Technical design note

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Design note title	Addressing Environment Agency Comments		
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Date	27 June 2023	Approved	☐

1. Introduction

Hydrock received a review from the Environment Agency dated 14/02/2023 of a Flood Modeller-TUFLOW model used to assess the flood risk at Gavray Drive. This model was truncated to a site-specific model from an Environment Agency model of Bicester. This technical note will address each amber and red comment from the review for both the hydrology and the hydraulics elements.

2. Hydrology

2.1 Method Statement

1.1. Provide commentary on the complexity of the hydrology within this catchment basin.

This is a complex catchment due to the urban nature of the catchment and permeability of the catchment. There is also a small area of cross-catchment flows introduced via the sewer network.

2.0. Provide further commentary on the main flooding processes that occur within this catchment into the report, from surface water, fluvial, groundwater etc. and how assessments have been made quantify the risk posed by these processes.

Request was made to provide further commentary on other sources of flooding. This was highlighted as a 'green' and therefore is not expected to have any impact on the calculated flood levels. However, an assessment of the potential risks from groundwater, surface water etc has been undertaken within the accompanying Flood Risk Assessment. Whilst this confirms there are risks associated with surface water it is considered these are shown as being similar to those of the model outputs and therefore it is considered that fluvial is the dominant source. This is the same argument as with groundwater flooding as the Langford Brook would act as the natural drawdown point for any increased groundwater levels. Given this it is again considered that peak fluvial levels would be controlled by fluvial events.

2.1. Have any assessments been carried out with evidence to show that this catchment is not groundwater dominated?
There will be some baseflow due to the permeable nature of the soils and underlying bedrock, has this been factored in to the flow estimation calculations?
The previous study quantified the amount of baseflow within each sub-catchment which should be replicated or acknowledged and the uncertainty in final flow estimates as a result of this factored into the study.

This study focusses on the proposed development site only and provides a truncated version of the model when compared to that originally provided by the EA. In summary this model focusses on sub-catchment LA1 and LA2 only. One of the limitations of this model is that access is limited to areas under the applicant ownership. In terms of information this is also limited to what is publicly available and/or provided by the EA/LLFA. In this instance that data is limited and in order to provide consistency to the previous study, the same approach has been used. That said a check on URBEXT was undertaken given the EA's data was previously undertaken in 2009. This confirmed no difference.

In terms of base flow, information available was limited and therefore the same approach as that adopted by the EA previously was used – i.e. application of a base flow to respect the potentially raised groundwater levels. It is considered the impact of this is relatively unaffected by the time elapsed since the first study.

The latest assessment has taken on board the comments relating to using observed data. Unlike the previous assessment this updated method utilises the recorded depths for the gauge immediately downstream of Gavray Drive. This data has been made available in the form of daily maximums and a copy of this data accompanies this report.

This data was used to calculated associated flows from the depths using a Manning's 'n' equation in the absence of gauged flows being available. These flows were used to then create a QMED value based on 15 complete water years' worth of data. A spreadsheet detailing the methodology used (Gauged Depth Data v2) has been attached to this note.

The QMED calculated was then to inform develop (through fittings curve via Statistical Analysis) all return period event flows. This is in line with accepted EA principles and as detailed within the Flow Estimation Handbook. This has been detailed in the Flood Estimation Calculation Record.

2.2. Provide justification for why this level gauge has not been acknowledged and used for calibration and improving estimates.
This gauge could be used to develop rating curves by converting level into flow data as described in chapter 5.2 of the original model report. The continuous data from this gauge could help improve flow estimation values for the model and should be utilised.

This exercise has now been done. Gauge data has been used, depths converted to flows and used to generate QMED which forms the basis of this updated assessment. See section 2 in the hydrology report.

2.3. Provide commentary on whether other datasets have been looked into.

No other datasets for the Langford Brook are known to be available and owing to the depth gauge in relation to the site (approx 50m downstream) none are considered as being more appropriate for assessing risk to the site.

2.7 Please include plots and interpretation of the 3 - 5 largest events on record into the report. Can rating curves be created from looking at the recorded flood events, this was done in the previous study to help calibrate the hydraulic model to good effect and would reduce uncertainty in the estimates.

Hydrographs cannot be made from the largest events at the gauge as the data provided was only daily maximums. Calibration cannot occur as sub daily level information has not been provided in order to aid this calibration. The five biggest events have been included and analysed in Appendix A of the original EA report. This ensured that the time to peak and overall shape of the hydrology was represented in the model. The hydrograph shape and time to peak was retained from the previous model and scaled to the peak flows generated. Therefore, this analysis is not required.

However, a flood frequency analysis using the Gringorton plotting position formula was undertaken to understand the return periods of the largest events at the gauge. A graphical representation of this can be found in Figure 1. Our statistical analysis showed that a 20-year return period has a peak flow of 9.21 m^3/s. The flood frequency analysis showed that a 20-year return period has a peak flow of 10.53 m3/s. The similarity of these two flows gives confidence to the hydrological inflows into the model. Due to the short record of the gauge there is not high confidence in a single site analysis and therefore we can be more confident in our statistical analysis which also included information from other sites with longer records.

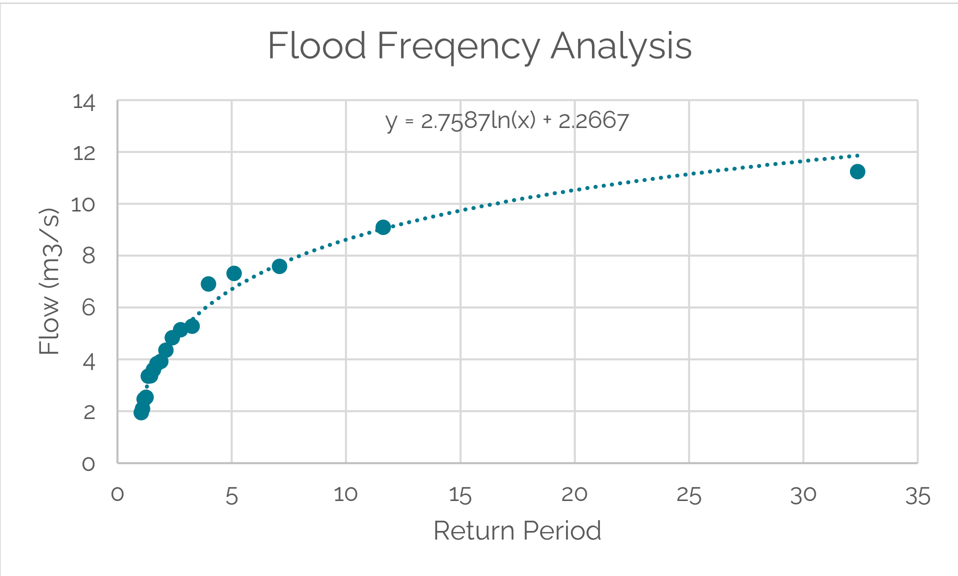

Figure 1: Flood Frequency Analysis on the Langford Brook Gauge.

A flood frequency analysis on gauged data shows the highest flows occurring at the gauge was ~32-year return period. Therefore, the higher return periods used in this analysis will rely on a hydraulic model. The previous rating curve was generated using the hydraulic model for the higher flows and was accepted by the Environment Agency. Therefore, as the hydraulic model has not been altered, only truncated, this rating curve will remain acceptable.

3.0 Where possible use the most recent version of the NRFA dataset.

This has been undertaken within the latest assessment. NRFA data set used at time of assessment (May 2023) was the most up to date available.

3.1 See comment 2.2.

Recorded Depth data has been used as the basis for this assessment. Theoretical approaches have only been used to derive higher return period events but again based on the QMED so linked to observed.

3.2 See comment 2.2.

As above.

3.3 I would reiterate that whilst the previous hydrology calculations have been used to compare flood peaks, it would be expected that the previous studies methods be replicated utilising up to date software to increase confidence and as a best practice approach, especially given the presence of gauge data available.

The ability to address this point is again limited as to information availability. However, and on completion of the latest assessment and using the gauged data the calculated (and observed) values were compared to those within the previous EA study. Whilst QMED is around 80% higher than that previously calculated all other return period are similar with the latest assessment providing flows that are circa 7-9% greater than those previously calculated.

With respect to the higher QMED value this is not unexpected. On review the recorded depths (and rainfall events) during recent years (from around 2013) have been higher than the preceding 6 years for which there is recorded data. Given this, QMED would be higher than the previous study and therefore a sense check on the data has been undertaken.

3.4. Previous flood events are mentioned within the main model report however this is not within the FECR where it is more relevant.

This has been undertaken within section 2.5 of the FCER.

3.5 Have the historical flood extents been compared to events with good correlation?
Cross section of river node has been used to compare levels however hydrographs of events would be useful to show how they correlate.

This has been undertaken based on the best data available. Hydrograph information isn't available and therefore depth data is all that is realistically available. Agreed on importance of reviewing historical events and exercise undertaken is believed to provide good correlation with (limited) data available and therefore decreases uncertainty. A flood frequency analysis shows that the 2020 event was a 32-year event with a flow of 11.25 m^3/s. This correlates closely to our statistical analysis showing a peak flow of 10.17 m^3/s.

3.6 Flood alleviation schemes are present downstream of the site on the Langford Brook. Add this information into conceptual model and understanding of catchment section.

A flood alleviation scheme is shown downstream of the site in the form of a pond. This is located a short distance downstream of the site and following a request to the EA and LLFA data and levels for this feature have not been provided. It should also be noted that this feature is located within 3rd party land and access would not be easily possible. Owing to the location of this feature being downstream of the site and the downstream limit of the catchment being assessed (i.e. to the gauge) it is not considered that this falls within the catchment of interest and therefore it wouldn't have an impact of the assessment undertaken.

2.2 Catchment Schematisation

4.0 Please provide justification for choosing only one flow estimation point and why this has been defined as a sub-catchment. How the specific location has been derived for the catchment descriptors. It would be expected that at least two FEPs are used, one at the upstream boundary of the model and one at the downstream boundary, preferably with another placed at the site of interest to provide a more comprehensive picture of flows throughout. This is especially the case given the urbanised nature of the lower catchment compared to the upper.

The single FEP was owing to the small nature of the site and given it is located at the downstream limit of one of the identified sub catchments within the original report. However, this point is noted and within the original report flows have been calculated and then weighted as per the original EA assessment. Therefore, there is 3 FEPs within the updated models.

4.1 As above, please provide explanation for how the hydrological flow estimate point have been derived.
Explain the choice of using lumped catchments over a distributed approach.

The comments raised no longer relate to the methodology being used in the study. The approach now utilises gauged data where at all possible and then, as with the original EA study, calculates return period events using the statistical analysis. This has been undertaken for the previous sub-catchments LA1 and LA2.

4.2 Provide the calculations used to calculate area-weighting where it has carried out and calculations for any descriptors that have been modified so that the results are reproducible.

This have been detailed within section 1.1.3 of the model report but are the same as those used within the EA's original assessment as sub catchments remain unchanged. This is therefore reproducing the EA's approved methodology from previous assessments.

4.3 Please provide evidence of checks against the sewer network and LiDAR/topography to ensure the full drainage catchment is being represented and that flows are not being added into or taken out of the catchment.

As with the comment to 4.2, a review of key catchment descriptors (FARL, AREA, BFIHOST etc) have been undertaken. This has been through using google earth imagery to look at developed area, review of LiDAR and soil maps to confirm catchments and BFI values. A cursory review of sewer maps was also undertaken to ensure any cross-catchment flows were picked up (see comment 5.2). This all confirmed that the catchment descriptors are suitable for use.

4.4 Please provide comments on whether checks have been carried out against other catchment descriptors and the justification for modifying them or leaving them.

These checks have been undertaken and were detailed in previous reports. Focus on the 'key' descriptors in terms of AREA, URBEXT, and SPRHOST. This is detailed in section 2 of the modelling report.

4.5 Please provide maps to illustrate that the catchment falls suitably within the topographical boundaries.

The catchments are unchanged from those within the original assessment (by EA). An assessment with the latest available 1m LiDAR shown in Figure 2 shows that the catchment delineated by FEH is correct.

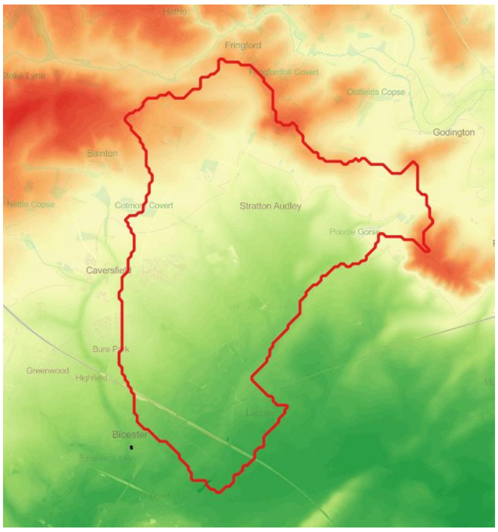

Figure 2: 1m Lidar used to analyse topographical boundaries.

4.6. Please provide the equations and calculations that were used to produce the new URBEXT estimate.
Provide geological maps to illustrate the distribution of bedrock and superficial deposits within the catchment.

This was based on the URBEXT calculation Science Report and following industry standard approaches. The equation is shown in equation 1.

$$URBEXT_{2000} = 0.629URBAN_{50k} \quad (1)$$

where $Urban_{50k}$ were manually derived from Ordnance Survey (OS) 1:50,000 maps according to the FSR methodology.

Initial assessments were based on the mastermap. However, in order to meet the requirements of the document 50k mapping was used so as to strictly follow guidance.

Figure 3 shows the site bedrock geology to largely consist of mudstone, limestone and sandstone owing to a permeable catchment. This shows that the BFIHost of 0.629 is an accurate representation of the catchment. There are also superficial deposits of Alluvium along the Langford Brook owing to a mixed nature of permeability.

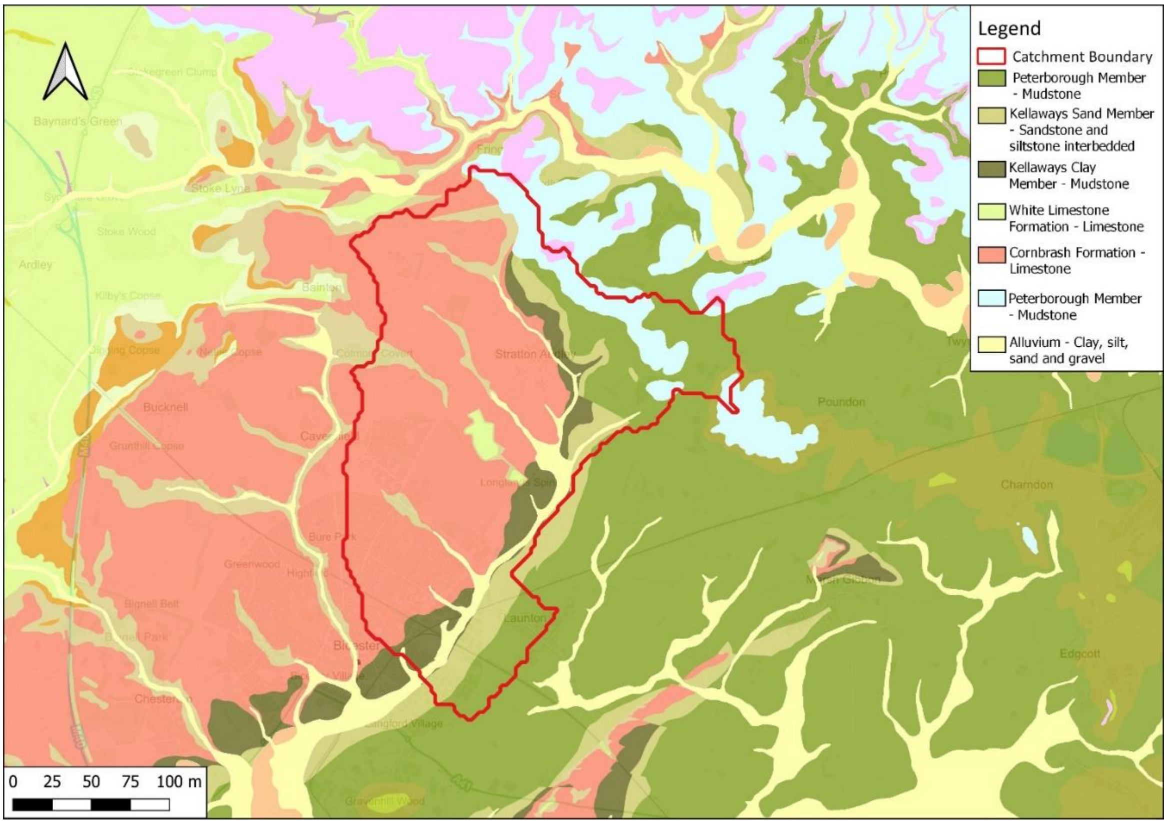

Figure 3: Catchment Superficial and Bedrock Geology,

4.9 Similar to comment 4.6 the methods and calculations that have been made to modify the urbext need to be provided and methods clearly stated so that the calculations can be reproduced to confirm accuracy.

The URBEXT extent has been reviewed using the 50k os mapping to determine what, if any, increases there have been since the previous study. The urban extent was found to be 3.745 km^2 generating a $URBAN_{50k}$ value of 0.194. This was inputted into the calculation one and therefore 0.629 x 0.194 gives the $URBEXT_{2000}$ value of 0.122. This has shown that whilst there is a slight increase (original value was 0.1) the categorisation has not changed and the site would still be classified as 'moderately urbanised'.

2.3 Unusual Catchment

5.0 Please provide a statement of whether there is expected to be other flooding processes such as surface water flooding risk at this site or off the site as a result of increased development.
It is noted that the flooding event in December 2020 was primarily driven by surface water processes rather than fluvial.

Surface water sources of flooding have been detailed within the supporting FRA and are not a subject of this study. However, the site has a drainage strategy designed to reduce peak surface water runoff and alleviate flooding from surface water which has received approval from the LLFA. Therefore, there is no other sources of flooding at the site.

5.2 Please provide a map of the drainage network for the catchment and surrounding areas to show whether flows are being added or removed from the catchment.
See screenshot for illustration of drainage network, this needs to be more robustly evidenced how checks have been carried out, currently it appears some flows may not be accounted for.

As detailed in the response to 4.2 a check of the sewer mapping has been undertaken. This confirmed a small area of cross catchment flows had been introduced (to the west) but that an area which was shown by the generated catchment area was not 'in catchment' and could be removed.

Figure 4 displays the plan and a check with Thames Water has confirmed this is accurate.

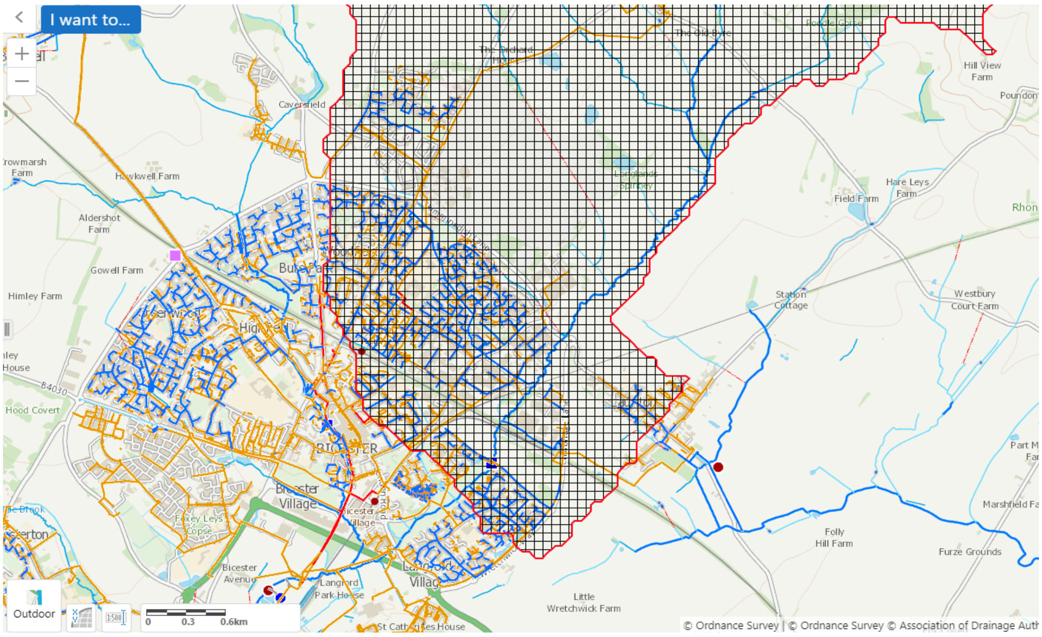

Figure 4: A map of the drainage network for the catchment.

5.4 Has this been investigated further to understand whether groundwater flooding needs to be considered as a flood source within the catchment, please provide further evidence for groundwater flood risk, using past flood events and the processes involved during these events.

Yes, but limited to the approach/methodology detailed within the EAs previous assessment owing to reasons mentioned previously - lack of information and scale of development being an individual site rather than catchment wide. However, a base flow has been included and this is consistent with EAs values. In absence of other data this is considered as an appropriate check.

2.4 FEH Statistical

6.3. See comment 2.2.

As with response to comment 2.2. This exercise has now been done. Gauge has been used, depths converted to flows and used to generate QMED which forms the basis of this updated assessment. However, the Tp estimations and calibration cannot occur as the data provided is daily maximum levels. Sub daily data would be needed for this analysis.

7.2 Consider using the latest NRFA dataset to assess the suitability of sites within the pooling group.

Given time elapsed (and new datasets) this comment is noted and latest dataset used.

2.5 ReFH and ReFH2

8.1 Please provide further explanation for how an 11 hours storm duration has been derived, why was the previous studies storm duration of 17.5 hours not used in this study?

This has been amended within the latest study and calculations undertaken for the storm duration. This was based on a combination of available gauge data (15min) to understand response times. However, this provided varying results. Given the relatively minor change expected the previous duration of 17.5 hours are used.

8.2 See comment 4.0.

As with response to 4 - this has been amended. The hydrology study from the previous study had not been provided to Hydrock until recently. Now this is available a similar approach has been adopted with the two sub catchments being used and split in line with methodology used in EA report.

8.3. Please clarify why a sub-catchment has been chosen as the primary flood estimation point.

The model has been truncated and only sites within LA1 with minimal area in LA2 and as such calculating for the whole catchment seems excessive. This was why a single FEP was provided previously - as this model is much reduced from the previous one given location and scale of site.

8.5 Please consider assessing whether a summer duration may be more appropriate for this catchment and provide explanation for the final choice of rainfall profile. Provide evidence to support your decision making.

This has been assessed and the summer profiles for each FEP has been used. This profile was deemed suitable as it a moderately urbanised catchment and therefore a summer thunderstorm is typically the flood causing mechanism. However, this does not cause any significant change to the hydrograph shapes an example of this is shown in figure 5 and 6, therefore there would be no change to flood extents.

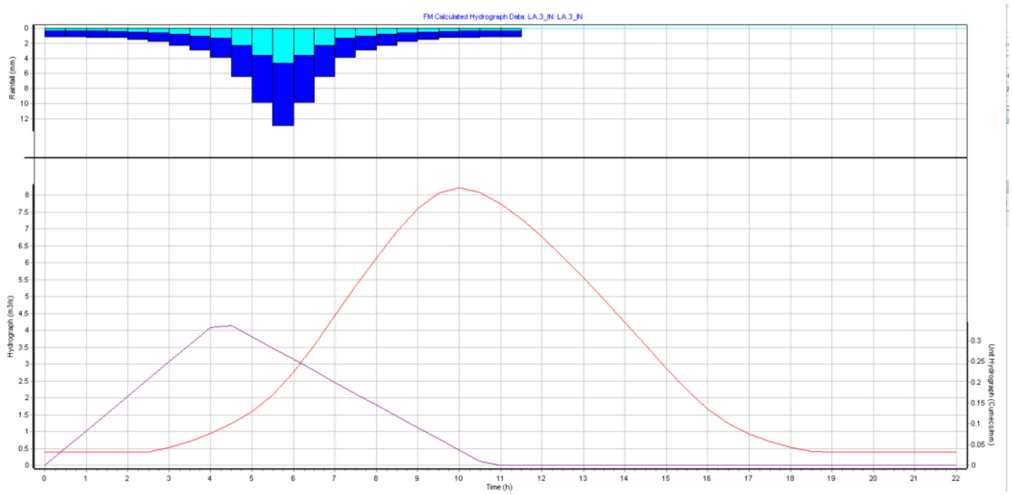

Figure 5: Summer Profile for the LA.3 node.

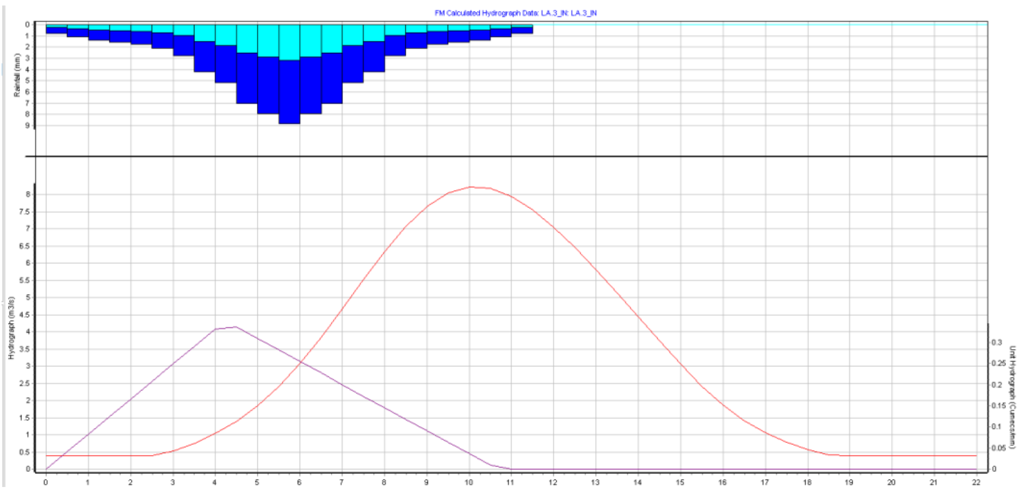

Figure 6: Winter profile for the LA.3 node.

8.7 Please consider using the level gauge to assess and improve Tp lag estimates, and consider using this gauge data to calibrate the hydraulic model.

This has been done but note limitation of data available - this is just a gauge and daily maximums so responses are difficult to calculate with suitable accuracy to be suitable for informing this study. As such, and given the wider area and increased information, the EAs study has been preferred for this. Given approved nature of that study it is considered this remains acceptable.

8.8 As response to 8.7.

As above.

2.6 Choice of Method

9.0 Provide commentary in the reporting to explain the results of the comparisons in section 7.1 and what the implications of these comparisons are on deciding what the final choice of methods should be.

This comment has been addressed and changed through the use of the gauged data. This data has been used to calculated an 'overserved' QMED owing to the length and regularity of data. This QMED value was then input as the QMED value as part of a statistical analysis to determine return period flows. On completion of this exercise, and as with the previous report, the weightings were applied to separate flows for the LA1 and LA2 inflows so as to follow the same approach as was done previously. These weightings were recalculated and shown as remaining the same as those in the PBA report given the limited changes in the catchment since 2009. This was then used to calculate the LA1 and LA2 inflows that were then input into the IED files within the Flood Modeller .DAT file. In summary the method adopted is as follows:

- QMED - using observed data from the existing depth gauge downstream of the site. Depth values used to calculate flow values for all years where data available and then used to calculate QMED.
- Return Periods - Statistical Analysis using WINFAP. This is the same method as was used in the original EA report for the same reasons - catchment make up, data availability etc. Fittings generated from this but using QMED as the calculated 'known' event. This value was around 4 cumecs compared to the previous 2 cumecs (to the nearest number). This is reflective of the increased depths recorded from 2013 when compared to pre 2011 - i.e. a wetter period which would result in higher QMED flows.
- Weighting applied to split calculated flows into the sub catchments as per original assessment and to maintain consistency.

9.1 Further justification could be brought forward on why FEH was not most suitable or why the previous hydrological study could not still be used with renewed calculations, given the considerable difference in flow estimations between the two studies.

Owing to the comments, and where possible, the previous study was used but with further checks (as outlined above) and renewed calculations. The main difference from previous Hydrock studies is that availability of the gauge data has allowed the previous process to be followed and updated. On receipt of this data and confirmation of the previous hydrological assessment it was agreed that consistency should be maintained. The output flows when adopting the similar approach has provided flow that are very similar, and slightly higher, than those previously calculated. This again is not unexcepted given the gauged data and wetter years.

9.2 Please include the choice of methods in the assumptions and limitations of the study and that due to wider dataset the statistical method is often preferable.

Methodology outlined in response to point 9.0 above.

9.3 Provide clarity in the report for how hydrograph shapes and volumes are derived and whether these are checked against model outputs. The hydrographs in the model appear to be incorrect and the flows have been applied to the incorrect events. (See hydraulic review comment 4.2)

Hydrograph shapes were informed by ReFH calculations in the absence of suitable data from the gauge. These were then compared to the assessment undertaken by the EA previously and it was agreed that due to limited changes in the catchment the EA's approach remained more accurate owing to the wider area datasets used to generate flows. These were therefore adopted as considered more appropriate.

9.4 Please provide further clarity on what type of inflow is being applied at the upstream extent of the model and why lateral inflows have been removed.

Applied via a FEH unit within the 1D elements. Based on comments provided within this review lateral inflow have been removed by multiple inflow to replicate EA sub catchments reinstated.

2.7 Results

10.0 Please provide hydrographs and all return periods for peak flow comparisons.

These have been provided within the updated IED modelling files and ready for review.

10.2 Please supply extra information where it has been requested.

Additional information has been provided in line with what has been requested.

11.0 Provide further commentary on the level gauging's and what confidence is in the flow estimates based on how well compare.

A flood frequency analysis on the gauge was carried out. Our statistical analysis showed that a 20-year return period has a peak flow of 9.21 m3/s. The flood frequency analysis showed that a 20-year return period has a peak flow of 10.53 m3/s. The similarity of these two flows gives confidence to the hydrological inflows into the model. Due to the short record of the gauge, there is not high confidence in a single site analysis and therefore we can be more confident in our statistical analysis which also included information from other sites with longer records.

11.1 Assess flows against level gauge and derive rating curve from gauge history where possible to assess how compatible they are.

A flood frequency analysis on gauged data shows the highest flows occurring at the gauge was ~32-year return period. Therefore, the higher return periods used in this analysis will rely on a hydraulic model. The previous rating curve was generated using the hydraulic model for the higher flows and was accepted by the Environment Agency. Therefore, as the hydraulic model has not been altered only truncated, this rating curve will remain acceptable.

11.2 Please provide further commentary on what checks have been carried out to assess the suitability of the pooling groups and justification for retaining sites where catchment descriptors are not similar.

This has been provided and, where possible, the previous method/approach has been adopted for consistency. The pooling group information is in Figure 7.

AM Data | Catchment Descriptors

	Station	Distance (SDM)	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
1	36010 (Bumpstead Brook @ Broad Gree	0.352	54	7.545	0.372	**0.374**	0.168	**0.167**	1.244
2	26016 (Gypsey Race @ Kirby Grindalyth	0.536	24	0.103	0.304	**0.304**	0.240	**0.240**	0.119
3	26014 (Water Forlornes @ Driffield)	0.553	23	0.437	0.315	**0.316**	0.164	**0.163**	0.327
4	39033 (Winterbourne Stream @ Bagnor)	0.762	59	0.403	0.338	**0.338**	0.375	**0.375**	1.218
5	33054 (Babingley @ Castle Rising)	0.764	45	1.136	0.229	**0.229**	0.183	**0.182**	1.271
6	36004 (Chad Brook @ Long Melford)	0.784	54	4.873	0.301	**0.302**	0.170	**0.169**	0.402
7	27073 (Brompton Beck @ Snainton Ings	0.786	41	0.820	0.212	**0.213**	0.006	**0.005**	0.730
8	25019 (Leven @ Easby)	0.801	43	5.677	0.334	**0.335**	0.373	**0.372**	0.836
9	26013 (Driffield Trout Stream @ Driffield)	0.840	11	2.700	0.281	**0.282**	0.196	**0.195**	2.818
10	7011 (Black Burn @ Pluscarden Abbey)	0.860	9	5.205	0.491	**0.491**	0.521	**0.521**	2.357
11	33032 (Heacham @ Heacham)	0.877	53	0.449	0.297	**0.298**	0.129	**0.128**	0.179
12	36003 (Box @ Polstead)	0.910	61	3.900	0.311	**0.313**	0.082	**0.080**	0.903
13	30004 (Lymn @ Partney Mill)	0.926	59	7.240	0.223	**0.223**	0.021	**0.020**	0.596
14									
15									
16									
17									

Figure 7: Final Pooling Group.

11.3 As earlier in the spreadsheet, could data and methods be replicated from the previous study to give a more comprehensive comparison of flow estimates.

This has been done and as will be seen from the final results the calculated flows are now closely matched (though slightly higher) than those calculated previously. The QMED calculated (from gauge) is higher than in the previous study but from a review of the gauged data this is not unexcepted given a series of (and increasingly) wetter water years. This would be considered acceptable. However, in summary the previous method has been replicated.

3. Hydraulic Modelling

3.1 Model Approach

1.4. Difficult to assess which model files are relevant to the study as too many iterations have been provided, some with failed runs so it is difficult to tell which are the final runs that are to be reviewed with this submission. Please provide only the updated model runs that are requiring review so that the review can be undertaken more efficiently and to ensure the correct model runs are being looked at.

In the latest submission, only the latest model runs and files have been included. Therefore, there should be no more confusion about what files to review.

2.1. Consider running some lower order events to improve model calibration against gauge levels. i.e. 50% AEP and 20% AEP and include the results with the next submission.

Only daily level data for the gauge on the Langford Brook have been provided and therefore calibration cannot take place as sub daily data is needed. No parameters have been altered from the Environment Agency model therefore the calibration done previously is sufficient.

2.2. It would be expected that buildings be represented in the proposed scenario rather than an asc grid showing ground elevations. This would be useful to help show flood risk to individual buildings at the proposed site.

The layouts of the buildings are not final as this is for outline planning. No water reaches the site on the proposed scenario and therefore it is not necessary to show individual buildings as a z shape.

2.3. Blockage runs have been produced and briefly discussed in the reporting. Provide maps comparing flood depths/extents of the blockage scenario.

This has now been included in the report in section 5.3.

2.4. 15% climate change runs have been carried out which is the central allowance for the 2080 epoch.

No action needed.

3.2 1D Boundary Conditions

4.2. The original study provided two additional inflows within this catchment, please provide explanation for why these are no longer required. An unusual hydrograph shape can be seen throughout the model with an initial sharp rise in stage/flow before plateauing for several hours. Please investigate and amend the hydrograph so it does not have the plateauing. Additionally, the model run scenarios have been set up incorrectly, the graph included hopefully illustrates the issue but the 0.1% hydrograph has been applied to the 1%CC model runs and vice versa and should be re-run so that the model runs correspond correctly.

Figure 8 displays the three inflows in the ied file for the EA inflows. The Hydrock inflow contained one lumped inflow but this was not the inflows used in the model as explained in the report. These inflows have now been updated with the new flows we have generated. The picture on the right shows the 100yr+CC (green) and 1000yr (red) where the 1000-year flow is larger. The plateauing is due to the minimum flow used in the boundary in order to keep the model running at low flows.

	LB_US	QTBDY
	LA.2_IN	FEHBDY
	LA.3_IN	FEHBDY

Figure 8: Inflows in the Bicester Model

Figure 9 shows that shows the 100yr+CC (green) and 1000yr (red) where the 1000-year flow is larger. The plateauing of flow is due to the minimum flow set on the inflow of 0.4 in order for the model to run during low flows and only occurs for 2 hours, therefore does not affect the maximum flood extents or depths.

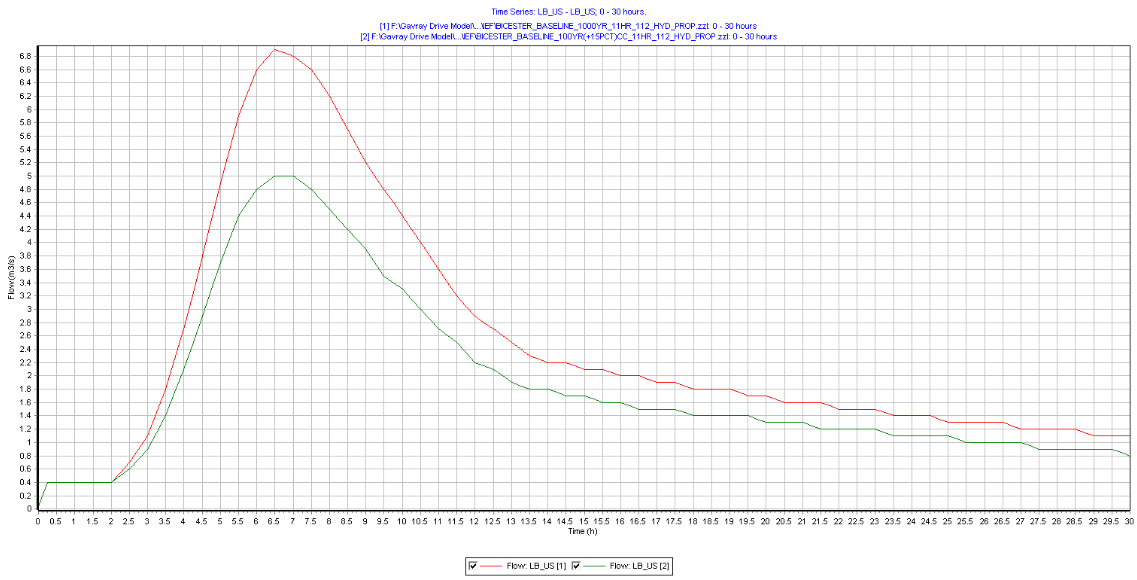

Figure 9: Hydrological Inflows at the Upstream Node LB_US. 100-year+ CC in Green and 1000 year in Red.

4.3. The downstream boundary has been modified with the model truncation. The new downstream boundary has been placed in an unusual place, normally this would be placed at a control structure where possible that cannot be bypassed by out of bank flows. In this instance the DSB is bypassed in the 2D domain where HQ boundaries have been placed at the edge of the domain, to take flows out of the model. Please provide explanation for the schematisation of this DSB and why the bridge just downstream could not be used as a suitable downstream limit for the model.

Sensitivity testing has been carried out for +/- 20% slope, this shows some minor difference in levels at the site of interest, have these been replicated for the 2D boundary as this is also taking flow out of the model. It is recommended that the 2D boundary is realigned with the B4100 so it is not taking flow out of the model and all flows are routed correctly through the 1D as normally flow would not be leaving the model in the place where the 2D boundary has been schematised.

Figure 10 displays that the downstream boundary has been changed to below the B4100 as suggested and shown in Figure 11. No water escapes from this boundary.

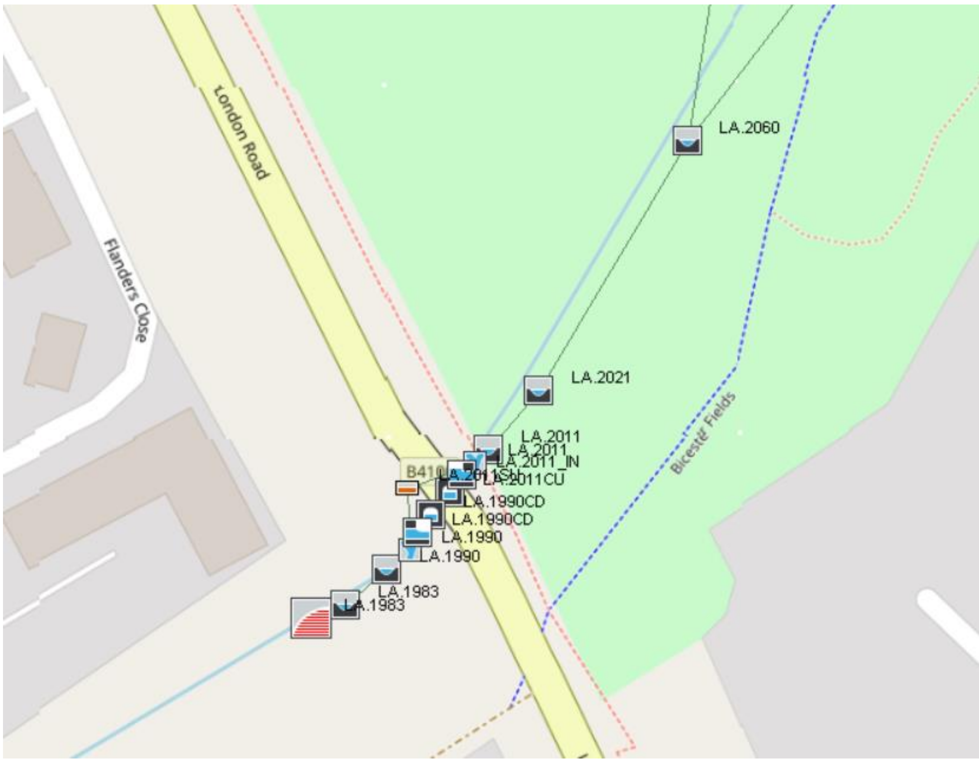

Figure 10: 1D Downstream Boundary Location

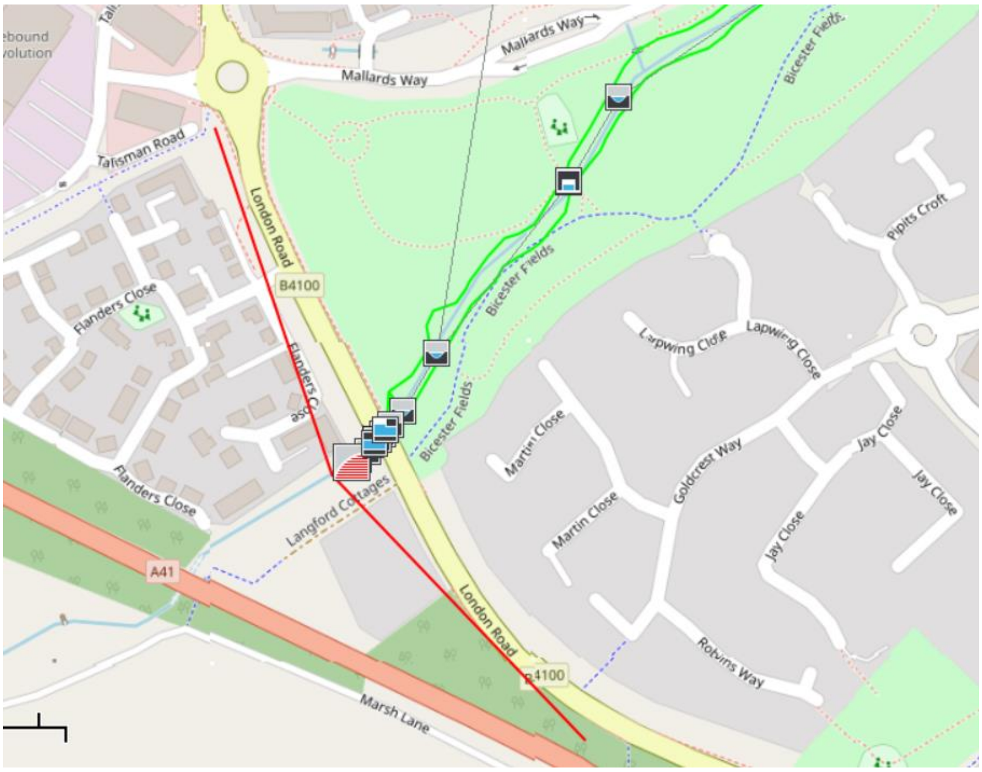

Figure 11: 2D Downstream Boundary location.

4.5. See item 4.3, this needs to be altered to a more suitable location, ideally where no out of bank flows are occurring and then sensitivity testing carried out again to ensure it is not affecting the site of interest.

Sensitivity tests have been carried out on the new downstream boundary with results presented in the report in section 5.2.

3.3 1D Structures

5.1. Water storage area upstream of the site is deemed to be in poor condition and not representing this structure formally provides a more conservative approach.
No explanation for the omission of missing structure at nodes LA.3764 and LA. 4458

According to satellite imagery and basemapping there are no structures present at these nodes. There were no structures in the initial model.

5.6. Weir coefficients vary between 0.8 and 1, this is within expected ranges.
Please add a statement within the report detailing the variance in weir coefficient values.

These have not been changed from the EA model and with the absence of survey it is not possible to check their validity. However, they have been reverted back to flood modeller pro default values of 0.9 modular limit and 1.2 for standard weirs.

3.4 1D Run Parameters

6.3. Slot depths have been modified to 2.0000m however this is not acknowledged in the reporting.
Dummy coefficient has been set to 0.0001 and 0.001 for some run scenarios.
Provide justification for the changes to default parameters in the reporting. Where these are legacy

parameters from the EA model, investigate the effects of changing the parameters back to default and provide evidence of this.

The slot depths have been removed and the parameters have been returned to default values. The model still runs to completion and thus these have been retained.

3.5 2D Model Build

7.4. 4M resolution has been retained, could this be reduced with the smaller catchment area to improve channel representation?

The grid size has been reduced to 2m to improve channel representation.

7.5. Has the DTM been rotated to improve optimisation with the Langford Brook? It may improve results to realign this to be better optimised.

The DTM This has now been rotated to realign with the flow direction of the Langford brook.

7.6. A 1D network layer is still included in the model which represents culverts in the floodplain, these are outside of the model domain so do not affect the results but it would be best practice to remove these as these are no longer required in this model.

This network layer has been removed in the latest submission.

7.8. Some buildings still do not appear to be represented within the latest TMF files.
Please update the mapping to incorporate the missing building representation.

The buildings that were not in the 2D domain were far away from the floodplain and therefore does not impact the model. However, for completeness this has been done.

7.10. It is usually expected that proposed building footprints be included as z-shape files to define individual objects rather than simply defining the floor levels as an ascii grid.
With respects to the site lowering and ponding of water adjacent to the watercourse, what mechanisms are in place to facilitate the storage areas to empty once levels recede back into the channel?

The building layout is not final as this is for outline planning. No water reaches the buildings in the proposed scenario and therefore it is not necessary to represent them as a z shape.

3.6 2D Boundary Conditions

9.1. 2D boundary has been implemented at the downstream extent of the model domain.
Two HQ boundaries have been applied however it is not clear how and why these have been schematised the way they have.
It is usual for the 1D channel to be snapped to the 2D code boundary rather than the 2D boundary extend further than the 1D.
Please provide justification for the choice of HQ boundary and it's location and consider changing the location and setup of this boundary to more appropriately handle flows leaving the model.
See item 4.3 for further details.

The HQ boundary has been moved in accordance with the 1D downstream boundary. This is one continuous boundary a considerable distance away from the 1D boundary based on an average slope. It has been located at a motorway in which the water in the floodplain does not overtop.

9.2. Some runs show flows interacting with the HQ boundary at the downstream extent of the model. It would be expected that flows only leave the model through the 1D boundary where possible with a suitable control on flows to keep channels in bank at the downstream location.
See item 4.3 for further details.

The boundary location has changed so this does not occur anymore.

3.7 2D Structures

10.3. Ponds downstream of the site are represented by z shapes, some ponds have not been represented which fill with water during the run, provide justification for the omission of the pond . Provide details for how the elevations for bank full have been derived, it would appear there is still some capacity left in the ponds.
Flood storage area upstream of the site remains omitted to provide a conservative approach to flood risk.

The pond has now been included. All ponds on OS mapping have now been filled in at the start of the simulation using z shapes. LiDAR was used to find the approximate bank full level.

3.8 Linked 1D 2D

12.2. See item 7.4, it would be preferable to lower the grid resolution, if possible, to improve channel representation with less 1D-2D interaction which could improve model stability.
See screenshot for example of flows exiting 1D and re-entering due to code layer not being aligned with the DTM.

The grid resolution has been lowered to 2m and the code layer has been checked and aligned with the DTM. Figure 12 shows that the flows do not exit and re-enter the 1D.

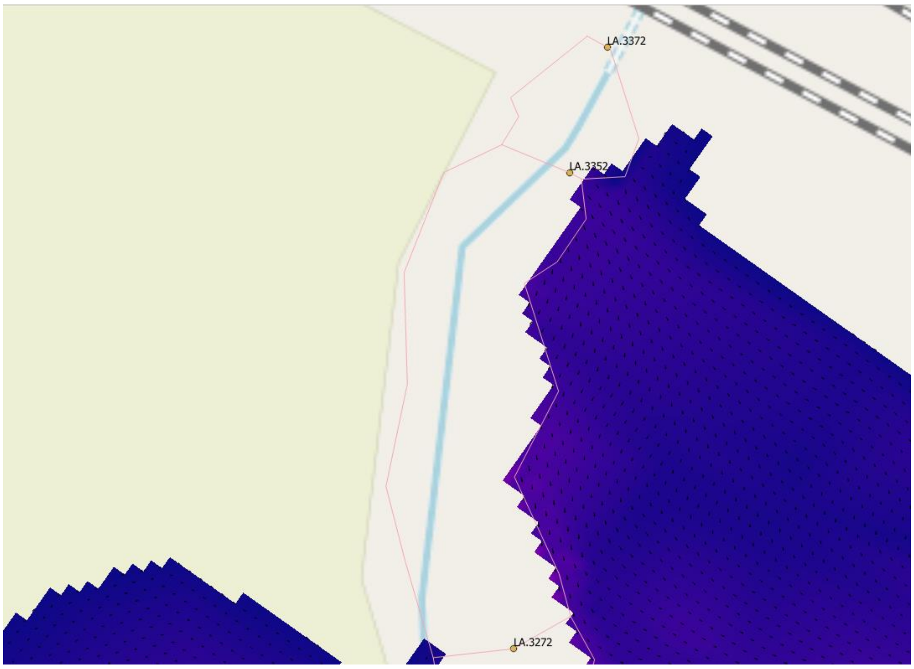

Figure 12: New results showing the code layer has been aligned to the DTM.

12.5. Double Precision has been enabled and synchronising of HPC timestep however HPC is not used in this model. Provide explanation for why synchronise HPC timestep is selected.

This was a legacy of the previous model. It has been unselected in the current runs.

3.9 Model Stability

13.2. Model convergence has been improved however there is still significant convergence, this is not above the threshold. Consider investigating what is causing these stability issues, it is apparent when viewing the animation of cross sections that there are frequent stage changes which is unrealistic and makes it difficult to judge.

Whilst there are still some convergence issues under the threshold (figure 13), the animations and time series (figure 14) show that the stage and flow are smooth and the convergence does not impact the maximum extent.

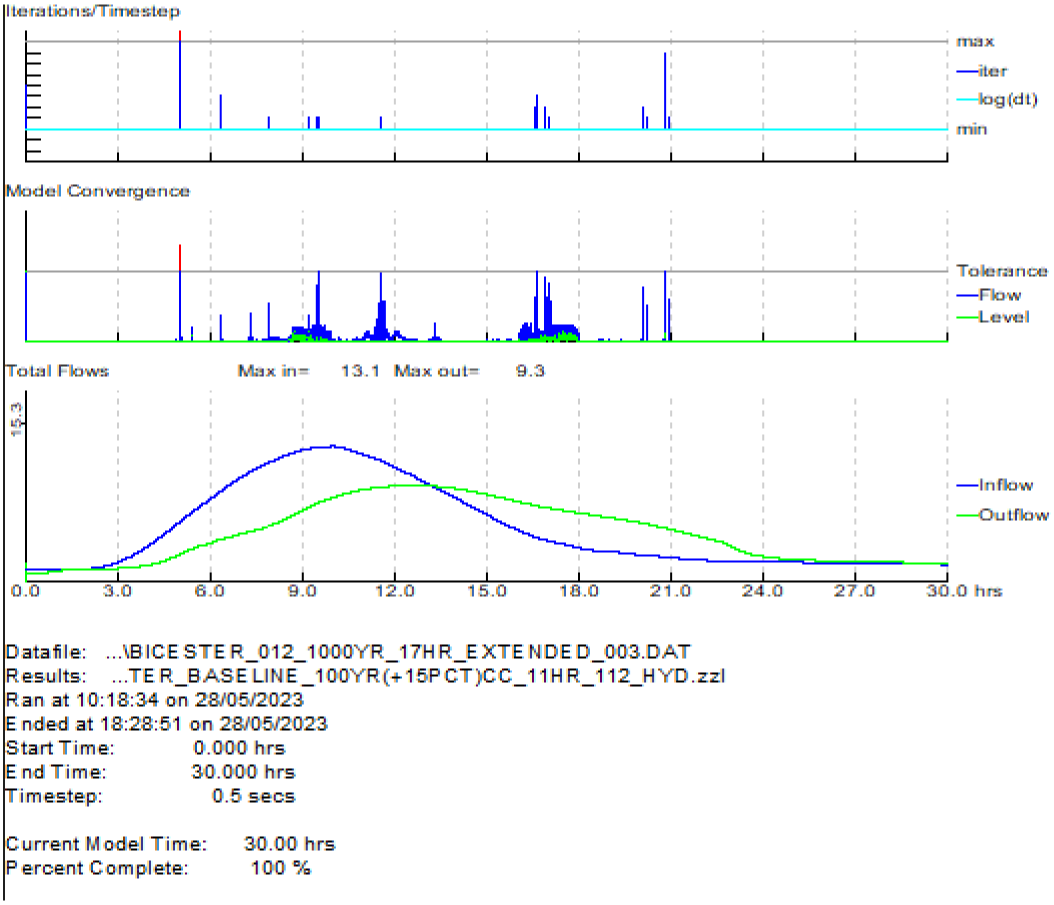

Figure 13: BMP File of the 100 year plus 15% CC.

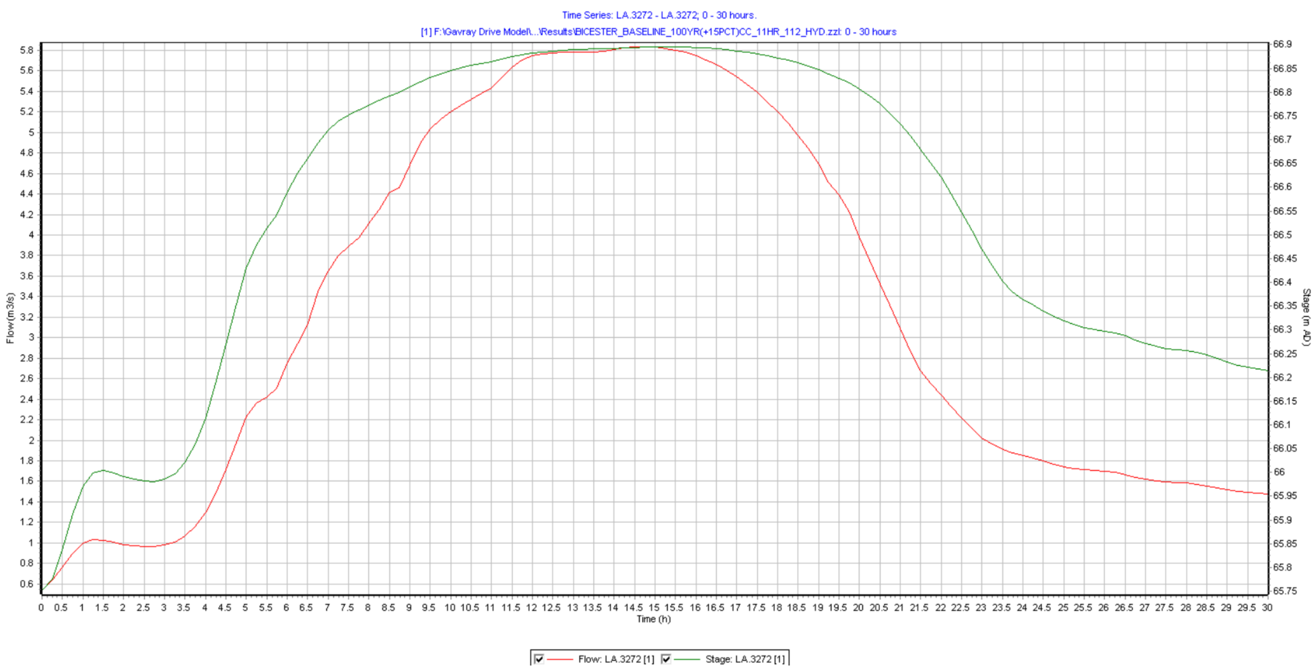

Figure 14: Time series of a node adjacent to the site in the 1 in 100 year +15% Climate Change scenario.

13.3 There is still significant oscillation in the stage and flow when viewed through cross section animation, this is due to underlying stability issues which makes it difficult to determine whether the modelled peaks are representative.
Time series data backs this up with fluctuations visible in the flow/stage graphs. There is also an usual period at the beginning of the run where flow/stage initially increase before plateauing and then increasing again which needs investigating and fixing.
Please investigate the underlying issues that are causing oscillation of flow/stage throughout the model runs.

The stability has improved since decreasing the grid size. There are no oscillations in the hydrograph shown in figure 6. The fluctuation at the beginning of the run is due to minimum flow needed to keep the model running at low flows.

14.6. Extents do not show as expected due to the wrong hydrographs being applied to the IED files meaning the 0.1% event has a lower extent than the 1%CC event. See item 4.2

This is not the case, figures 2 show that the 1% CC scenario is smaller than the 0.1% scenario.

3.10 Model Outputs Calibration

15.1. Level gauge data is available at Langford Brook Village, flows have not been adequately calibrated against this.
More detail can be found in the hydrology review and previous study for how the gauge data has been used to calibrate the hydraulic model for improved accuracy.

Sub daily level data has not been provided to us. Only daily level is available and flooding in the catchment happens in a matter of hours. Therefore, there is no full hydrograph to calibrate to. Fifteen-minute data would be needed for this calibration.

15.6. Previous modelling outputs shown a significant increase in extents and outputs compared to the current study. The calibration that was carried out using hydrometric data in the previous study should be applied to this study where applicable to improve model performance.

Sub daily level data has not been provided to us. Only daily level is available and flooding in the catchment happens in a matter of hours. Therefore, there is no full hydrograph to calibrate to. Fifteen-minute data would be needed for this calibration.

3.11 Model Sensitivity

16.1. All requested sensitivity tests have been carried out and results discussed in the report.
Please redo the sensitivity testing using the correct hydrographs to show the effects of this.

This has been undertaken and the report has been updated in section 5.

16.2. Results show the model to be sensitive to roughness parameter changes with a change of +/-47mm, blockage scenario shows increased flood extents and depths across the site of interest with roughly 15mm flood depth. Downstream boundary indicates a change of around 1-3mm in channel depth. Please update the report once sensitivity testing has been rerun using the correct hydrographs for the run scenarios.

The sensitivity runs were ran using the correct hydrographs but have since been updated as the grid size and downstream boundary has changed.

16.3. Provide confidence limits from the results of the sensitivity testing.

Confidence limits have been provided in the sensitivity section of the report (Section 5).

3.12 Audit Trail

17.2. Naming conventions could still be improved to remove legacy naming where they are no longer relevant.

This is noted but not actioned for this model as it is likely to cause models to crash.

17.5. Version control could be improved and when submitting model files to review please only include the runs that need reviewing as there are a lot of legacy files present in this submission making the review process more difficult to determine which files are relevant to this.

This has been actioned and only the relevant files have been provided for the latest submission.

17.7. Model technical note has been updated to include the changes made, ensure further justification and any new changes are logged in the reporting with supporting evidence where applicable.

This has been undertaken and included in section 3.

17.8. Provide updated results once scenarios have been run with the correct hydrographs to give realistic outputs.
It would appear the sensitivity testing has been run with the 0.1% hydrograph which may change the results of the sensitivity tests once they are run with the correct flood estimates.

These have been provided in the latest submission in section 5.

17.9. As with the hydrology review, the calculations need revising to better incorporate the hydrometric data available and then calibration of the model to improve confidence in model outputs.

The flows have been updated and the results have been adjusted in the report in section 6.

18.1. Greater detail in the reporting is required, for example where sensitivity testing has been carried out a detailed analysis of the results with confidence limits and graphs/gridded outputs to illustrate the difference with clear statements on how the model has been schematised and the decision making taken for how the model has been setup after being truncated is advised.

This has now been included in the report in section 5.

18.2 Provide proposed site with buildings represented via z shapes to give more detail around different roughness values and where the buildings are to be located compared to flood extents.

The building layout is not final as this is for outline planning. No water reaches the buildings in the proposed scenario and therefore it is not necessary to represent them as a z shape.