

HYDROLOGY REVIEW

Project	Modelling & Mapping Call-Off 2022-2023	Job Number
Competence level of analyst who carried out study	Level 1 – Hydrologist with minimum approval	Complexity of study
Revision		Date
Area Lead		Reviewer

PURPOSE OF THE HYDROLOGICAL STUDY and any particular concerns or aspects

WSP have been commissioned to look at two sites in Bognor Regis and Middleton. The proposal is to re-greenfield site into a new golf course. A 2015 ICM model (EA) was modified for investigating the flood risk but updated using the latest FEH

SUMMARY - IS THE HYDROLOGY SUITABLE? (CHANGED FROM FIT FOR PURPOSE)

Follow on review comments 08/09/2022

1. The reporting mentions a 10.25 hour storm duration but then goes on to say 27.5hrs was selected. It is 27.5 hour storm duration in the reporting? Please make this clear in the reporting as it currently implies that
2. An example rainfall hyetograph has been included in the hydrology report (figure 4). In addition a table of hyetographs and depths presented in the hydrology report were compared against the rainfall data for the 1 There appear to be differences between the rainfall applied within the hydraulic model and the rainfall rate/ differences.

Previous comments 06/06/2022

Rainfall runoff applied to catchment with three different zones - high, medium and low to try and ca

MODEL REVIEW PROCESS

Hydrology report and model reviews are an essential component of the Hydrology Quality Assurance (QA) suitable for the intended purpose. Evidence that the Hydrology has undergone QA may be requested by external could be read externally.

Should any issue(s) be raised during the review process, which require attention, the reviewer should detail changes as appropriate. Completion of this Hydrology Review document does not automatically constitute completed, the reviewer may require that the Hydrology calculation be resubmitted for further review to establish amendments have been completed satisfactorily, will the model be approved and the quality assured by the

It is recommended that the reviewer makes good use of the fluvial design guide chapter 2

Depending on the work being reviewed some questions or entire sections may not be relevant, in which case may choose to use the following colour coding system to alert the modeller to the priority of the actions required

Colour coding used (RAG):

Green – Good practice – not strictly necessary in this case but good practice for future studies.

Amber – Useful – please follow recommendation if time allows.

Red – Must do.

CHECKLIST FOR REVIEWING FLOOD ESTIMATES

This checklist is taken from a supporting document to the Environment Agency's Flood Estimation Guidelines (used by consultants working for us), supervisors carrying out internal reviews or staff reviewing consultants' calculations attempting to cover every aspect of a flood estimation study, which would make the list rather long and unworkable. Errors or omissions are highlighted. Reviewers are assumed to be familiar with the Flood Estimation Guidelines.

The structure of the checklist generally follows that of the calculation record, starting with the method statement.

The answer to most of the questions should be "Yes". It is not always the appropriate answer, though. For example, some studies normally include a historic review or a lengthy calculation of ReFH model parameters from flow and rainfall data. Before reviewing studies carried out on behalf of the Environment Agency, check the brief and ask the reviewer to provide details.

Some of the answers may not be immediately obvious to some reviewers. For example, it is hard to tell whether a reviewer is familiar with the catchment and with what features need to be accounted for in flood estimation. Reviewers should refer to the Calculation Record.

B550P025

Moderate	1st review	2nd review
06/06/2022	06/06/2022	08/09/2022
	LB/JC	P Sale

ts that need review.

develop a current golf course into residential scheme and the second is to turn a of the sites. The hydrology approach in general was retained from the 2015 study software

E, AS THIS HAS LEGAL IMPLICATIONS)

clear that the model uses a 10.25hr storm duration so what is the reference to a t both 27.5hr and 10.25hrs are the preferred storm duration

s presented in table 4 which presents the revised rainfall depths. The rainfall 100 year 10.25 hr mm/hr+25%CC scenario included within the Infoworks Model. depths reported within the hydrology report. Please clarify why there are

apture the spatial variability in rainfall. Detail/reporting in general is lacking.

process that provides confidence in Hydrology calculations and that they are ternal parties and hence all reviews should be written with an expectation that they

l the action(s) required in sufficient detail to allow the Hydrologist to complete the Hydrology calculation approval. Once the suggested changes have been ablish whether the actions have been completed satisfactorily. Only once all the a reviewer.

se they can be marked 'not applicable'. On completion of the review the reviewer uired (if any).

ies. It can be used by analysts checking their own work (both internal staff and
itions. The list can be filled in to create a record of the review. Rather than
vieldy, it concentrates on common pitfalls. Some of the most common or severe
elines and competent to judge what choices are appropriate.

ment and ending with the presentation of the results.

r example, lower risk studies needing a quick and approximate answer would not
l data. Evaluation should be appropriate to the level of detail and risk of the
he project manager what has been agreed with them.

hether some unusual feature of the catchment has been left out unless you are
s may need to refer to other parts of the FEH Guidelines or the Calculation

	3rd review	4th review

Method Statement

Method Statement General

Item No.	Item Checked
1	Was a method statement produced at the start of the study?
1.1	Has the supplier discussed and agreed the method statement with the Project Manager?
1.2	Has an Flood Estimation Report been produced?
1.3	Does it include a summary of the purpose of the study and the scope / complexity?

Method Statement Specifics

Item No.	Item Checked
2	Does the Flood Estimation Report clearly detail the catchment and its flooding processes?
2.1	Does the catchment contain any unusual features? Is this identified and discussed within the Flood Estimation Report?
2.2	Does it include both flow and level stations, and closed stations as well as current ones?
2.3	Have stations outside the NRFA peak flows dataset been considered, e.g. temporary loggers?
2.4	Is it appropriate to update the flood peak series from those in the NRFA peak flows dataset and, if so, has this been done?
2.5	Is the data quality reviewed – at a minimum, giving the NRFA peak flows classification?

2.6	Is a more detailed review of data and ratings appropriate for this study, and if so has it been done?
2.7	Does the report include plots and interpretation of flood peak time series and flood event hydrographs?
2.8	Does it include a description of the catchment?
2.9	Does it include a description of the conceptual model, including flooding processes?
2.10	Does it list any unusual features of the catchment and how they will be taken into account?
2.11	Does it include a preliminary choice of method(s), with adequate reasons?

Existing Data	
Item No.	Item Checked
4	Does the method statement include a review of data?
4.1	Has a thorough review of available rain gauge and river level/flow data within the study catchment been undertaken?
4.2	Has a thorough review of all other types of available data been undertaken?
4.3	If statistical analysis has been undertaken has the latest version of the NRFA database been used?
4.4	Does the method statement refer to any other sources of data, e.g. flood event data or historical information?
4.5	Is a historical flooding review required for this study? If so, has a flood chronology been provided and interpreted?
4.6	Have any flood alleviation schemes been carried out, or have any other changes been made which might affect the relevance of historic data?



1st Review Comments	1st Review Actions
Unknown	
Unknown	
No. Appendix B contains hydrology approach details	
Purpose of study included in wider report	

1st Review Comments	1st Review Actions
No	Please add to reporting
Low gradients in downstream of catchment noted and cited for approach of rainfall run off. Pumping mentioned in appendix A	Is the catchment pumped? Please note in hydrology/appendix B details
No mention of gauges. Same approach - rainfall runoff, has been applied as the 2015 study	
N/A	
N/A	
N/A	

N/A	
N/A	
Catchment description is lacking	Please add to reporting
No	Please add to reporting
Low gradients in downstream of catchment noted and cited for approach of rainfall run off	
Using same approach as 2015 study which concluded rainfall run off to be best approach	

1st Review Comments	1st Review Actions
No	
Unknown	Any rainfall gauges to compare to?
Unknown	
N/A	
No mention	Please comment on flood history - add to reporting
No mention	Please comment on flood history - add to reporting
Unknown	



1st Review Response (DATE)	2nd Review Comments

1st Review Response (DATE)	2nd Review Comments
Description added to hydrology report	Detail has been added to the reporting. No further action required
The catchment is pumped under certain conditions, details added to hydrology report.	Brief detail is included in the reporting. Three pumps are included in the hydraulic model (Felpham). A direct rainfall approach has been taken with pumps represented explicitly within the hydraulic model. This approach is considered reasonable and is retained from the previous JBA (2015) modelling

Catchment description added to hydrology report	Detail has been added to the reporting. No further action required
Details added to hydrology report.	Detail has been added to the reporting. No further action required

1st Review Response (DATE)	2nd Review Comments
No rain gauge data was requested from the Environment Agency.	There are raingauges at Westergate and Bognor Regis as noted in the previous study reporting. These were used to help inform model calibration in the previous study. This gauge data has not been utilised in this study. A direct rainfall modelling approach has been adopted. No further action is deemed necessary in this instance
Commentary on flood history added to report.	Brief reference is made to flood history in the reporting. The report mentions that there have been no more recent flood events since 2012. The nearest gauge relevant to the study watercourse is Barnham Rife. Inspection of data at this gauge confirms that the largest historic event in recent years was the June 2012 event. No further action required
Commentary on flood history added to report.	Detail has been added to the reporting



2nd Review Response (DATE)	Review Comm	3rd Review Response (DATE)	4th Review Comments

2nd Review Response (DATE)	Review Comm	3rd Review Response (DATE)	4th Review Comments

2nd Review Response (DATE)	Review Comm	3rd Review Response (DATE)	4th Review Comments



4th Review Response (DATE)

4th Review Response (DATE)

4th Review Response (DATE)

Catchment Schematisation

Catchment Schematisation	
Item No.	Item Checked
5	Do you agree with the choice of flow estimation points – do they cover the main locations of interest (e.g. confluences, areas of known flood risk, gauging stations, model boundaries) without including an excessive number of subcatchments or very similar catchments?
5.1	Does the report clearly distinguish between flow estimation points for lumped catchments and those for sub-catchments / intervening areas and explain the purpose for which they have been created?
5.2	Are catchment descriptors for sub-catchments / intervening areas calculated using an appropriate method, particularly for DPLBAR, FARL and URBEXT?
5.3	Have FEH catchments been checked against high resolution LIDAR, sewer network, and OS data and refined where appropriate?
5.4	Have other catchment descriptors been checked, and any changes recorded?
5.5	If catchment area has been refined, have catchment descriptors been adjusted accordingly based on the adjusted area?
5.6	Have catchment descriptors been checked against available OS map, Soils, and British Geological Survey datasets?
5.7	Has BFIHOST been corrected if on a clay catchment in south-east England?
5.8	Does the calculation record state whether URBEXT ₁₉₉₀ or URBEXT ₂₀₀₀ has been used? Has the correct value been identified for the method(s) to be applied?

5.9	Have the URBEXT values been updated to the current year or revised using the URBAN _{50k} method if a discrepancy between the FEH urbanisation layer and current OS mapping has been identified?
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1st Review Comments	1st Review Actions
N/A	
N/A	
N/A	
N/A	
N/A	
N/A	
N/A	
N/A	
N/A	

N/A	
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1st Review Response (DATE)	2nd Review Comments

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2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)

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4th Review Comments	4th Review Response (DATE)

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FEH Statistical

Estimation of QMED	
Item No.	Item Checked
6	Has the use of urbanised donor catchments been avoided unless appropriate for the catchment being assessed?
6.1	Has the choice and number of donor sites been justified?
6.2	Are there donor sites upstream or downstream of any subject sites? If so, have the adjusted QMED estimates been checked for consistency with the estimates at the gauges? If subject sites lie between gauges, have averaged adjustment factors been used?
6.3	In summary, do you believe that local data been used to its full potential to adjust QMED?
6.4	If any records shorter than 14 years have been used to estimate QMED, have they been adjusted for climatic variation?
6.5	Has an urban adjustment factor been applied to the QMED estimates after data transfer and has the latest equation been used (WINFAP 4)?
6.6	Has an alternative method been used to derive QMED? If yes, is the method appropriate and has it been applied correctly?
6.7	Have distant analogue sites been avoided for adjustment of QMED?

Estimation of Growth Curves	
Item No.	Item Checked
7	If there are several similar flow estimation points on a reach, have they used a single pooling group to aid simplicity and consistency?
7.1	Has the composition of the pooling group(s) been recorded?
7.2	Has the removal or retention of sites in the pooling group(s) been adequately justified? (in particular, has the removal of any discordant sites been explained in terms of data quality or catchment properties?)

7.3	Are there any flood peak records suitable for deriving single-site growth curves? Have these been compared with pooled curves over a suitable range of return periods, and the differences discussed?
7.4	Has enhanced single site analysis been carried out for pooling groups derived at gauged sites?
7.5	Has an urban adjustment factor been applied to the growth curve (for each flow estimation point)?



1st Review Comments	1st Review Actions
N/A	

1st Review Comments	1st Review Actions
N/A	



1st Review Response (DATE)	2nd Review Comments

1st Review Response (DATE)	2nd Review Comments



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)

2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)



4th Review Comments	4th Review Response (DATE)

4th Review Comments	4th Review Response (DATE)

ReFH2

ReFH Method	
Item No.	Item Checked
8	Has the ReFH2 method been used in preference to other rainfall-runoff methods? If not, is an adequate reason given?
8.1	If ReFH2 has been applied at or near a flow gauging station, have model parameters been estimated from flow and rainfall data, or $T_p(0)$ from lag analysis if near a level gauge?
8.2	If ReFH2 parameters have been estimated from observed data (including $T_p(0)$ from lag analysis), is a list of the events and description of the results provided?
8.3	Has ReFH2 been avoided for estimating peak flows for large catchments?
8.4	If the catchment is highly impermeable (very low BFIHOST) has the runoff volume been checked against rainfall volume?
8.5	Does the calculation record state what storm durations were used for the rainfall-runoff calculations and if more than one storm duration will be tested?

8.6	Does the Flood Estimation Report acknowledge that a single storm will be applied to all inflow hydrographs being used in a distributed modelling application?
8.7	Are only lumped catchment flows recorded?
8.8	(If ReFH1 is used then this need to be checked) If the catchment is urbanised has the use of the ReFH urban approach been explored?
8.9	Is the chosen rainfall profile suitable (Winter/Summer)?



1st Review Comments	1st Review Actions
Pass. ReFH2 used	
Unknown, appendix B mentions Westergate TBR - could rainfall gauges be used to verify any of the values?	Could rainfall gauges be used to verify any of the values?
N/A	
N/A	
N/A	
27.5 storm duration picked with other durations tested	

Areal reduction factor generated using whole catchment (97.3km ²) to be consistent across whole model	
3 areas grouped as Low, Medium and High due to spatial difference in rainfall across catchment from top of catchment to d/s	
N/A	
Default winter used, this is reasonable	



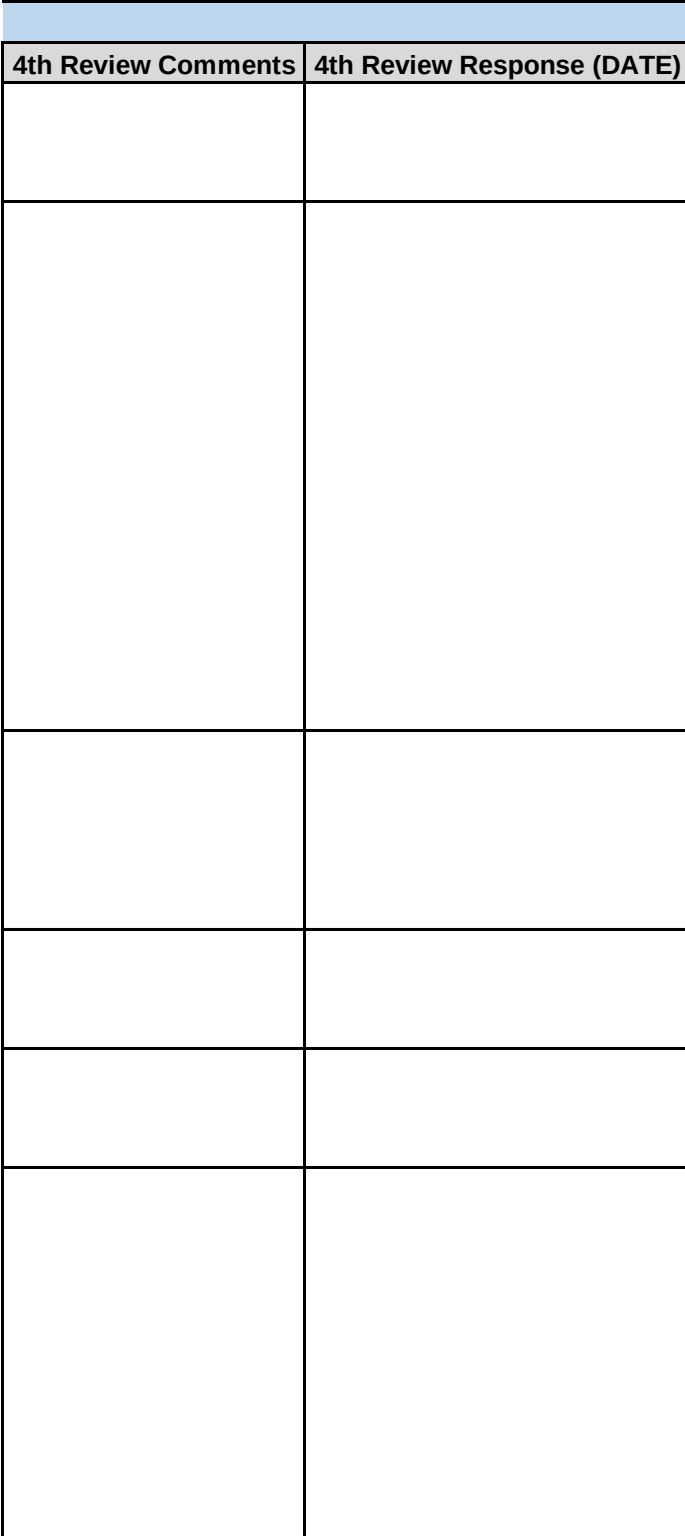
1st Review Response (DATE)
Limited rainfall data is available within the catchment and so verification / calibration was not possible.



2nd Review Comments
In the previous study rain gauges were used for hydraulic model calibration and for informing storm durations to test within the model. The last significant event within the catchment was June 2012 which was tested in the previous modelling (JBA, 2015). In terms of this hydrological assessment, a direct rainfall approach has been adopted. Typically rain gauge and river level data are used in conjunction for lag analysis to inform time to peak (Tp). This is not relevant in this case as a direct rainfall approach has been adopted and calibration has not been revisited because the baseline model which is being utilised has already been calibration. No further action is deemed necessary in this instance although for future reference please note that a hydrological assessment should list all available hydrometric data within a study area and use/discount as necessary. The FEH Calculation Record template provides a useful template for hydrological calculations
This does not appear to be the case, the reporting mentions 10.25 hour storm duration but then goes on to say 27.5hrs was selected. It is clear that the model uses a 10.25hr storm duration so what is the reference to a 27.5 hour storm duration in the reporting? Please make this clear in the reporting as it currently implies that both 27.5hr and 10.25hrs are the preferred storm duration



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
The 27.5 hr results are now provided, these show no adverse impacts		



Choice of Method

Choice of Method	
Item No.	Item Checked
9	Have results from all methods applied been compared at example locations?
9.1	Is the choice of method justified by discussing the type of problem, the type of catchment and the type of data?
9.2	Does the choice of method recognise that the statistical approach is generally preferable, since it makes use of a much wider dataset and relies on fewer assumptions than rainfall-runoff approaches?
9.3	If appropriate, does the Flood Estimation Report explain how hydrograph shapes or volumes have been derived?
9.4	If the design flows are to be applied to a hydrodynamic model, is there an explanation of how flows will be derived within the model reaches?



1st Review Comments	1st Review Actions
N/A	
Background such as catchment description is lacking	
Statistical not looked at or compared. Assumed looked at in 2015 and rainfall used instead. This study used the conclusions of that study and updated the rainfall runoff approach	
N/A	
N/A	



1st Review Response (DATE)	2nd Review Comments
Detail added to the report	



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)



4th Review Comments	4th Review Response (DATE)

Unusual Catchment

Choice of Method		
Item No.	Item Checked	1st Review Comments
10	If the catchment is urbanised does the analysis closely examine any local flow and river level data and consider the specific effect that the urbanisation might have on local flood-generating processes?	N/A
10.1	If ReFH2 has been applied on an urbanised catchment, has the analysis followed the advice from the small catchments research SC090031 on whether to model the catchment as rural or urban, how to set the Tp scaling factor, whether to use a summer or winter design storm and what storm profile to apply?	N/A
10.2	If the catchment is urbanised, has the influence of the urban drainage network been discussed and accounted for?	N/A
10.3	If there is a significant reservoir influence (FARL<0.9, with reservoirs not kept permanently full), and there is inadequate flood peak data available downstream of the reservoirs, has a reservoir routing calculation been carried out?	Rainfall runoff used however unknown if any in catchment
10.4	If the catchment is permeable (BFIHOST>0.65), does the report include a review of the geological and hydrogeological setting? Does it present a conceptual understanding of the processes that might result in a flood? Does it include a chronology and interpretation of the longer-term flood history?	No, appendix B notes that the catchment is permeable
10.5	If the catchment is pumped, has the lowland catchment version of the FEH rainfall-runoff method (or an alternative based on the ReFH2 method) been used? If not, has the choice of an alternative method been justified?	Unknown



1st Review Actions	1st Review Response (DATE)
Please add catchment description	There is no significant reservoir or lake influence in the catchment. Details added to hydrology report.
Please add catchment description - add details on CDs, geology, flooding process etc	Details of catchment descriptors and flooding processes added to the hydrology report.



2nd Review Comments	2nd Review Response (DATE)	3rd Review Comments
Detail added to the reporting. No further action required		
Detail added to the reporting. No further action required		



3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

Results

Presentation of Results	
Item No.	Item Checked
11.1	Are the final results presented in a table of peak flows and (if appropriate) plots of hydrographs?
11.2	Do the results include any other information needed for the next stage of the study?
11.3	Has all information been presented in figures and tables appropriately?

Checks on Approach and Results	
Item No.	Item Checked
12	Have the design flows been checked for spatial consistency, e.g. at confluences and along reaches?
12.1	Have they been checked against flood peaks in the gauged record, and any longer-term flood history?
12.2	Have the 1% and 0.1% AEP growth factors been derived and sense-checked? If the 1% AEP growth factors are outside the typical range, has a justification been provided?
12.3	Have the results been compared with any from other studies and justification given for any differences?
12.4	If the design flows are to be applied within a hydrodynamic model, is there an explanation of how flows will be derived within the reaches?

Assumptions, Limitations and Uncertainty	
Item No.	Item Checked
13	Are the assumptions and limitations of the methods acknowledged? Are the assumptions listed specific to this study?
13.1	Does the report comment on uncertainty in the design flows?



1st Review Comments	1st Review Actions
No	Some example hyetographs might be useful to present in Appendix B
Lacking information	
Lacking information	

1st Review Comments	1st Review Actions
N/A	
No mention	Please comment on flood history - add to reporting. Can any past events be used for verification of both parameters used and also of the model/results?
Not presented	
Appendix B states 'revised rainfall depths are between 16.5% and 19.6% lower than the design rainfall depths from existing EA model'. No additional commentary	Any thoughts on why this is, please add to reporting (even if believed to be due to updated approach)
Unclear	Please add to reporting

1st Review Comments	1st Review Actions
None listed	Please add to reporting
None listed	Please add to reporting



1st Review Response (DATE)
Example Hyetographs for the 100yr event have been included in the report

1st Review Response (DATE)
The 27.5hr rainfall event was tested as this corresponds to the recorded 2012 flood event.
These differences are believed to be due to differences between the FEH1999 and the FEH2013 rainfall models. We have utilised the most up to date approach.

1st Review Response (DATE)
Details added about limitations, assumptions and uncertainty of the rainfall estimates has been added to the report.
Details added about limitations, assumptions and uncertainty of the rainfall estimates has been added to the report.



2nd Review Comments
An example rainfall hyetograph has been included in the hydrology report (figure 4). In addition a table is presented in table 4 which presents the revised rainfall depths. The rainfall hyetographs and depths presented in the hydrology report were compared against the rainfall data for the 100 year 10.25 hr mm/hr+25%CC scenario included within the Infoworks Model. There appear to be differences between the rainfall applied within the hydraulic model and the rainfall rate/depths reported within the hydrology report (see comment within this cell which shows the applied rainfall). Please clarify why there are differences.

2nd Review Comments
See response in cell F22 below regarding the 27.5hr storm duration
Detail added to the reporting. No further action required

2nd Review Comments
Assumptions, limitations, and uncertainty section added to the model report (page 9). The reporting mentions that the 27.5hr storm duration was also tested. This is referenced in the reporting but it is not clear whether this is referring to the JBA original modelling (2014) or this modelling? Please make this clear as results for the 27.5hr storm duration test have not been provided within the ICMT and are not shown in the modelling report. The reporting suggests that both the 27.5hr and 10.25hr storm durations have been used



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
There are no differences between the numbers in the report and those in the model, the differences observed by the reviewer relate to one set being for the 1 in 100 year scenario and the others for the 1 in 100 year plus climate change scenario, when climate change is applied to the 1 in 100 year values the numbers match.		

2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
The 27.5hr storm duration results have been provided and show no difference.		

2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
The 27.5hr storm duration results have been provided and show no difference.		



4th Review Comments	4th Review Response (DATE)

4th Review Comments	4th Review Response (DATE)

4th Review Comments	4th Review Response (DATE)

Conclusion

Conclusion of Review		
Item No.	Item Checked	1st Review Comments
14	Have the design flows been checked for spatial consistency, e.g. at confluences and along reaches?	N/A
14.1	Have they been checked against flood peaks in the gauged record, and any longer-term flood history?	No checks of results listed against observed flooding/flood history
14.2	Have the 1% and 0.1% AEP growth factors been derived and sense-checked? If the 1% AEP growth factors are outside the typical range, has a justification been provided?	Not included
14.3	Have the results been compared with any from other studies and justification given for any differences?	Appendix B states 'revised rainfall depths are between 16.5% and 19.6% lower than the design rainfall depths from existing EA model'. No additional commentary
14.4	Has enough information been given to enable the work to be reproduced?	Detail is lacking
14.5	Other	There is no details in the hydrology / appendix B on joint probability analysis or a pumping station but this is mentioned briefly in Appendix A.



1st Review Actions	1st Review Response (DATE)
Please add checks/commentary	The 27.5hr rainfall event was tested as this corresponds to the recorded 2012 flood event.
Any thoughts on why this is, please add to reporting (even if believed to be due to updated approach)	These differences are believed to be due to differences between the FEH1999 and the FEH2013 rainfall models. We have utilised the most up to date approach.

Please provide more details and include in hydrology reporting how this will be carried out as currently appendix B suggests that hydrology is just the rainfall runoff approach for the whole catchment	The focus of the assesmsent is to support the developments. They are located sufficiently upstream that the tidal impacts are minimal. Joint probability has therefore not been undertaken
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2nd Review Comments	2nd Review Response (DATE)	3rd Review Comments
See previous comments with regards to the 27.5hr storm duration (within the Results worksheet)	The 27.5hr storm duration results have been provided and show no difference.	
This is considered reasonable. No further action required		

This is considered reasonable. No further action required



3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)