

Staverton Cereal Factory

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Model Report



Prepared for:

CPUK
Cereal Partners,
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1 Introduction

1.1 Overview



Figure 1-1: Location of the site

Edenvale Young was commissioned by Cereal Partners UK (CPUK) to undertake fluvial hydraulic modelling to investigate local flooding and provide advice and understanding of the flood risk to the existing CPUK factory in Staverton. The site of interest, shown in Figure 1-1-Figure 1-3 is located in Staverton, just north of Trowbridge at 385809, 160941. The site is located at CPUK Staverton, Trowbridge, Wiltshire BA14 6PG.

CPUK requires a more detailed assessment of flood risk at the site, as the current EA mapping is based on JFLOW and shows the site inside Flood Zone 2 and partially inside Flood Zone 3 (See Figure 1-2). To address this, they have appointed Edenvale Young to develop a refined hydraulic model to better understand the extent of flood risk, inform appropriate resistance and resilience measures, and support any future site changes. Figure 1-2 shows the current flood zones.

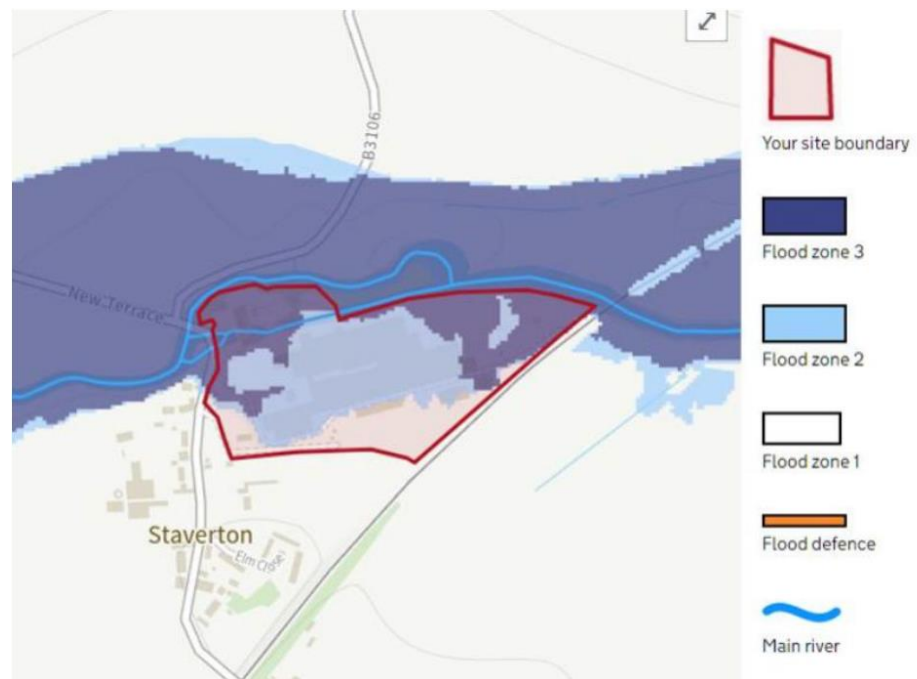


Figure 1-2: Environment Agency Flood Map in the vicinity of the site

The River Avon approaches the site from the east and a weir takes the majority of the water around the north of the site while a shallow leat takes the rest of the water through the site before it reconnects with the main river to the west of the site. At the location of the site, the floodplain for the River Avon primarily falls to the north of the river, on the other side of the channel to the factory.

1.2 Scope and Objectives

The aim of this hydraulic modelling project is to inform the client and provide advice regarding flood risk to the existing CPUK factory and footprint over the next 100 years, including potential mitigation measures:

To achieve the project aims, EVY's scope of works included: -

- Building a 1D-2D fluvial model for the Staverton factory and local River Avon. Figure 1-3 shows the model extents in relation to the location of the site.
- Incorporating the survey data to build the 1D river channel, culverts and establish threshold levels.
- Validating the model against observed flooding at the site.
- Hydraulic modelling reporting.

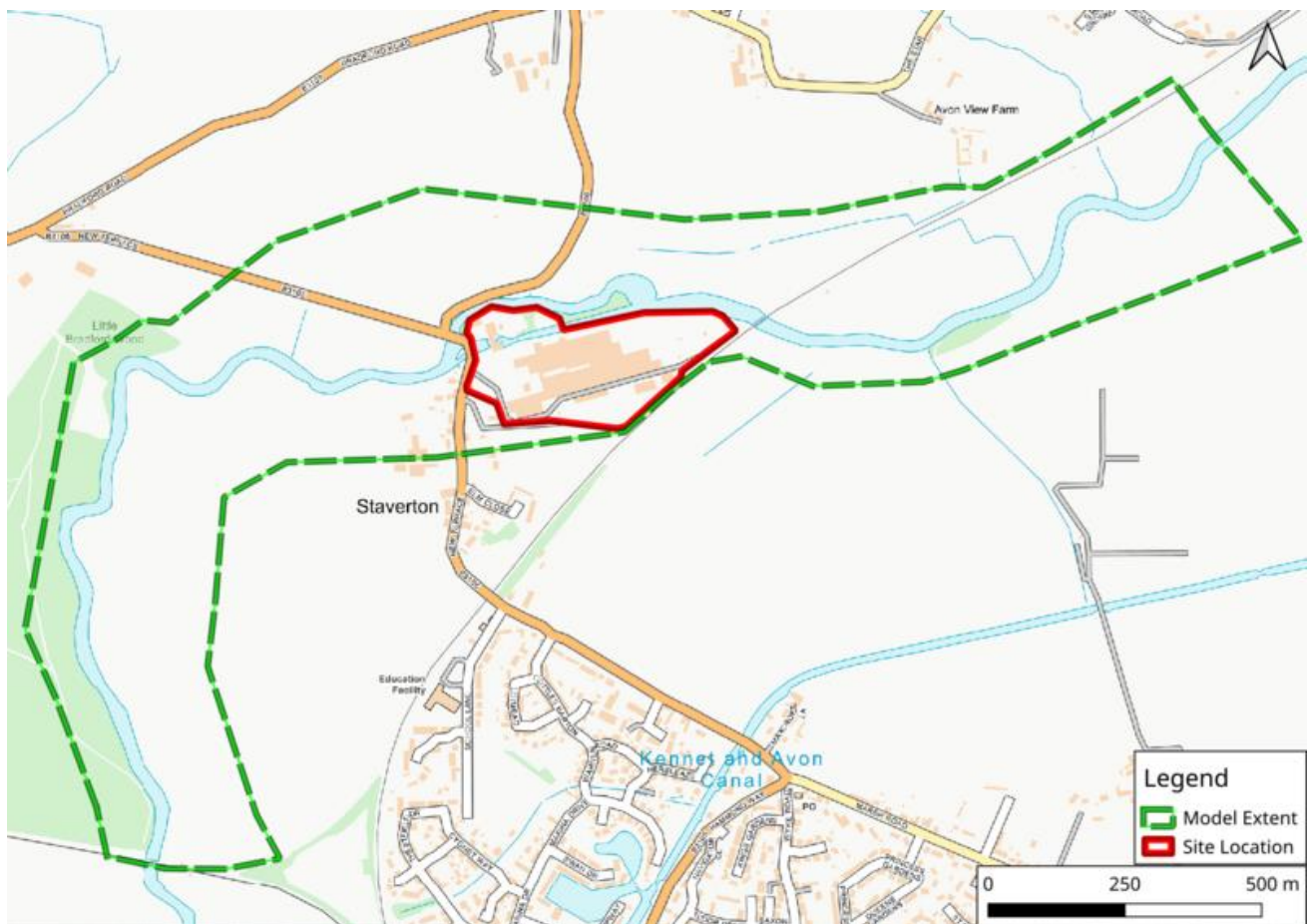


Figure 1-3: Model Extents and location of the CPUK factory in Staverton.

2 Hydraulic Modelling

2.1 Description of the site

The site of interest as shown in Figure 2-1 is adjacent to the River Avon, and is also divided by a large channel called Weston Cut, fed by the River Avon. Weston Cut may have been used in the past for power and other purposes, but no longer has a use to CPUK.

The River Avon is on the North of the site, which incorporates a weir at the northwest of the site to maintain flows through the Weston Cut. Beyond the River Avon is a wide verge, the B3106 and a wide flood plain leading to Holt on high ground. Southeast of the site is a railway line on an embankment, with low-lying fields beyond. The River Avon passes under the railway line at the eastern point of the site.

South of the site the land rises with housing, farms and the railway leading into Trowbridge. West of the site is the B3105 bridging over the River Avon and Weston Cut, the rejoining of Weston Cut and the River Avon, with the village of Staverton and farmland beyond.

The site is therefore located within the flood plain of the River Avon, with fields mainly around the site and Trowbridge to the south.

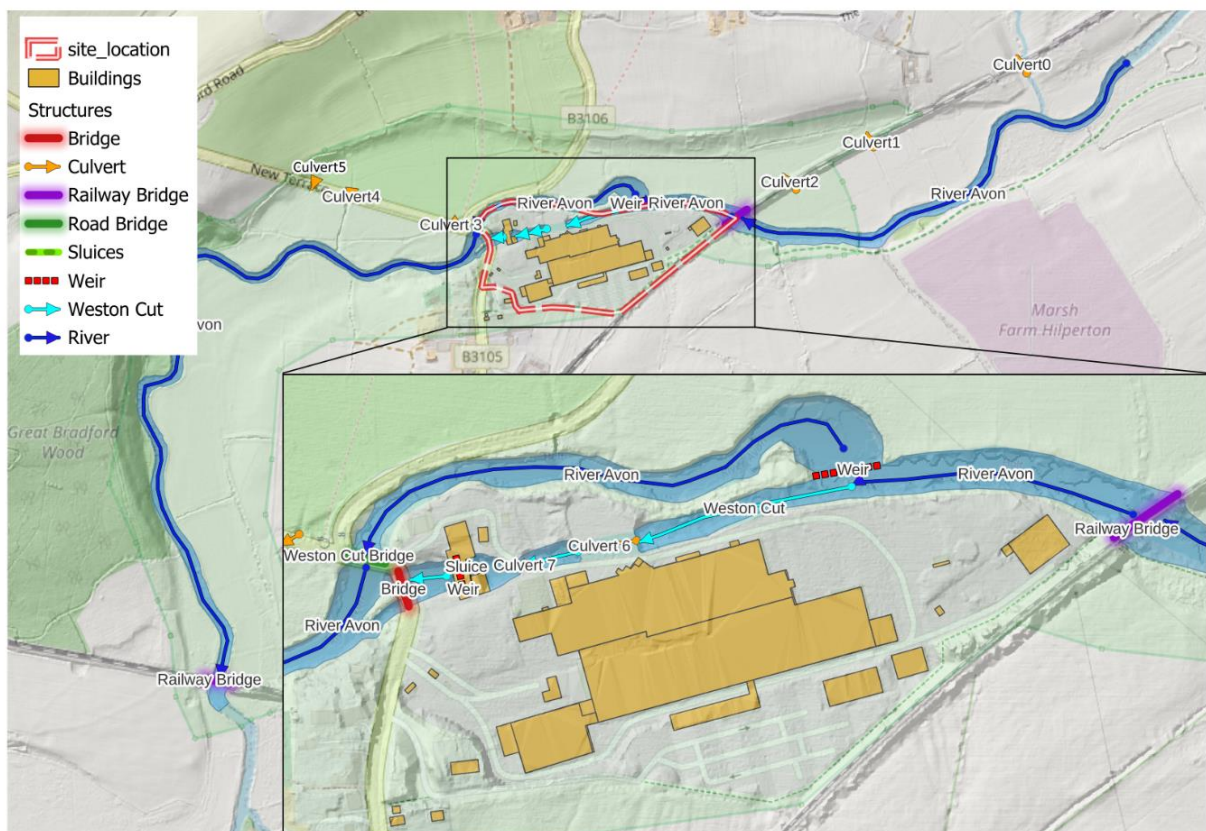


Figure 2-1: Key elements in the site

2.2 Model Build

The model was built as a 1D-2D ESTRY-TUFLOW model and run on the latest version of the software: TUFLOW-2025.0.1. The model boundary followed the River Avon floodplain. Figure 2.1 shows the model extent. The model was run for the following return periods:

- 1 in 20-year event (1% AEP)
- 1 in 100-year event (1% AEP)
- 1 in 100-year event (1% AEP) + 26% climate change allowance
- 1 in 100-year event (1% AEP) + 71% climate change allowance
- 1 in 1000-year event (0.1% AEP)



Figure 2-2: Railway Bridge
Weymouth Line

Survey

Survey of the River Avon was carried out for the purpose of this project, which included cross sections along the River Avon approximately 1km upstream and 1.5km downstream of the site. The relevant culverts, sluices, bridges and weir along the river, the Weston Cut and the floodplains were also surveyed. The locations of the cross sections are shown in Figure 2-4. Threshold levels were also taken as part of the survey and included in the hydraulic model. The survey information is included as Appendix A.



Figure 2-3: Railway Bridge
Wessex Mainline

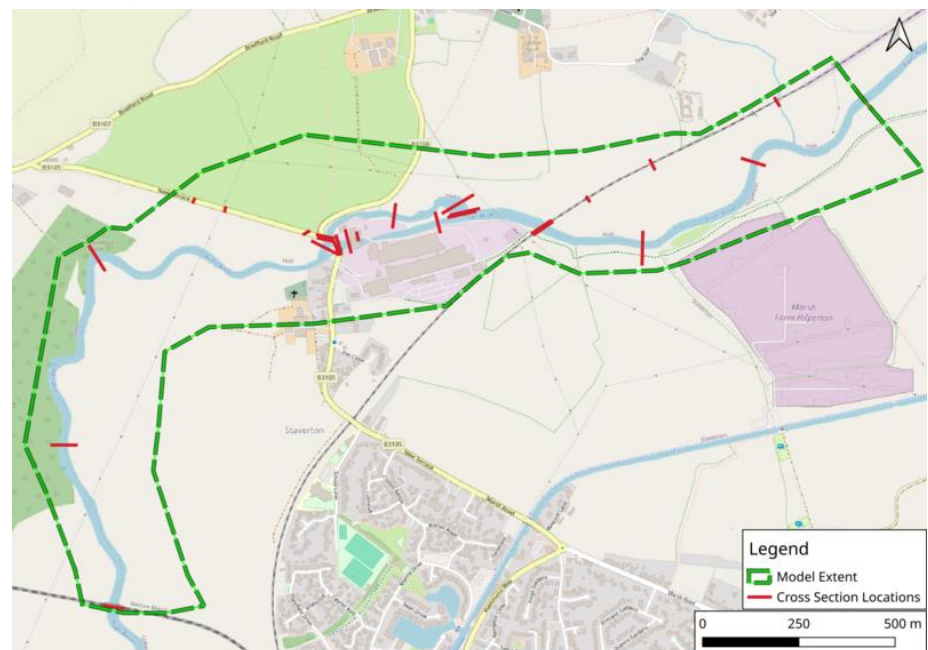


Figure 2-4: Locations of the surveyed cross sections.

Hydraulic Structures

The current model includes 2 railway bridges, the Weymouth Line Bridge located upstream of the site is a multi-span bridge with 4 openings, as shown in Figure 2-2. The second railway bridge is the Wessex Mainline Bridge located in the Lower Avon is a Multi-Span Plate Girder Railway Bridge, as shown in Figure 2-3.



Figure 2-5: Culvert 0, Mason Arch Culvert



Figure 2-6: Culvert 1, Mason Arch Culvert



Figure 2-8: Culvert 2, Mason Arch Culvert

There are 3 culverts under the Weymouth Rail Line embankment, shown in Figure 2-1 and labelled as Culvert 0 (See Figure 2-5), Culvert 1 (See Figure 2-6) and Culvert 2 (Figure 2-8). These structures have been included to convey the flow between the floodplains of the River Avon as Irregular Conduits.

The weir located in the junction between the River Avon and the Weston Cut has been schematised as a WD weir. The coefficients used are representative of a broad crested weir.



Figure 2-7: Weir

Culvert 6 shown in Figure 2-1 has been included in the model as a 15m wide, 2.5m high rectangular conduit with the overtopping represented in 2D.

Culvert 7 shown in Figure 2-1 has been included in the model as a 7.66m wide, 2.0m high rectangular conduit with the overtopping represented in 2D.

The following structures downstream two openings under a building (see Figure 2-9), and shown in the surveyed section in Figure 2-10. Both of these openings have been included as SG ESTRY Units 4.5m wide by 0.76m high and 3.03m wide by 1.49m high.



Figure 2-9: Sluices under building



Figure 2-11: Weston Cut Bridge



Figure 2-12: Road Arch Bridge on the River Avon

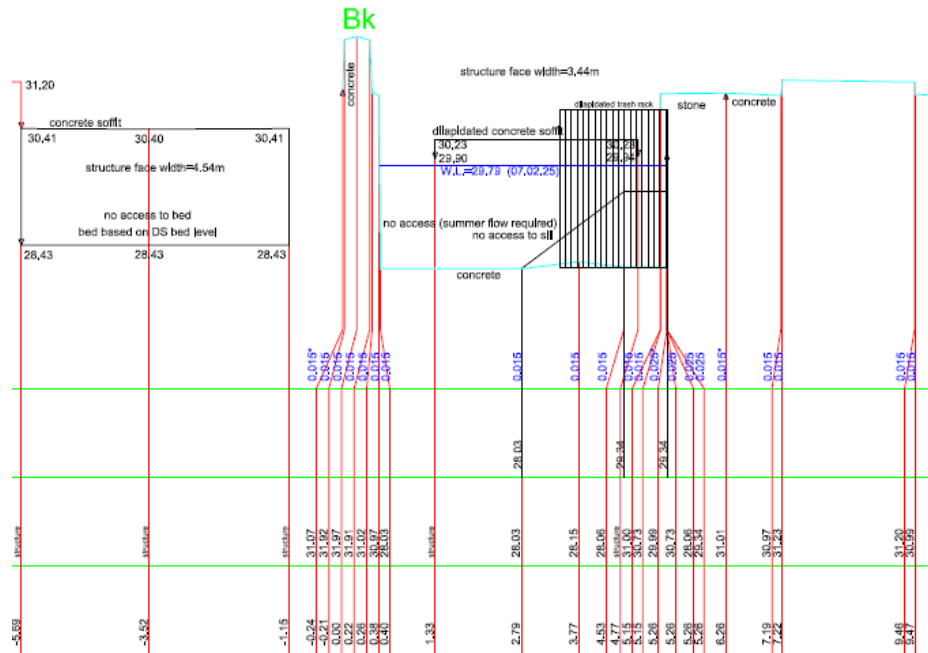


Figure 2-10: Surveyed Section Weston Cute Leat, CS0096

Following downstream is an arch masonry bridge that has been included in the model as ESTRY Irregular Conduits. These two arches are shown in Figure 2-11

There is another section of this bridge on the side of the River Avon. This bridge has been included in the model as 4 Irregular Conduit Units. See Figure 2-12.

Elevation

1m digital terrain model (DTM) 2022 LiDAR data has been obtained from the [Department for Environment, Food and Rural Affairs](#). Figure 2-14 shows the extent of LiDAR used for the hydraulic modelling assessment. The floodplain can be clearly seen in dark blue. The terrain in the model has been defined by the LiDAR data as it is sufficiently recent and of good quality, so no further refinements for the bulk of the terrain were necessary, except for the bridge decks for the road and railway. LiDAR data produces an underlying DTM for each grid cell, which TUFLOW translates into single point elevation. The model was run on a 2m resolution grid.

Z-shapes were used to model the buildings. These z-shape regions were set at the threshold levels surveyed. The threshold levels are shown in Figure 2-13.

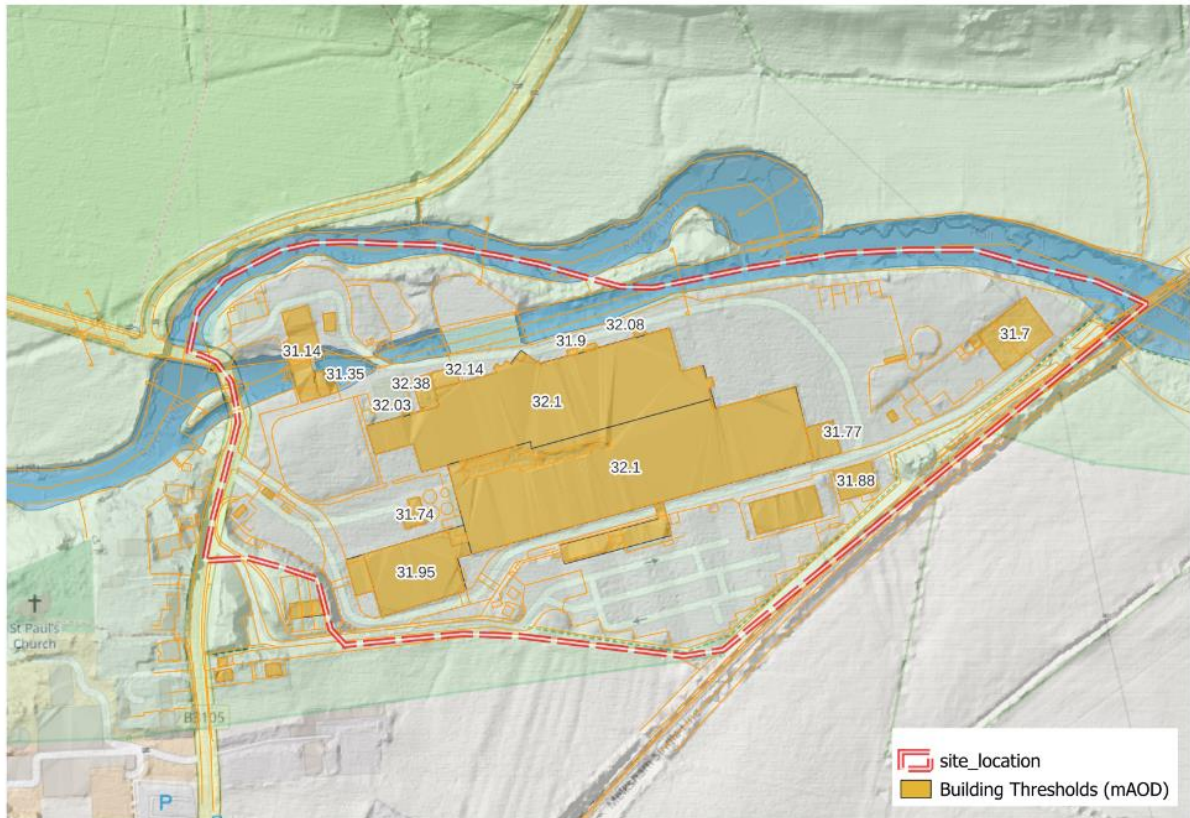


Figure 2-13: Building threshold levels

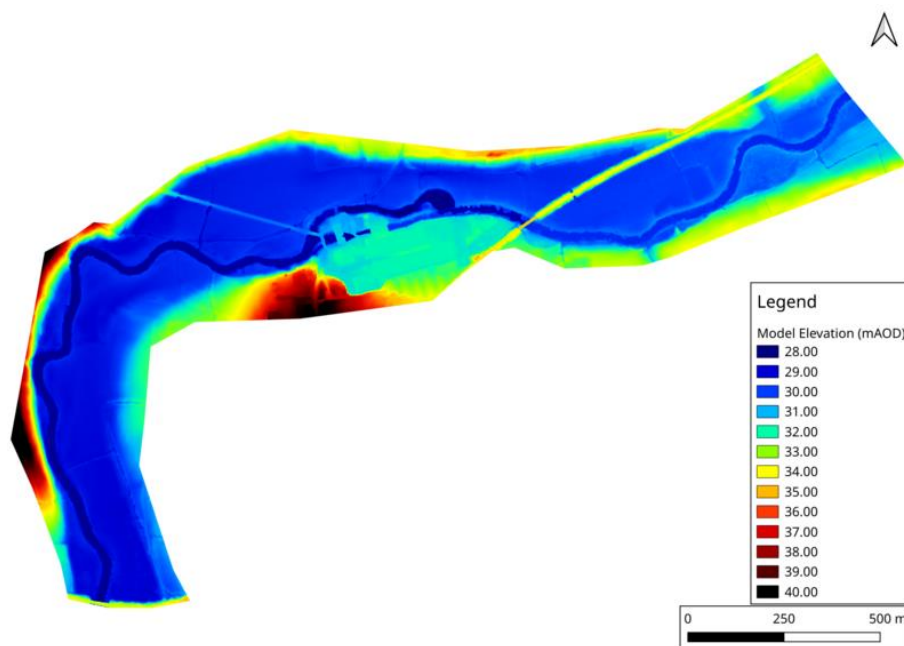


Figure 2-14: LiDAR elevations within the hydraulic model extent.

Materials

In hydraulic modelling, the material specifies the hydraulic roughness of the terrain (energy lost due to friction) in addition to the fraction of the ground surface which is considered to be impervious to infiltration. The hydraulic roughness of a material is commonly measured using the Mannings 'n' parameter.

Manning's 'n' on the 2d floodplain has been spatially assigned using OS Open Map data, with different classes of land being assigned different Manning's 'n' roughness parameters (the industry standard parameterisation of roughness). The values selected are typical values for floodplains in the UK. Manning's 'n' in the 1d channel was determined from the survey which provided the materials of the river bed. These materials were assigned appropriate Manning's 'n' values.

3 Hydrology

3.1 Overview

This section provides a summary of the hydrological analysis undertaken to derive the hydrological boundaries required as input to the hydraulic model of the River Avon. Design hydrological estimates have been derived for the lumped catchment of the River Avon at NGR 385050 160050. The selected Hydrological Estimation Point (HEP) has been identified at the d/s extent of the hydraulic model and is considered appropriate given the purposes of the study. Design peak flow estimates and hydrographs are required for the following Annual Exceedance Probabilities (% AEPs): 50, 5, 1, and 0.1. In addition, the impact of climate change on flood risk is assessed by applying to the 1%AEP peak flow estimate the 2080s central and upper end allowances for the Avon Bristol and North Somerset Streams Management Catchment. These are equal to, respectively, 26% and 71%, in accordance to current climate change guidance [1]. The catchment boundaries defined on the FEH web service and the selected HEP are shown in figure 3.1 and figure 3.2.

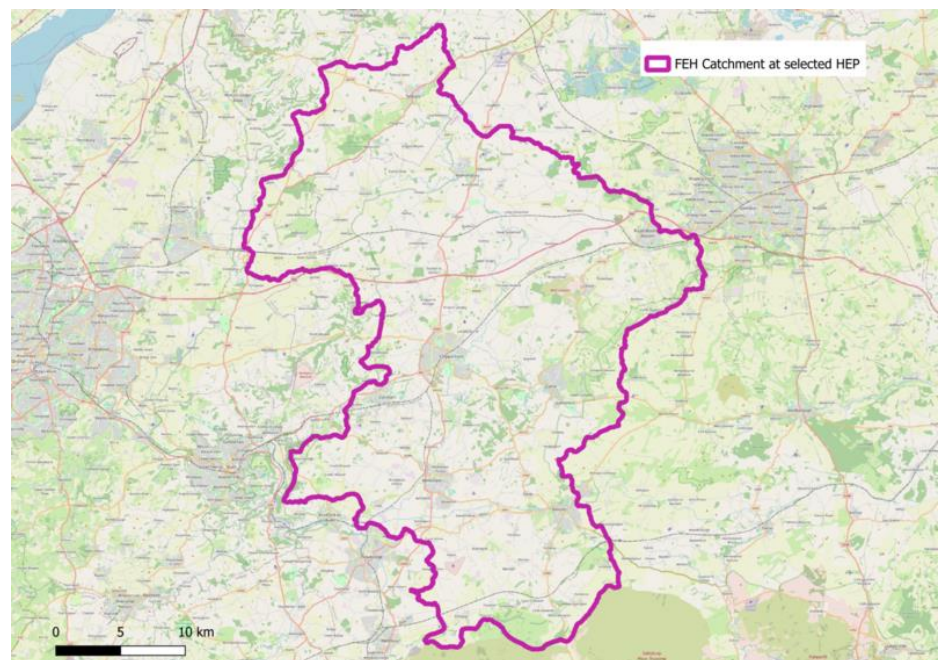


Figure 3-1: River Avon catchment boundaries defined on the FEH web service at the selected HEP.

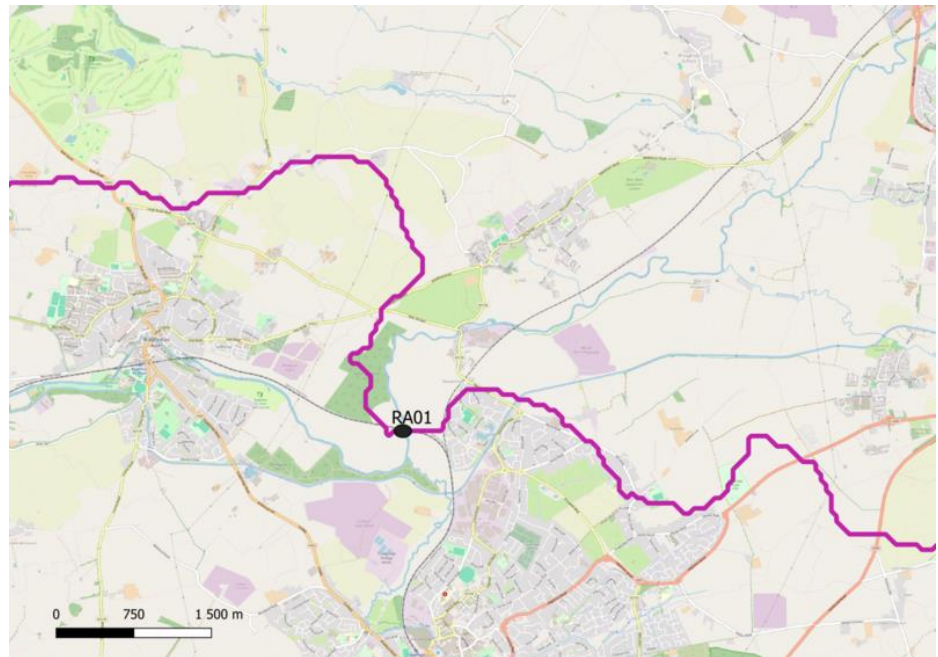


Figure 3-2: Selected HEP (RA01) on the River Avon at the d/s extent of the hydraulic model.

3.2 FEH Analysis

Catchment Descriptors

A selection of catchment descriptors at the HEP identified for the purposes of this study is detailed in 3.1. URBEXT2025 is the default URBEXT2000 value updated to present day using the national average Urban Expansion Factor (UEF) according to current FEH guidelines [2]. The catchment is classified as essentially rural.

HEP	Area(km ²)	BFIHOST19	FARL	SAAR	URBEXT2025
RA01	893.185	0.575	0.99	755	0.0263

Table 3-1: Selection of catchment descriptors at RA01

Q Peak Estimates

The FEH Statistical method and ReFH2 rainfall-runoff approach are both applicable to the subject catchment, according to current flood estimation guidelines¹. Both methods have been applied to derive and compare peak flow estimates for the required AEPs. The ReFH2 approach produces peak flow estimates that are lower than the Statistical estimates for all %AEPs except the 0.2 and 0.1% AEPs. It should be noted that the Statistical method is based on the use of a larger dataset of peak flow records which, due to the catchment being essentially rural, not permeable and not particularly affected by attenuation, can be considered reasonably reliable. In order to reconcile the ReFH2 and FEH Statistical results at %AEPs lower than 1, the following approach has been adopted in order to derive the final peak flow estimates:

- For %AEPs larger than or equal to 1, peak flow estimates are from the FEH Statistical method.
- For %AEPs smaller than 1, the ReFH2 ratio method has been adopted (i.e. the ratio of ReFH2 peak to the 1%AEP ReFH2 peak is multiplied by the 1%AEP FEH Statistical peak).

QMED at RA01 has been derived from catchment descriptors and adjusted by donor transfer and for urbanisation, according to current FEH guidelines [2]. A summary of the QMED estimation process is provided in table 3.2, where:

- DONORS are the NRFA gauges selected for the purposes of the donor adjustment.
- QMED CDS is QMED estimated from catchment descriptors (in m^3/s).
- QMED donor adj is QMED CDS adjusted by donor transfer (in m^3/s).
- Final QMED is QMED donor adj further adjusted for urbanisation (in m^3/s).

HEP	DONORS	QMED CDS	QMED donor adj	Final QMED
RA01	53013 (Marden@Stanley) 53018 (Avon@Bathford) 53028 (By Brook@Middlehill) 53008 (Avon@GreatSomerford) 53023 (Sherston Avon@Fosseway) 53002 (SemingtonBrook@Semington)	78.680	90.131	93.360

Table 3-2: QMED estimation at RA01. All QMED values are in m^3/s .

Statistical Pooled analysis at RA01 has provided growth factors to obtain flows at lower AEPs. The GEV distribution has been selected in order to derive the growth curve as it had the best fit to the pooling group data. The growth curve has also been adjusted for urbanisation following current guidance [2]. A summary of final peak flow estimates is provided in table 3.3.

HEP/%AEP	50	5	1	0.1	1+26%cc	1+71%cc
RA01	93.360	158.884	197.010	323.750	248.233	336.887

Table 3-3: Final design peak flow estimates at RA01 in m^3/s .

Design Hydrographs

A single storm representative of the River Avon at RA01 has been selected to derive a representative hydrograph shape. The recommended storm duration (33 hours), ARF (Area Reduction Factor) and SCF (Seasonal Correction Factor) for the catchment at RA01 have informed the ReFH2 lumped model at this location. Design hydrographs at RA01 have been

obtained by fitting ReFH2 hydrographs to match final peak flow estimates in table 3.3. Final design hydrographs are shown in figure 3.3.

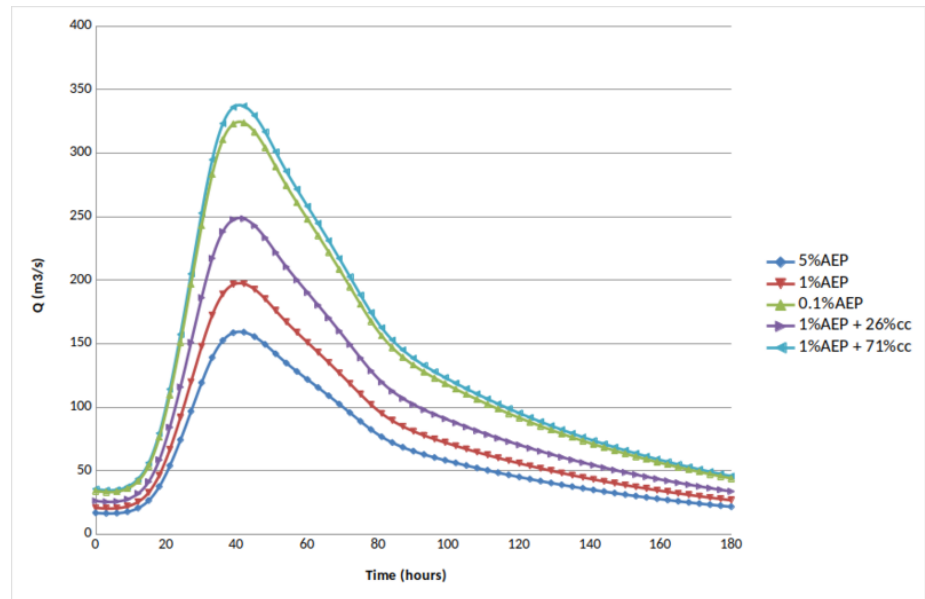


Figure 3-3: Hydrographs showing the calculated flow over different return periods.

Climate Change

Climate change allowances of 26% and 71% were applied to the 1 in 100-year event (1% AEP) in accordance with the central allowance for the 2080s. [UK Centre for Ecology and Hydrology](#).

Appendix B includes the Flood Estimation Report carried out for this analysis.

4 Hydraulic Modelling Results

4.1 Overview



Figure 4-1: Zoomed in area North of the site, 1 in 20-year return period maximum water levels

Earlier phases of this study involved a series of tests aimed at understanding the flood mechanisms at the site. These tests revealed that the majority of flow is conveyed through the floodplains, with the Avon River Channel and the Weston Cut carrying only a relatively small proportion. This finding was not unexpected. Consequently, the dimensions of structures such as sluices, weirs, and bridges have a limited impact on the overall conveyance of flow through the area. Nonetheless, all key structures were surveyed as part of this study to reinforce the reliability of the results.

The latest detailed modelling indicates a significant reduction in flood extents when compared to the JFLOW flood zone outlines.

4.2 Analysis of the results

Water Level Maps are shown in Figure 4-5, Figure 4-6, Figure 4-7, Figure 4-8 and Figure 4-9 for the 1 in 20 year, the 1 in 100 year, the 1 in 100 year plus 26% Climate Change Allowance, the 1 in 100 year plus 71% Climate Change Allowance and the 1 in 1000 year return period respectively.

The largest event tested is the 1 in 100-year return period plus 71% climate change, since, as shown in Table 3-3, it is higher than the 1 in 1000-year return period.

The results show flooding in some locations in the North of the site; however, the flood level does not raise to the threshold level at this location (See Figure 4-1, small clip of Figure 4-5). The 1 in 100 year return period results do not show a large difference in flood extents except for a small area, also in the North of the site (See Figure 4-2 small clip of Figure 4-5). Figure 4-3 (a clip of Figure 4-7) shows how the additional 26% climate change increase in flow floods this area all around the building and then Figure 4-4 (a clip of Figure 4-8) shows this area fully flooded. When the Weston Cut comes out of bank to the North

Figure 4-4 also highlights a couple of instabilities over the road bridge. These are caused by the River Avon overtopping the bridge parapets and flowing across the bridge onto the site. Several iterations of the model were carried out to address this instability. As convergence in this area improved, the flood extents gradually reduced until they stabilised. It is therefore considered that the slight increases in water levels, resulting from convergence issues, will not affect the conclusions of the study.

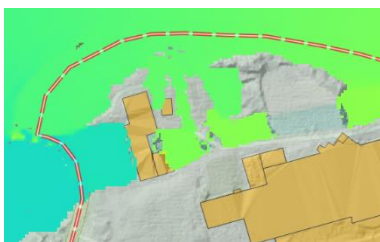


Figure 4-2: Zoomed in area North of the site, 1 in 100-year return period maximum water levels

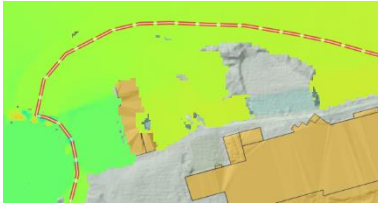


Figure 4-3: Zoomed in area North of the site, 1 in 100-year return period plus 26% Climate Change Allowance maximum water levels

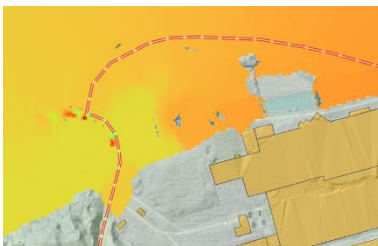


Figure 4-4: Zoomed in area North of the site, 1 in 100-year return period plus 71% Climate Change Allowance maximum water levels

4.3 Calibration/Validation

The model has not been calibrated due to the absence of a flow gauge upstream of the site. However, a general validation was performed by comparing the modelled flood extents for the 1-in-100-year event with observed flooding from November 2025 near the site. The model results generally align with the observed event. Some small areas of flooding captured in photographs were not replicated by the model. These may have been caused by surface water ponding or blocked drainage systems, and no further analysis was undertaken to replicate these localised effects.

4.4 Sensitivity Analysis

Industry standard sensitivity tests have been run on roughness, downstream boundaries and blockage. A $\pm 20\%$ change to the Manning's n roughness coefficient to the 1D channels and the floodplains. Figure 4-11 and Figure 4-10 show difference plots of these results. Red indicates new flooding as a result of the change in roughness; blue indicates flooding removed.

An increase in the roughness coefficients of 20% produces water levels between 0.11m and 0.12m near the site. A reduction of the roughness coefficient of 20% produces a water level reduction between 0.07m and 0.011m near the site. There is localised increase and decrease of flood extents in the edges of the flood extents, as expected.

Downstream boundaries have been analysed increasing and decreasing the normal depth slope by 50%. There is a variation on water levels that increases the water levels in the vicinity of the site of approximately 0.05m when reducing the downstream slope and a lesser reduction when the slope downstream is increased. Changes in the flood extents are negligible and have no impact on the conclusions of this analysis.

Blockage sensitivity was carried out by reducing the width of the 4 arches on the Road Arch Bridge on the River Avon, West of the site. The blockage increased the water levels locally by approximately 0.06m. The model results show a location of instability that increases the water levels in the floodplain erroneously, this instability increases the water levels near the site and causes no changes in the conclusion of the study.

Additional analysis was carried out to analyse the impact of the grid size. A couple of key return period events were run using a 1m grid instead of a 2m grid. This results show that there is no significant impact on reducing the size of the grid.

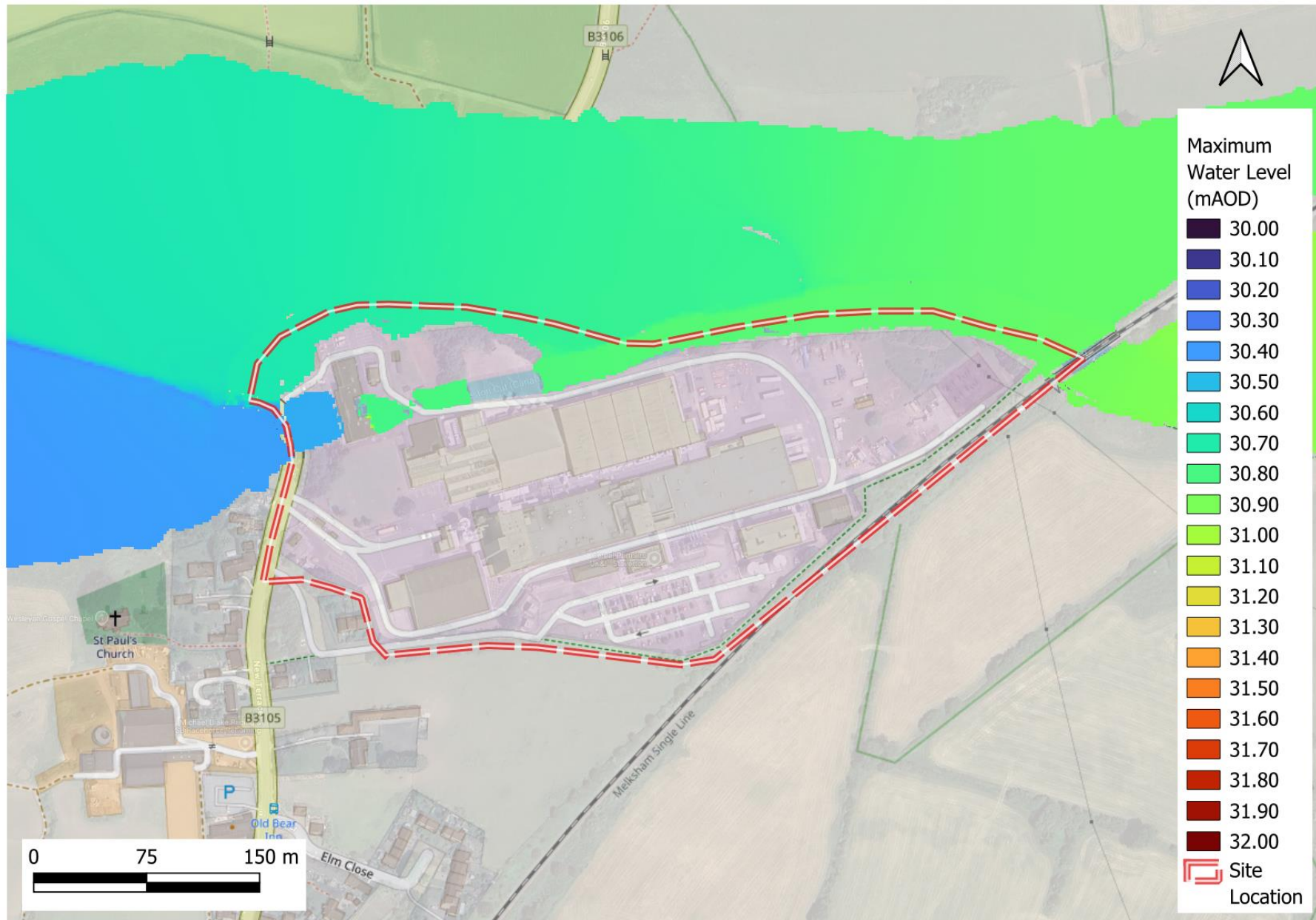


Figure 4-5: Maximum Water Levels 1 in 20-year Return Period

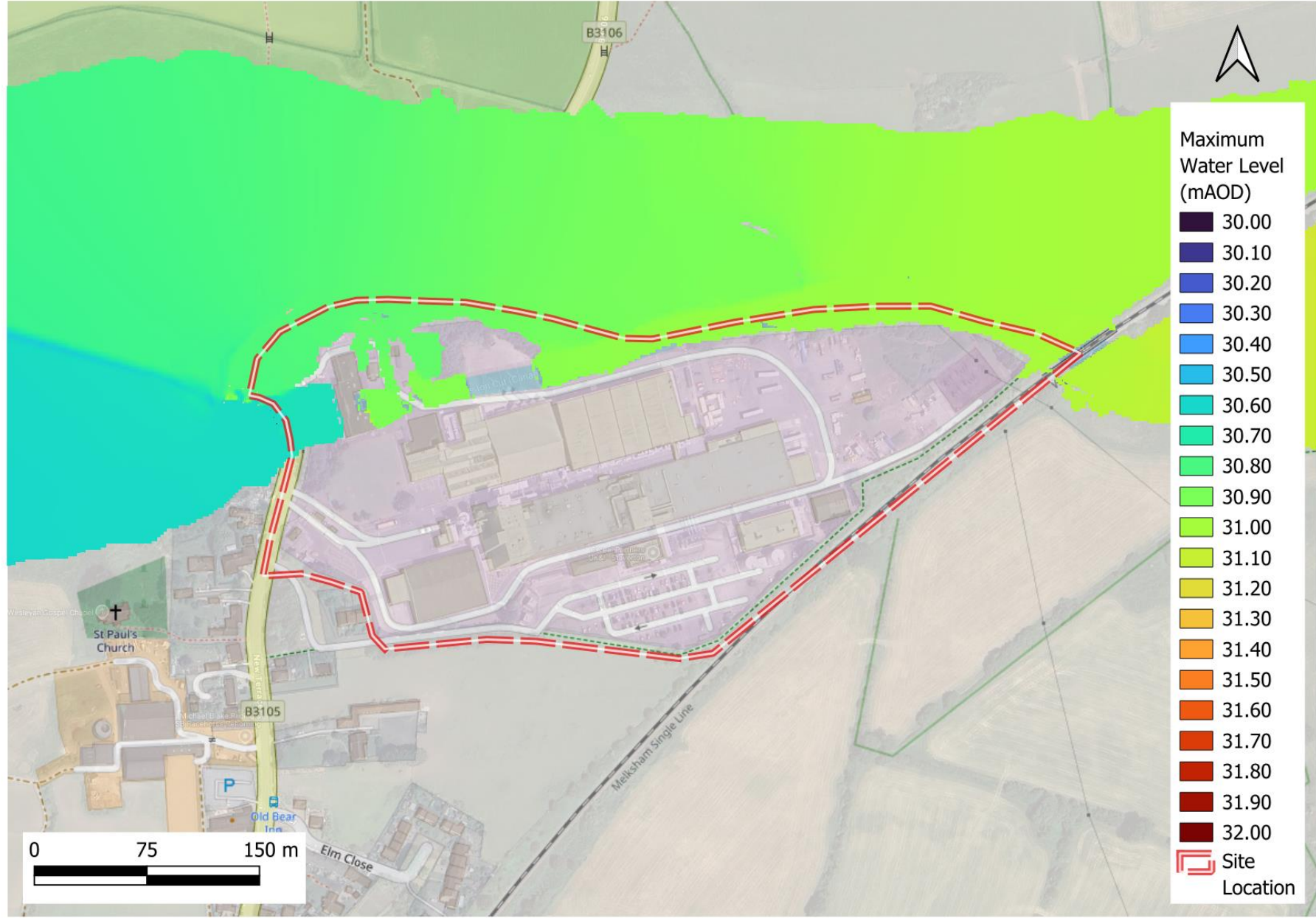


Figure 4-6: Maximum Water Levels 1 in 100-year Return Period

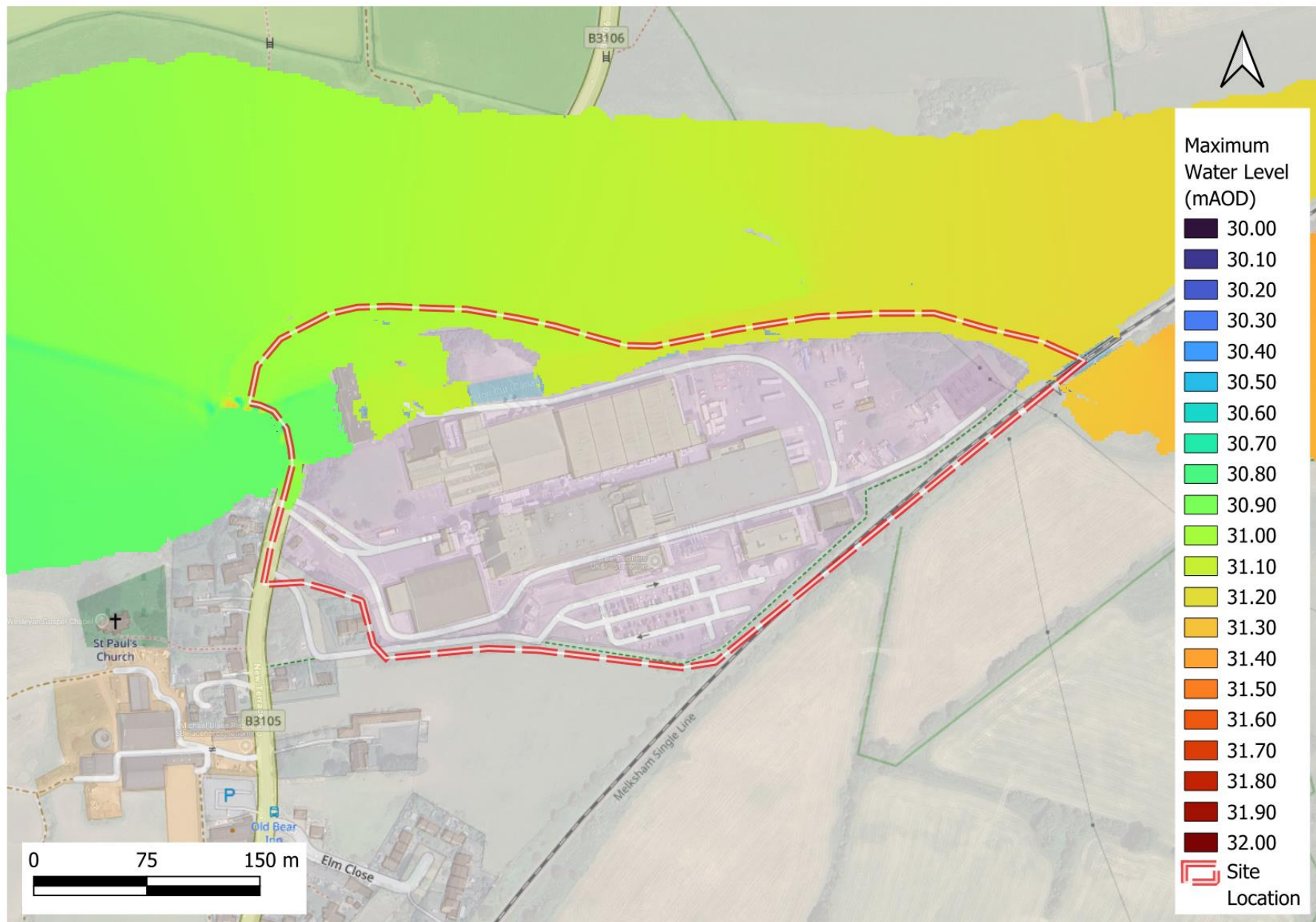


Figure 4-7: Maximum Water Levels 1 in 100-year Return Period plus 26% Climate Change Allowance

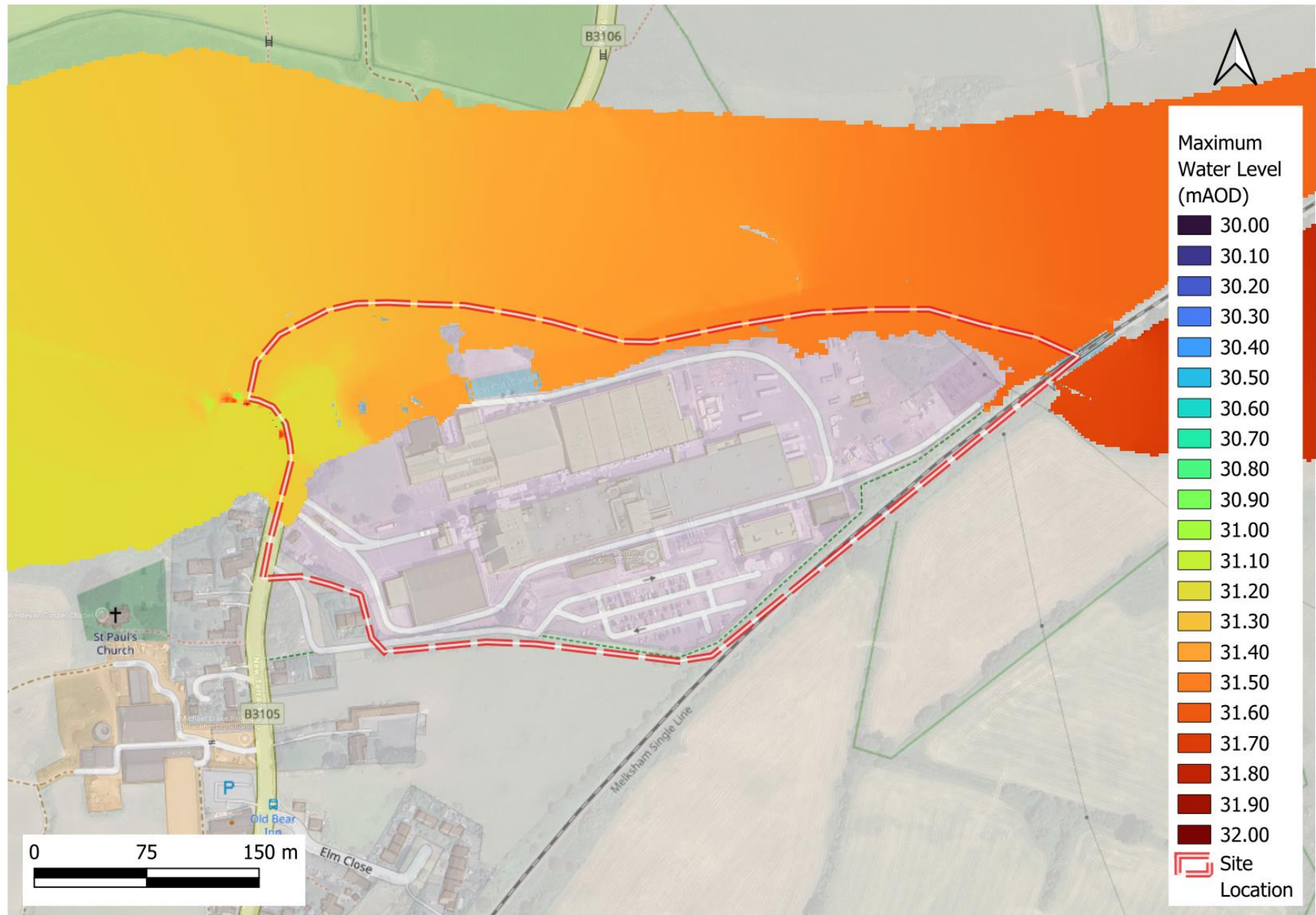


Figure 4-8: Maximum Water Levels 1 in 100-year Return Period plus 71% Climate Change Allowance

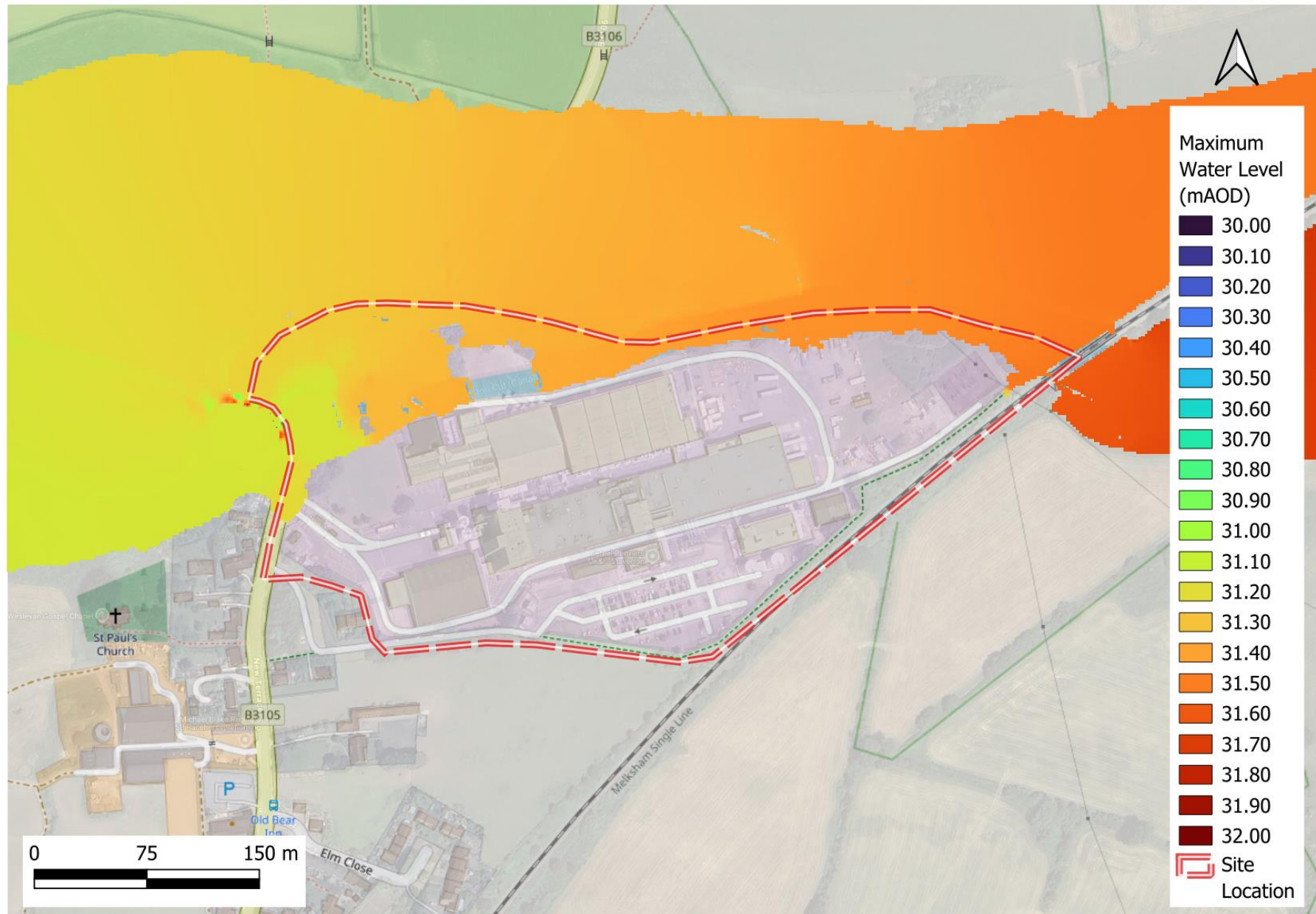


Figure 4-9: Maximum Water Levels 1 in 1000-year Return Period

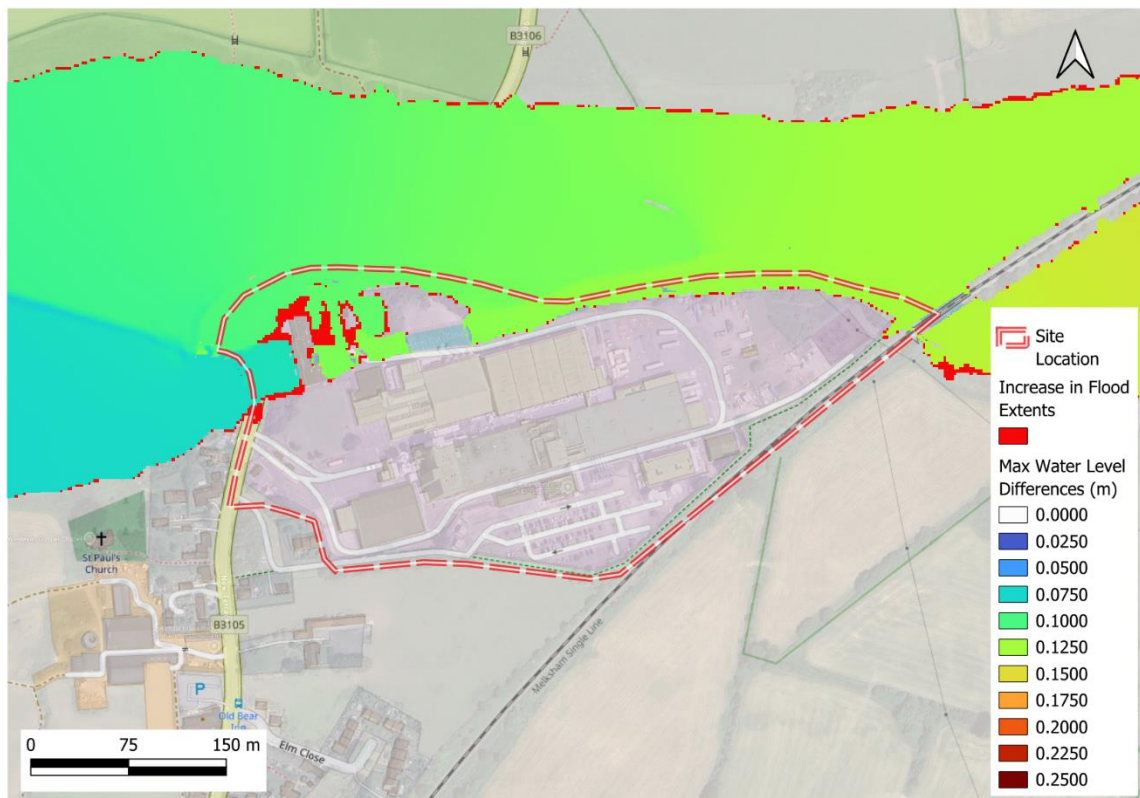


Figure 4-11: Water Level Differences sensitivity test (20% increase in roughness coefficient)

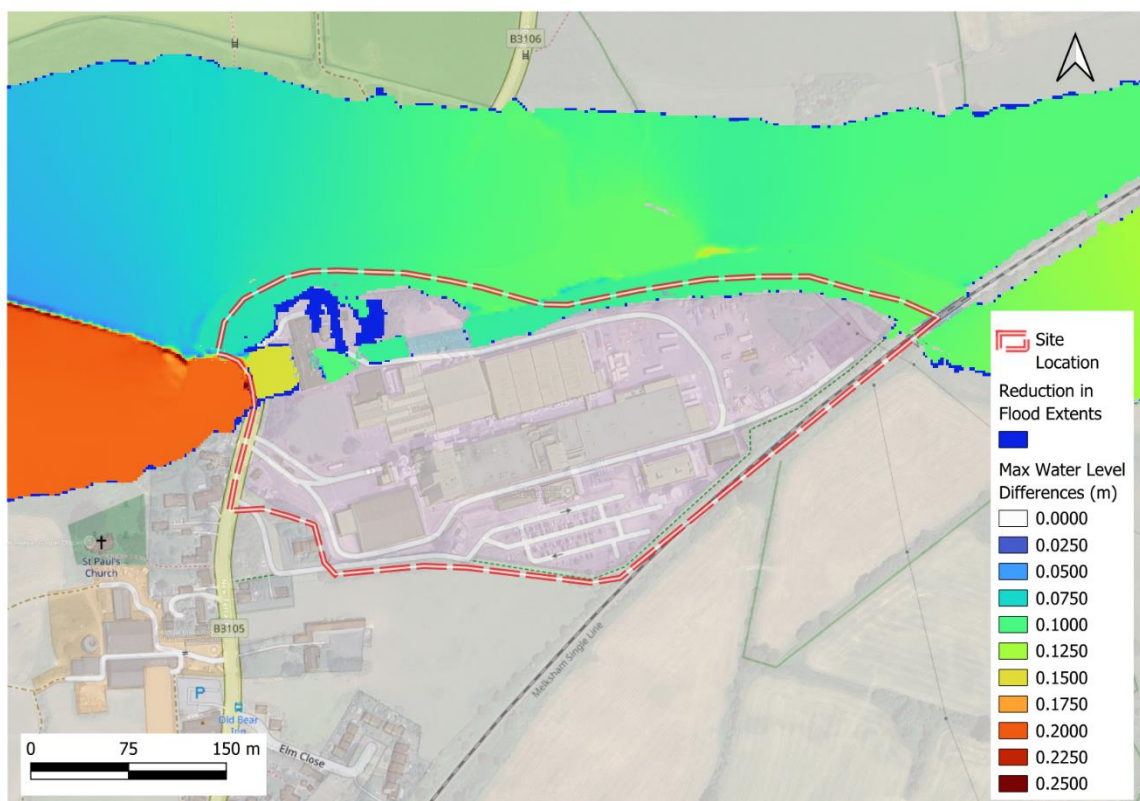


Figure 4-10: Water Level Differences sensitivity test (20% decrease in roughness coefficient)

5 Assumptions and Conclusions

5.1 Assumptions

The following assumptions have been made:

- Some dimensions have been estimated from the LiDAR and photos to fill gaps in the survey data.
- The Mannings roughness values for the river cross sections have been cross-referenced from the .dwg file.
- Where uncertainty was there in the data, the value that will produce the most conservative value has been assumed.

5.2 Conclusions

A 1D-2D hydraulic model has been developed for the purpose of this study to assess flood risk at the site. The model incorporates the most up-to-date hydrological inputs, ensuring a robust and accurate representation of flood behaviour in the area. Based on the results, it can be concluded that the majority of the site located on the left bank of the Weston Cut lies above the flood extent associated with the 1 in 100-year return period event, including a 71% allowance for climate change. This indicates that the site is generally at low risk of fluvial flooding under current and projected future conditions.

6 Appendix A: Survey Information

7 Appendix B: Flood Estimation Report

8 Appendix C: Model Files and Results

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