TECHNICAL NOTE

JBA Project Code	2023s0381
Contract	Tunbridge Wells Borough Council Local Plan Support
Client	Tunbridge Wells Borough Council
Version / Date	V1 / September 2023
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Subject	Paddock Wood Streams updated present day and climate change Flood Zone modelling and mapping

1 Introduction

JBA Consulting was commissioned by Tunbridge Wells Borough Council to prepare updated present day and climate change fluvial flood modelling for the Paddock Wood Streams model which produces flood predictions within the parishes of Capel and Paddock Wood. The updated modelling maintained the existing model as its basis, but with targeted updates made to the model geometry (informed by new data) and boundary conditions (rainfall inputs).

The Paddock Wood Streams model predictions contributed to the preparation of Flood Zones for the council's Strategic Flood Risk Assessment[1], and the updated modelling and mapping prepared as part of this project should replace the flood predictions from the Strategic Flood Risk Assessment mapping.

The updated flood modelling and mapping is prepared for the 3.3%, 1% and 0.1% Annual Exceedance Probability (AEP) events, which relate to Flood Zone 3b, Flood Zone 3a, and Flood Zone 2, respectively. No formal flood defences are present within the Paddock Wood Stream model area, and so the no differentiation between defended and undefended scenarios was required. In addition to the events stated above, the 5% AEP event (which formerly informed Flood Zone 3b) was also simulated, as this was an important element of model sense-checking/validation in the previous modelling assessment.

1.1 Climate change allowances

The modelling and mapping is prepared for flow allowances of +27% and +37%, reflecting the Central and Higher central estimates of climate change applicable to the catchment for the 2080s epoch (years 2070-2125) according to the latest guidance[2]. Climate change modelling was available for the 1% AEP event for use in the Strategic Flood Risk Assessment (SFRA), but this reflected the now superseded climate change flow allowances of +35% (Higher central) and +70% (Upper end). The August 2022 updates to the Planning Practice Guidance now introduce a requirement to consider climate change impacts as part of the Sequential Test, necessitating modelling of the 3.3%, 1% and 0.1% AEP events.

1.2 Existing modelling

1.2.1 Previous modelling

The previous Paddock Wood Streams flood modelling and mapping was finalised in December 2018[3], and the model and its predictions were accepted by the Environment Agency for publication in the Flood Map for Planning.

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[1] Tunbridge Wells Borough Council, Level 1 and Level 2 Strategic Flood Risk Assessment, Final Report, July 2019.
[2] Environment Agency, Flood risk assessments: climate change allowances. Last updated 27 May 2022. Available: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[3] JBA Consulting for Tunbridge Wells Borough Council, Paddock Wood flood risk model: Model Operation Manual, December 2018.

This model was used as the basis for the updates made during this project. It is recommended that the reader refers to the previous (2018) model report for a full account of the model and its development. This technical note only covers information relevant to the model updates made and changes in predictions.

2 Modelling approach

2.1 Overview

This section records the updates made to the hydraulic model, and the updated flood mapping derived from the model predictions. Updates, which are described in the sub-sections below, included:

- Use of updated rainfall statistics informing the rainfall hydrology inputs.
- Refinement in model mesh resolution.
- Use of updated LIDAR data to inform ground elevations.

2.2 Boundary conditions: rainfall

Since completion of the 2018 modelling project, updated rainfall statistics have been released which change the rainfall depths that are applicable to the duration and return period of rainfall specified. The updated statistics, from what is known as the FEH22 rainfall model, were released in December 2022 by the UK Centre for Ecology and Hydrology. Updated rainfall inputs to the hydraulic model were prepared using this latest information, obtained from the FEH Web Service[4], and used in the updated flood modelling for Paddock Wood.

Rainfall totals for the 3.75-hour duration rainfall event (which was the critical duration rainfall used in the previous assessment and which remains the critical duration in the updated model) were compared between the FEH22 statistics and those used in the previous modelling (based on the FEH99 rainfall model). This comparison indicates the following changes in rainfall totals for the Tudeley Brook catchment close to Paddock Wood:

- 20-year return period (5% AEP): +7%
- 30-year return period (3.3% AEP): +3%
- 100-year return period (1% AEP): -9%
- 1,000-year return period (0.1% AEP): -27%

It is evident that there are relatively small increases in rainfall depths for the 5% AEP and 3.3% AEP events, while more notable decreases in rainfall depths are noted for the 1% AEP and 0.1% AEP events.

The rainfall totals obtained from the FEH Web Service for the 3.75-hour duration event were converted to rainfall hyetographs using ReFH 2 (version 2.3) software. The

[4] Flood Estimation Handbook Web Service, Available: https://fehweb.ceh.ac.uk.

rainfall, which is applied catchment and model-wide, was prepared using an Areal Reduction Factor [5]of 0.928, and a Seasonal Correction Factor [6]of 0.66.

2.3 Hydraulic model updates

2.3.1 Software version

InfoWorks ICM software version 2021.6.1 was used for the updated modelling.

2.3.2 Mesh resolution

The 2018 modelling 2d Zone mesh has a maximum triangle area of 250m^2 and a minimum element area of 25m^2, which was created using the classic meshing approach. In the southern half of the 2d Zone, upstream of the main urban area, a mesh zone has been used to increase the minimum element area to 50m^2.

The mesh resolution was refined in the urban area so that the maximum triangle area was 25m^2 and the minimum element area was 5m^2, improving the resolution of the model. The mesh zone in the upper catchment was unchanged. For the updated modelling, the clipped meshing approach was used instead of the classic meshing approach so that the mesh produced remains more consistent model-wide if amendments are made to features in the future e.g. as part of any options testing.

2.3.3 Bank and ground levels: LIDAR

The ground level information applied within the model, which informs the elevation of the river bank lines and inline banks, and mesh elements was updated with the latest LIDAR Composite DTM data collected and made available by the Environment Agency on the Defra Data Services Platform. This latest data was collected in November 2018. The previous model data was collected in December 2011 (covering the majority of the model area, including Paddock Wood) and February 2009 (covering a smaller region of the model area, to the east and north of Paddock Wood).

An exception to the use of this data is for some regions close to the railway line within Paddock Wood, where it was identified that the latest LIDAR data had removed (filtered out) high ground associated with the railway station platforms and raised banks west of Maidstone Road. Refer to section 2.3.4 for further details.

Appendix A presents a map which compares the elevations within the latest data with that applied to the previous modelling. Generally, differences in elevations are relatively minor within Paddock Wood. However, elsewhere differences in elevations are more notable, with the latest LIDAR data typically recording higher elevations than the older data.

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[5] Areal Reduction Factor (ARF): this factor is used to convert point rainfall estimates to rainfall estimates which are representative of catchment average rainfall e.g. as required for the Paddock Wood Streams model area.
[6] Season Correction Factor (SCF): this factor is used to convert annual maximum rainfall data to values which are representative of a summer or winter design rainfall conditions. The winter profile rainfall was found to produce greatest extents and depths of flooding within Paddock Wood, and so this was used to inform the selection of SCF.

2.3.4 Elevations applied at Paddock Wood railway line

Inspection of the model mesh elevations identified that higher ground in some locations close to the railway line at Paddock Wood had been removed/filtered from the latest LIDAR data. Thes elevations are quite influential to overland flow routes. To enforce these elevations, a mesh level zone was applied to the model, with elevations applied to the mesh level zone informed by the 2009/2011 LIDAR data. The location of mesh level zones, and elevations at the railway line within the two LIDAR datasets are displayed in Figure 2-1.

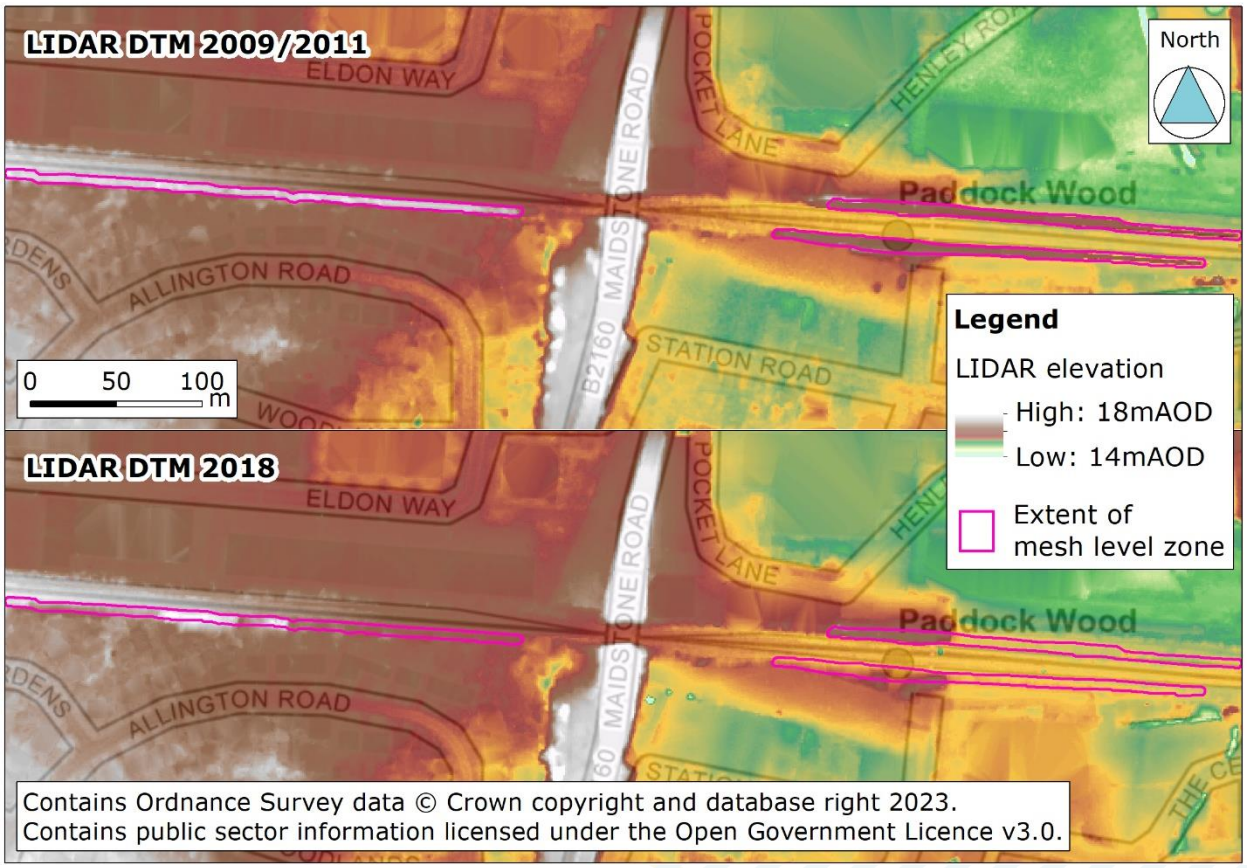


Figure 2-1: LIDAR comparisons at the railway line and location of mesh level zones

2.4 Model proving

The absence of water level or flow monitoring within the Paddock Wood Streams watercourses, in addition to the availability of limited flood history information, impacts the ability to prepare quantitative calibration or verification information as part of a model-proving exercise. No new recorded flood history information has been made available to inform re-assessment of model proving.

During delivery of the previous modelling, agreement on model flood extent predictions largely centred around producing a flood extent south of the railway line in Paddock Wood for the 5% AEP event, which generally agreed with the understanding of the

parties involved in the modelling discussions (from Tunbridge Wells Borough Council, the Environment Agency, Kent County Council and Upper Medway Internal Drainage Board). The flood extent predictions south of the railway line at Paddock Wood for the 5% AEP event in the updated modelling are similar to those of the previous modelling, and so the predictions are considered to remain representative.

2.5 Model simulation names

Table 2-1 lists the InfoWorks ICM model simulation run name for each of the events simulated.

Table 2-1: Final model simulation run names

Event	Simulation run name
5% AEP	M20-225 Winter - Baseline 2023 FEH22_New_MLZ_20yr_Baseflow
3.3% AEP	M30-225 Winter – Baseline 2023 FEH22_New_MLZ_M30-225_30yr_Baseflow
1% AEP	M100-225 Winter – Baseline 2023 FEH22_New_MLZ_M100-225
0.1% AEP	M1000-225 Winter – Baseline 2023 FEH22_New_MLZ_M1000-225+1000yr Baseflow
3.3% AEP +27%	M30-225 +27% Winter - 2023 FEH22_New_MLZ_30yr_Baseflow
3.3% AEP +37%	M30-225 +37% Winter - 2023 FEH22_New_MLZ_30yr_baseflow
1% AEP +27%	M100-225 +27% Winter - Baseline 2023 FEH22_New_MLZ
1% AEP +37%	M100-225 +37% Winter - Baseline 2023 FEH22_New_MLZ
0.1% AEP +27%	M1000-225 +27% Winter - 2023 FEH22_New_MLZ_1000yr_Baseflow
0.1% AEP +37%	M1000-225 +37% Winter - 2023 FEH22_New_MLZ_1000yr_Baseflow

2.6 Mapping

2.6.1 Mapping process

The mapping process used during delivery of the December 2018 Strategic Flood Risk Assessment modelling was maintained. This processing was completed in ArcGIS and the steps required to prepare the mapping extents are provided below:

1 Extracted model mesh elements with flood depths greater than 0.01m and a hazard rating greater than 0.575.

2 Merged all the extracted mesh elements together.

3 Buffered the merged flood extent by 0.01m. This was completed so that individual triangles merge and the triangles intersect bank locations.

4 Merged in the 1D zone from the InfoWorks ICM model. This was completed so that the channel and areas of floodplain wetting are merged.

5 'Exploded' the flood extent so that single part polygons are produced. This was completed to enable independent parts of the flood extents to be selected.

6 Selected only flood extents that intersect the 1D zone from the InfoWorks ICM model or the Detailed River Network (buffered by 0.5m). This step removes flooding that was disconnected from the watercourse (e.g. surface water ponding not related to fluvial flooding). Where surface water flow paths draining into the channel were connected to the river centreline, these were still present at the end of this step.

7 Filled dry islands and remove self-intersections. Following Environment Agency fluvial outline cleaning guidance, any dry islands (areas of dry land completely surrounded by flood water) within the flood extent less than 200m^2 were filled.

2.6.2 Mapped outputs

Appendices B, C and D present the flood extent predictions for the Flood Zone 3b (3.3% AEP), Flood Zone 3a (1% AEP) and Flood Zone 2 (0.1% AEP) conditions, respectively for the present day and with climate change allowances.

The following observations are made when the previous (2018) flood extent outputs are compared with the updated flood extent outputs within the Paddock Wood area for present day events:

General observations

- The finer scale mesh resolution refines the extent of flooding, and generally appears to produce a reduction in areas of flooding, due to the smaller mesh element area, and also refinement of flow routes.

3.3% AEP present day event

- South of the railway line/west of B2160 (Maidstone Road): Generally, a slight reduction in flood extent.
- South of the railway line/east of B2160 (Maidstone Road): Similar extent of flooding, although the extent is larger north of The Shires road, which connects two regions of flooding. Flooding onto the railway line immediately to the east of Maidstone Road is now predicted.
- North of the railway line: Generally a slight reduction in flood extent.

1% AEP present day event

- Typically reductions in the extents of flooding.

0.1% AEP present day event

- Typically reductions in the extents of flooding.

Appendices

A Comparison of elevations within the model area: LIDAR Composite DTM 2020 1m data vs LIDAR used in the 2018 model

North

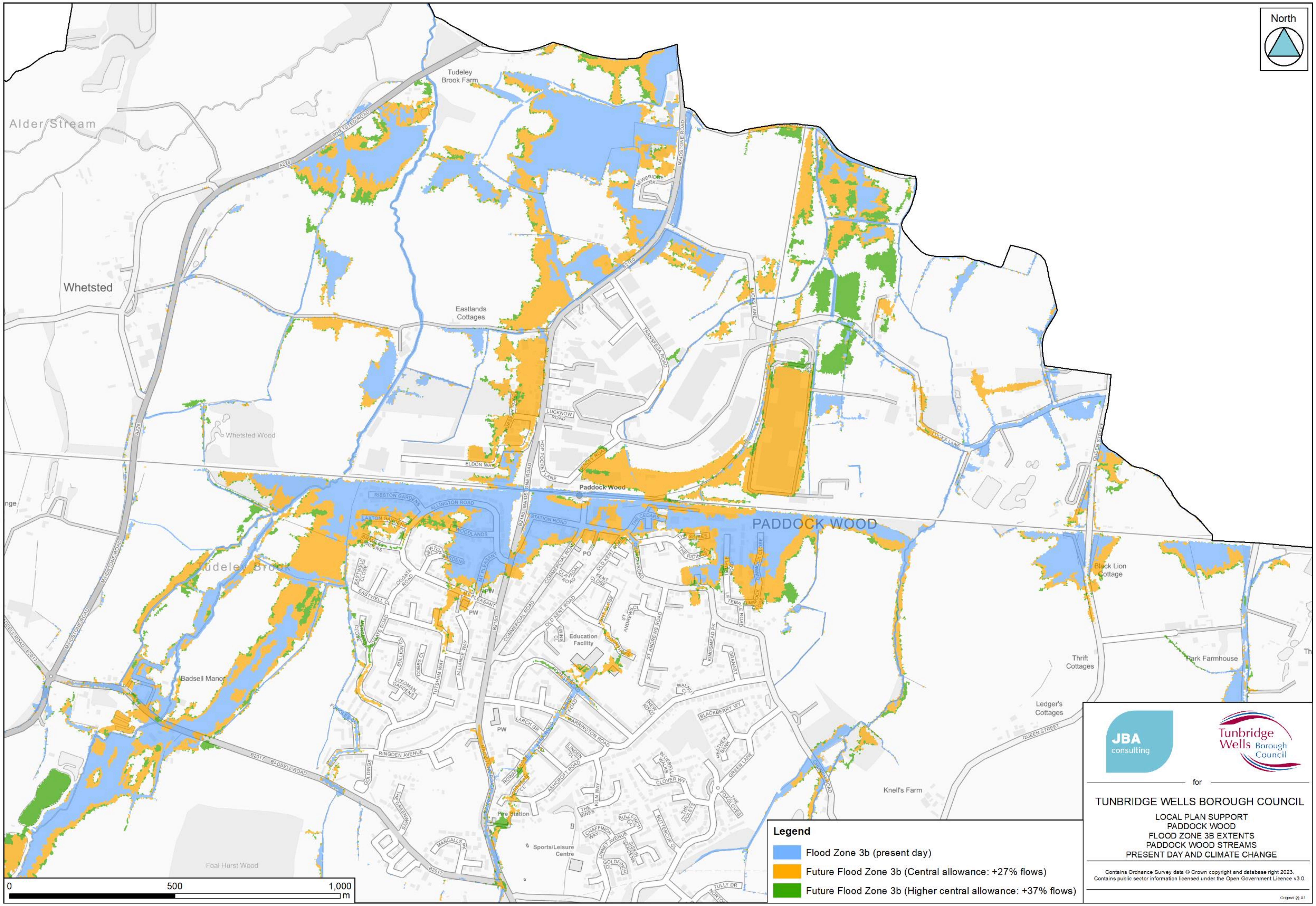
PADDOCK WOOD ICM MODEL
LIDAR DATA
ELEVATION COMPARISONS
2020 COMPOSITE DTM vs EXISTING MODEL

0 250 500 1,000
m

Change in LIDAR elevations
(increase = latest data higher than existing)

- >0.50m decrease
- 0.30m to 0.50m decrease
- 0.20m to 0.30m decrease
- 0.10m to 0.20m decrease
- 0.05m to 0.10m decrease
- 0.05m to 0.10m increase
- 0.10m to 0.20m increase
- 0.20m to 0.30m increase
- 0.30m to 0.50m increase
- >0.50m increase
- Less than ±0.05m change

B Paddock Wood Streams Flood Zone 3b mapping: present day and climate change allowances


North
Alder Stream
Whetsted
Tudeley Brook Farm
Eastlands Cottages
Whetsted Wood
Paddock Wood
PADDOCK WOOD
Tudeley Brook
Badsell Manor
Foal Hurst Wood
Education Facility
Sports/Leisure Centre
Fire Station
Black Lion Cottage
Park Farmhouse
Thrift Cottages
Ledger's Cottages
Knell's Farm
A228
B2160
B2017
MAIDSTONE ROAD
BADSELL ROAD
WHETSTED ROAD
TRANSFESA ROAD
LUCKS LANE
QUEEN STREET
COMMERCIAL ROAD
RINGDEN AVENUE
WARRINGTON ROAD
STATION ROAD
ALLINGTON ROAD
RIBSTON GARDENS
WOODLANDS
EASTWELL CLOSE
LUCKNOW ROAD
HOP POCKET LANE
ELDON WAY
0
500
1,000
m
Legend
Flood Zone 3b (present day)
Future Flood Zone 3b (Central allowance: +27% flows)
Future Flood Zone 3b (Higher central allowance: +37% flows)
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LOCAL PLAN SUPPORT
PADDOCK WOOD
FLOOD ZONE 3B EXTENTS
PADDOCK WOOD STREAMS
PRESENT DAY AND CLIMATE CHANGE
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C Paddock Wood Streams Flood Zone 3a mapping: present day and climate change allowances

North

Alder Stream

Whetsted

Tudeley Brook Farm

Eastlands Cottages

Whetsted Wood

Tudeley Brook

Badsell Manor

Foal Hurst Wood

Paddock Wood

PADDOCK WOOD

Education Facility

Fire Station

Sports/Leisure Centre

Black Lion Cottage

Thrift Cottages

Park Farmhouse

Ledger's Cottages

Knell's Farm

A228

B2160

B2017

WHETSTED ROAD

MAIDSTONE ROAD

BADSELL ROAD

QUEEN STREET

0 500 1,000 m

Legend

- Flood Zone 3a (present day)
- Future Flood Zone 3a (Central allowance: +27% flows)
- Future Flood Zone 3a (Higher central allowance: +37% flows)

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FLOOD ZONE 3A EXTENTS
PADDOCK WOOD STREAMS
PRESENT DAY AND CLIMATE CHANGE

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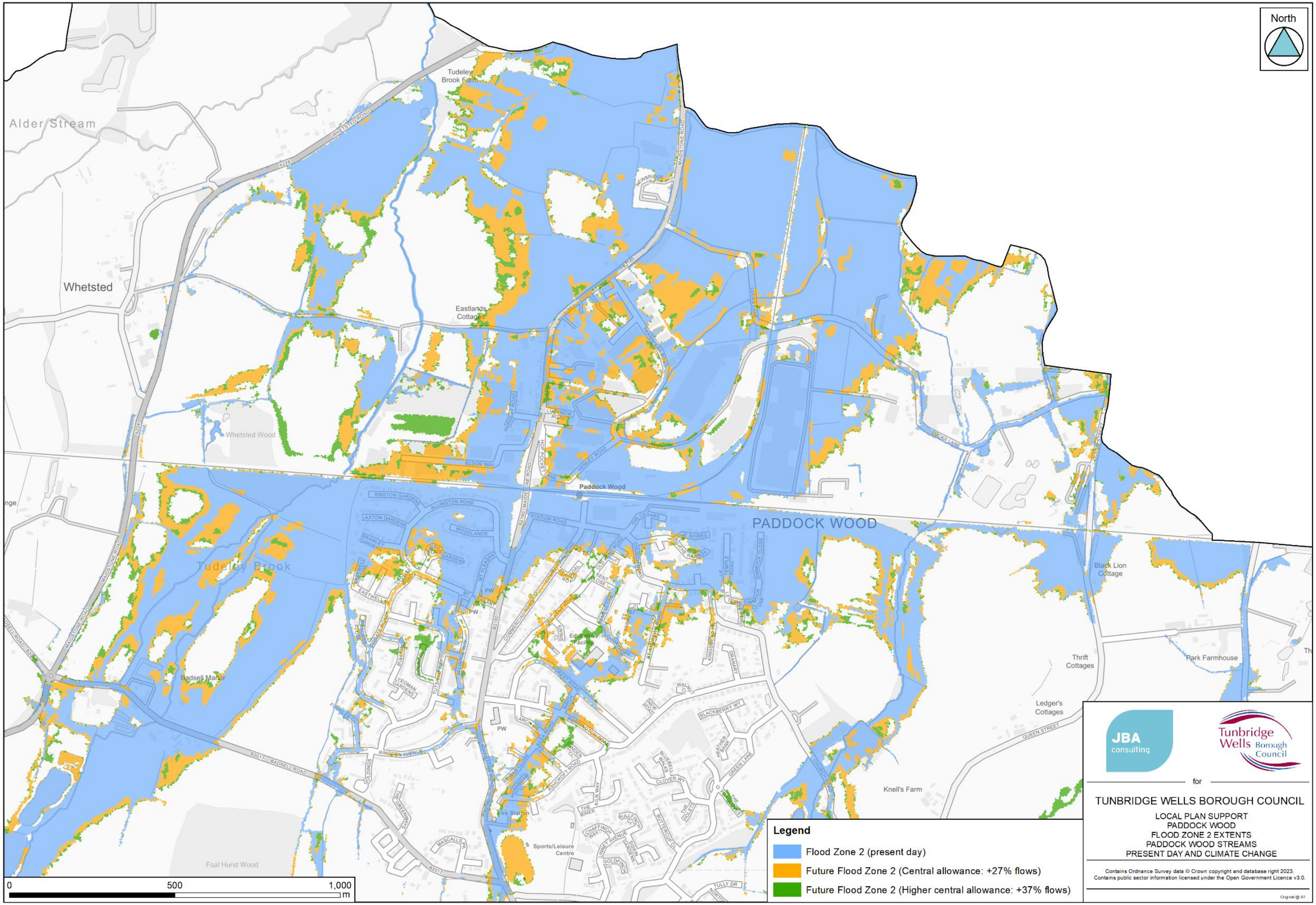
D Paddock Wood Streams Flood Zone 2 mapping: present day and climate change allowances



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FLOOD ZONE 2 EXTENTS
PADDOCK WOOD STREAMS
PRESENT DAY AND CLIMATE CHANGE

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