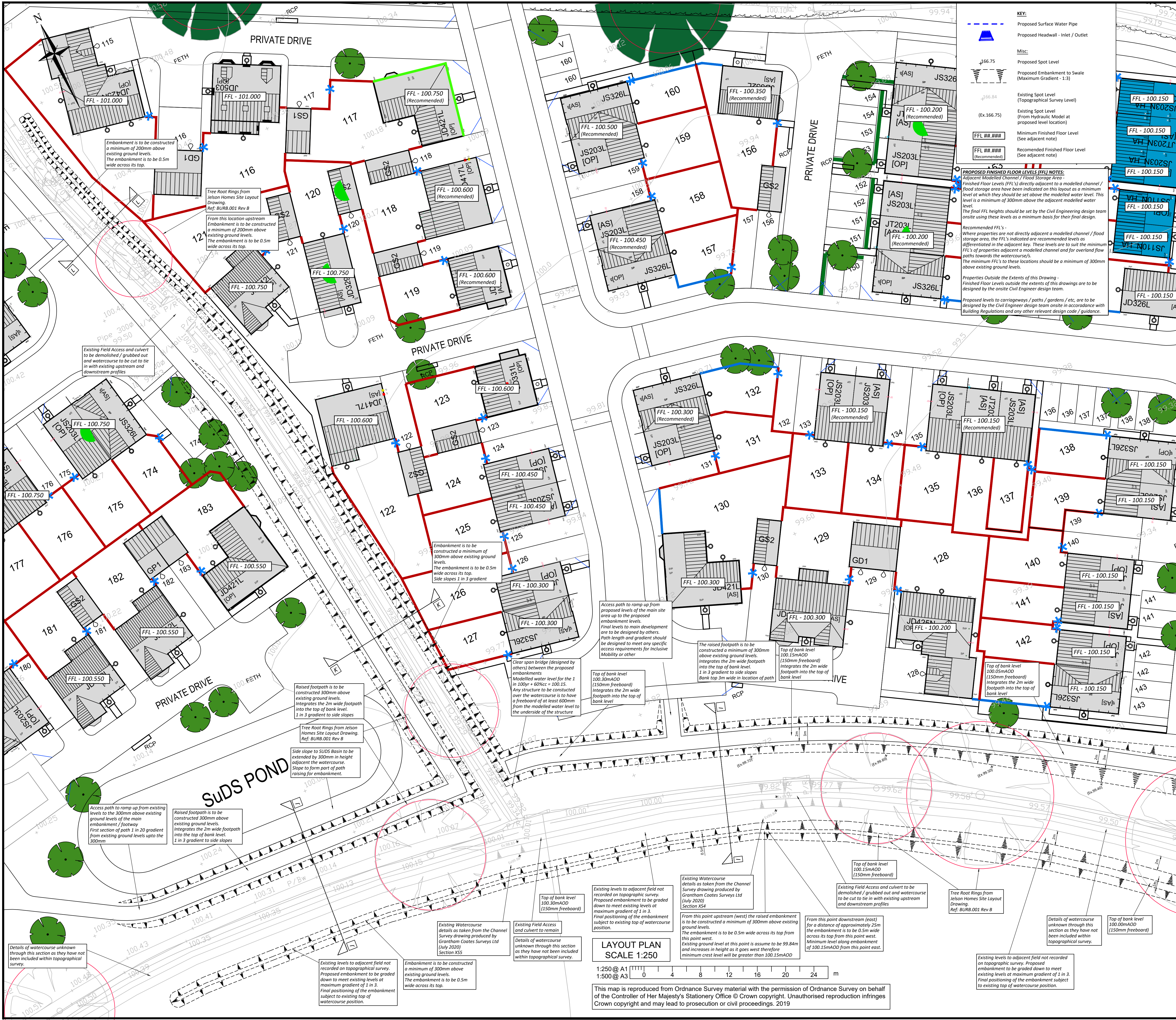
Scale

1:1000 @ A1

Author	Designer	Checker	Approver
ES	LG	LG	JP

Suitability	Information Container	Status	Revision
PRELIMINARY	PIB-JBA-XX-XX-DR-C-0001	S1	P03

A1 Sheet Size



GENERAL NOTES

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- ALL COORDINATES ARE IN METRES RELATIVE TO ORDNANCE SURVEY NATIONAL GRID.
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- ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE SUPERVISOR IMMEDIATELY.
- THIS DRAWING IS BASED ON TOPOGRAPHIC SURVEY REFERENCE 'S3396' BY PHOENIX SURVEY SERVICES LTD DATED APRIL 2013 AND PROPOSED SITE LAYOUT DRAWING NUMBER 'BURB.001' REVISION B, BY JELSON HOMES LTD DATED JANUARY 2025.

DRAWING NOTES

- PROPOSED EMBANKMENT TO BE CONSTRUCTED FROM AS-DUG MATERIAL ON SITE. ANY MATERIAL REUSED FROM SITE SHOULD BE GRADED BY A GEOTECHNICAL ENGINEER TO DETERMINE COMPACTION RATES AND INSTALLATION DEPTHS. COMPACTION OF THE EMBANKMENT TO BE IN ACCORDANCE WITH MCHW SERIES 600. TOP-SOILED AND SEEDED IN ACCORDANCE WITH LANDSCAPE ARCHITECT'S SPECIFICATION. PLEASE SEE DRAWING 0004 TYPICAL SECTION FOR CONSTRUCTION DETAIL FOR EMBANKMENT.
- GROUND DATA MISSING FOR SECTIONS F-L. SPOT LEVELS TAKEN FROM TOPOGRAPHIC SURVEY TO DERIVE CHANNEL DATA AND SOUTHERN MOST EMBANKMENT.
- EXISTING GROUND LEVELS WITHIN PROPOSED FLOOD STORAGE AREA ARE TO BE ADJUSTED TO SMOOTH PROFILE OF EXISTING GROUND IN ACCORDANCE WITH THE HYDRAULIC MODELLING. SEE SETTING OUT INFORMATION FOR PROPOSED LEVELS.

REFERENCE DRAWING SCHEDULE:

- PIB-JBA-XX-XX-DR-C-0001-General Arrangement (Overall Layout)
- PIB-JBA-XX-XX-DR-C-0009-General Arrangement (Sheet 1 of 3)
- PIB-JBA-XX-XX-DR-C-0003-General Arrangement (Sheet 3 of 3)
- PIB-JBA-XX-XX-DR-C-0004-Construction Details
- PIB-JBA-XX-XX-DR-C-0006-Embankment, Sections, Sheet 1 of 3
- PIB-JBA-XX-XX-DR-C-0007-Embankment, Sections, Sheet 2 of 3
- PIB-JBA-XX-XX-DR-C-0008-Embankment, Sections, Sheet 3 of 3

Hazards Summary

Construction and maintenance:

- Working in watercourses. Contractor its to prepare a method statement to ensure operatives are familiar and competent with the dangers of working in watercourses.
- Excavations within existing tree root zones. Contractor is to seek advice from an Arboriculturalist and work to the methodology and requirements set out in the Arboriculturalist's report.
- High groundwater levels. Contractor to undertake necessary work to mitigate against groundwater ingress into excavations.

Public Risks:

- Unauthorised access

Environmental Risks:

- Pollution to watercourse and groundwater
- Damage to existing trees and hedgerows

UTILITY SERVICES INVESTIGATION GAUGE TO PAS 128

TYPE D	TYPE C	TYPE B	TYPE A
XX/XX/XX	XX/XX/XX	XX/XX/XX	XX/XX/XX

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Rev.	Description	Date	Author	Designer	Checker	Approver
P05	UPDATED FOR REVISED MODELING LEVELS	29/09/26	LG	LG	JP	JP
P04	NOTES & DRAWING NUMBER UPDATED	26/06/25	LG	LG	LG	JP
P03	NOTES UPDATED	25/06/25	LG	LG	LG	JP
P02	FINISHED FLOOR LEVELS ADDED	24/06/25	LG	LG	LG	JP
P01	PRELIMINARY ISSUE	03/06/25	ES	LG	LG	JP

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Project Title

Sherborne Road, Burbage

Drawing Title

**General Arrangement
(Sheet 2 of 3)**

Parent Model

PIB-JBA-XX-XX-DR-C-0001-GENERAL ARRANGEMENT

Security Classification	Scale
OFFICIAL USE ONLY	1:250 @ A1

Author	Designer	Checker	Approver
ES	LG	LG	JP

Suitability	Status	Revision
PRELIMINARY	S1	P05

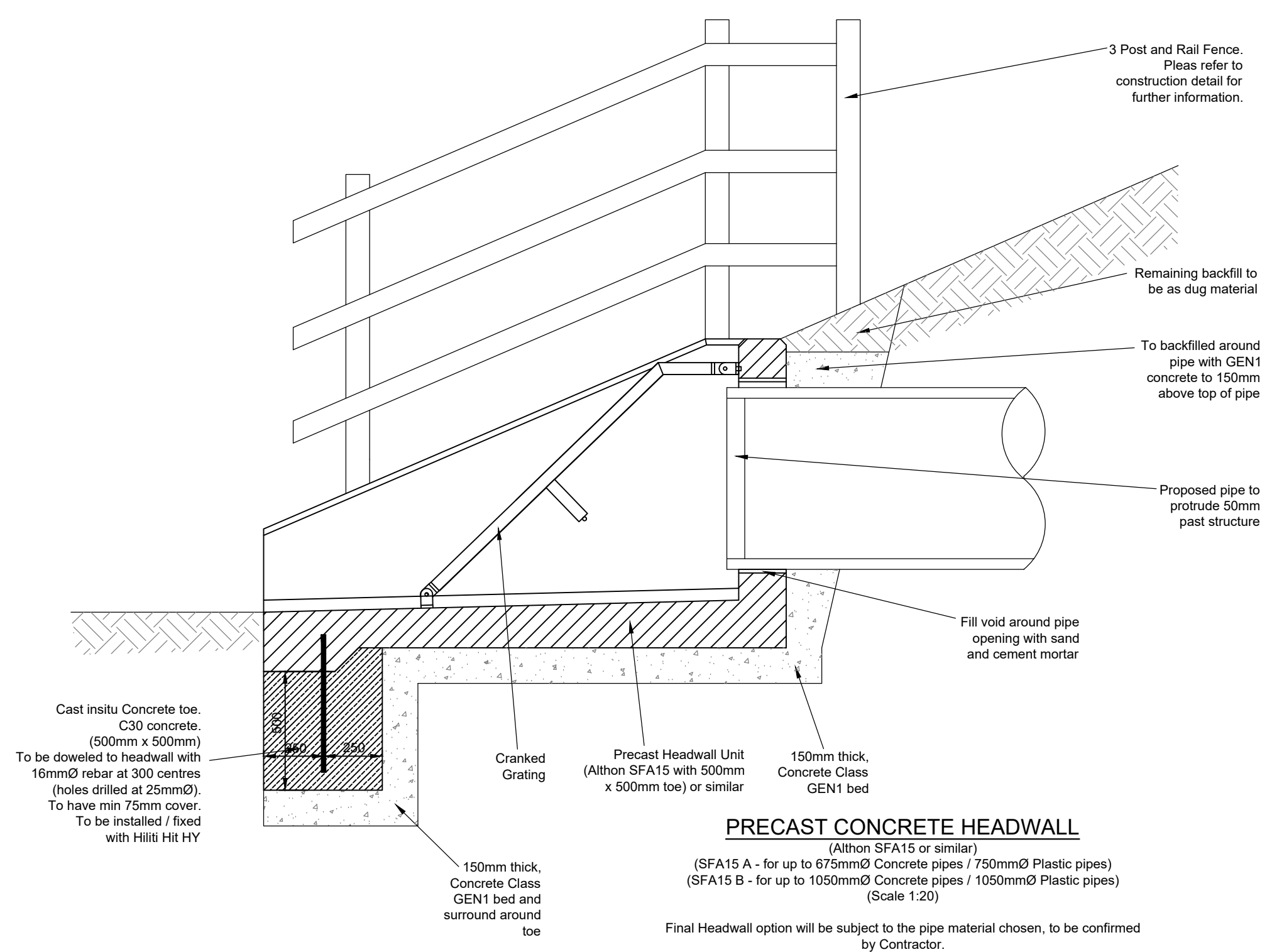
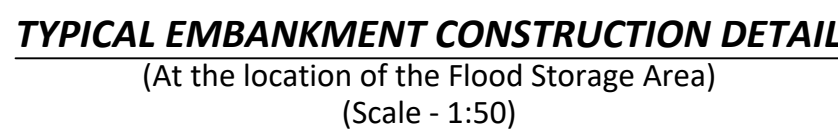
Information Contained

PIB-JBA-XX-XX-DR-C-0002

A1 Sheet Size

**LAYOUT PLAN
SCALE 1:250**

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GENERAL NOTES

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2. ALL COORDINATES ARE IN METRES RELATIVE TO ORDNANCE SURVEY NATIONAL GRID.
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4. ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE SUPERVISOR IMMEDIATELY.

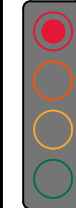
DRAWING NOTES

1. PROPOSED EMBANKMENT TO BE CONSTRUCTED FROM AS-DUG MATERIAL ONSITE. TOP-SOILED AND SEEDED IN ACCORDANCE WITH LANDSCAPE ARCHITECTS SPECIFICATION.
2. GROUND DATA MISSING FOR SECTIONS F-L. SPOT LEVELS TAKEN FROM TOPOGRAPHIC SURVEY TO DERIVE CHANNEL DATA AND SOUTHERMOST EMBANKMENT.
3. EXISTING GROUND LEVELS WITHIN PROPOSED FLOOD STORAGE AREA ARE TO BE ADJUSTED TO SMOOTH PROFILE OF EXISTING GROUND IN ACCORDANCE WITH THE HYDRAULIC MODELLING. SEE SETTING OUT INFORMATION FOR PROPOSED LEVELS.

REFERENCE DRAWING SCHEDULE:

- PIB-JBA-XX-XX-DR-C-0001-General_Arrangement (Overall)
- PIB-JBA-XX-XX-DR-C-0002-General_Arrangement (Sheet 1 of 2)
- PIB-JBA-XX-XX-DR-C-0003-General_Arrangement (Sheet 2 of 2)
- PIB-JBA-XX-XX-DR-C-0006-Embankment_Sections_Sheet_1_of_3
- PIB-JBA-XX-XX-DR-C-0007-Embankment_Sections_Sheet_2_of_3
- PIB-JBA-XX-XX-DR-C-0008-Embankment_Sections_Sheet_3_of_3

UTILITY SERVICES INVESTIGATION GAUGE TO PAS 128



TYPE D: DESK STUDY

TYPE C: DESK STUDY WITH SITE RECONNAISSANCE

TYPE B: DESK STUDY, SITE RECONNAISSANCE AND DETECTION SURVEY

TYPE A: DESK STUDY, SITE RECON, DETECTION SURVEY AND TRIAL HOLES

TYPE D	TYPE C	TYPE B	TYPE A
<XX/XX/XX>	-	-	-

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P02	UPDATED FOR REVISED MODELING LEVELS	29/09/26	LG	LG	JP	JP
P01	PRELIMINARY ISSUE	07/05/25	ES	LG	LG	JP
Rev.	Description	Date	Author	Designer	Checker	Approver

Document Control

Supplier	
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Project Title

Sherborne Road, Burbage

Drawing Title

Construction Details (Section A-A & Headwall Details)



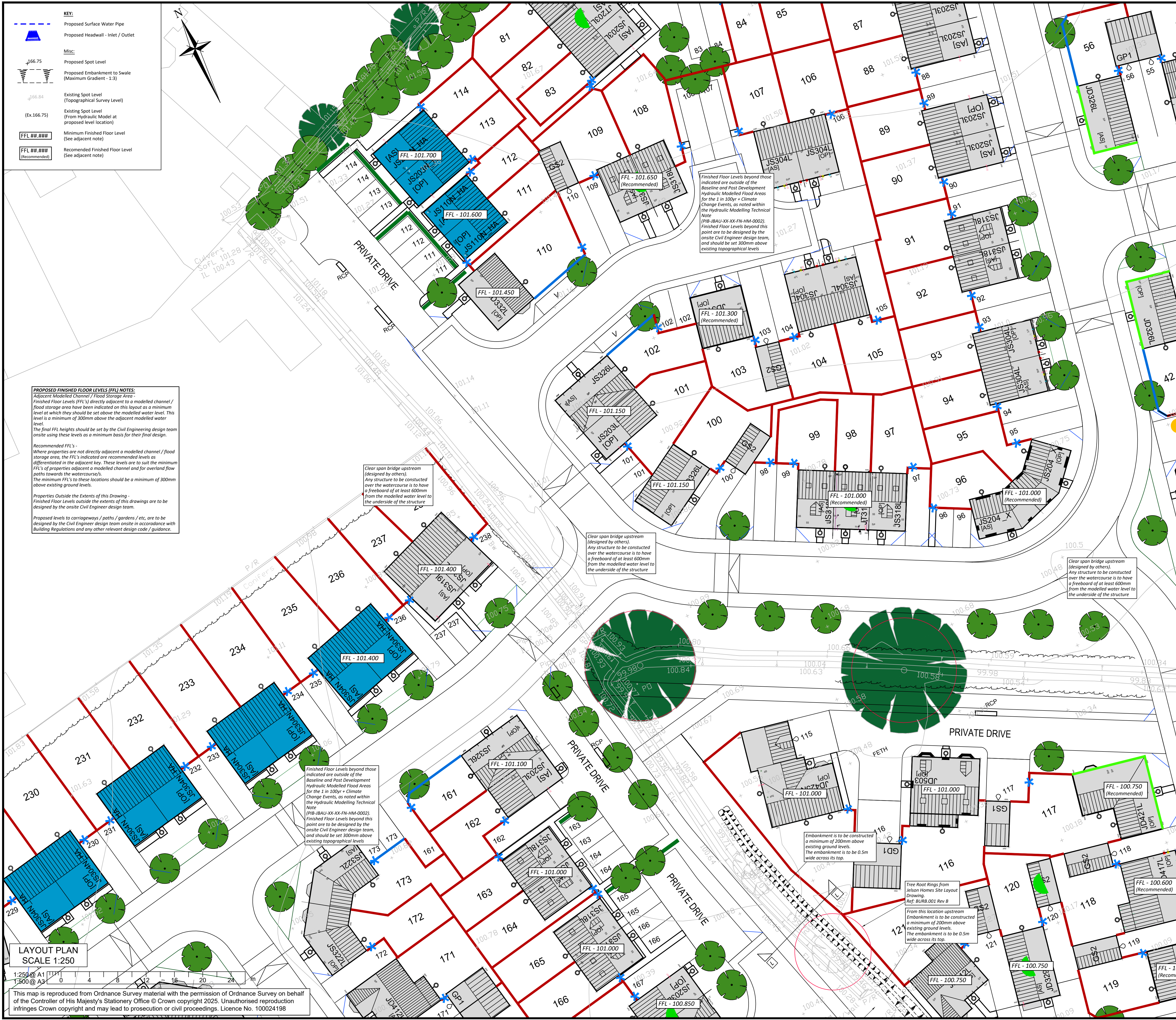
Parent Model

Security Classification OFFICIAL USE ONLY	Scale AS SHOWN
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Author ES	Designer LG	Checker LG	Approver JP
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Suitability	Status	Revision
PRELIMINARY	S1	P02

Information Container	A1 Sheet Size
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KEY:

- Proposed Surface Water Pipe
- Proposed Headwall - Inlet / Outlet
- Misc:
- Proposed Spot Level
- Proposed Embankment to Swale (Maximum Gradient - 1:3)
- Existing Spot Level (Topographical Survey Level)
- Existing Spot Level (From Hydraulic Model at proposed level location)
- (Ex.166.75)
- Minimum Finished Floor Level (See adjacent note)
- Recommended Finished Floor Level (See adjacent note)

PROPOSED FINISHED FLOOR LEVELS (FFL) NOTES:

Adjacent Modelled Channel / Flood Storage Area - Finished Floor Levels (FFLs) directly adjacent to a modelled channel / Flood storage area have been indicated on this layout as a minimum level at which they should be set above the modelled water level. This level is a minimum of 300mm above the adjacent modelled water level.

The final FFL heights should be set by the Civil Engineering design team onsite using these levels as a minimum basis for their final design.

Recommended FFLs -

Where properties are not directly adjacent a modelled channel / flood storage area, the FFLs indicated are recommended levels as differentiated in the adjacent key. These levels are to suit the minimum FFLs of properties adjacent a modelled channel and for overland flow paths towards the watercourse/s.

The minimum FFLs to these locations should be a minimum of 300mm above existing ground levels.

Properties Outside the Extents of this Drawing -

Finished Floor Levels outside the extents of this drawings are to be designed by the onsite Civil Engineer design team.

Proposed levels to carriageways / paths / gardens / etc. are to be designed by the Civil Engineer design team onsite in accordance with Building Regulations and any other relevant design code / guidance.

LAYOUT PLAN
SCALE 1:250

1:250 @ A1
1:500 @ A3

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REFERENCE DRAWING SCHEDULE:

- PIB-JBA-XX-XX-DR-C-0001-General Arrangement (Overall Layout)
- PIB-JBA-XX-XX-DR-C-0002-General Arrangement (Sheet 2 of 3)
- PIB-JBA-XX-XX-DR-C-0003-General Arrangement (Sheet 3 of 3)
- PIB-JBA-XX-XX-DR-C-0004-Construction Details
- PIB-JBA-XX-XX-DR-C-0006-Embankment, Sections, Sheet 1 of 3
- PIB-JBA-XX-XX-DR-C-0007-Embankment, Sections, Sheet 2 of 3
- PIB-JBA-XX-XX-DR-C-0008-Embankment, Sections, Sheet 3 of 3

Hazards Summary

Construction and maintenance :

- Working in watercourses. Contractor its to prepare a method statement to ensure operatives are familiar and competent with the dangers of working in watercourses.
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- High groundwater levels. Contractor to undertake necessary work to mitigate against groundwater ingress into excavations.

Public Risks:

- Unauthorised access

Environmental Risks:

- Pollution to watercourse and groundwater
- Damage to existing trees and hedgerows

UTILITY SERVICES INVESTIGATION GAUGE TO PAS 128

TYPE D: DESK STUDY

TYPE C: DESK STUDY WITH SITE RECONNAISSANCE

TYPE B: DESK STUDY, SITE RECONNAISSANCE AND DETECTION SURVEY

TYPE A: DESK STUDY, SITE RECON, DETECTION SURVEY AND TRIAL HOLES

TYPE D	TYPE C	TYPE B	TYPE A
<XX/XX/XX>	-	-	-

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Rev	Description	Date	Author	Designer	Checker	Approver
P02	UPDATED FOR REVISED MODELING LEVELS	29/09/26	LG	LG	JP	JP
P01	PRELIMINARY ISSUE	26/06/25	ES	LG	LG	JP

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Project Title

Sherborne Road, Burbage

Drawing Title

**General Arrangement
(Sheet 1 of 3)**

Parent Model

PIB-JBA-XX-XX-DR-C-0001-GENERAL ARRANGEMENT

Security Classification	Scale
OFFICIAL USE ONLY	1:250 @ A1

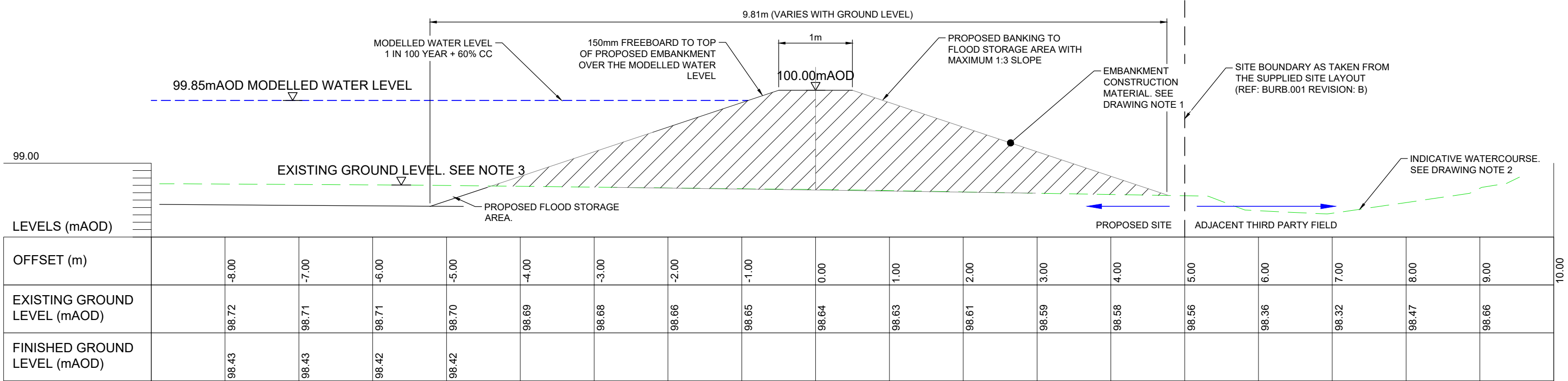
Author	Designer	Checker	Approver
ES	LG	LG	JP

Suitability	Status	Revision
PRELIMINARY	S1	P02

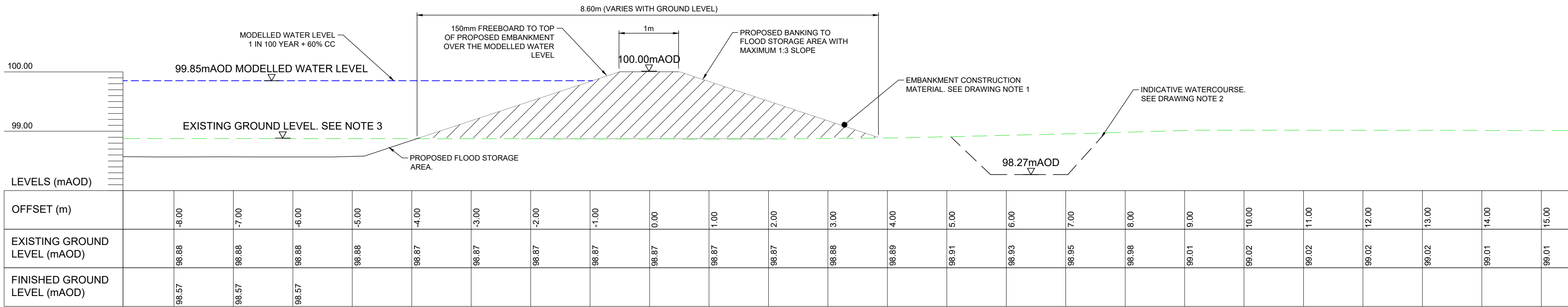
Information Contained

PIB-JBA-XX-XX-DR-C-0009

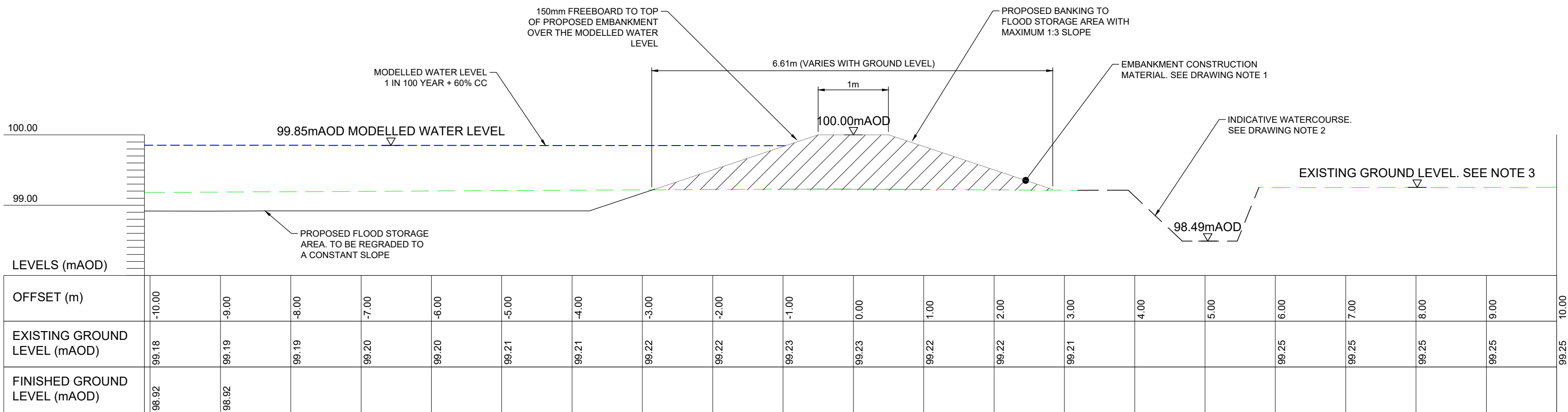
A1 Sheet Size



SECTION B-B



SECTION C-C



SECTION D-D

GENERAL NOTES

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REFERENCE DRAWING SCHEDULE:

- PIB-JBA-XX-XX-DR-C-0001-General_Arrangement (Overall)
- PIB-JBA-XX-XX-DR-C-0002-General_Arrangement (Sheet 1 of 2)
- PIB-JBA-XX-XX-DR-C-0003-General_Arrangement (Sheet 2 of 2)
- PIB-JBA-XX-XX-DR-C-0004-Construction_Details
- PIB-JBA-XX-XX-DR-C-0007-Embankment_Sections_Sheet_2_of_3
- PIB-JBA-XX-XX-DR-C-0008-Embankment_Sections_Sheet_3_of_3

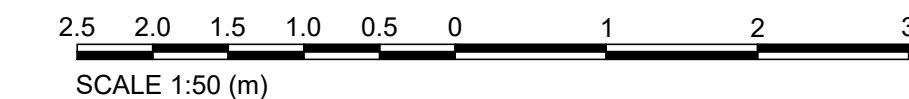
- EMBANKMENT FILL MATERIAL
- EXISTING GROUND LEVELS
- MODELLED WATER LEVEL
- PROPOSED GROUND LEVELS

UTILITY SERVICES INVESTIGATION GAUGE TO PAS 128

- TYPE D: DESK STUDY
- TYPE C: DESK STUDY WITH SITE RECONNAISSANCE
- TYPE B: DESK STUDY, SITE RECONNAISSANCE AND DETECTION SURVEY
- TYPE A: DESK STUDY, SITE RECON, DETECTION SURVEY AND TRIAL HOLES

TYPE D	TYPE C	TYPE B	TYPE A
<XX/XX/XX>	-	-	-

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P02	UPDATED FOR REVISED MODELING LEVELS	29/09/26	LG	LG	JP	JP
P01	PRELIMINARY ISSUE	30/04/25	ES	LG	LG	JP
Rev.	Description	Date	Author	Designer	Checker	Approver

Document Control

Supplier	Kings Chambers 7-8 High Street NEWPORT South Wales NP20 1QU	T: +44 (0)1633 413 514 E: info@jbaconsulting.com www.jbaconsulting.com Twitter @JBAConsulting	JBA consulting
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Project Title

Sherborne Road, Burbage Civils 3D

Drawing Title

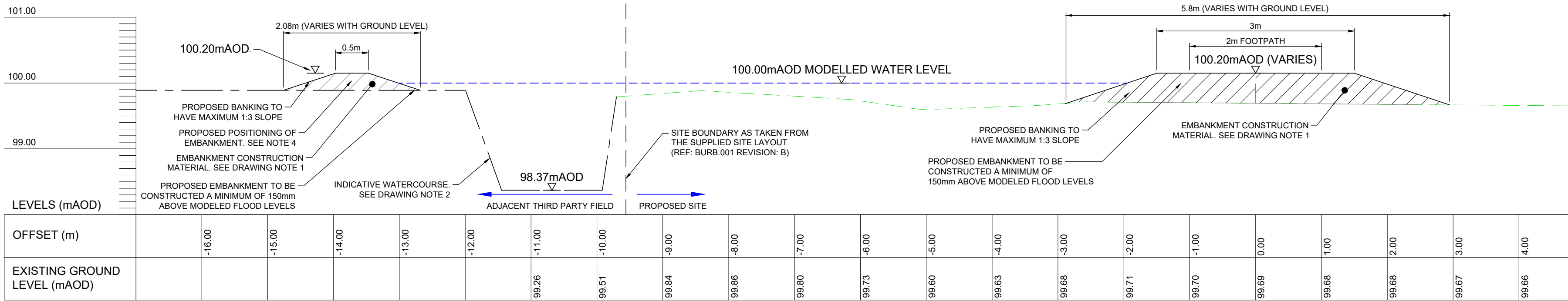
Embankment Sections
Sheet 1 of 3



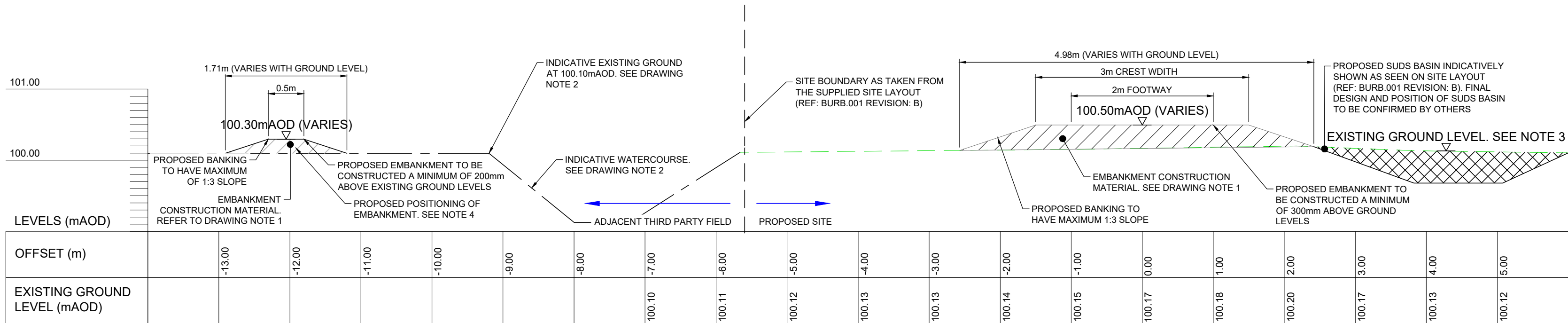
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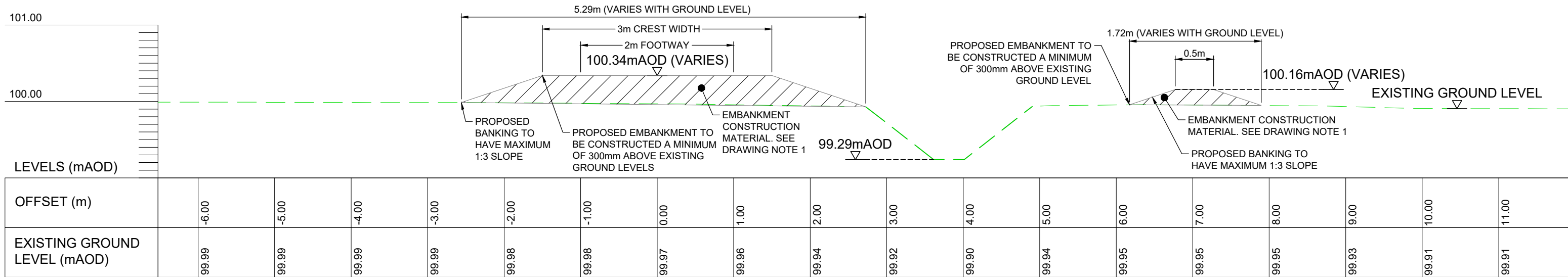
Security Classification	Scale	Author	Designer	Checker	Approver
OFFICIAL USE ONLY	1:50	ES	LG	LG	JP
Suitability	Status	Revision	Information Container		
WORK IN PROGRESS	S1	P02	PIB-JBA-XX-XX-DR-C-0006		



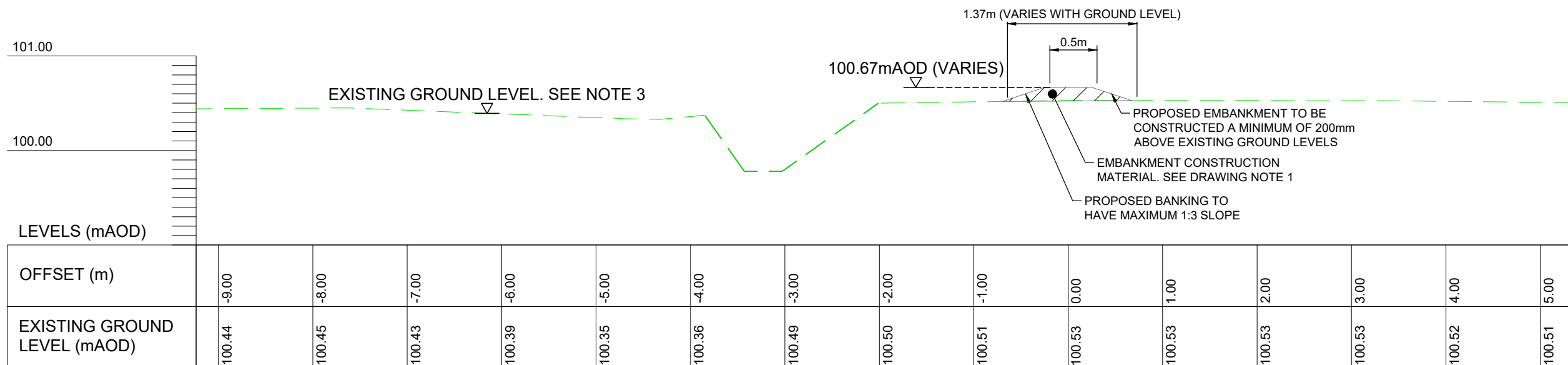
SECTION I-I



SECTION J-J



SECTION K-K



SECTION L-L

GENERAL NOTES

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- SITE BOUNDARY POSITION HAS BEEN BASED ON THE RED LINE BOUNDARY FROM THE SUPPLIED SITE LAYOUT (REF: BURB.001 REVISION: B). THE POSITION OF THE PROPOSED EMBANKMENT IS LOCATED OUTSIDE OF THE RED LINE BOUNDARY. CLIENT IS TO CONFIRM WITH THIRD PARTY LANDOWNER THE POSITION OF THE EMBANKMENT AND UNDERTAKE ANY NECESSARY LEGAL AGREEMENT.

REFERENCE DRAWING SCHEDULE:

- PIB-JBA-XX-XX-DR-C-0001-General_Arrangement (Overall)
- PIB-JBA-XX-XX-DR-C-0002-General_Arrangement (Sheet 1 of 2)
- PIB-JBA-XX-XX-DR-C-0003-General_Arrangement (Sheet 2 of 2)
- PIB-JBA-XX-XX-DR-C-0004-Construction_Details
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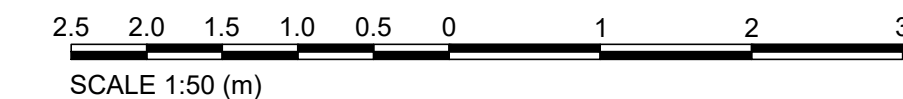
	PROPOSED SUDS BASIN
	EMBANKMENT FILL MATERIAL
	EXISTING GROUND LEVELS
	MODELED WATER LEVEL
	EXISTING GROUND LEVELS (ASSUMED)
	PROPOSED GROUND LEVELS

UTILITY SERVICES INVESTIGATION GAUGE TO PAS 128

	TYPE D: DESK STUDY
	TYPE C: DESK STUDY WITH SITE RECONNAISSANCE
	TYPE B: DESK STUDY, SITE RECONNAISSANCE AND DETECTION SURVEY
	TYPE A: DESK STUDY, SITE RECON, DETECTION SURVEY AND TRIAL HOLES

TYPE D	TYPE C	TYPE B	TYPE A
<XX/XX/XX>	-	-	-

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Rev.	Description	Date	Author	Designer	Checker	Approver
P02	UPDATED FOR REVISED MODELING LEVELS	29/09/26	LG	LG	JP	JP
P01	PRELIMINARY ISSUE	01/05/25	ES	LG	LG	JP

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Project Title	Sherborne Road, Burbage Civils 3D
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Drawing Title	Embankment Sections Sheet 3 of 3
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Jelson

Parent Model					
PIB-JBA-XX-XX-M2-C-0001					
Security Classification			Scale		
OFFICIAL USE ONLY			1:50		
Author		Designer		Checker	
ES		LG		LG	
Approver		JP			
Suitability		Status		Revision	
WORK IN PROGRESS		S1		P02	
Information Container				A1 Sheet Size	
PIB-JBA-XX-XX-DR-C-0008					

Appendix II

Model QA Record

	Sherborne Rd hydraulic model		
Date of model	July 2021		
Name of reviewer	Habtom Gebre		
Date of review	27/06/2023		
Revision	Version1		
Applicable standards or guidance	TUFLOW Manual EA modelling guidance		
Nature of study watercourse/s / constraints	Hydraulic Modelling Study at Sherborne Road, Burbage		
Study objectives	JBA Consulting (JBA) were commissioned by by Avision Young to undertake a hydraulic modelling study to develop an understanding of the flood risk posed from an ordinary watercourse to a proposed residential development site (at Sherborne Road, Burbage, Leicestershire).		
Summary of review	The model review show the baseline and design model has no numerical issues and geometric data were checked found to be consistent with survey data. Model roughness and structural coefficients were checked and found to be acceptable. The 100 year plus 60%climate change were assessed for massblance check and found to be generally acceptable.		

Category	Detail	Prompts	ID	Comment	1st Review		Modeller's Response (if required)
					Suitability	Suggested actions	
Data to be reviewed							
Data to be reviewed	Software	~ Versions	-1	TUFLOW Build: 2020-10-AD-IDP-w64 for baseline and Build: 2023-03-AF-IDP-w64 for design scenario	Minor issue	the same version of the software should be used for both baseline and design scenario	
			-2	ESTRY Build: 2020-10-AD-IDP-w64 and Build: 2023-03-AF-IDP-w64 for design scenario	Minor issue	the same version of the software should be used for both baseline and design scenario	
	AEPs provided / reviewed		-3	Model Versions: CUX_BURBAGE_BL_Q30_4hr_009.tcf CUX_BURBAGE_BL_Q100_4hr_009.tcf CUX_BURBAGE_BL_Q100CC28_4hr_009.tcf CUX_BURBAGE_BL_Q100CC37_4hr_009.tcf CUX_BURBAGE_BL_Q100CC60_4hr_009.tcf CUX_BURBAGE_BL_Q1000_4hr_009.tcf CUX_BURBAGE_Q0030_021 CUX_BURBAGE_Q100CC28_021 CUX_BURBAGE_Q100CC39_021 CUX_BURBAGE_Q100CC60_021 CUX_BURBAGE_Q1000_021	Acceptable	Consider use of scenario management to simplify file manning.	
		-4					
	Scenarios provided / reviewed		-5	Main focus has been on the CUX_BURBAGE_BL_Q100_4hr_009.tcf and CUX_BURBAGE_Q0030_021.tcf for review purposes	Acceptable		
	Reports	~ Reference versions ~ Technical reporting ~ General reporting	-6	CUX-JBAU-XX-XX-RP-A1-C01-BurbageModellingReport_App.pdf and PIB-JBAU-XX-XX-FN-HM-0003_Hydraulic_Modelling_TN_final_with_attachments.pdf	Acceptable		
Reporting							
Reporting	Reporting	~ Objectives ~ Constraints ~ Approach Justification (both model scale and structure scale) ~ Clarity ~ Assumptions ~ Interpretation of results	-7	The report is comprehensive, tells the story of the model development journey for the baseline and options tested, fluvial hazard-to-people rating... variety of results and analysis available.	Data to be reviewed	Data to be reviewed	
			-8				
			-9				
			-10				
			-11				
General comments							
General comments	File organisation / naming convention	~ Scenarios ~ Naming ~ Flags	-12	The file structure follows standard TUFLOW and FMP folders.	Acceptable		
			-13	The naming of the files is consistent and easy to follow.	Acceptable (but does not meet best practice)	Consider use of scenario management to simplify file manning.	
			-14	No flags have been used.	Acceptable		
			-15				
	Survey / topographic data	~ Age ~ Quality ~ Suitability	-16	Grantham Coates Survey (GCS) Ltd was commissioned to collect channel survey data along the ordinary watercourse and the tributary channel in July 2020, collecting a total of 12 cross-sections including structures across the channel and culverted sections of the watercourse. Spot checks on survey data vs cross section data from the .Dat file shows consistency	Acceptable		
			-17	Floodplain topography and model domain were informed by combining site-specific topographic survey data captured by Phoenix Survey Services Ltd in July 2020 (provided by the client) together with LIDAR data (flown in 2017 and obtained from the Open Data website, with a grid resolution of 1m). topography survey data shows within report which makes it hard to read. Report does not mention how these two data sets were combined.	Acceptable		
	Other	~ Any significant missing data	-18	N/A			
	General modelling approach						
General modelling approach	Model extents	~ Domain boundaries ~ Upstream/downstream boundaries ~ Potential downstream influences on water levels ~ Glass walling	-19	1D domain: 1D channel representing the ordinary watercourse starts approx. 190m upstream of the development site. 1D tributary begins at the site, inflows were located at these upstream m nodes. D/S boundary represented as normal slope calculated using the change in elevation with LIDAR around the downstream area of the model.	Acceptable		
			-20	2D domain: The 2D domain has an area of 0.458km2 with a 2m grid resolution. Two HQ lines based on the average slope in the floodplain at the downstream end of the model were used to represent the downstream boundary conditions in the floodplain/2D domain.	Acceptable		
			-21	review the hydrology is done separately. A hydrological assessment was carried out on the unnamed watercourses and tributary to derive flow estimates at the upstream ends of the models. No lateral inflows. This approach is conservative as some of the flow would be expected to run in to the watercourse laterally.	Acceptable		
			-22	Panel markers seem suitable	Acceptable		
	Modelling approach	~ 1D / 2D / Linked ~ georeferenced (xy/gpy/2d links)	-23	1D-2D links.	Acceptable		
			-24	all georeferenced.	Acceptable		
			-25	Flows applied at the top of the ordinary watercourse and tributary on the 1D domain. Approach is suitable for scale and complexity of the area modelled.	Acceptable		

	Application of hydrological estimates	~ Lumped / distributed ~ Applied to 1D or 2D domain ~ Lateral or point inflows ~ Consistency with reporting	-26				
			-27	The hydrology has been considered reviewed elsewhere.			
ESTRY_TUFLOW	Model build	~ Hard bed / soft bed ~ Accuracy of modelled channel length	-27	Hard bed seems to have been used to build the model. No soft bed seems to have been surveyed.	Acceptable		
			-28	Survey long sections correlates well with model length	Acceptable		
	Schematisation	~ Representation of flow paths ~ Representation of storage	-29	Floodplain in the 2D domain - See TUFLOW	Acceptable		
			-30	the updated Storage foot print is checked and is represented as reported in the technical note. represented as a zshape adjacent to watercourse with raised banks.	Acceptable		
	ISIS Health Check	~ Summarise key findings ~ Take care to interpret findings and consider relevance	-31	Model is stable with no negative depths.	Acceptable		
			-32	QT units - seems applied sensibly	Acceptable		
	Boundary conditions	~ Upstream boundary ~ Downstream boundary ~ Phasing of boundary conditions	-33	DSBDY - See comment B-19 and B-20.	Acceptable		
			-34				
			-35				
	Open channel representation	~ Manning's n ~ Panel markers ~ Section spacing ~ Geometry	-36	Roughness value of 0.05 is used for the channel bed and 0.065 for the channel bank	Acceptable		
			-37	Spacing of sections appears sensible.	Acceptable		
			-38	Panel markers applied - seems sensible	Acceptable		
			-39	Spot check with original survey data in the report show channel geometry seems sensible	Acceptable		
			-40				
			-41	Model have few culverts and roughness values seems sensible.	Acceptable		
	Hydraulic structure representation	~ Structure coefficients ~ Bypassing options ~ Choice of model unit ~ Geometry	-42	Spot check show the model geometry appears and matching survey quite well	Acceptable		
			-43				
			-44				
			-45				
			-46				
			-47				
			-48				
	Floodplain representation	~ Suitability of approach ~ Implementation ~ Glass walling	-49	Floodplain area been modelled as TUFLOW model	Acceptable		
			-50				
			-51				
			-52	Output - 300s.	Acceptable		
	Run parameters and output data	~ Results generated ~ Temporal resolution of results ~ Run parameters	-53	Timesstep are acceptable based on 2m grid cell	Acceptable		
			-54				
			-51	Model orientation - NW - SE, in line with the direction of flow.	Acceptable		
	General Schematisation	~ Grid orientation ~ Grid resolution ~ Grid extent ~ Active domain extent ~ Use of water level lines	-52	2m - seems sensible.	Acceptable		
			-53	No glass walling that could affect results at the development site.	Acceptable		
			-54				
			-55				
	Geometry	~ Representation of flow paths ~ Representation of topographic obstructions ~ Other modifications to ground model	-56	Flow paths appear to be sensibly modelled as far as the grid resolution allows.	Acceptable		
			-57	Structures are modelled in 1D except for FSA for optioneering where the ground model was modified adjacent to watercourse to recreate banks	Acceptable		
			-58				
			-59				
	Model parameterisation	~ Schematisation of materials layers ~ Manning's n values ~ Flow constriction layers ~ Storage reduction factors	-60	The materials layer has different material types included based on land use and is suitable for baseline and for the Post Development scenario the same material is used. Its good practice the layer updated for the reflecting the proposed development but is unlikely to make big difference to the overall result in this instance.	Recommendations		
			-61	No flow constriction layers have been used.	Acceptable		
			-62	No storage reduction factors have been used.	Acceptable		
			-63	2d_mat_stability, Burbage_002_R used to modify roughness at tree locations at the interface between the 1D and the 2D domains with values varying between 0.1-0.5. Limited used of patches so considered acceptable practice	Acceptable		
	Representation of buildings		-64	Manning's 'n' of 0.3	Acceptable		
			-65				
	Boundary conditions	~ Locations & Implementation of boundaries ~ Internal boundaries (HX & SX) ~ External boundaries	-66	HX boundaries used for the banks. 'a' Parameter have been modified to 0.1 additional energy (form) loss along the HX line. These typically look well digitised	Acceptable		
			-67	The HX boundaries appear to be match the deactivated XS from FM to within a cell width.			
			-68				
			-69				
			-70				
			-71	No IWL in the model - no water body with in the model extent	Acceptable		
	Initial conditions	~ IWL	-72				
			-73				
	Use of event and scenario controls		-74	Event file used for the running of model. Appears to relate to the naming of results etc.	Acceptable		
			-75				
	Run parameters and output data	~ Results generated ~ Temporal resolution of results ~ PO lines ~ Run parameters	-76	Map Output Interval == 300 Time Series Output Interval == 300 No unusual model run parameters in TUFLOW selected.	Acceptable		
			-77	No PO line added - model is short reach therefore deemed acceptable	Acceptable		
			-78				
Model simulations	~ Model simulation runs ~ Existing (baseline) ~ Climate change ~ Sensitivity ~ Blockage	-106	A range of events and scenarios have been run which are explained in the report	Acceptable			
		-107	Model sensitivity was tested for increases in Manning's roughness, changes to the downstream boundary and flow in the previous submission and is not carried out in this stage	Acceptable			
Model results, interpretation, verification and stability	~ zzd, eof, tf ~ Model warnings and errors ~ Non-convergence ~ Mass balance ~ unsuitable configurations transfer failed	-108	model is stable with no Negative depths	Acceptable			
		-109	2D volume error and final cumulative mass error below +/-1% threshold for most part except at around 2.4hr where this limit was exceeded for short period of time see figure 1in sheet.	Acceptable (but does not meet best practice)			
		-110					
		-111					
		-112					

		- Suitability of sensitivity testing undertaken - Results & interpretation of sensitivity testing	-113				
			-114				
			-115				
	Sensitivity testing		-116	Same as Row 107	Acceptable		
	Calibration / performance		-117	No calibration data was available from the Environment Agency or the Lead Local Flood Authority to support this modelling study. As a result, the model is uncalibrated	Acceptable		