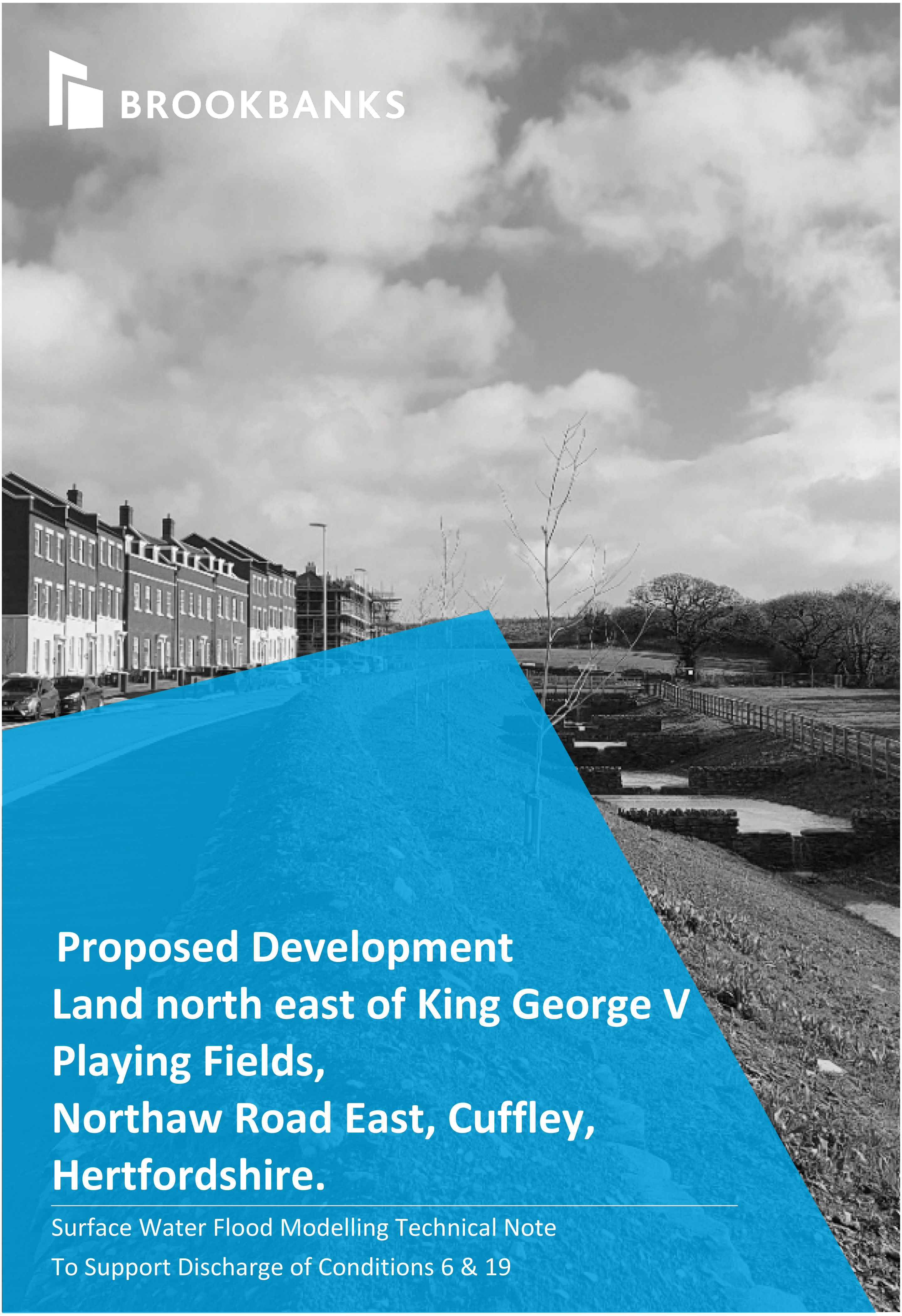

Proposed Development
Land north east of King George V Playing Fields, Northaw Road East, Cuffley, Hertfordshire.

Surface Water Flood Modelling Technical Note

To Support Discharge of Conditions 6 & 19

Document Control Sheet

Document Title	Surface Water Flood Modelling Technical Note
Document Ref	10929/TN01
Project Name	Northaw Road East, Cuffley, Hertfordshire
Project Number	10929
Client	Bellway Homes

Document Status

Rev	Issue Status	Prepared / Date	Checked / Date	Approved / Date
0	DRAFT	AM / 05.04.23	TM / 11.04.23	RM / 12.04.23
1	DRAFT	AM / 19.04.23	TM/19.04.23	RM /19.04.23
2	FINAL	AM / 28.06.23	TM/28.06.23	RM /28.06.23

Issue Record

Name / Date & Revision	13/04/23	19/04/23	28/06/23			
George Daniel - Savills	0	1	2			
Fiona Flaherty – Bellway Homes Ltd (North London)	0	1	2			

10929 Northaw Road East, Cuffley

Technical Note 01: Surface Water Modelling

Rev 02 - 23rd June 2023

1 Introduction

1.1 Brookbanks (BCL) is appointed by Bellway Homes to provide a surface water flood model for their proposed residential development at Cuffley. The model has been built in order to comply with Lead Local Flood Authority (LLFA) requirements.

1.2 The objective of the modelling, and this technical note detailing its findings, is to resolve the LLFA concerns regarding surface water flooding at the proposed development and to demonstrate that the proposed layout drains surface water effectively.

1.3 This technical note provides the modelling results for the existing baseline and post development conditions, for the 1 in 1000yr and 1 in 100yr+ 40%CC rainfall events, as requested by the LLFA.

1.4 In December 2022 and January 2023, the LLFA provided objection to the submitted reserved matters application relating to the surface water drainage strategy, Ref (6/2022/1774/RM). Brookbanks have subsequently built a surface water model (rainfall model) in order to addressed the LLFA concerns.

1.5 In May 2023 the LLFA maintained its objection (6/2023/0444/COND) and requested additional information regarding the modelling methodology and hydrology, this updated TN (Rev 02) provides a full response to these concerns. The recent objection letter is provided in **Appendix A**.

1.6 The recent objection by the LLFA has influenced a change in strategy for the mitigation of the surface water. The previous strategy captured proposed surface water flow and added it to the on-site surface water drainage network, however the objection raised concerns that the local flood risk from surface water flow paths originating offsite to the north and flowing through the site had the potential to overwhelm the onsite drainage scheme. Further development of the model and modelling of shorter duration periods has led to a change in approach. The proposed strategy now utilises a cut off ditch on the northern boundary to capture flow and pass it into a filter trench which provides an north to south flow path without utilising the onsite drainage network. Refer to section 5 for further details.

1.7 This report should be read in conjunction with Drainage report 10929-SWDR. Within this report drawings 10929-500-001 and 002 have been updated as requested and Finished Floor Levels have been added to demonstrate sufficient freeboard.

2 Hydrology

Location

2.1 The proposed development is situated on Land north east of King George V playing fields, Northaw Road East, Cuffley.

2.2 The site is bound to the north by a developed are of South Drive to the east by the Cuffley-Crews Hill connection railway, to the south by Cuffley Football Club and agricultural land and to the west by Northaw Road East (B156).

2.3 The site is currently undeveloped agricultural land.

Hydrology calculations and design rainfall

2.4 Brookbanks has acquire Flood Estimation Handbook (FEH) catchment descriptors (CD) for the catchment within which the development lies.

2.5 The development falls within the FEH catchment 530950 201600 draining in total 8.99km^2 for the Northaw Brook and Hempshill Brook towards Cuffley Brook.

2.6 Together with the FEH CD the rainfall depth-duration-frequency (DDF) curves for the FEH22 and FEH13 models were also obtained.

2.7 **Figure 2-1** below show the FEH13 DDF curve calculations for the Cuffley catchment.

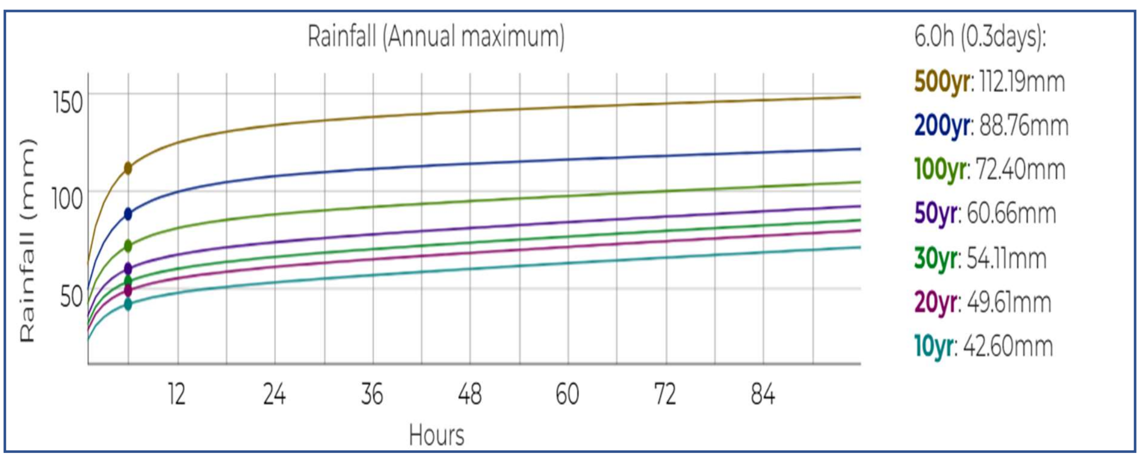

Figure 2-1 DDF calculations FEH13.

2.8 Using the DDF curve calculations rainfall depths for design storms of 100yr and 1 in 1000yr events with durations of 1hr were obtained. Table 2.1 below shows the rainfall depths for these events.

Table 2-1 Rainfall depth from DDF calculations

Event	Rainfall model	1hr	+40%CC
100yr	*FEH13*	**42.5**	**59.5**
	FEH22	40.5	56.7
1000yr	*FEH13*	**74.2**	-
	FEH22	66.9	-

2.9 For the purpose of this report the FEH13 data has been used to build the design rainfall, as it will provide the most conservative modelling approach.

2.10 The hyetograph is a graphical representation of the distribution of rainfall density over time. To build the hyetographs for the 6 and 12hr rainfall durations, SCS Distribution were used. **Figure 2-2** below shows the 1h rainfall hyetograph for the 3 events.

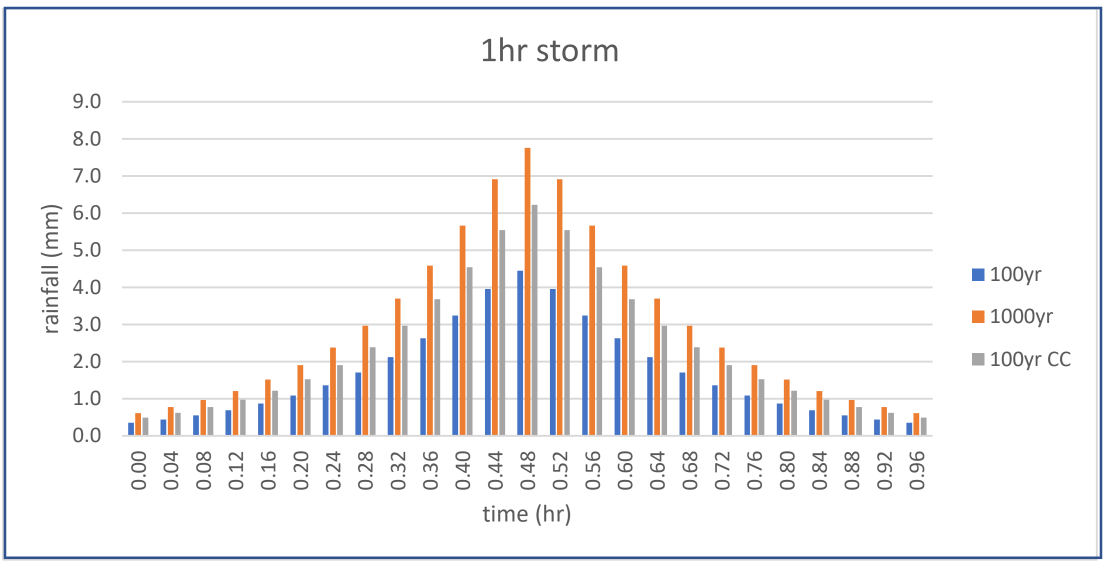

Figure 2-3 Hyetograph for 1h rainfall duration.

3 Modelling Methodology

3.1 To build the Model TUFLOW modelling software, Version 2023-03-AA was used. TUFLOW has the capability to model direct rainfall approach within a delimited 2D active domain.

2D domain

3.2 The previous report utilised the above modelling software to model direct rainfall within a delimited 2D active domain. Further to LLFA objection a more detailed catchment analysis has been undertaken to define the catchment area for the surface water flow path entering the site on the northern boundary. **Figure 3-1** below demonstrates how the direct rainfall region has been modified with the upper catchment section increasing the potential flow accessing the site from the northern and western boundaries.

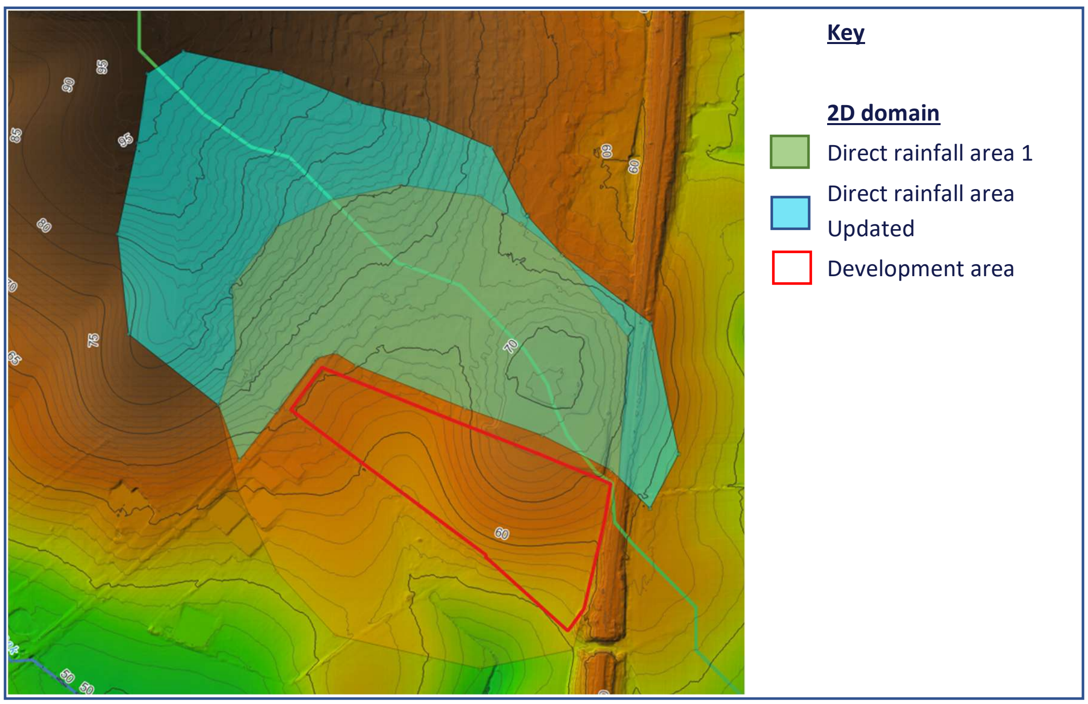

Figure 3-1 Updated direct rainfall area.

3.3 LiDAR composite (2022) Digital Terrain Model (DTM) data, with a resolution of 1m was used to define the ground model within the 2D domain. A cell size of 1m has been used in order to achieve enough accuracy to define the rainfall model.

3.4 The direct rainfall was located within the 2D domain with the feature 2d_rf, the design rainfall was located in comma separated values (.csv) format as boundary condition data base (bc_dbase). This database included the hyetograph (design rainfall) for the following events:

- 1 in 100yr ; 1h duration
- 1 in 100yr +40%CC; 1h duration, and
- 1 in 1000yr; 1h duration.

3.5 The downstream boundary condition is located at the Northaw Brook which slopes west to east with an approximate 2% grade.

3.6 Within the 2D domain the roughness associated with the various landscaped materials was determined according to their land-use classification which was defined using OS mapping and the Land Cover map 2019 (LANDIS).

3.7 Manning's roughness values within the Tuflow Materials File (.tmf) were set, with a general surface of 0.048, grass and open land of 0.040, railway of 0.040, roads and paved area of 0.025 and buildings with a high roughness value of 0.250.

3.8 As mentioned above the ground elevation at the Tuflow ground control (.tgc) was set with 1m resolution Lidar and the grid cell size selected was 1m, Figure 3-2 below illustrates the digital terrain model.

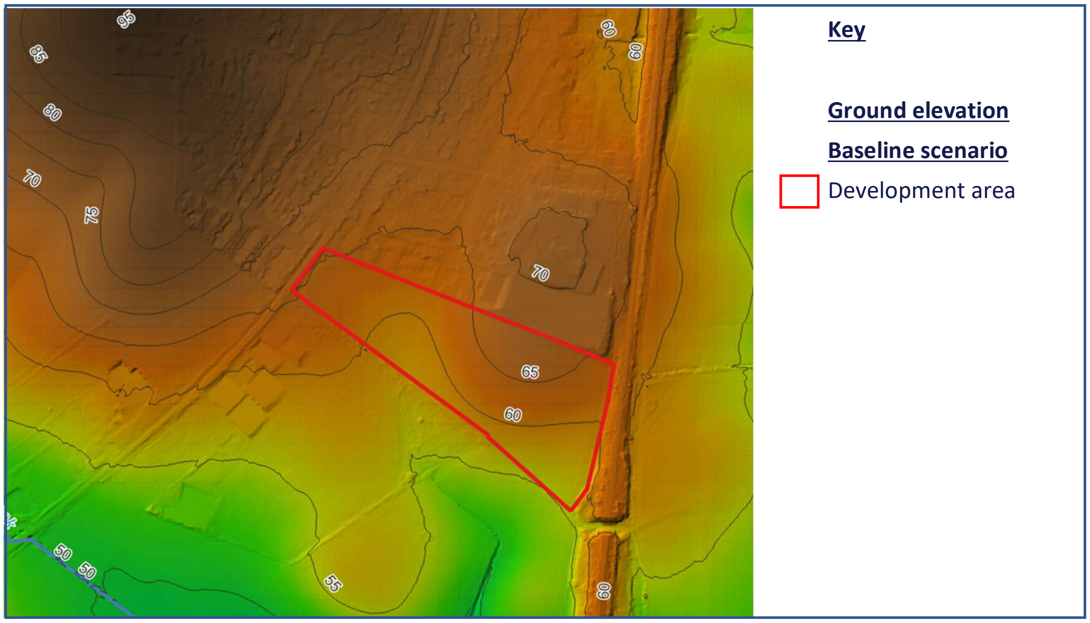

Figure 3-2 digital terrain model.

3.9 A digital elevation model of the proposed development site was built using the proposed house plot finish floor levels and ground levels and this was overlapped with the existing DTM.

3.10 The development area ground elevations are shown in **Figure 3-3**.

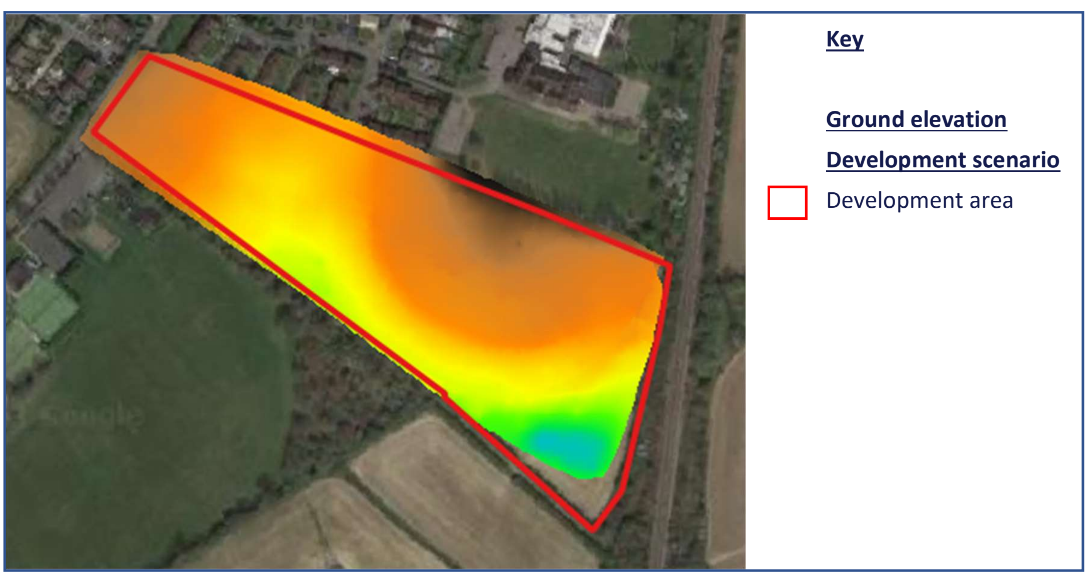

Figure 3-3 Development area patch -digital terrain model.

1D domain

3.11 The 1D domain refers to the surface water drainage system as hydraulic structures and includes for example, gullies, manholes, and pipes etc.

3.12 The 1D domain for the Baseline scenario was built to replicate the existing external site conditions and therefore includes the existing storm water drainage system located to the North of the site at the South Dr and Theobald’s Rd.

3.13 Brookbanks were unable to obtain full drainage network details for the southern section of South Drive which exists immediately north of the proposed site as this appears to be an unadopted network. However information for the Thames Water assets further north on South Drive were obtained and used to represent the existing condition. For the remaining areas of South Drive, some assumptions regarding the dimensions and invert levels of the manholes were used. However, the location of manholes and storm gullies was verified using online mapping.

3.14 1D structures were modelled within the Estry control file (.ecf) of the Tuflow modelling software. The storm drainage network was built using the 1d_nwke feature, the manholes were built using 1d_mh and the gullies using 1d_pit features.

3.15 The development scenario was built in detail with the hydraulic structures located as per the proposed development Drainage layout as detailed on drawings 10929-500-001C/002C, included in **Appendix B**.

3.16 The gullies, manholes and drainage network were built to match the proposed invert levels and dimensions, including the outfall, drainage swales and SuDS ponds..

3.17 **Figure 3-4** illustrates the proposed development surface drainage network.

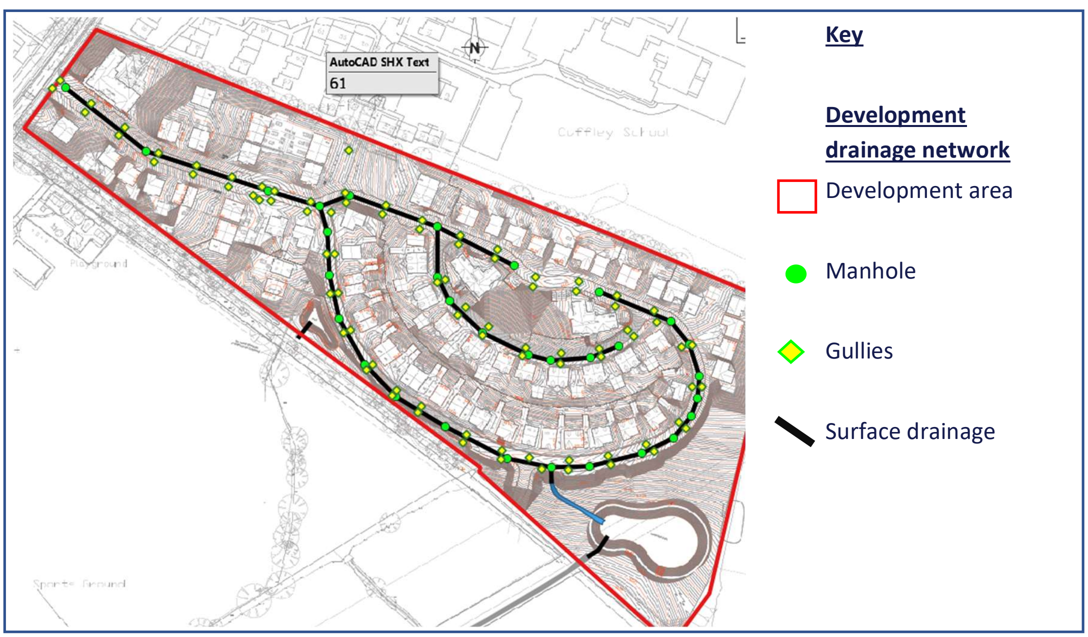

Figure 3-4 Development surface water drainage network.

4 Responding to LLFA comments

The following section provides direct responses against the queries raised by the LLFA objection letter (6/2023/0444/COND). Specific concerns raised are provided in *Italic* text prior to each response.

- *The rainfall catchment (polygon) for direct rainfall needs to be extended, as it does not provide an accurate representation of the full drainage catchment.*

4.1 As discussed in section 3.2 a detailed catchment analysis of the flow routes and flow accumulation has been undertaken since the previous modelling report.

4.2 In order to mitigate concerns and demonstrate the direct rainfall region has been modified, **Figure 3-1** has been provided. This demonstrates increases in the upper catchment section, which will generate the potential for additional flow accessing the site from the north and west boundaries.

4.3 The rainfall catchment polygon is focused on representing the rainfall which will generate the surface water flooding originating offsite. Drainage report 10929-SWDR provides a full detailed design of how rainfall to the development site is captured and dealt with.

- *Confirmation as to whether the railway underpass at the south-east extend of the site has been modelled, as this could potentially alter flow paths or downstream boundary.*

4.4 The railway underpass to the south-east section of the site has been included within the digital elevation model of the proposed development site as demonstrated in **Figure 4-1** below. The underpass is defined as a pedestrian route originating and Northaw Rd to the West of the development site and extending to the west where it meets Burntfarm Ride. The topography shows the cut under the railway line at the underpass location, however, Baseline and Development modelling scenarios does not show any flow traces in the direction of the underpass.

4.5 The main flow route is via Northaw Brook which extends further to the south of the site before crossing beneath the railway line at the Sopers Farm Viaduct.

4.6 **Figure 4-1** illustrates the baseline scenario and the natural flow path parallel to the railway line. The railway underpass and pedestrian pass is not affected.

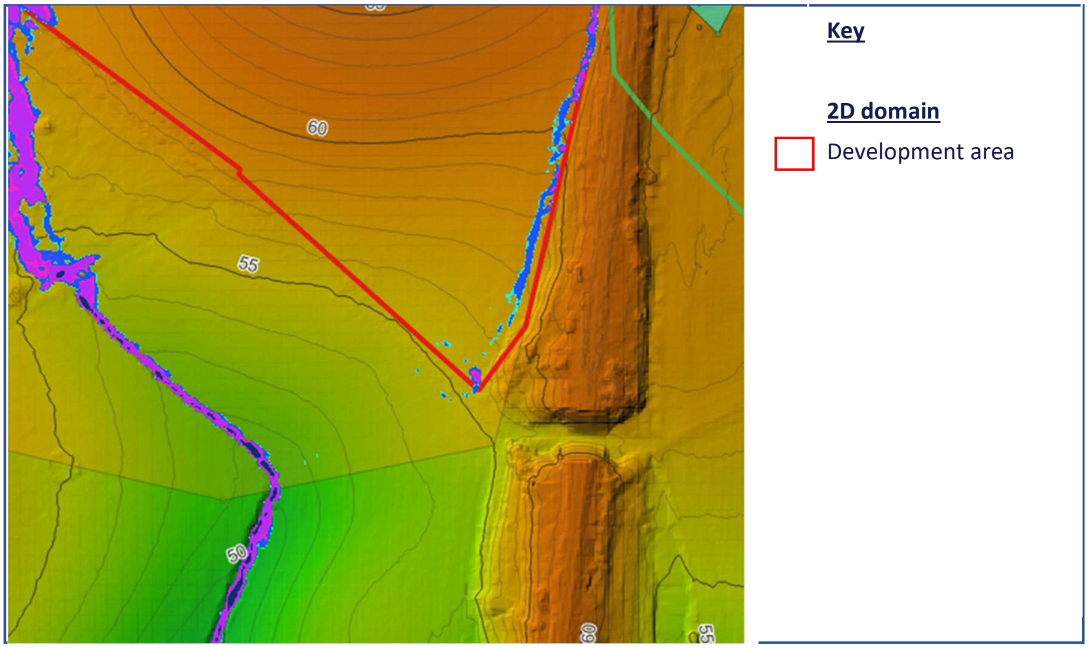

Figure 4-1 Railway underpass

- *Provide evidence as to how the storm duration values were chosen and provide evidence as to which one is defined as the critical storm duration (which would likely to be less than 6 hours).*

4.7 The time of concentration (Tc) is the time required for runoff to the travel from the hydraulically most distant point in the watershed to the outlet. For the sub-catchment section that drains towards the development site the time of concentration has been calculated using the Kirpich (1940) and Soil Conservation Service (SCS-1972), both adopted from Ven Te Chow.

Kirpich method : $Tc = 0.0078L^{0.77}\ S^{(-0.385)}$

SCS method : $Tc = L^{1.15}/[7700H]^{0.38}$

4.8 With the above methodology the maximum elevation is 96m AOD the minimum elevation is 41mAOD, the total distance is 1570m. Total gradient of 1:28 (3.5%).

4.9 Time of concentration calculated between 25 and 29 minutes.

4.10 Therefore the design storm for the sub-catchment in order to get more volume is to be determined to be for ~1hr duration.

4.11 Using the DDF curve calculations rainfall depths for design storms of 100yr and 1 in 1000yr events with durations of 1hr was obtained. **Table 2-1** in section 2 of this report shows the rainfall depths for design storms of 1 in 100yr and 1 in 1000yr events with durations of 1hr, calculated using the DDF curves in **Figure 2-1.**

- *Provide methodology of how rainfall has been applied to the model and whether it considers permeable and impermeable areas separately. Provide clarity as to whether land uses have been separated or not.*

4.12 A description of who rainfall is applied to the model is outlined in Section 2. The FEH catchment descriptors for the catchment 530950 201600 calculates the rainfall modelling for the FEH13 and FEH22 for different durations and frequencies, the Depth Duration Frequency (DDF) curves were obtained from the FEH portal for the entire catchment (8.99km2) or for 1km grid points. **Figure 2-1** shows the FEH13 DDF curve calculations for the Cuffley catchment.

4.13 The Depth for a 1h duration and 1 in 100yr+40%CC event is shown in **Table 2-1.** Within the model this depth is used as effective rainfall for the entire sub-catchment within the 2d boundary condition (2d_rf) at the area shown in **Figure 3-1**. The rainfall is set at the boundary condition data base (bc_dbase) with the total depth divided in a hyetograph throughout the 1hr duration, as is shown in **Figure 2-3**.

4.14 The entire depth of rainfall is considered as effective rainfall, therefore no losses have been considered for the entire domain, the material files provide Manning's n to represent the roughness of the different land-uses and buildings are set to a high roughness number, which is considered good practice.

4.15 As discussed in section 3 land-use classifications where defined using OS mapping and the Land Cover map 2019 (LANDIS). Manning's roughness values within the Tuflow Materials File (.tmf) are also provided within section 3.

4.16 To build the Model the latest TUFLOW , Version 2023-03-AA was used. TUFLOW has the capability to model direct rainfall approach within a delimited 2D active domain.

4.17 LiDAR composite (2022) Digital Terrain Model (DTM) data, with a resolution of 1m was used to define the ground model within the 2D domain. A cell size of 1m has been used in order to achieve enough accuracy to define the rainfall model.

4.18 A digital elevation model of the proposed development site was built using the proposed house plot finish floor levels and ground levels and this was overlapped with the existing DTM. This is provided in **Figure 3.3**.

- *Provide comparison of EA surface water maps alongside the surface model baseline scenario. Surface water flooding depth difference maps between pre and post development should be provided to illustrate comparisons to help verify results and identify where flood risk is reduced or increased. Appropriate key levels should be included.*

4.19 **Figures 4-2** and **4-3** below show the comparison between the EA Risk of Flooding from Surface Water (RoFSW) maps extracted from the DEFRA data service platform for 1 in 1000yr and 1 in 100yr respectively.

4.20 **Figure 4-2** shows the existing baseline scenario, for a 1 in 1000yr event, 1h rainfall duration.

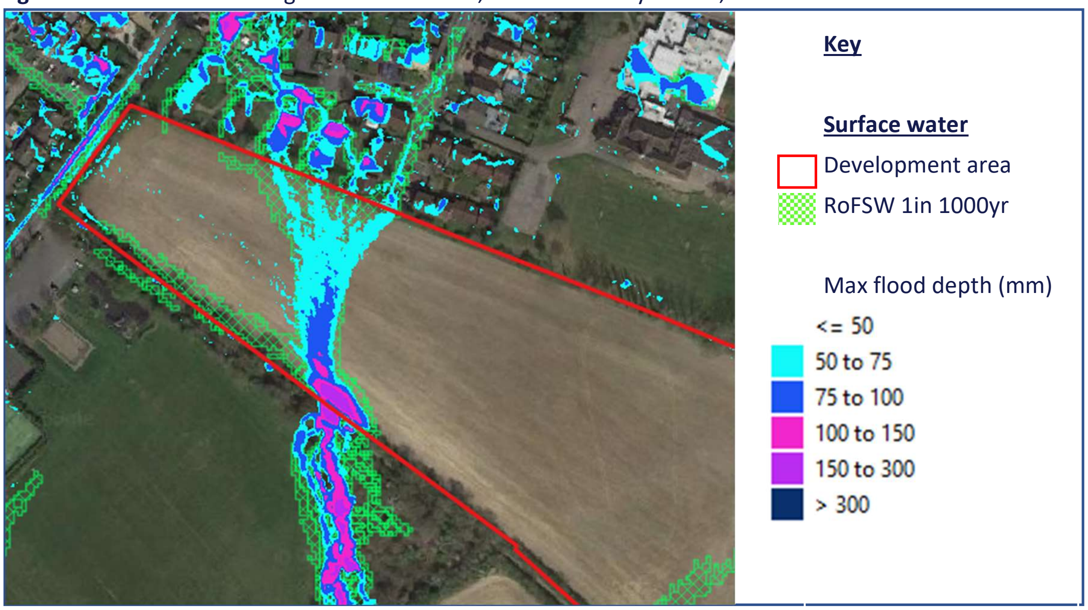

Figure 4-2 Maximum flood depth Surface water, 1h duration 1 in 1000yr

4.21 **Figure 4-3** shows the existing baseline scenario, for a 1 in 100yr event, 1h rainfall duration.

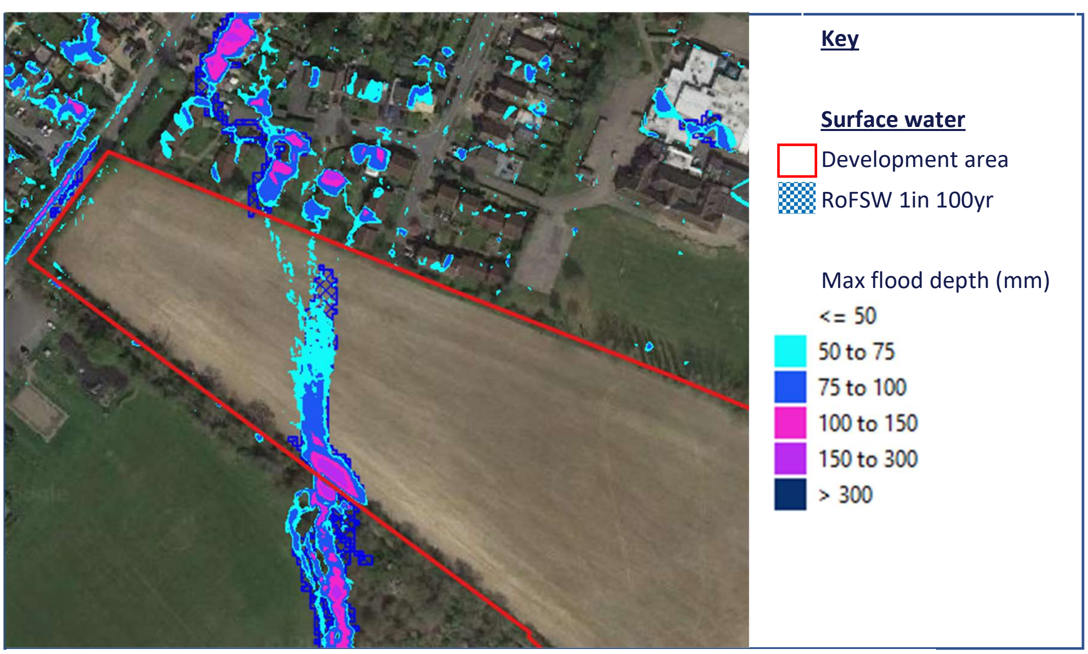

Figure 4-3 Maximum flood depth Surface water, 1h duration 1 in 100yr

4.22 The baseline scenario represents the as existing condition and shows the current flood risk at the development area without any changes in ground levels or any surface water drainage systems implemented on the development site. Figure 4-2 and 4-3 demonstrate good correlation between the EA RoFSW and our baseline models.

4.23 The Key shows that flood depths below 50mm (5.0cm) are not considered / mapped. The area of direct rainfall for this comparison is the area shown in **Figure 2-1** of this report. This therefore clearly illustrates the flow accumulation due to the topography which leads to the surface water flow route particularly across the northern boundary.

4.24 An arc to arc tool has been used to quantify the changes between the baseline scenarios versus the development ones as requested. This tool calculates the differences in flood levels between the compared scenarios for each grid cell.

4.25 **Figure 4-4** below illustrates the differences in flood levels between the 1 in 100yr +40%CC scenarios, the negative values (orange and reds) represent the reduction in flood levels and the positive values (green and blue) represent the increase in flood levels.

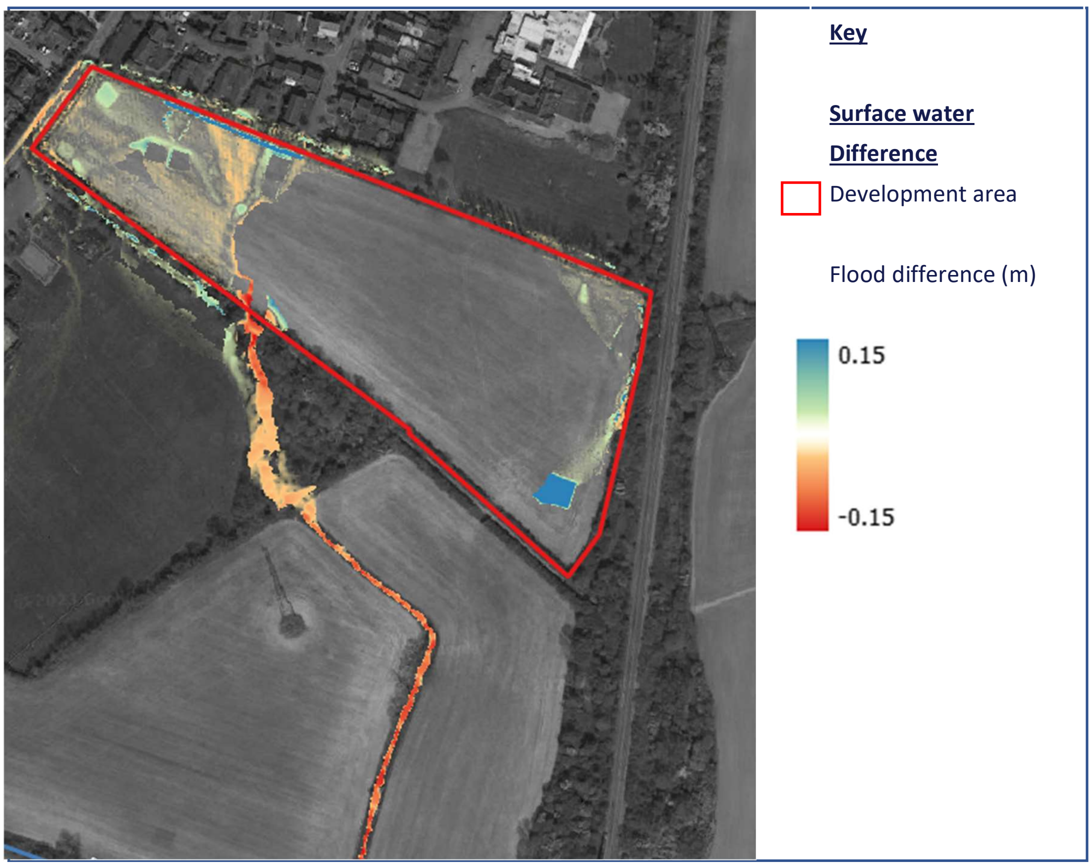

Figure 4-4 Flood depth difference Baseline vs Development, 1h duration 1 in 100yr+40%CC

4.26 **Figure 4-4** above shows that at the downstream section of the development the proposed development reduces the flood depth. That is due to the reduction if surface flood water draining from the development site as a portion of it is retained in the retention ditch and attenuation ponds.

4.27 The comparison between the RoFSW and the baseline scenario for the whole extent and the flood differences between all three modelled scenarios are shown in **Appendix C** of this report.

5 Rainfall Modelling Results

Baseline Scenario

5.1 The baseline scenario represents the as existing condition and shows the current flood risk at the development area without any changes in ground levels or any surface water drainage systems implemented on the development site.

5.2 In order to provide a more accurate representation of the baseline surface water situation, the existing stormwater drainage features located within South Drive have been modelled. In the previous report this recued the baseline impact on the development however for shorter duration of storm the modelling demonstrates that the drainage network will become overwhelmed with the excess of water draining south towards the proposed development.

5.3 **Figure 5-1** illustrates the baseline scenario for 1h duration and 1 in 100yr +40CC event.

Figure 5-1 Maximum flood depth Surface water Baseline scenario, 1h duration 1 in 100yr+40%CC

5.4 **Figure 5-1** identifies that most of the site remains below 100mm however next to the southern boundary the flow accumulation show higher depths between 150 to 300mm.

5.5 For 1 in 1000yr events the flood extent increases slightly at the south boundary of the proposed development area due to flood accumulation, however the flood depths will remain below 300mm.

5.6 All modelled events and durations for the baseline scenario are shown in **Appendix D**.

5.7 Historical flood events are outlined within the FRA submitted at outline planning stage (10710 FRA01 Rv1). Figure **5-3** of this report combines extracts from the Welwyn Hatfield Borough Council Strategic Flood Risk Assessment (SFRA) and additional information obtained from Hertfordshire Highways flooding database and outlines a low frequency of flooding events along the roads adjacent to the north and west of the site. Figure 5.3 of the FRA report has been replicated in **Figure 5.2** below for ease of reference.

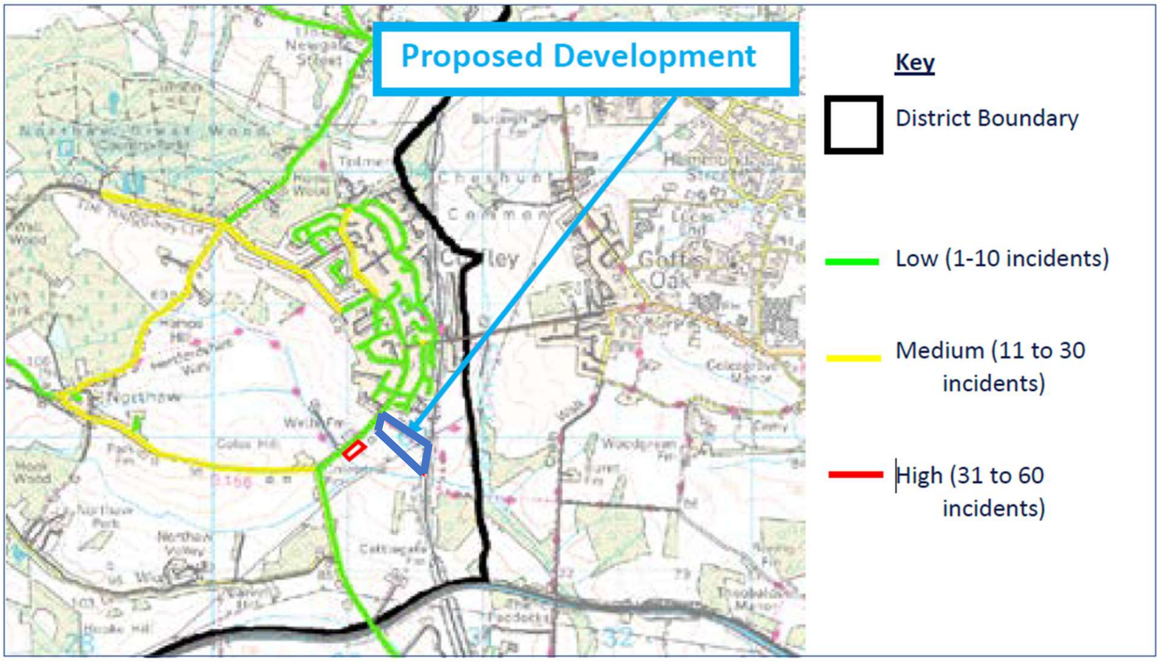

Figure 5-2 Frequency of road flooding events adjacent to the proposed development site

5.8 The limited historical flood events shown above appears at odds with the modelled surface water flow path through the proposed site. The modelling doesn't include for the provision of existing highway and storm water networks within the northern catchment and clearly they will have some impact on limiting flows. Infiltration is also not captured within the model and it's likely that infiltration will occur in garden areas and areas of public open space which will also have a positive impact on limiting storm water flows.

Development Scenario

5.9 The modelling results of the proposed Development scenario represent the proposed surface water flood risk within the area of the proposed development.

5.10 The new strategy which has been modelled involves capturing the surface water flow paths crossing the northern boundary within a retention ditch which feeds a 450mm pipe within a filter trench providing a flow route for excess flow from the northern boundary to the southern boundary.

5.11 The ditch is approximately 90m long, and it is proposed to be up to 2m wide and up to 1.1m deep. **Figure 5-3** shows the location of the ditch and its cross section in relation to the location of the 450mm outlet pipe.

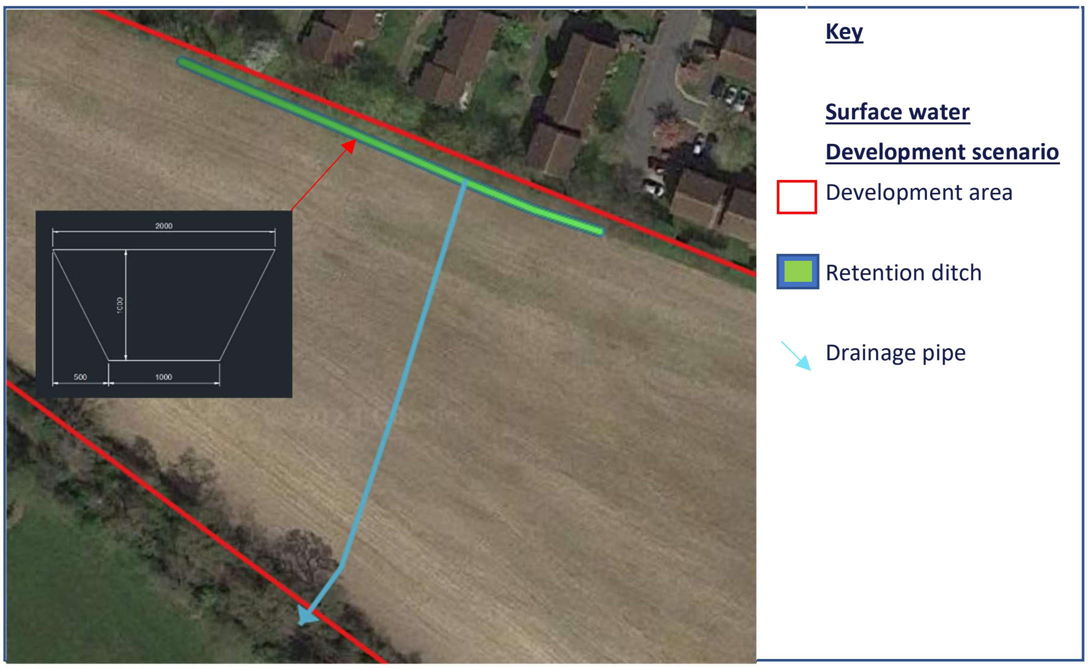

Figure 5-3 Proposed retention ditch and 450mm drainage pipe.

5.12 The development model uses the baseline scenario combined with the proposed development changes in ground level and the proposed surface water drainage network.

5.13 The retention ditch, and drainage pipe has been modelled to act independently of the storm water drainage network which will deal with all rainfall events falling on the development. **Figure 5-3** has been provided to demonstrate the impact of the retention ditch only. This shows that a degree of surface water flow under the worst case duration scenario will overtop the retention ditch and flow will follow the development contours through the site north to south. The route generally flows through garden areas with maximum depths in the order of 100mm.

5.14 Despite the depths of overland flow through the site being relatively low it is considered that the filter trench provides further mitigation. **Figure 5-5** demonstrates the development scenario with the retention ditch and filter trench. The pipe within the trench will be perforated with holes facing up so that if the pipe surcharges the filter trench will provide additional capacity without impacting upstream scenarios. The mitigation scenario therefore allows the excess overland flow volume to be passed downstream reducing the potential impact on the properties. Finished floor levels for all properties are provided on Drawings 10929-500-001 and 002 which have also been updated to show ditch and filter trench details. The drawings are provided in **Appendix D.**

5.15 A Test scenario with the cut off trench and without the drainage pipe was simulated in order to assess the impact and any betterment provided by the drainage pipe in the reduction of flood risk at the development area, **Figure 5-4** below illustrates this scenario.

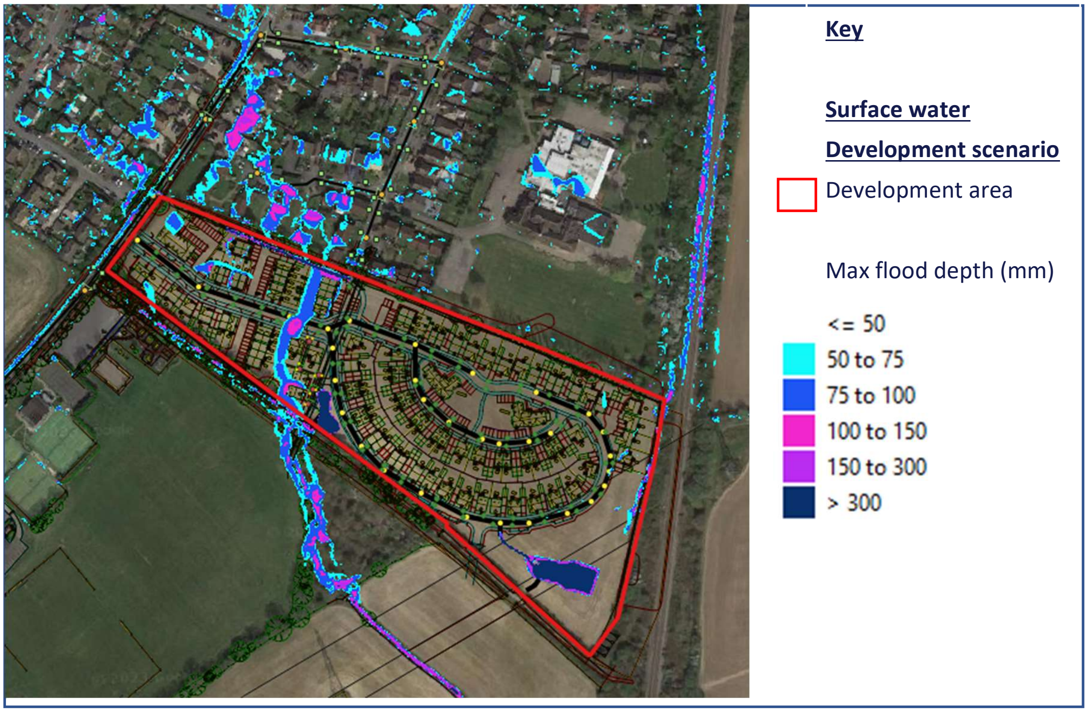

Figure 5-4 Maximum flood depth Surface water Development scenario, 1h duration 1 in 100yr+40%CC (No drainage pipe)

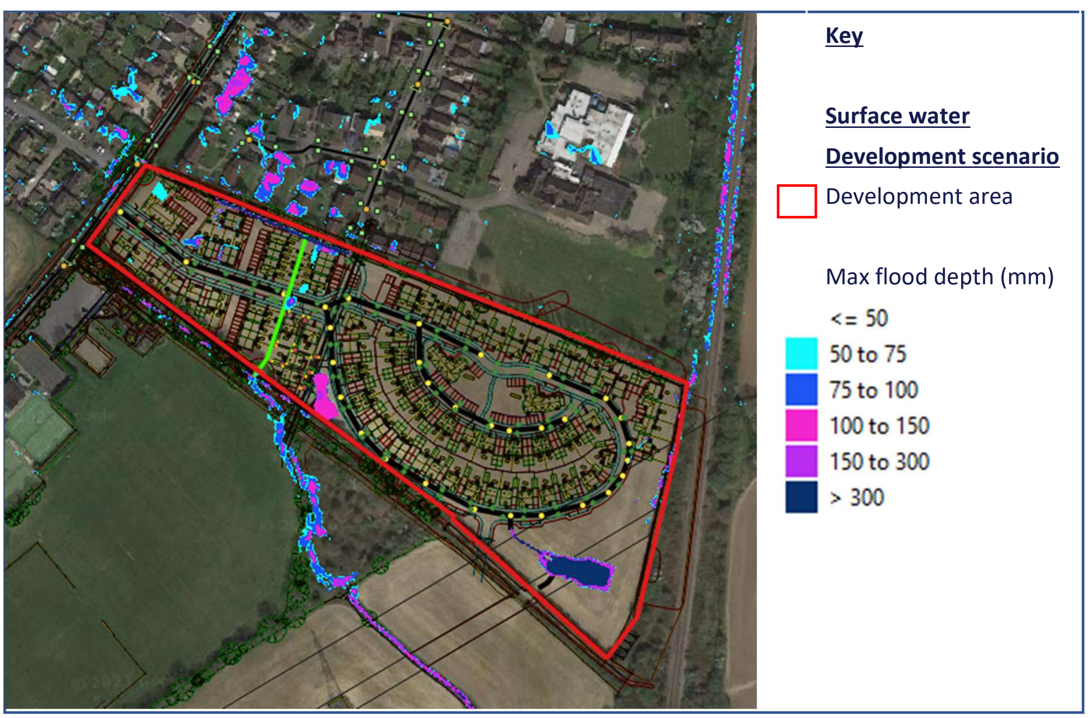

Figure 5-5 Maximum flood depth Surface water Development scenario, 1h duration 1 in 100yr+40%CC

5.16 Modelling of the proposed development scenario shows there are some small areas where there are influences around residual flooding to housing plots of less than 100mm. Floor levels in these areas have been set with sufficient freeboard as shown on the drawings.

5.17 The proposed development scenario shows that the proposed retention ditch stores water from the northern boundary and the drainage pipe discharges at the downstream section.

5.18 All modelled events and durations for the development scenario are shown in **Appendix D**.

6 Summary and Conclusions

6.1 The design rainfall duration and DDF calculation used for this report comply with the regulations and for this case represent conservative scenarios.

6.2 The baseline scenario shows that there is a local flood risk from a low flow surface water flow path originating offsite to the north and flowing through the site.

6.3 The proposed development will change ground levels and will implement a surface water drainage network throughout the development area. The proposed development will also include SuDS swales and ponds to retain surface water. To mitigate the impact of the surface water flow path on the proposed development a cut off ditch on the northern boundary has been modelled which captures flow and passes it into a filter trench. This provides a north to south flow path which is independent to the onsite drainage network.

6.4 Modelling of the proposed development scenario shows that the proposed mitigation measures provide satisfactory management of the local flood risk and do not adversely affect flooding elsewhere.

7 Limitations

Limitations

7.1 The conclusions and recommendations contained herein are limited to those given the general availability of background information and the planned usage of the site.

7.2 Third party information has been used in the preparation of this report, which Brookbanks, by necessity assumes is correct at the time of writing. While all reasonable checks have been made on data sources and the accuracy of data, Brookbanks Consulting Ltd accepts no liability for same.

7.3 The benefits of this report are provided solely to Bellway for the proposed development at Northway Road East, Cuffley only.

7.4 Brookbanks excludes third party rights for the information contained in the report.