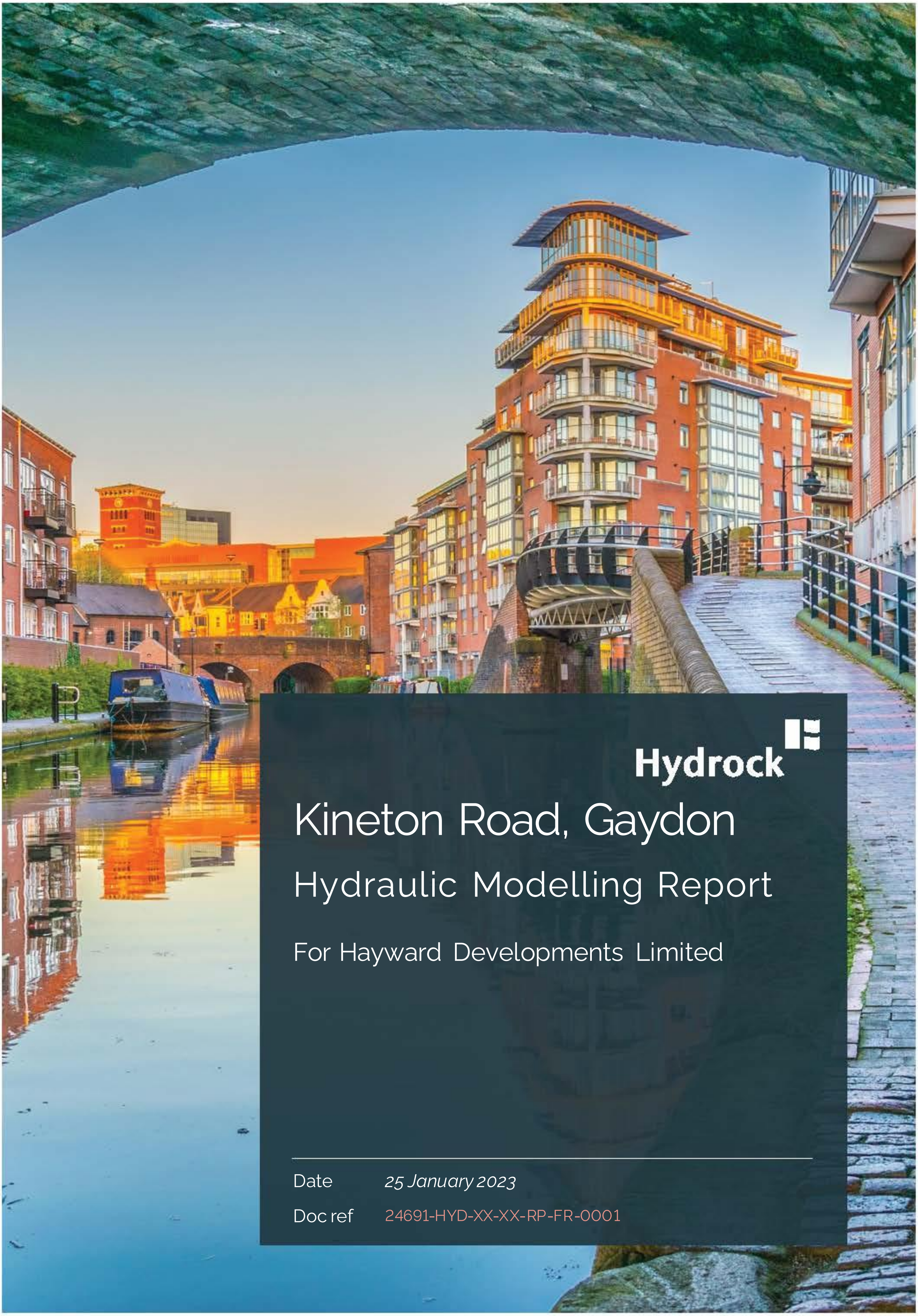

Hydrock

Kineton Road, Gaydon

Hydraulic Modelling Report

For Hayward Developments Limited

Date *25 January 2023*

Doc ref 24691-HYD-XX-XX-RP-FR-0001

Document control sheet

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P01	S2	27/10/2022	First Issue - For Comment
P02	S2	25/01/2023	Second Issue to include Post Development scenarios.

Hydrock Consultants Limited has prepared this report in accordance with the instructions of the above named client for their sole and specific use. Any third parties who may use the information contained herein do so at their own risk.

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1. Introduction

This report has been prepared by Hydrock Consultants Limited (Hydrock) on behalf of our client Hayward Developments Limited in support of a planning application for a proposed residential development on Kineton Road, Gaydon. An initial review of available mapping has identified areas of low, medium and high-risk surface water flooding. Warwickshire County Council as their role as Lead Local Flood Authority (LLFA) have provided a further response to (WCC002357 R2/FRM/SL/0003) initial baseline modelling of the watercourse. This requested a post development scenario to be run including the site levels and the drainage outfall into the watercourse.

Given the level of risk and the comments from the LLFA, this report has been prepared to model and address existing and post development overland surface water flows through a detailed hydrological and hydraulic study of the specific site.

2. Site Information

2.1 Site Location

The site is located within Gaydon in Warwickshire. There is an unnamed ditch that runs in a south easterly direction at the west of the site. The site is bound by Edgehill View road to the west of the site, Church Lane road to the north and undeveloped land to the east and south.

The site address and Ordnance Survey grid reference are provided in Table 1, with the site location shown in figure 1.

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Table 1. Site Referencing Information

Site Referencing Information	
Site Address	Edgehill View, Gaydon, Stratford-on-Avon, Warwickshire. CV35 0FL
Grid Reference	SP363538 436360, 253806

2.2 Topography

An up-to-date site-specific survey has not been provided. However, the 2020 LiDAR shown in Figure 2 shows that the site falls from 106.98m AOD in the north east of the site down to 102.23m AOD in the south west.

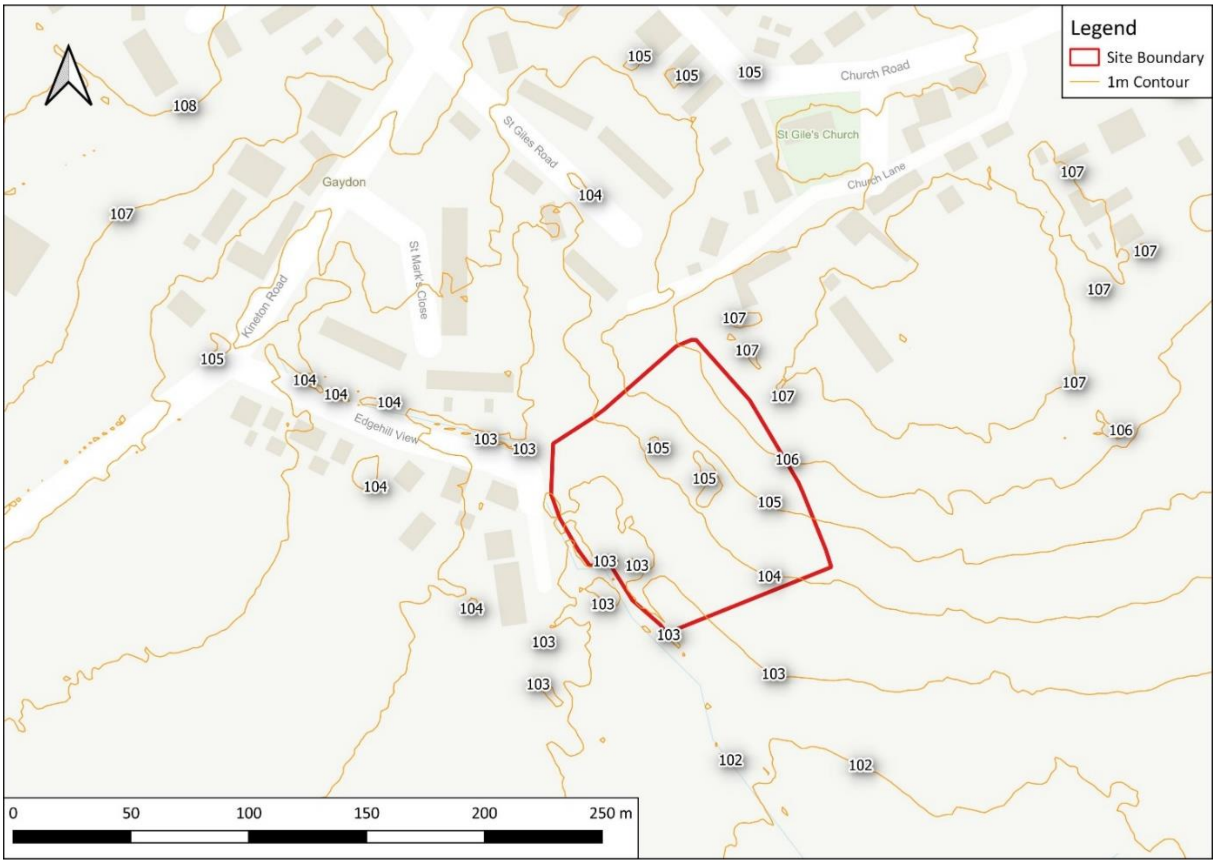

Figure 1: 1m Contours of the Site from 2020 2m LiDAR.

2.3 Current Site Use

The site is currently greenfield land and entirely undeveloped.

2.4 Proposed Development

The proposed scheme is for erection of 23 number 1, 2, 3 and 4 bedroom dwelling houses and garages together with roads, sewers and associated external works.

3. Hydraulic Modelling Methodology

3.1 Background

The site is located adjacent to a small unnamed ditch running to the west of the site, flowing in a south easterly direction. The west portion of the site is shown by the Environment Agency's Surface Water Flood Risk map (Figure 3) as 'High', 'Medium' and 'Low' risk of surface water flooding.

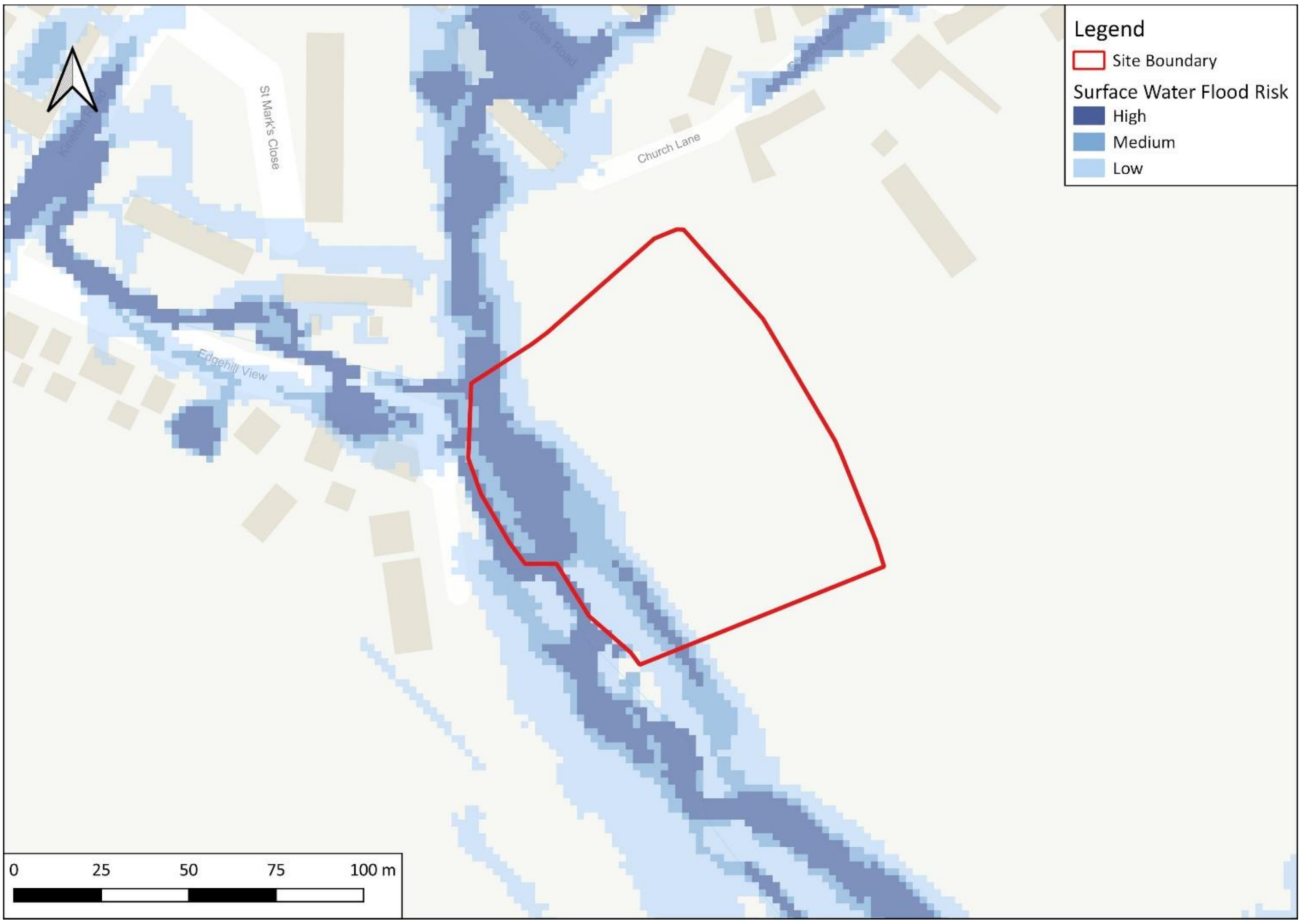

Figure 2: Environment Agency Surface Water Flood Risk Map

Figure 4 shows the drainage catchment for the ditch running through the site. Figure 4 shows a wider catchment to the north west of the site with an approximate catchment area of 0.67km2. Due to the small size of the catchment, it was deemed appropriate to create a detailed rainfall run-off model as this will create the worst-case scenario for both fluvial and surface water flooding as the majority of peak flows within the watercourse will be as a result of surface water run-off.

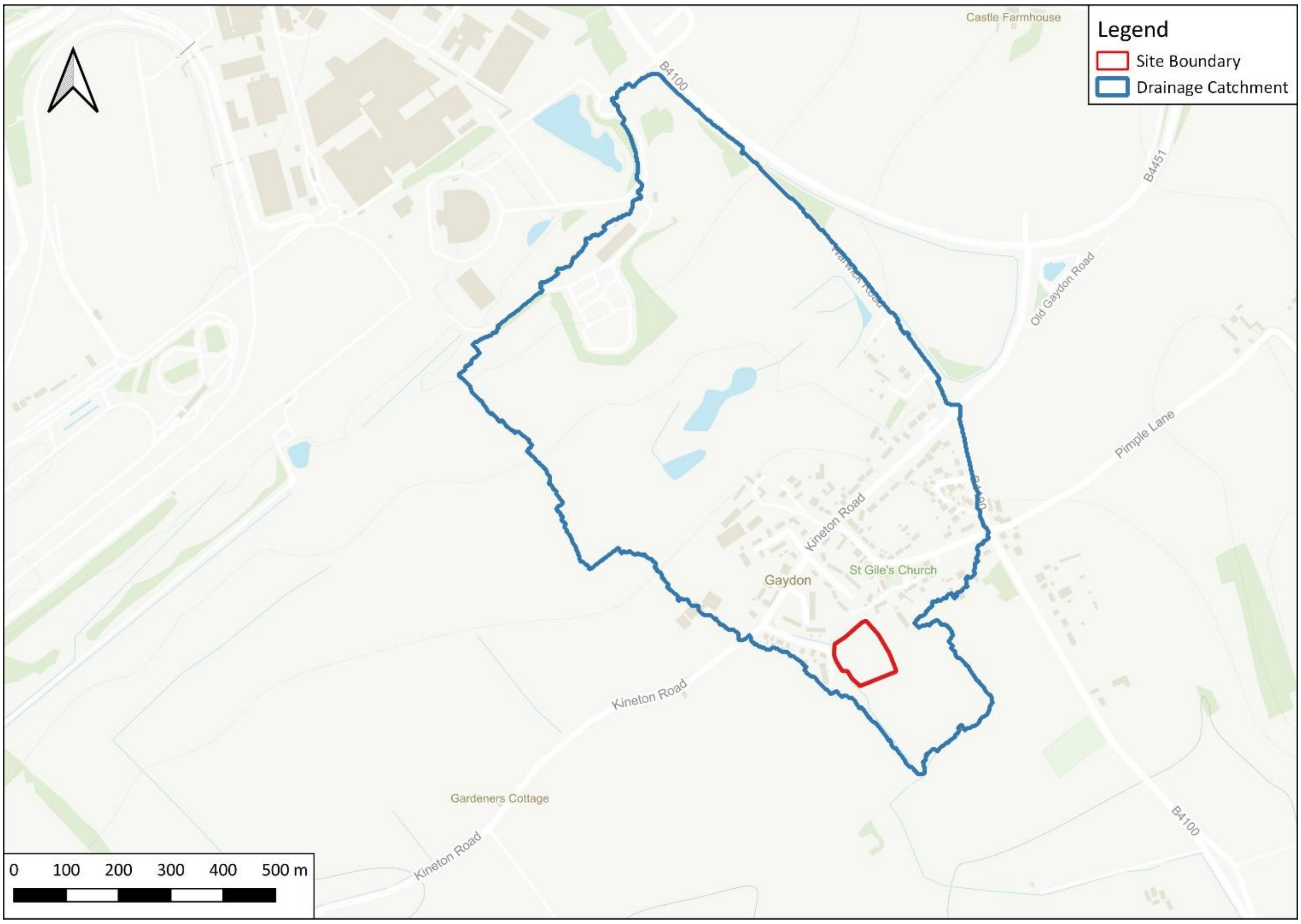

Figure 3: Drainage Catchment of the Ditch Adjacent to the Site.

Current EA Surface Water Flood Risk mapping (Figure 3) associates this watercourse and land around it as being up to 'High' risk, with the EA's Online Long-Term Flood Risk mapping predicting the flooding depths to mostly less than 300mm but with some areas indicated as having depths of between 300mm to 900mm. It should be noted as well that the EA Mapping indicates a secondary flow route, shown to be up to 'High' Risk, coming from off-site sources and entering via the northern boundary, flowing through the site and discharging into the existing watercourse. Mapping indicates the depths of this flooding to be between 300 to 900mm.

3.2 Model Type

A '1D-2D Direct Run-Off Model' has been constructed for the site and contributing catchment in order to understand the existing surface water flow routes affecting the site.

Flood Modeller Pro was used to model the unnamed ditch running through the site. TUFLOW was used to represent the flows through the floodplain. This was run in double precision to follow standard guidance for direct run-off modelling. The versions of software that were used are:

- Flood Modeller Pro version 6.0
- TUFLOW 2020-10-AB-iDP-w64

3.3 Baseline Model Construction

3.3.1 Rainfall

Rainfall depths are derived from the FEH DDF (Depth Duration Frequency) model with catchment parameters taken from the FEH Web Service from an outlet point at grid reference 436450, 253550. A rolling ball analysis was undertaken to see the drainage catchment for the ditch running adjacent to the site. This was different to the catchment on the FEH Web Service and therefore the catchment parameters were updated to reflect the new catchment.

The following storm events were modelled: 1 in 5, 1 in 20, 1 in 30, 1in 30 +35%CC, 1 in 100, 1 in 100 year + 40% allowances for climate change and 1 in 1,000-year rainfall events. Each were run for a duration of 6 hours which is the required storm length for calculating runoff volume as specified in guidance documents. For a catchment of this size, this is considered an appropriate duration, with the minimum recommended duration being a 3-hour event. Further sensitivity testing has also been undertaken to assess the 3-hour, 9-hour and 12-hour storms.

The events considered critical for the surface water drainage design are the 1 in 30-year and 1 in 100-year plus 40% climate change. The 1 in 30 year is the typical design standard under Sewers for Adoption Eighth Edition where no flooding of the system should occur. The 1 in 100 year plus 40% climate change event is the extreme storm which new developments should be designed to withstand, whereby flooding of the network may occur but it must be safely contained away from buildings or key access / egress routes. The 1 in 5-year event has also been run to represent the expected conditions in a more commonly occurring storm event.

3.3.2 Run-off Calculation

Factors which can affect runoff calculations are as follows:

» Permeability of soils, with runoff less accurately predicted in highly permeable soils. The soils in the wider catchment for the unnamed ditch were assessed to be of low permeability (SPRHOST of 49.4%).

» Small drainage catchments can result in small rainfall depths. Runoff calculated by models with an initial storage component (such as the PDM model used in ReFH) may therefore be very sensitive to storage parameters and initial conditions. Total runoff estimates may therefore be uncertain.

» Urbanisation resulting in different surface characteristics and runoff coefficients to the natural catchment.

Given the complex nature of the issues outlined above, the following method has been used to address the limitations identified above and provide a robust runoff parameterisation for modelling:

» Runoff calculated from 'rural' areas calculated by taking the SPRHOST value from the FEH Catchment Descriptors as a representative percentage run-off value for the site of interest.

» Runoff calculated from 'urban' areas using a hybrid approach which takes the weighted average of the rural runoff (as described above) and a 90% run-off from impermeable areas. The weighting factor is the Percentage Impermeable (PIMP) value as used in the Wallingford procedure. The majority of the study area however was considered to be 'rural' with no significant urban developments within the study area.

» It has been assumed for the purpose of the direct rainfall modelling that no water enters the sewer system. This is considered to be a conservative approach as this system will help to alleviate ponding in low-lying areas. This approach is not considered to impact the predicted flow routes as all flows will be routed via the topography and ultimately into the watercourse.

3.3.3 1D Model Construction

The 1D model includes river sections and structures that were constructed using site specific survey data. The river units were deactivated at bank tops (i.e. channel only) for linking to TUFLOW with approximately consistent widths along the watercourses. A summary of the model nodes used is included in Table 2. Figure 5 shows the location of the 1D nodes and links.

Table 2: 1D Summary

1D Summary	
Upstream Node	EDGE0413
Downstream Node	EDGE0000
River Sections	16
Replicates	3
Structures	9
Reservoir	1

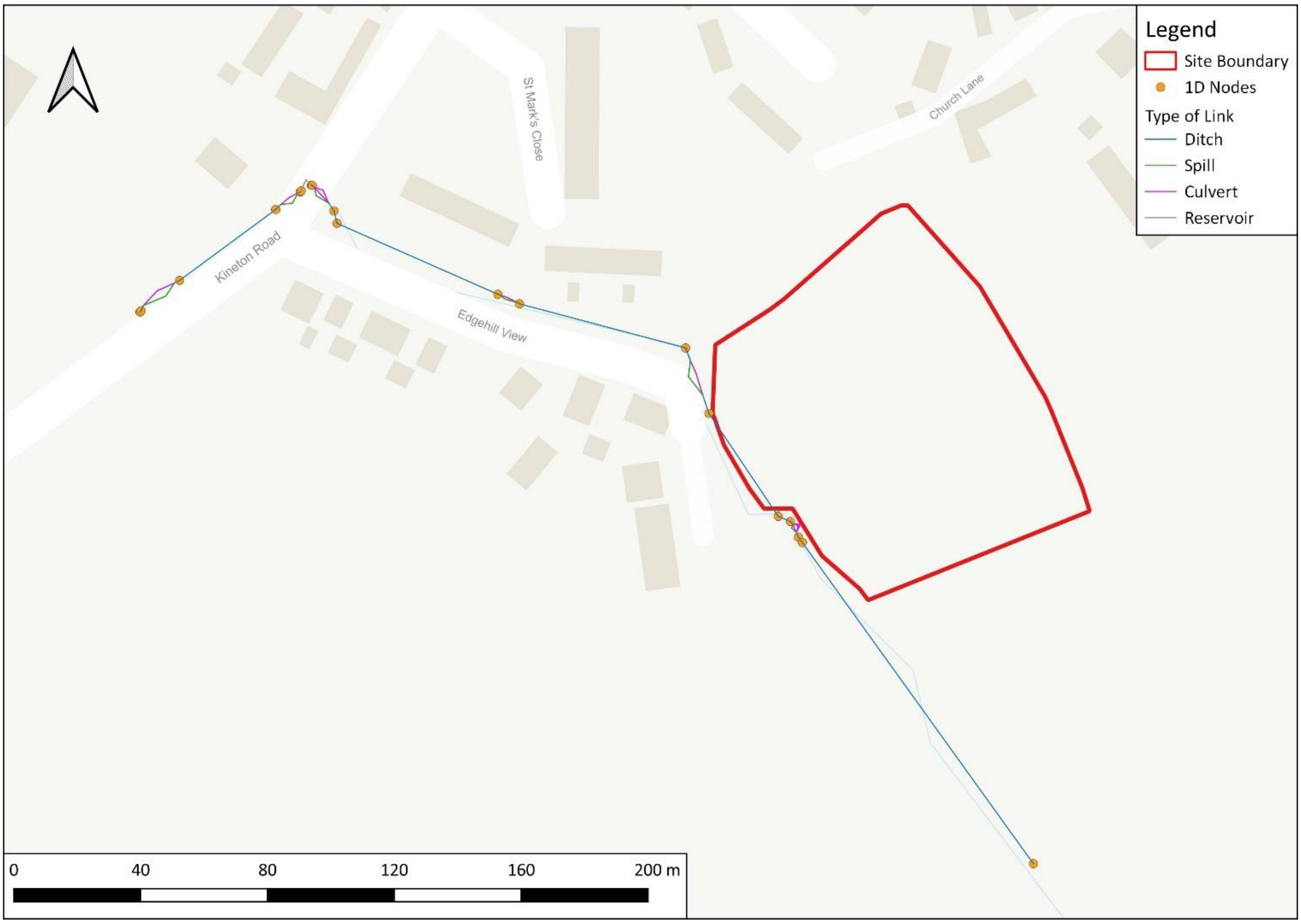

Figure 4: 1D Network.

3.3.4 2D Model Construction

The 2D model was based on available 2020 LiDAR data at a 2m resolution and is the most recent LiDAR data available for the area. Owing to the lack of any significant development within the site boundary or any noticeable development within the catchment it was considered that this provided an accurate representation of ground levels in the area and is appropriate for use in defining ground levels for the 2D Domain. This domain followed the line of high ground around all watercourses to all sides. In order to ensure the domain extended a suitable distance the model was extended downstream to remove any boundary impacts on flood levels at the site. The model grid size is 2m which is deemed a sufficient level of detail for the site.

3.3.5 Model Files

The construction of the model saw a number of iterations.

The list of files for the final baseline scenario are:

• DAT File - 24691_KinetonRd_1D

• IEF - KinetonRd_5yr_BASE, KinetonRd_20yr_BASE, KinetonRd_30yr_BASE, KinetonRd_30yr_CC_BASE, KinetonRd_100yr_BASE, KinetonRd_100yr_CC_BASE, KinetonRd_100yr_CC_3hr_BASE, KinetonRd_100yr_CC_9hr_BASE, KinetonRd_100yr_CC_12hr_BASE and KinetonRd_1000yr_BASE. KinetonRd_5yr_DEV, KinetonRd_20yr_DEV, KinetonRd_30yr_DEV, KinetonRd_30yr_CC_DEV, KinetonRd_100yr_DEV, KinetonRd_100yr_CC_DEV and KinetonRd_1000yr_DEV.

• TCF - Kineton_002_~s~_~e~

• TBC - KinetonRd_001_RAIN

• TGC - KinetonRd_001_RAIN

• Shapefiles - all references within the TCF, TBC, and TGC files

3.4 Boundary Conditions

3.4.1 1D Boundary Conditions

No 1D inflow has been applied within the modelling, as given the size of the watercourse it is likely that peak flows will be as a result of surface water run-off. A sweetening flow of 0.05 m3/s was used as Flood Modeller Pro requires some flow within the channel at all times.

A normal depth boundary was applied to the downstream boundary of the 1D domain. This is based on the slope of the last two cross sections.

3.4.2 2D Boundary Conditions

Rainfall inflows were applied across the model as a 2d_RF file using the SPR and PIMP-weighted values to define the urban and rural areas as shown in Figure 6.

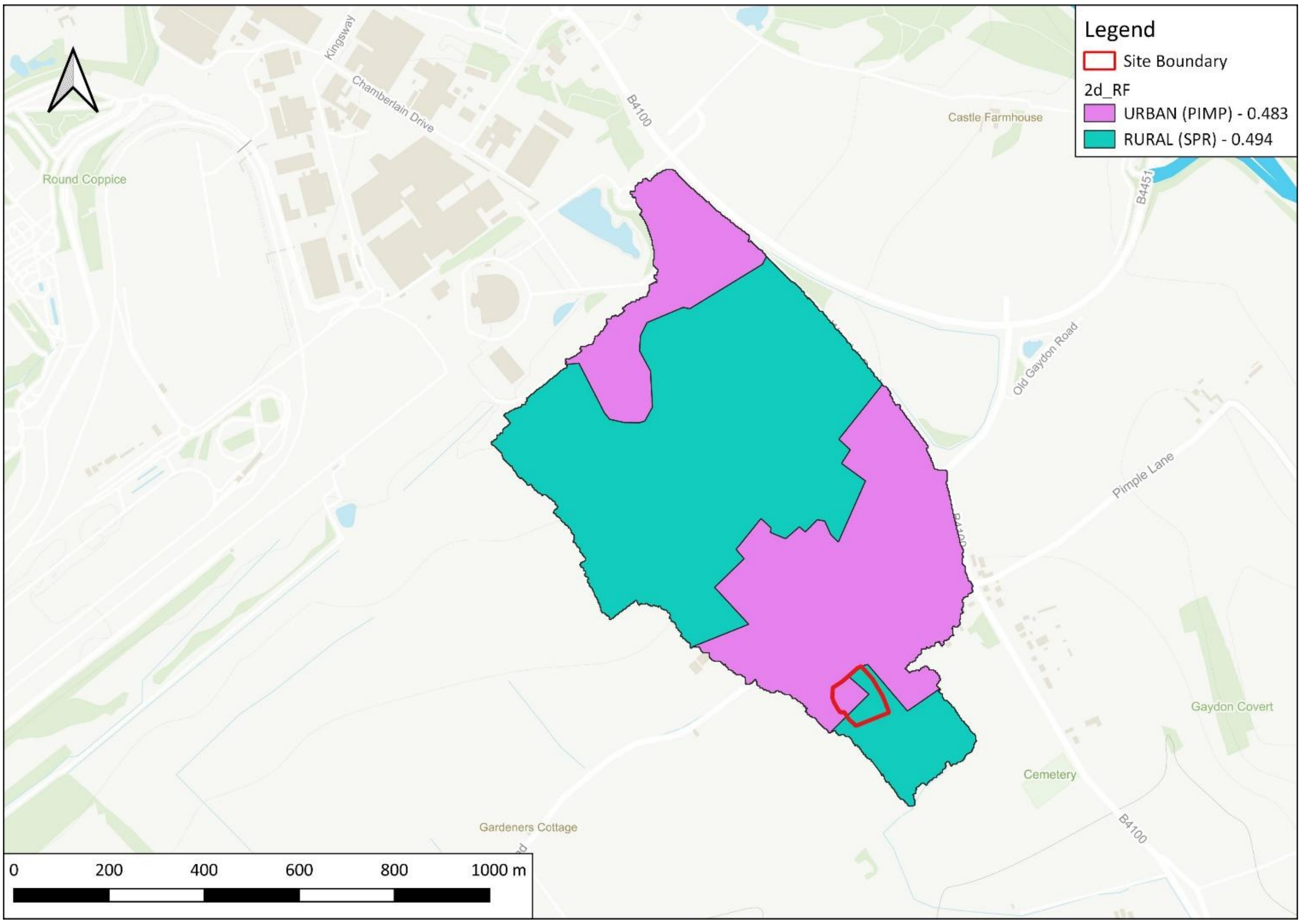

Figure 5: 2D RF Polygons.

A Stage-Discharge boundary was applied along the downstream edge of the TUFLOW domain to prevent any over-estimation of flood levels within the site due to 'backing up' at the downstream model limit and represented as a HQ boundary within the 2d_HXE file with a 1 in 1000 year gradient.

3.5 Structures

3.5.1 *1D Structures*

Structures included in the 1D model are outlined in Table 3.

Table 3: 1D Structures

Model Node	Type	Photo	Key Parameters
EDGE0413 CU	Culvert modelled as an orifice for stability.		0.22m diameter
EDGE0359 CU	Culvert modelled as an orifice for stability.		0.52m diameter

EDGE0350r	Pond modelled as a reservoir		
EDGE0333 CU and EDGE0344 CU	Double culvert modelled as orifices for stability		0.3m diameter for both culverts.

EDGE0271 CU	Culvert modelled as an orifice for stability		0.3m diameter
EDGE0208 CU	Culvert modelled as an orifice for stability		0.38m diameter

EDGE0136_1CU, EDGE0136_2CU and EDGE0136_3CU	Triple culvert modelled as orifices for stability		0.3m diameter for all three culverts.

3.5.2 2D Structures

One structure was included in the 2D model. This is outlined in Table 4.

Table 4: 2D Structures

Model Node	Type	Photo	Key Parameters
Pond culvert	Two culverts draining from an existing pond.		0.225m diameter for both culverts.

~~3.7~~3.6 Roughness

~~3.7.1~~3.6.1 1D Roughness

The in-channel Manning's n roughness coefficient was assessed using survey photograph. Most of the channel consisted of some weeds and stones and therefore a Manning's n roughness coefficient of 0.04 was used.

~~3.7.2~~3.6.2 2D Roughness

The baseline 2D roughness values were represented within a 2d_mat file. The location of all the features included within the materials file was initially taken from OS Open Map Local data, with aerial imagery being used to manually edit the shapefiles. The Manning's n roughness coefficient was based on a site walkover study. Table 5 shows the Manning's roughness values used.

Table 5: 2D Manning's n Roughness Coefficient

Manning's n Roughness Coefficient	
Pasture	0.06
Roads	0.022
Buildings	0.3
Woodland	0.07

~~3.8~~3.7 Model Timesteps

The 1D model timestep was 0.5 seconds which is half that of the 2D timestep of 1 second. This is in line with best practice.

~~3.9~~3.8 Post Development Scenario

A post development scenario was included to see the effects of the development on surface water flow routes and to ensure that the outfall of the retention basin does not increase flood risk downstream.

The outflow of the retention basin was taken from CAD Square's drainage strategy. The maximum outflow of the retention basin (0.002 m3/s) was inputted as a continuous flow time boundary into the 1D network 24691_KinetonRoad_1D_dev.dat for all scenarios. This provides a conservative approach.

Finished floor levels and site layout of the development site provided by CAD square and provided in Appendix A were represented in the 2D domain in the file 2d_zsh_FFL_R.shp.

The retention basin location and elevations were taken from the information provided by CAD Square in Appendix A and embedded into the 2D domain using the files, 2d_zsh_detentionbasin_R.shp and 2d_zsh_detentionbasin_P.shp.

The road in the development was represented in the materials file 2d_mat_Kineton_dev_001_R.shp with a roughness value of 0.022.

An initial analysis of the post development scenario found this retention basin to be overtopped by a surface water flow route in all modelled scenarios.

Therefore, a mitigation scenario with an embankment surrounding the retention basin was run. This was designed to be a height of 104.12 mAOD. This withstands the maximum flood depth from the 100 year plus climate change scenario with a freeboard of 0.3m. This was embedded into the 2D domain using the files, 2d_zsh_embankment_L.shp and 2d_zsh_embankment_P.shp.

~~3.10~~3.9 Events & Scenarios

A baseline and post development model has been run for each of the seven events listed in Table 6. Sensitivity tests of the rainfall duration (3, 6, 9 and 12 hours) was undertaken on the 100-year plus 40% climate change run. This showed negligible differences in flood extent at the site. Therefore, the 6-hour duration was run for all return periods.

Table 6: Modelled Scenarios for baseline and post development.

Modelled Scenarios	
Return Period	**AEP**
1 in 5 year	20%
1 in 20 year	0.5%
1 in 30 year	3.33%
1 in 30 year +35% Climate Change	3.33% +35% Climate Change
1 in 100 year	1%
1 in 100 year plus 40% Climate Change	1% +40% Climate Change
1 in 1000 year	0.1%

4. Model Warnings and stability

4.1 1D Warnings

Warning 2058 - Model convergence criteria were not met for one or more timesteps during the run. This occurs at the end of the simulation due to the channel becoming dry and thus will not affect the maximum flood extents.

Warning 2019 - Water level rose beyond the max level of section data. Solution computed assuming extra 3m wall for non-CES sections, or max depth x 1.5m for CES sections, at max breadth. This occurs at the end of the simulation due to the channel becoming dry and thus will not affect the maximum flood extents.

4.2 2D Warnings

Warning 0305 - Projection of .shp file is different to that specified by the GIS Projection == command. An inspection shows that this does not impact the model.

Warning 2073 - Object below ignored. Only Lines, Polylines & Multiple Polylines used. These are outside the model domain and thus will not impact the model results.

Warning 2218 - Manning's n value of 1 is unusually high. This is the industry standard manning's n value for buildings.

Warning 2468 - Active cell has no active faces. These warnings occur near the code polygon boundary and are not near the site. Therefore, there will be no impact on the site.

4.3 Model Convergence

Figure 7 indicates good model convergence in the 1D. There are a few isolated periods of poor model convergence but these occur outside of the peak rainfall. Therefore, there is confidence in the model.

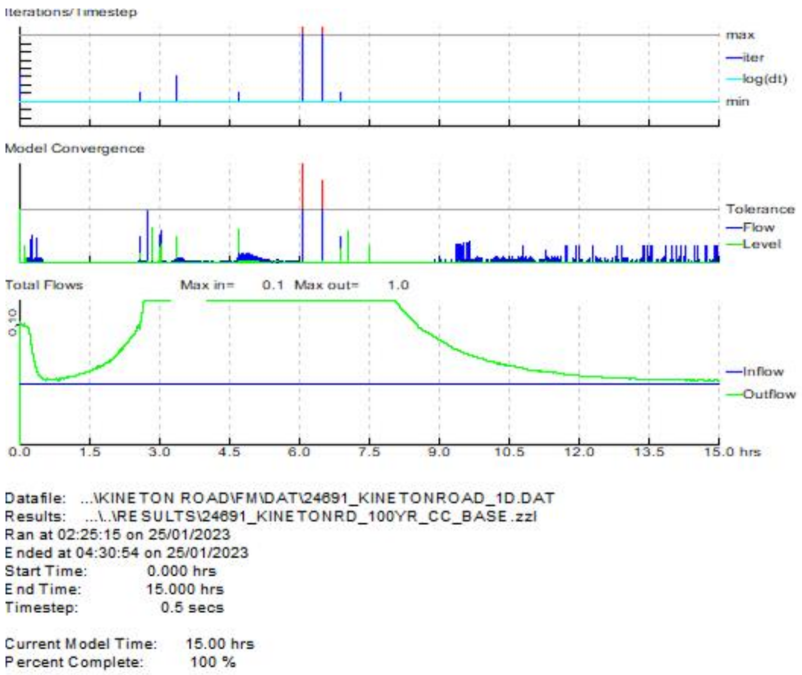

Figure 6: 1 in 100 Year +CC Baseline BMP

4.4 Mass Balance

Figure 8 shows that cumulative mass error stays within ±0.4% for the 1 in 100 Year +CC baseline scenario. This is well within the Environment Agency's criteria for keeping mass error within ± 1% and thus indicating good model stability.

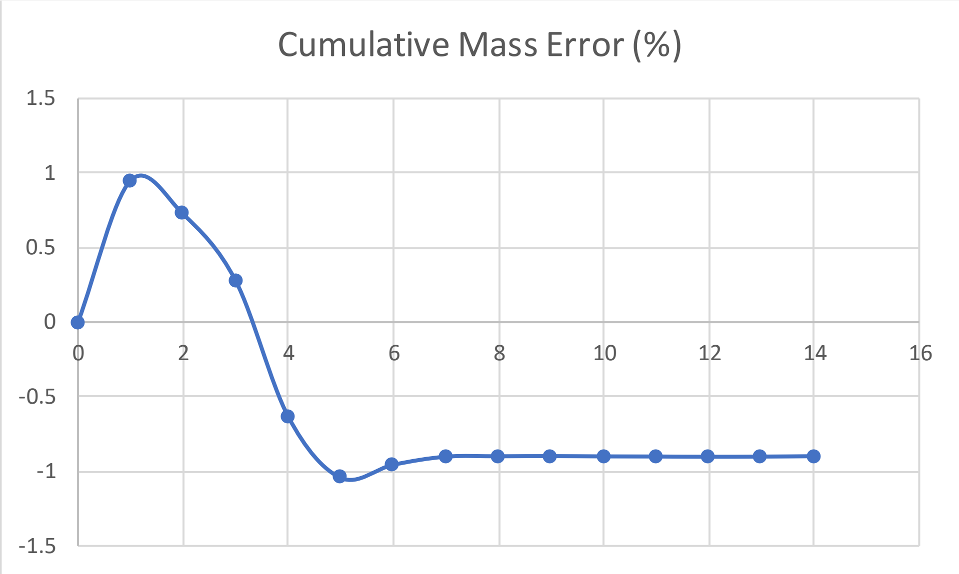

Figure 7: Cumulative Mass Error for the 1 in 100 Year +CC Baseline Scenario.

Figure 9 shows a smooth transition of dVol. DVol indicates the volume of water stored in the 2D and thus a smooth transition indicates good model stability.

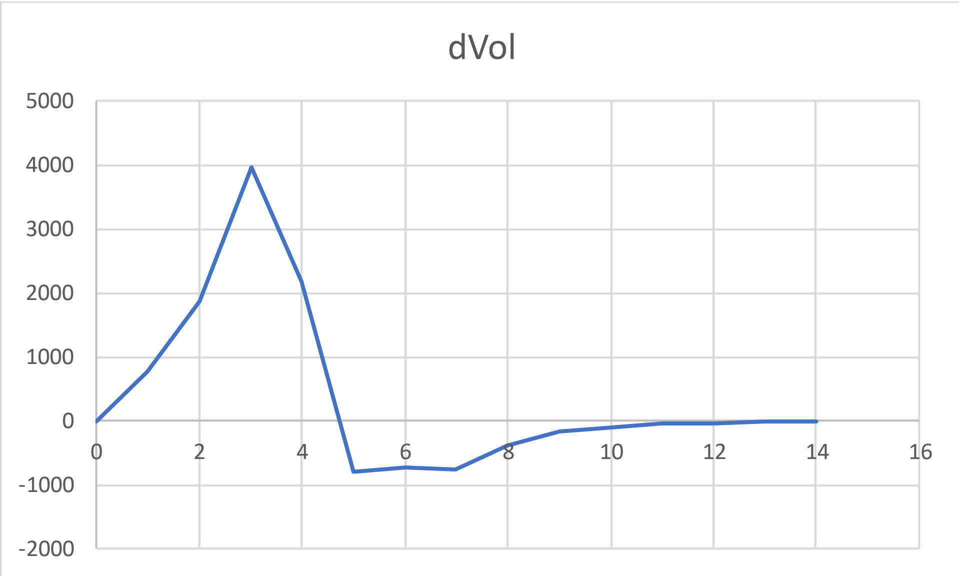

Figure 8: Dvol of the 1 in 100 Year + CC Baseline Scenario.

5. Results

5.1 Baseline Results

In the majority of events modelled, surface water flooding is predicted to occur within the site boundary and is predicted to impact an area of land within the western portions of the site. This flooding in all events, except the larger 100 year plus climate change and 1000 year events, is not indicated to show connectivity to wider flooding in the north or to the watercourse to the south and as such is an indicator of locally lower lying topography within the site. The flooding in this area is predicted to be below 300mm deep and would therefore be considered as shallow.

In the larger events, such as the 100 year plus CC and 1000 year events, flooding is predicted to enter the site via the northern boundary (confirming the existing EA Flood Maps) and flow through the site discharging into the watercourse with the majority of this flow route indicated to be below 300mm and therefore shallow. In the larger events, there is a deeper area of flooding predicted to have a maximum depth of 360mm. Flooding of the watercourse into the site occurs in an isolated location and does not impact the development (see figures 10-12).

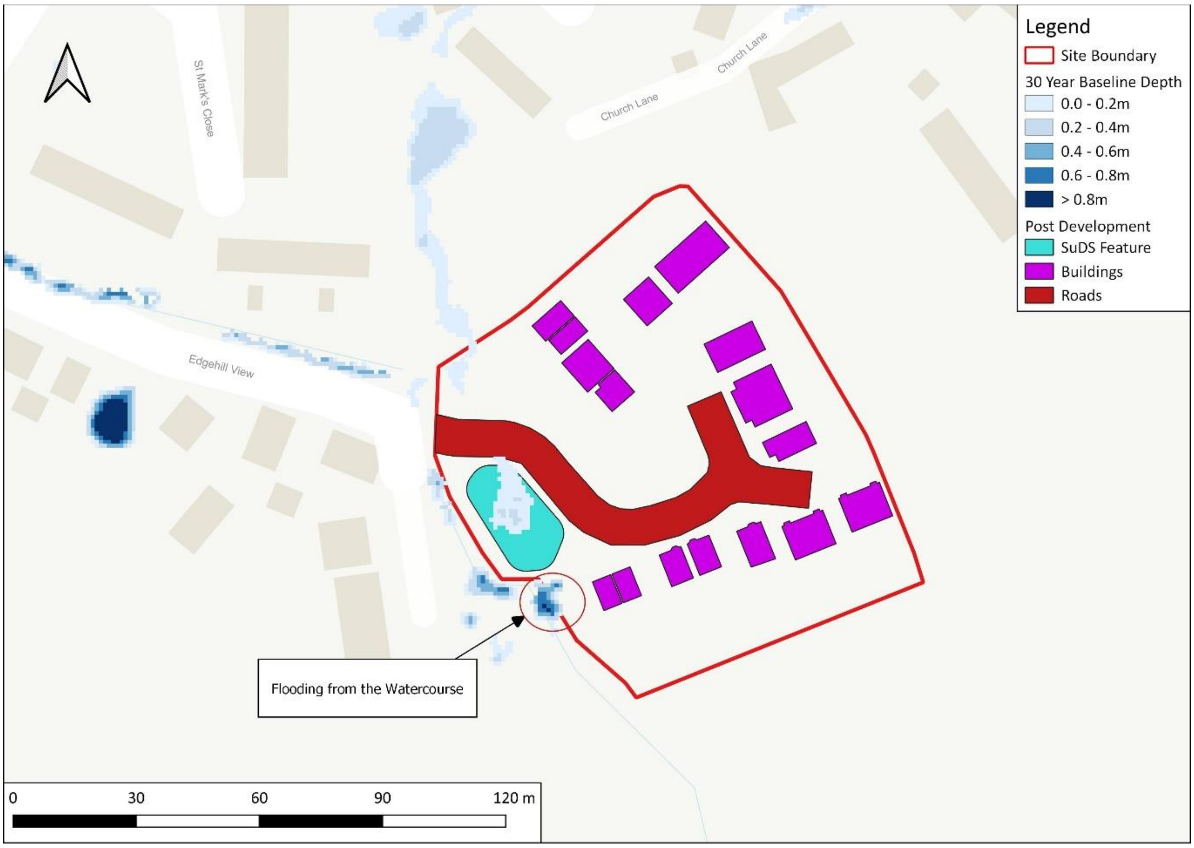

Figure 9: 1 in 30 Year Baseline Depth

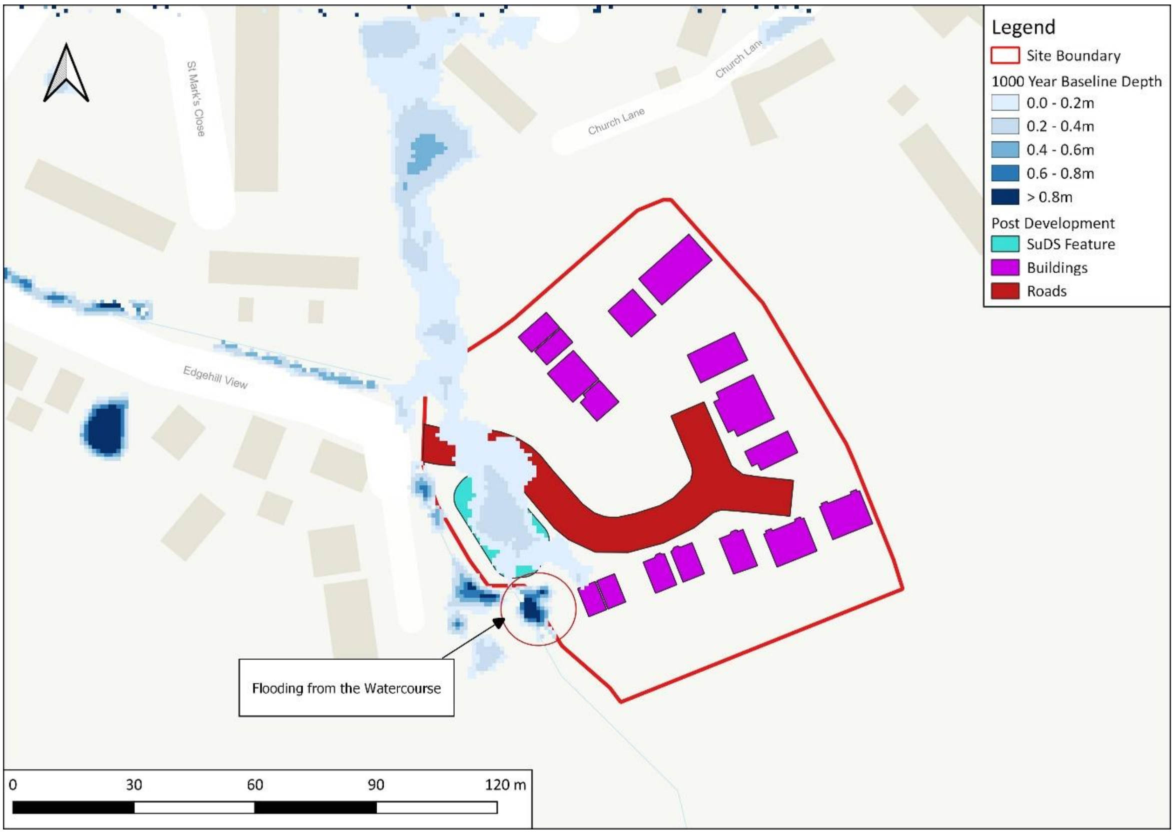

Figure 10: 1 in 100 Year +40% Climate Change Depth.

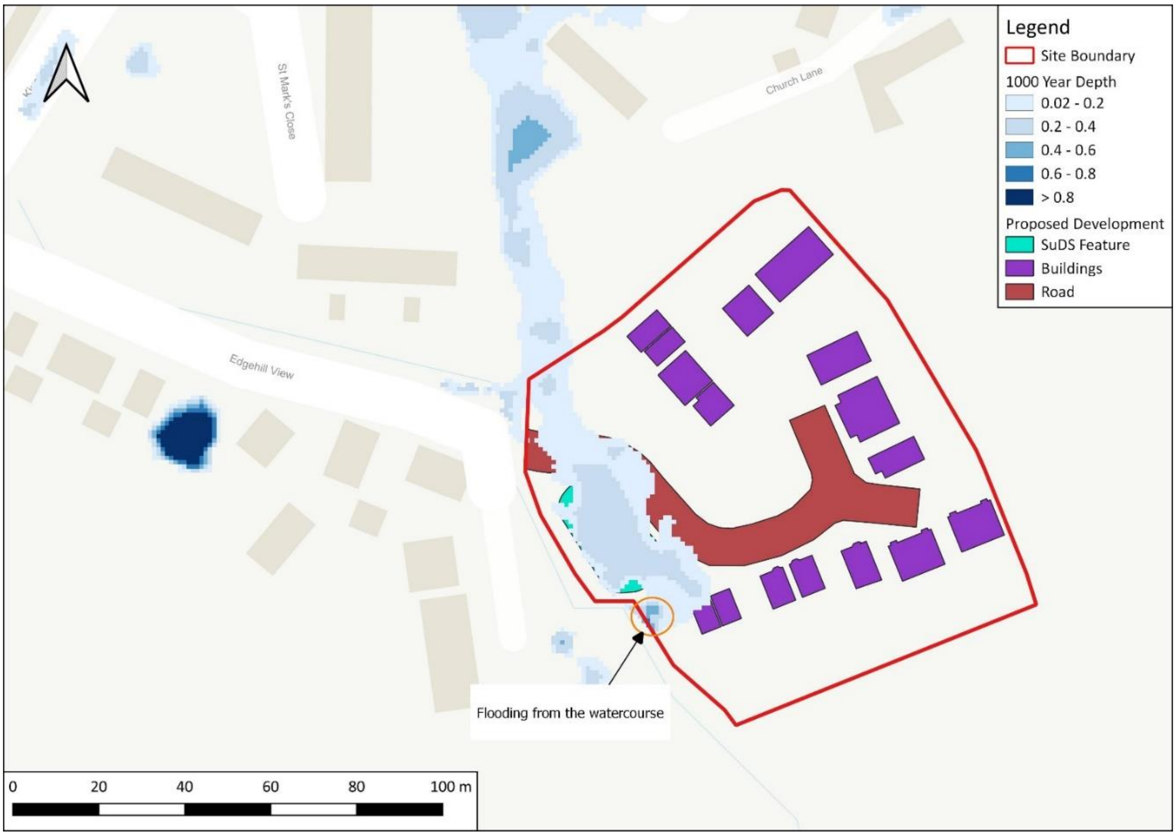

Figure 11: 1 in 1000 Year Baseline Depth

5.2 Post Development Results

In the initial post development run, all modelled scenarios showed the retention basin to be affected by a surface water overland flow route.

The mitigation scenario discussed in section 3.8 was then run. This showed that in all modelled scenarios, surface water is not predicted to affect the retention basin (see figures 13-15). The majority of the established flow route is indicated to be below 300mm and is therefore shallow. In the larger events, there is a deeper area of flooding at the south west boundary predicted to have a maximum depth of 820mm. Flooding of the watercourse occurs in a few isolated locations and does not impact the development or other developments.

Unit 23 is affected by shallow surface water flooding with a maximum flood depth of 157 mm in the 100 year plus 40% climate change scenario. Therefore, the finished floor level of this building will need to be raised by 457 mm to prevent the property from flooding with an 300mm freeboard.

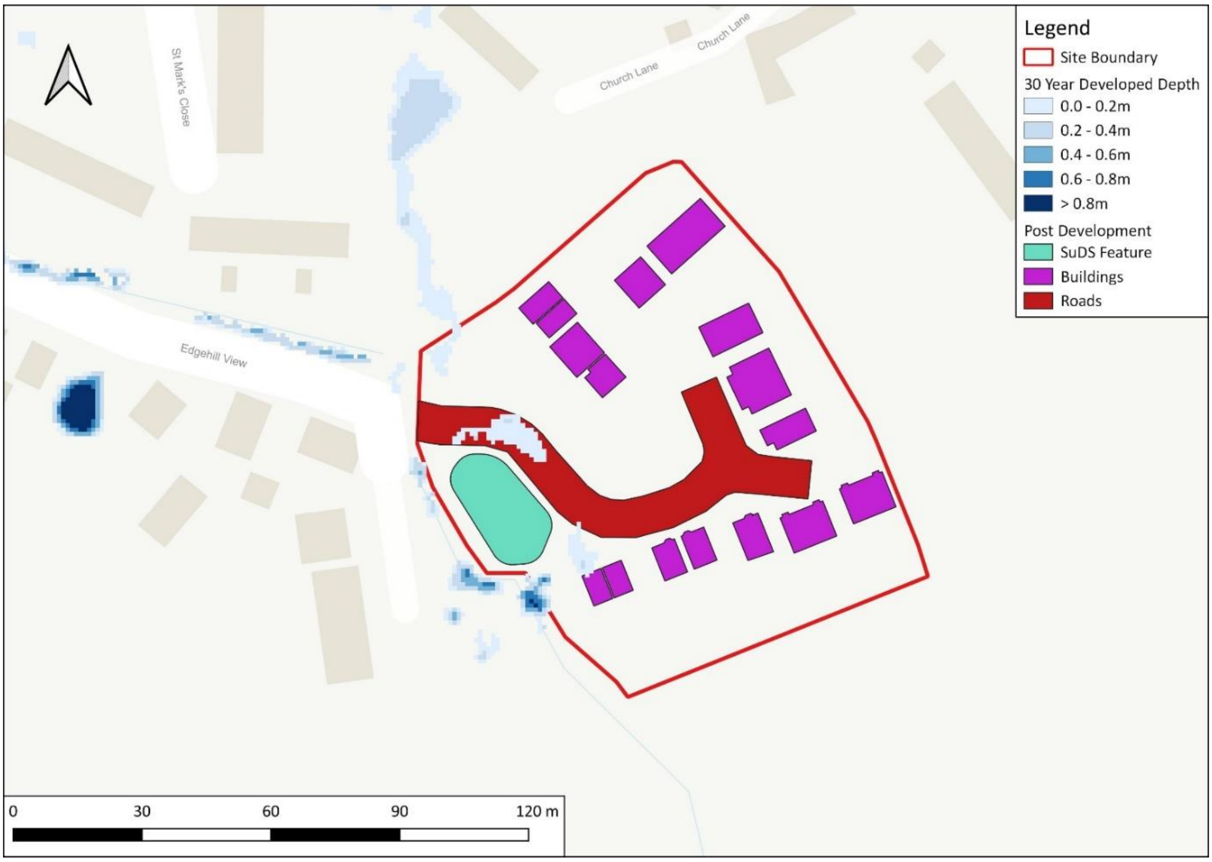

Figure 12: 1 in 30 Year Post Development Depth

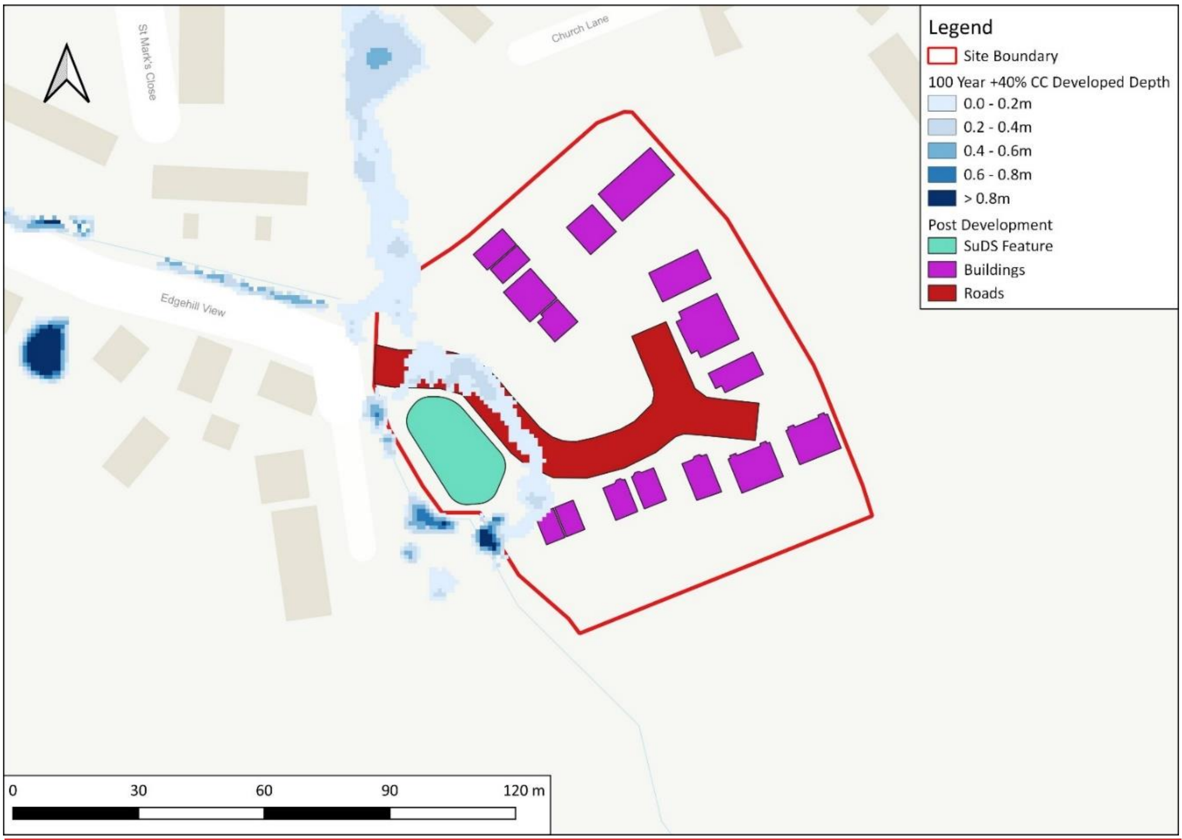

Figure 13: 1 in 100 Year + 40% Climate Change Post Development Depth.

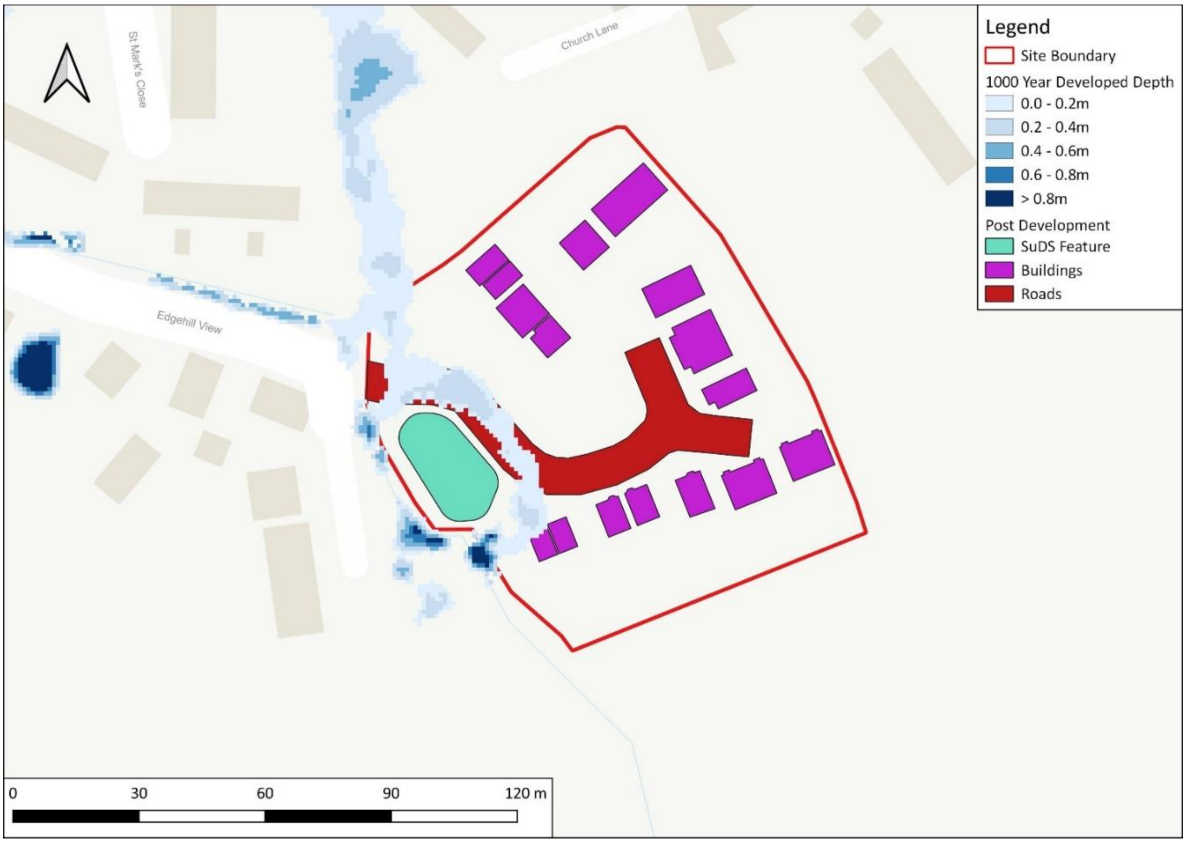

Figure 14: 1 in 1000 Year Post Development Depth

Figure 16 shows that there is no detriment caused around the site caused by the development. There is increased depths on the site caused by the embankment. However, this prevents water reaching the ditch and thus reduces depths outside of the site.

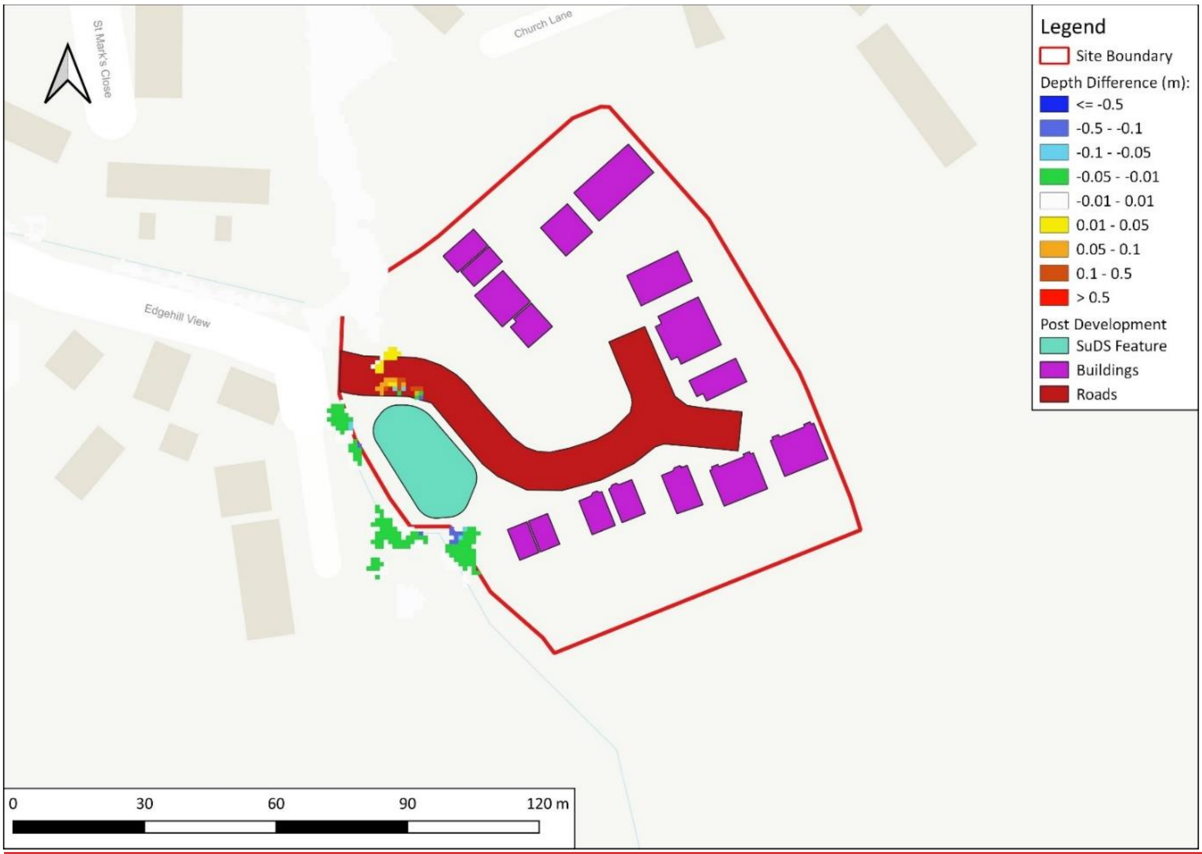

Figure 15: Depth difference between baseline and post development 1 in 100 year +40% Climate Change scenarios.

5.3 Summary

The hydraulic modelling undertaken by Hydrock confirms the site to be mostly within Flood Zone 1 for fluvial flooding as the adjacent watercourse has capacity to receive the flows from the development in most places. There is a small area of Flood Zone 3 on the site, however this does not affect proposed properties and thus does not affect floodplain storage. There is no evidence that the watercourse will flow into the attenuation feature.

Most of the surface water flooding occurs from an overland flow route leading to the watercourse in the west of the site. Depths indicate that a majority of this flooding will be less than 300mm and therefore is classified as shallow. This model does not include existing drainage networks to the north of the site and thus this model provides a conservative estimation of surface water flood risk.

An initial post development showed the retention basin to be affected by surface water flooding, Therefore a mitigation scenario with an embankment surrounding the retention basin was run. The retention basin will need an embankment set to a height of 104.12 mAOD to prevent any surface water entering the basin through the overland flow route.

On this basis, the site is concluded to be at low risk of flooding from surface water.

6. Summary

This hydraulic modelling report has been prepared by Hydrock on behalf of Hayward Developments Limited in support of a planning application for a proposed development of Kineton Road, Gaydon.

A detailed hydraulic modelling assessment of the unnamed watercourse next to the site has been undertaken for key design events. The modelling remains subject to approval from the EA, but on the modelled outputs the site is concluded to be at low risk from fluvial flooding. There is no evidence that the watercourse will flow into the retention basin, thus addressing the LLFA concerns.

On the basis that the Application is largely within Flood Zone 1, it is concluded that the Sequential and Exception Tests need not be applied in accordance with the requirements of the NPPF.

An overland flow route leading to the watercourse in the west of the site occurs. However, the majority of the flooding is less than 300mm and therefore is classified as shallow.

A mitigation scenario of a retention basin surrounded by an embankment was run. This embankment was set to a height of 104.12 mAOD. This prevents surface water from entering the retention basin, thus addressing the LLFA concerns.

The development does not cause any increased flood risk to the surrounding developments.

Furthermore, the site:

» Is suitable in the location proposed.

» Will be adequately flood resistant and resilient.

» Will not place additional persons at risk of flooding.

» Will not increase flood risk elsewhere as a result of the proposed development through the loss of floodplain storage or impedance of flood flows.

As such, the Application is concluded to meet the flood risk requirements of the NPPF.

Hydrock Consultants Limited

Appendix A - Site Layout

Schedule of Accommodation

Ref:	Type:	No.
HA Rent		
A	1 Bed Apartment	2
B	2 Bed Bungalow	1
C	2 Bed House	3
D	3 Bed House	1
		Total = 7
Shared Ownership		
B1	2 Bed Bungalow	2
G	2 Bed House	3
		Total = 5
Owner Occupier		
E	2 Bed Bungalow	2
F	3 Bed Bungalow	1
H	2 Bed House	1
		Total = 4
Open Market		
J	2 Bed House	1
K	2 Bed House	2
L	3 Bed House	1
M	2 Bed Bungalow	2
N	2 Bed Bungalow	1
		Total = 7
		Site Total 23

Planning application boundary

Land within applicants ownership

Indicative existing landscaping

Existing landscaping removed

Indicative new landscaping

50 Plot number

8 Parking space & reference (V-visitor)

SW 1.8m high screen wall

CBF 1.8m high close board fence

PR 1.2m high timber post and three rail fence

Plot access point

Refuse / recycling bin location

SH 2.1x1.5m shed to provide secure cycle storage where no garage provided

Electric Vehicle Charging Point (To be located in garage where provided to property)

BCP Bin Collection Point

2.4 x 2.4m Pedestrian visibility splays

SCALE

REVISIONS

Rev:	Description:	Date:	By:
A	Red Line revised to include junction visibility to Kineton Road	21.12.21	PNH
B	Amended to accord with Highway comments	11.01.22	PNH
C	Amended to accord with HA Mix Requirements	16.03.22	PNH
D	House Type H amended to accord with HA Mix Requirements	31.03.22	PNH
E	Ped vis splays added to PROW in acc with Highway reqts	07.09.22	PNH
F	Ped and fwd vis splays revised in acc with Highway reqts	15.12.22	PNH
G	Visibility splays added to drives for Plots 1 - 6	26.01.23	PNH

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Architecture
Planning
Engineering

HAYWARD DEVELOPMENTS

PLANNING

PHASE II
EDGEHILL VIEW
GAYDON
WARWICKSHIRE

PLANNING LAYOUT

18-058/02 Rev G

OCT 2021

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