A1 Birtley to Coal House

Scheme Number: TR010031

Applicant's Responses to ExA's Second Written Questions - Appendix 2.10C - Environment Agency confirmation of Flood Model

Planning Act 2008

Rule 8(1)(b)

Infrastructure Planning (Examination Procedure Rules) 2010

Volume 7

April 2020

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Examination Procedure Rules) 2010

A1 Birtley to Coal House Development Consent Order 20[xx]

Applicant's Response to ExA's Second Written Questions - Appendix 2.10C - Environment Agency confirmation of Flood Model

Rule number:	Rule 8(1)(b)
Planning Inspectorate Scheme Reference	TR010031
Application Document Reference	N/A
Author:	A1 Birtley to Coal House Project Team, Highways England

Version	Date	Status of Version
Rev 0	20 April 2020	Application Issue

Technical Model Review Report		
Client	Environment Agency	
Single project or WEM package?	WEM Package	
Package name (if applicable)	2018-19 National Modelling and Forecasting Technical Support Contract	
Project name	Review No. 57 - A1 Birtley to Coal House	
JBA Project Number (or overarching project)	2018s0387	
JBA Sub-Project Number (if applicable)	57	
Review requirements	A) Previous project - hydrology	
	B) Previous project - hydraulic	
	C) New project - hydrology	Yes
	D) New project - hydraulics	Yes
	E) Survey data	
	F) Reporting	

"RAG" key	
Major issue	Omission that could make the findings subject to challenge and which requires correction/further work.
Minor issue	Non-standard method or method not following guidance but unlikely to have impacted on results
Clarification required	The approach used is unclear and requires further clarification before it can be reviewed
Recommendations	Suggestion for improved / good practice but which is unlikely to change the project outcomes.
Acceptable (but does not meet best practice)	The approach is acceptable, however it is not in line with standard industry best practice
Acceptable	Suggestion for improved / good practice but which is unlikely to change the project outcomes.

Summary of 1st hydrology review findings

Hydrology review

A few suggestions have been given below, which may give more conservative results. The reporting in Appendix A regarding the inflow calculations would benefit from additional detail , but is generally well written. The maps provided are excellent and are very helpful.

There are a few omissions that should be addressed, see individual comments below.

Summary of 1st hydraulics review findings

Allerdene Burn model:

Minor issues have been identified. Generally the baseline model and option 1 are well constructed. There were some issues identified in Option 2 that could be impacting the results. Therefore it is recommended that this model is revised.

As for all modelling studies, results of the sensitivity testing and model proving, should be provided for review.

Kingsway Viaduct model:

As the baseline model was constructed by JBA, only the described changes at the viaduct have been reviewed to avoid a conflict of interest. The representation of the existing and proposed viaduct has been done well. However, the stability of out of bank flows in the area of interest is a concern in the 0.1% AEP event, proposed scenario examined.

Summary of 2nd hydrology review findings
Hydrology review Thank you for addressing the comments from the first review, the vast majortiy of these have now been rectified. Minor comment below on using a different storm duration when checking the ReFH1 method. Best practice for pluvial modelling has not been followed regarding use of different %runoffs on different land types, but the broad-scale method used by the authors likely gives an indicative result. Generally recommended in detailed studies to calculate two rainfall profies, one with a large %runoff applied on hard surfaces (roads, buildings, etc) and a second with smaller %runoff - usually informed from the rural ReFH2 loss model - to apply to the remianning rural surfaces. The lumped method used by the authors essentially averages these two mechanisms out; for the purposes of informing likely surface water flow routes this approach is not ideal but OK. A detailed assessment, eg, if surface water drainage is being designed, would require the above approach however.
Summary of 2nd hydraulics review findings
Allerdene Burn model: No further actions required.
Kingsway Viaduct model: No further actions required.

A	Hydrology Review
Date of hydrology analysis	Dec-18
Name of reviewer	James Molloy BE(Hons) MEngSc
Date of review	08/07/2019
Revision	V1
Applicable standards or guidance	Flood Estimation Handbook (IH, 1999) updates including Kjeldsen (DEFRA, 2008), and recent outputs from the FEH Local project ReFH1 and/or ReFH2 guidance documents EA Flood Estimation Guidelines (Operational instruction 197_08, V6)
Nature of study watercourse(s)/constraints	The study looks at various sources of flood risk along a reach of the A1 road, to the south of Allerdene near Newcastle. Various proposed engineering works along the road require an assessment of (a) fluvial flood risk from Allerdene Burn, a small tributary of the River Team and (b) surface water flood risk around Longacre Dean a short distance to the south-east. **The report also looks at flood risk from the River Team, however as no changes have been applied to the hydrology used in the underlying model for this watercourse (previously signed off by the Environment Agency), this aspect is not reviewed in this document.**
Study objectives	The aim of the analysis is to determine if the proposed changes to the road layout have any effect on local flood risk. Information provided in Appendix A of the provided modelling report is used as the basis of this review.
Summary of 1st review	A few suggestions have been given below, which may give more conservative results. The reporting in Appendix A regarding the inflow calculations would benefit from additional detail , but is generally well written. The maps provided are excellent and are very helpful. There are a few omissions that should be addressed, see individual comments below.

Key
Purple - no change
Red - changes made

Summary of 2nd review

Thank you for addressing the comments from the first review, the vast majortiy of these have now been rectified. Minor comment below on using a different storm duration when checking the ReFH1 method.

Best practice for pluvial modelling has not been followed regarding use of different %runoffs on different land types, but the broad-scale method used by the authors likely gives an indicative result. Generally recommended in detailed studies to calculate two rainfall profies, **one with a large %runoff applied on hard surfaces** (roads, buildings, etc) and **a second with smaller %runoff - usually informed from the rural ReFH2 loss model - to apply to the remianning rural surfaces**. The lumped method used by the authors essentially averages these two mechanisms out; for the purposes of informing likely surface water flow routes this approach is not ideal but OK. **A detailed assessment, eg, if surface water drainage is being designed, would require the above approach however.**

Category	Detail	ID	1st review: Comment	1st review: Suitability	1st review: Suggested actions	Consultants Response (if required)	2nd review: Review comment	2nd review: Suggested action
General comments								
General comments	Method statement	A-1	Quite detailed in places, as various sources of flood risk need to be considered in the analysis. The maps provided alongside the report are very useful and clear. Some of the details regarding the hydrological inflows are quite sparse however, see individual comments below.	Clarification required	Reasoning is given in the main report text (Chapter 3) for the study requirements at each watercourse crossing of the A1 road. It seems an unusual decision why fluvial modelling was carried out on Allerdene Burn, but only pluvial modelling around Longacre Dean (why not carry out fluvial modelling at the latter site also?)	Significiant works are proposed on the channel at Allerdene Burn, no works are proposed at Longacre Dean. Therefore, fluvial modelling was not required at Longacre Dean due to the proposals not impacting the main channel. At Long acre dean the culvert is substantially lower than the road, with no flow route on to the A1 and no changes are proposed but the surface flow routes to the channel are of interest.	Thank you for clarifying.	No further action required, this is now discussed in the accompanying note.
	Previous studies	A-2	It is understood that there are no previous studies looking at flood risk for Allerdene Burn, and that only broad-scale pluvial mapping has been carried out in the region surrounding Longacre Dean, which the authors correctly point out does not account for local drainage features that would affect local flood risk.	Acceptable		N/A		
	Catchment description (any unusual features such as pumps, reservoirs, heavy urbanisation?)	A-3	Small catchments, some of which drain densely urbanised areas.	Recommendations	Has the Urban ReFH2 method been considered adequately? Checked in further detail below.	This is addressed within the accompanying technical note	Individual comments checked below.	
Method statement								
Flow estimation points and descriptors	Location of FEPs / catchment descriptors provided?	A-4	Yes in Section 3.3.	Acceptable		N/A		
	Unusual catchment features (which may influence choice of approach)	A-5	The Allerdene catchment is heavily urbanised, and also has a moderately high BFIHOST, noted by the authors.	Recommendations	It may also be useful to obtain sewer drainage information for the area around the Allerdene Burn catchment, in case there are sewered areas outside the topographic catchment draining into this watercourse. However, this is unlikely given the steep slope in the urban area, but still would be a useful to check.	Sewer plans were not available for use within the project, we agree that additional inflows are unlikely given the local topography.	Agreed, but should be acknowledged as an assumption in the report text.	Mention this in an "Assumptions" section of the report or in the accompanying revision note.
	Checks on catchment descriptors	A-6	The catchment area has been correctly checked using LIDAR data, noted that this gives a larger area compared to the "default" FEH catchment.	Major issue	No further reporting given on how the change in catchment area influences other key catchment descriptors. DPLBAR should increase, and there could be significant changes to URBEXT2000 from the change in catchment boundary. Both of these need to be altered, and could have a big effect on calculated flows.	This is addressed within the accompanying technical note	Thank you for updating this. The updated DPLBAR and URBEXT values should give more conservative results in ReFH2. Good method used to update DPLBAR, acknowledging the uncertainty in the AERA^0.548 method for small catchments.	Happy with the given changes.
Data review	Hiflows-UK version	A-7	NRFA V7 is the latest version	Recommendations	Should be used in FEH statistical as an independent check on ReFH2, see below.	This is addressed within the accompanying technical note	See comments below	
	Review of hydrometric data	A-8	No local hydrometric data available to calibrate hydrological methods unfortunately.	Acceptable		N/A		
	Rating reviews	A-9	n/a, no local gauges in the area apart from on the River Team, not reviewed here.	Acceptable		N/A		
	Flood history	A-10	Yes, the authors have queried data held by the Environment Agency and briefly reported this in Chapter 4 of the main report, giving some details of recent floods. This shows that the region assessed here is vulnerable to a range of flood mechanisms.	Acceptable - but does not meet best practice	There are other useful sources of flood history as well. I would recommend having a look on the CBHE website (http://www.cbhe.hydrology.org.uk/index.php), and a general internet search also.	No changes proposed		No further action required.
Initial choice of methods	Approaches suggested	A-11	Only the ReFH2 method is proposed for use for the Allerdene modelling. Depending on the software implementation used, urbanisation adjustments may/may not have been automatically applied given the very high URBEXT200 values.	Major issue	Confirm whether or not the ICM implementation of ReFH2 automatically applies the urban adjustment, giving faster response times and peak flows on highly urbanised catchments. There is no mention anywhere in the document of the FEH statistical method, which should also be applied here, given the uncertainty from catchment-descriptor methods. This at least would be useful as ball-park check on the peak flow produced from ReFH2.	The ReFH2 analysis was undertaken outside of ICM within the ReFH2 software. This is addressed within the accompanying technical note	Thank you for confirming how the ReFH2 and FEH methods were implemented.	Implementation of the FEH statistical method checked below.
	Justification of approach	A-12	A sensible argument is given for using FEH99 rainfalls over FEH13 (although it's hidden in a footnote!), given that the former is reported to give higher rainfall totals in this case. For the purposes of construction options modelling this is a good idea. Some data needs to be presented in the Appendix however to back this up, perhaps a table comparing rainfall totals across multiple storm durations. However using FEH99 rainfall in the ReFH2 model may have an unforeseen drawback. In this situation with FEH99 rainfall, ReFH2 applies the "alpha" factor when calculating runoff (essentially a fudge factor that reduces runoff for increasing return periods - introduced to try to match FEH statistical peaks, but conceptually does not make a lot of sense!). So even though FEH99 might give more rainfall, the "alpha" factor may cancel out the effect. This factor is not used with FEH13 rainfall in the model.	Major issue	Add a table comparing FEH99 and FEH13 rainfalls to back up the argument given in Chapter 2 of Appendix A. Run the ReFH2 model for the 100 and 1,000yr events with the FEH13 rainfall also, to test if this gives larger peak flows, due to the "alpha" issue discussed to the left.	This is addressed within the accompanying technical note	Thank you for checking this, Table 2 in the additional note shows using the 1999 rainfall still gives larger peak flows with ReFH2, for various storm durations. Noted that the authors have also checked the ReFH1 method as well for compelteness, which is a good idea.	The ReFH1 checks given at the bottom of p.6 / top of p.7 use a different storm duraiton (1.25hrs) to the ReFH2 resutls presented further above (3.5hrs). Therefore the comparison of methods in Table 5 of the additioal note is not a true like-for-like check. (on permeable catchments ReFH2 is generally preferred to ReFH1 however, so the overall effect on final calculations is likely low).
	Lumped / distributed	A-13	n/a, as a single inflow to the model is sufficient for this case for the Allerdene model.	Acceptable		N/A		
		A-14						

Flow estimation								
FEH Statistical	Suitable for statistical?	A-15					Yes the FEH statistical method has now been used as an independent check on ReFH2 results.	
	QMED estimation - CDs	A-16					Appears sensible. The urban adjustment is quite large in this case.	
	QMED estimation - AMAX / POT	A-17					n/a, the catchment is ungauged	
	Choice of donors	A-18	Yes, as a check on ReFH2 results, but not used, see above.	Major issue	See above		The authors have attempted to find a QMED donor, demonstrating that due to the small size of the target catchment the process was unsucessful on this occasion. This is a common issue in such cases.	The search for potential QMED donors is well documented in the additional note. No further action needed.
	Growth curve methodology	A-19					Pooling group method applied, with manual modifications to remove impermeable catchmetns and one site with a short record. Individual permeable adjustments also applied.	A bit overkill to be honest (these methods are somewhat uncertain on small cathments!), but the calculations presented look sensible. The permeable adjustment usually does not significantly alter the flood-frequecny curve. No further action needed.
	Hydrology shape	A-20				As above	From ReFH2	
ReFH method	Suitable for ReFH?	A-21	Yes with caution given the heavy urbanisation	Acceptable		N/A		
	Calibration	A-22	n/a, the small catchment assessed here is ungauged.	Acceptable		N/A		
	Choice of design storm	A-23	Summer rainstorm profile is suitable in this case. However only very little discussion given for the choice of design storm duration, choosing the value used in the existing River Team model, simply assuming this will also be critical for Allerdene Burn.	Major issue	Run the ReFH2 model for a range of storm durations to see which gives the largest peak flows for Allerdene Burn. Assuming the same critical storm duration as the downstream River Team model could under-estimate peak flows on this small and fast-responding stream, especially important when testing models needed to size culverts, bridges, etc (in this case I think it's OK to mix and match durations from the main Team model and the Allerdene model, to give conservative results). Give a table of peak flows from ReFH2 versus storm duration in the text.	This is addressed within the accompanying technical note	Thank you for checking this. ReFh2 has now been run for some representative storm durations, with the one giving the most conservative peak flow adopted for modelling.	No further action required
Urban ReFH variant	Suitable for urban ReFH?	A-24	Yes, see previous comments	Major issue	Clarify in the text if the ICM implementation applies the urban adjustments from ReFH2.	This is addressed within the accompanying technical note	Thank you for clarifying. Yes the ReFH2 software applies urbanisation adjustments automatically.	No further action required
	Catchment delineation	A-25	n/a, a lumped approach is OK here.	Acceptable		N/A		
	Calibration	A-26	n/a, no gauges available to calibrate the ReFH2 model on these small streams.			N/A		
	Choice of URBEXT values	A-27	See comments above	Major issue	See adjustments for URBEXT200 required above.	This is addressed within the accompanying technical note	Addressed further above	
	Choice of percentage runoff	A-28	ReFH2 defaults are presumably applied for the Allerdene Burn model, this should be OK (but should be reported, e.g. was urbanised %runoff left at the default 70%?)	Acceptable		This is addressed within the accompanying technical note		No further action required
Final choice of method	Final flows	A-29	N/A as only one method used. Given reliance on (uncertain) catchment descriptor methods, it is important to look at both FEH statistical and ReFH2.	Recommendations		N/A		
Miscellaneous								
	Direct rainfall modelling - 2D domain extent	A-30	The model domain for the direct-rainfall modelling around Longacre Dene looks sensible, based on LIDAR. The plot in Table 6 in Appendix A is very useful to demonstrate this.	Acceptable		N/A		
	Direct rainfall modelling - 2D downstream boundary condition	A-31	The authors state that there was no need to apply a 2D downstream boundary condition to remove excess ponding at the southern edge of the model.	Minor issue	It is usually best practice to place a downstream boundary on a direct rainfall model, to stop any glasswallng affecting results. This might be more important if longer rainstorms are being tested.	To clarify, a normal flow boundary condition was applied to the 2D mesh in ICM rather than no boundary condition.	Thank you for clarifying.	No further action required
	Direct rainfall modelling - range of storm durations tested	A-32	There is no information given on the range of storm durations used in this direct rainfall modelling in the report. The EA national-scale pluvial mapping runs separate models for storm durations of 1hr, 3hrs and 6hrs, then merges the modelled maximum depths in a final grid. This allows for runoff rates on regions with different topography to influence the results. A similar method needs to be adopted for this more detailed assessment.	Major issue	Run the direct rainfall model for a range of storm durations, then merge the results taking the maximum from each individual model grid.	The model has been tested against the critical duration for the catchment, the national modelling was undertaken at a significantly larger scale and therefore wasn't looking at an individual catchment and couldn't be certain on the impacts /cirtical duration in scheme specific terms. In this instance, we are assessing the potential flow routes and flood depths on a slip road which will need to be managed, it is not considered necessary to undertake further analysis, as no changes to surfaces or flow routes or buildings are proposed This is addressed within the accompanying technical note	Noted. Information given in the additional note seems to have carried out this procedure anyway, noting that the 1-hr storm gives the most conservative result.	No further action required
	Direct rainfall modelling - Percentage runoff	A-33	Not much detail given on this, other than use of the ReFH rainfall. Not clear from the text if this is before or after application of the ReFH2 loss model (i.e., is gross or net rainfall used)? Another issue is the use of different percentage runoff on different parts of the model. Has base mapping been used to inform where percentage runoff should be increased on urban surfaces? This is typically set at 70% but can be altered in some cases, with the ReFH model used to inform %runoff on other surfaces.	Major issue	See list of issues to the left.	This is addressed within the accompanying technical note	Noted from the additional information (bottom of p.8) that a lumped NET rainfall has been calculated for the pluvial calculations. For a detailed study, this approach is over-simplified, but might be OK for the purposes of initially informing surface water flow routes. See suggested method to the right for best practice in future, but depending on the required outcomes of the modelling may be OK for a first-run analysis.	Suggested more representative method for pluvial runoff modelling: - Use base mapping to determine a split between 1) paved areas and 2) unpaved areas in the model domain. - Get a starting GROSS rainfall from ReFH2 (no need to buy a catchment from FEH Web Service, just get the nearest poiint rainfall and tick the "plot-scale" button in the ReFH2 software. This saves you having to alter things like DPLBAR, which is not needed here). - As a worst-case assume 100% runoff on the fully paved parts of the model domain from the gross rainfall series. - Use the rural ReFH2 loss model to get a second rainfall series for the remaining unpaved regions of the catchment. The above method will therefore give two rainfall profiles to apply to the model for each run, one for the paved surfaces and a second for the unpaved, The "lumped" method used by the authors represents the entire region as partially urbanised, potentially under-estimating runoff on the road and other hard surfaces and over-estimating runoff on bare-earth surfaces.
Climate change	Consistent with latest guidance?	A-34	The text in Section 3.3.4 of Appendix A suggests an unusual method was used to apply climate change allowances, altering the rainfall applied to ReFH2. As the Allerdene part of the study is a fluvial analysis, it is standard practice to simply multiply the final fluvial hydrographs by the percentage increase.	Minor issue	(Minor issue) For climate change runs on the Allerdene catchment, recommend instead simply multiplying the initial flow hydrographs using the fluvial uplift factors, instead of altering the input rainfall to ReFH2. As the results of this unusual method are not too far off the required percentages, this is a minor issue only. However this complicated method is needed for applying climate change uplifts for the pluvial analysis (the ReFH loss model is non-linear). (comment for EA) The EA also had a query on use of UKCP18 outputs instead of UKCP09 for climate change analysis. While some UKCP18 outputs are now available, research is ongoing to convert these large datasets to simple uplift factors for fluvial / rainfall inputs, due to be released later this year by CEH. Data from UKCP18 can be used manually to inform updated uplift factors, but current guidance recommends this is only needed on very high-risk areas (e.g. power stations). Therefore the use of uplift factors from the current EA guidance (2016 document) using UKCP09 is suitable in this case. (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances)	The River Team model is direct rainfall so therefore the normal fluvial approach is not available. As the reveiwer outlines this approach gives very similar answers, therefore no change is required. The approach to climate change was agreed with Caroline seperatly.	Since the first review was carried out, the UKCP18 climate change uplift factors have now been published.	Perhaps worth a quick check with the latest published factors, these may not have changed significantly from UKCP09. No action required apart from this, given the transition from UKCP09 to UKCP18 occurred over the life of this project.

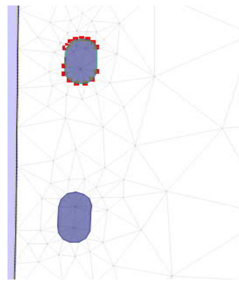
Reporting and follow up actions								
Reporting and Results.	Suitability of reporting	A-35	Quite detailed in places, but lacking detail in others, see the list above. The maps given alongside the report are very well put together and are very helpful.	Minor issue		No changes other than above are proposed		
	Results	A-36	Some issues and omissions spotted, as listed above.	Major issue	See above	No changes other than above are proposed		
	Recommendations	A-37	Key recommendations as follows: - Consider if fluvial modelling on Longacre Dene is needed as well as general pluvial modelling? - Carry out FEH statistical method as an independent ball-park check on the ReFH2 fluvial calculations - Consider sensitivity of using FEH13 rainfall due the "alpha" issue discussed above - Look at sensitivity of results to storm duration, for both fluvial and pluvial analysis.	Major issue	See above	No changes other than above are proposed		

B	Review of River Team Viaduct
Date of model	August 2018
Name of reviewer	Jenny Hill
Date of review	03/03/2020
Revision	v3
Applicable standards or guidance	
Nature of study watercourse(s)/constraints	Allerdene Burn
Study objectives	The reporting states: Flood Risk Assessment (FRA) to support the Environmental Impact Assessment (EIA) and DCO Application for the A1 Birtley to Coal House Scheme. Three areas were identified for further modelling: - Hydraulic modelling to the River Team at Junction 67 to assess the impact of the extension of the Kingsway Viaduct. This modelling utilises an existing Environment Agency hydraulic model of the River Team constructed by JBA in 2014. - Hydraulic modelling of the Allerdene Burn to understand the impact of the A1 realignment which will require either: a. the extension of the existing Allerdene culvert and replacement of the existing section of the Burn; b. or daylighting of the existing culvert and replacement and realignment of the existing burn to accommodate a new viaduct over the existing railway line. - Hydraulic modelling of the surface water flood risk at Junction 66. **This review focusses on the River Team at Junction 67**
Summary of 1st review	As the baseline model was constructed by JBA, only the described changes at the viaduct have been reviewed to avoid a conflict of interest. The representation of the existing and proposed viaduct has been done well. However, the stability of out of bank flows in the area of interest is a concern in the 0.1% AEP event, proposed scenario examined.

Key
Purple - no change
Red - changes made

Category	Detail	Prompts	ID	Comment	Suitability	Suggested actions	Consultants Response (if required)	Comment	Suggested action
Data to be reviewed									
Data to be reviewed	Software	~ Versions	B-1	InfoWorks ICM v6	Acceptable		N/A		
			B-2	Updated to v8 for the purpose of this review	Acceptable		N/A		
	AEPs provided / reviewed		B-3	1% AEP + 20 or 40% and 0.1% AEP.	Acceptable		N/A		
			B-4	1% AEP event reviewed.	Acceptable		N/A		
	Scenarios provided / reviewed		B-5	Base and 'Kingsway Bridge Extension'. The Kingsway Bridge Extension scenario has been the focus of this review.	Acceptable		N/A		
	Reports	~ Reference versions ~ Technical reporting ~ General reporting	B-6	FRA report with technical appendices	Acceptable		N/A		
Reporting									
Reporting	Reporting	~ Objectives ~ Constraints ~ Approach Justification (both model scale and structure scale) ~ Clarity ~ Assumptions	B-8	The report states that Modelling changes are confined to the A1 junction 67 roundabout 424950, 558550 and included the modelling of the existing Kingsway Viaduct and the proposed widening of the viaduct to include an additional pillar.	Acceptable		N/A		
			B-9	Reporting generally clear and thorough	Acceptable		N/A		
			B-10	Results discussed	Acceptable		N/A		
General comments									
General comments	File organisation / naming convention	~ Scenarios ~ Naming ~ Flags	B-12	Flags ED and AD have been used at the changed structure, although flags have not been included in the model describe what this means.	Clarification required	In future include a CSV export of flags or a table of flags in the report	ED = Engineering Design, based upon Scheme drawings AD = Assumed Data, engineering judgement used	Thank you for clarifying	No further action required.
			B-13	The viaduct option has been created as a scenario from the base model, which follows best practice.	Acceptable		N/A		
			B-14	The scenario is clearly named which is helpful for future users.	Acceptable		N/A		
	Survey / topographic data	~ Age ~ Quality	B-15	Source of data is unknown as flag not included, although it is assumed that ED refers to Engineering Drawings.	Clarification required		See B-12 response	Thank you for clarifying	No further action required.
	Other	~ Any significant missing data	B-16	DTM was not provided although the commit history suggests a custom DTM which included topographic survey was used.	Clarification required	In future, provide the DTM used	DTM issued	Thank you for supplying	
General modelling approach									
General modelling approach	Model extents	~ Domain boundaries ~ Upstream/downstream boundaries ~ Potential downstream influences on water levels ~ Glass walling	B-18	Domain is unchanged from the base model	Acceptable		N/A		
	Modelling approach	~ 1D / 2D / Linked ~ georeferenced (ixy/gxy/2d links)	B-19	A 1D-2D approach has been used for the watercourse and a 2D representation of the viaduct pillars has been used.	Acceptable		N/A		
			B-20	The model is fully geo-referenced.	Acceptable		N/A		
	Application of hydrological estimates	~ Lumped / distributed ~ Applied to 1D or 2D domain ~ Lateral or point inflows ~ Consistency with reporting	B-21	The application of the hydrology is unchanged from the base model	Acceptable		N/A		
InfoWorks ICM									
InfoWorks ICM	Model build	~ Hard bed / soft bed ~ Accuracy of modelled channel length	B-23	The model is an adapted version of the JBA built, Environment Agency approved model. The changes made to the existing model have been documented in the commit history. Changes listed are all in relation to Kingsway Viaduct. The 'compare network' tool has been run on the WSP and existing EA model. This concluded that WSP's description of the changes was accurate.	Acceptable		N/A		
			B-24	The modelling report does not comment on whether hard or soft bed have been modelled. However, as the is a proposed design, it is assumed a hard bed level was implemented.	Acceptable		N/A		
			B-25	The modelled length has been calculated from the centre line and the centre line matches the mapped watercourse well.	Acceptable		N/A		
	Watercourses	~ Deactivation ~ Interpolates ~ Bank level and DTM matchup ~ Bank coefficients ~ Baseflow	B-26	1D river reaches have been voided from the 2D zone to avoid double counting	Acceptable		N/A		
			B-27	Based on the cross section naming convention, it is not thought that any interpolates have been applied. The resolution of cross sections in the study area mean no interpolates were necessary.	Acceptable		N/A		
			B-28	Discharge coefficient of 1 and modular limit of 0.9 consistently used.	Acceptable		N/A		
			B-29	The 1D river banks generally track the DTM level well. However, at chainage 50m on river reach TEAM_5156.1 the 1D bank is 1m higher than the 2D level. The 0.1% AEP water level predicted to exceed bank tops so this has potential to impact the results.	Minor issue	Modify 1D or 2D water levels to allow a better match of levels in area of interest	This is addressed within the accompanying technical note	The consultant has documented attempts to improve stability as suitably justified the apprach and documented the limitations.	No further action required.
			B-30	River sections look sensible but few panel markers have been used.	Acceptable		N/A		
			B-31	Conveyance plots for TE05365 and TE05340 are kinked at higher depths.	Minor issue	Update panel markers and channel roughness to smooth conveyance plots at deeper flows.	See B-29 response		
	Watercourse structures	~ Bridges ~ Culverts ~ Screens ~ Weirs ~ Flap valves ~ Sluices	B-32	25 mesh zones have been used to represent viaduct pillars in the flood plain	Acceptable		N/A		
			B-33	In the proposed scenario, all the pillars use a level of 20mAOD. This is 7.5m above ground level which seems appropriate. In the base scenario, the proposed pillars are included but with a level change of 0m.	Acceptable		N/A		
			B-34	Notes have been used to describe which pillars are existing and which are proposed, which is helpful.	Acceptable		N/A		
	Mesh	~ Mesh optimisation ~ Infiltration surfaces ~ Initial conditions ~ Rainfall applied to the mesh. Use of sub catchments ~ 1D/2D linking: bank lines, manhole flood types, inline banks	B-35	The use of mesh zones with small footprints is causing the generation of small triangles (Figure 1) around the area of interest which could slow model run times.	Minor issue	In future models, simplify the geometry of 2D features (while retaining area) to avoid small triangles.	We havent had a significant issue with model run times, therefore no changes have been made	This was only a suggestion for future models, non changes were required.	No further action required.
	Mesh modifications	~ Representation of roads and buildings	B-36	See watercourse structures above	Acceptable		N/A		
	Scenarios	~ Do minimum (baseline) ~ Do nothing ~ Do something	B-38	As the baseline model was constructed by JBA, only the described changes at the viaduct have been reviewed to avoid a conflict of interest.	Acceptable		N/A		
			B-39	Only Kingsway Bridge Extension scenario has been reviewed.	Acceptable		N/A		
	Run parameters and output data	~ Results generated ~ Temporal resolution of results ~ Run parameters	B-40	Results are saved every 5 minutes.	Acceptable		N/A		
			B-41	Timestep used was 4 seconds	Acceptable		N/A		
			B-42	Simulation was run for 30-hours which allows the full storm to pass in the area of interest.	Acceptable		N/A		
Runs									
	Model simulations	Model simulation runs ~ Existing (baseline) ~ Climate change ~ Sensitivity	B-136	Sims provided for the base and scenario for the 1, 1 +20 or 40% and 0.1% AEP events.	Acceptable		N/A		
			B-137	No sensitivity tests were provided.	Minor issue	Run sensitivity tests	This is addressed within the accompanying technical note	The consultant has documented the model's sensitivity to channel roughness. This did not suggest any ammendments to the base model where required.	No further action required.

Figure 1: Small triangles around pillars



Model results, interpretation, verification and stability									
Model results, interpretation, verification and stability	Model stability	~ zzd, eof, tlf ~ Model warnings and errors ~ Non-convergence ~ Mass balance ~ unrealistic oscillations (water level / flow / boundaries / dVol).	B-139	The base 0.1% AEP event ended incomplete.	Minor issue		See response to B-29	The consultant has reported that the 0.1% AEP event has now been run to completion.	No further action required.
			B-140	Total mass error = 9.9 m3	Acceptable		N/A		
			B-141	Volume balance error = 0.9 %	Acceptable		N/A		
			B-142	There is some oscillation in the peak flows in the area of interest during a 0.1% AEP event (Figure 2)	Minor issue	Make updates to conveyance and bank lines to improve stability	See response to B-29	The consultant has documented attempts to improve stability as suitablly justified the apprach and documented the limitations.	No further action required.
			B-143	There is some significant oscillations in the out of bank flows in the area of interest during the 0.1% AEP event (figure 3)	Major issue	Make updates to conveyance and bank lines to improve stability. If appropriate, lower bank co-efficient	See response to B-29	The consultant has documented attempts to improve stability as suitablly justified the apprach and documented the limitations.	No further action required.
	Sensitivity testing	~ Suitability of sensitivity testing undertaken ~ Results & interpretation of sensitivity testing	B-144	Sensitivity tests not provided for review	Minor issue	Run sensitivity tests	See response to B-137	The consultant has documented the model's sensitivity to channel roughness. This did not suggest any ammendments to the base model where required.	No further action required.
	Calibration / performance		B-145	No model performance testing was provided for review.	Minor issue	Use the model report to provide commentary on the sensibility of predicted flooding.	This is addressed within the accompanying technical note	The consultatn has provided justifaction for not completing model proving.	No further action required.

Acceptable
Acceptable - but does not meet best practice
Clarification required
Minor issue
Major issue
Recommendations

Figure 2: In channel flows ate TEAM_5156.1

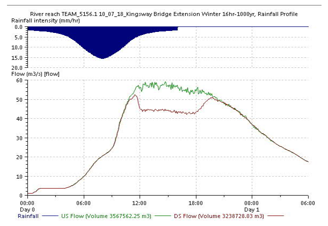
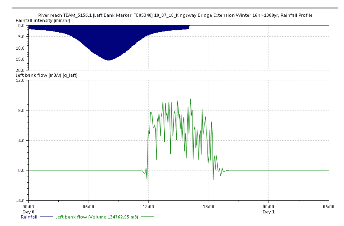


Figure 3: : Left bank flows at TEAM_5156.1



B	Review of Alledene Burn
Date of model	August 2018
Name of reviewer	Jenny Hill
Date of review	19/07/2019
Revision	v1
Applicable standards or guidance	
Nature of study watercourse(s)/constraints	Alledene Burn
Study objectives	The reporting states: Flood Risk Assessment (FRA) to support the Environmental Impact Assessment (EIA) and DCO Application for the A1 Birtley to Coal House Scheme. Three areas were identified for further modelling: - Hydraulic modelling to the River Team at Junction 67 to assess the impact of the extension of the Kingsway Viaduct. This modelling utilises an existing Environment Agency hydraulic model of the River Team constructed by JBA in 2014. - Hydraulic modelling of the Alledene Burn to understand the impact of the A1 realignment which will require either: a. the extension of the existing Alledene culvert and replacement of the existing section of the Burn; b. or daylighting of the existing culvert and replacement and realignment of the existing burn to accommodate a new viaduct over the existing railway line. - Hydraulic modelling of the surface water flood risk at Junction 66. **This review focusses on the Alledene Burn options**
Summary of 1st review	Minor issues have been identified. Generally the baseline model and option 1 are well constructed. There were some issues identified in Option 2 that could be impacting the results. Therefore it is recommended that this model is revised. As for all modelling studies, results of the sensitivity testing and model proving, should be provided for review.

Key
Purple - no change
Red - changes made

Category	Detail	Prompts	ID	Comment	Suitability	Suggested actions	Consultants Response (if required)	Comment	Suggested action
Data to be reviewed									
Data to be reviewed	Software	~ Versions	B-1	InfoWorks ICM v8	Acceptable		N/A		
	AEPs provided / reviewed		B-2	0.1% AEP model files and results	Acceptable		N/A		
	Scenarios provided / reviewed		B-3	Base, Option 1 ditch realignment, Option 1 realignment flow control, Option 2 and Option 3	Acceptable		N/A		
	Reports	~ Reference versions ~ Technical reporting ~ General reporting	B-4	FRA report with technical appendices	Acceptable		N/A		
Reporting									
Reporting	Reporting	~ Objectives ~ Constraints ~ Approach Justification (both model scale and structure scale) ~ Clarity ~ Assumptions ~ Interpretation of results	B-6	Objectives clearly stated in the reporting	Acceptable		N/A		
			B-7	Reporting generally clear and thorough	Acceptable		N/A		
			B-8	The scenarios are a bit unclear - more models provided than options discussed.	Clarification required	Check consistency between model and reporting provided for review.	This is addressed within the accompanying technical note	The consultants note clarifies this.	No further action required.
			B-9	Results discussed	Acceptable				
General comments									
General comments	File organisation / naming convention	~ Scenarios ~ Naming ~ Flags	B-11	Scenarios and files well labelled although it was a bit confusing to establish what is the base scenario. One model network with all options as scenarios could have been a neater way to organise the options.	Acceptable - but does not meet best practice	In future, use one model network with a series of scenarios to represents options	N/A		
			B-12	Flags have not been included although data has been flagged.	Acceptable - but does not meet best practice	In future include a CSV export of flags or a table of flags in the report	N/A		
			B-13	Naming conventions are clear and descriptive	Acceptable		N/A		
			B-14	The DTM has not been provided which makes comparisons more difficult. A lidar clip has been made but it understood that the model DTM was a composite of three sources	Clarification required	In future, provide the DTM used	DTM provided	Thank you for supplying	No further action required.
	Survey / topographic data	~ Age ~ Quality ~ Suitability	B-15	According to the report, Channel survey for Alledene Culvert was undertaken by Longdin and Browning in March 2018	Acceptable		N/A		
			B-16	Lidar data was supplemented by topo survey in the study area.	Acceptable		N/A		
	Other	~ Any significant missing data	B-17	NextMap 5m has been used to north east of the A1 which has partial or no Lidar coverage.	Acceptable		N/A		
General modelling approach									
General modelling approach	Model extents	~ Domain boundaries ~ Upstream/downstream boundaries ~ Potential downstream influences on water levels ~ Glass walling	B-19	The Alledene Burn is not mapped. However, a check against 1m Lidar suggests that the full length of the watercourse has been modelled in 1D with 2D linking.	Acceptable		N/A		
			B-20	A check on the maximum flood extent for the 0.1% AEP event showed no glass walling. Therefore the extent of the 2D model is considered appropriated.	Acceptable		N/A		
	Modelling approach	~ 1D / 2D / Linked ~ georeferenced (ixy/gxy/2d links)	B-21	1D river reaches are linked to the 2D domain at banks.	Acceptable		N/A		
			B-22	Model is fully georeferenced	Acceptable		N/A		
	Application of hydrological estimates	~ Lumped / distributed ~ Applied to 1D or 2D domain ~ Lateral or point inflows ~ Consistency with reporting	B-23	Inflows have been applied at the upstream extent of the model	Acceptable		N/A		
			B-24	No lateral inflows are made, but it is not anticipated that these would be required for a watercourse of this size.	Acceptable		N/A		
			B-25	A downstream water level from the River Team for the same AEP has bee applied.	Acceptable		N/A		
InfoWorks ICM									
InfoWorks ICM	Model build	~ Hard bed / soft bed ~ Accuracy of modelled channel length	B-27	Hard bed/ soft bed not specified in the reporting	Clarification required	Specify if hard or soft bed levels were used..	Hard bed levels used.	Thank you for clarifying.	No further action required.
			B-28	All river reach lengths have been calculated based on the length of the centre line and the centreline follows the channel indicated in the DTM well.	Acceptable		N/A		
	Watercourses	~ Deactivation ~ Interpolates ~ Bank level and DTM matchup ~ Bank coefficients ~ Baseflow	B-29	1D river reaches have been voided from the 2D zone to avoid double counting	Acceptable		N/A		
			B-30	Interpolates have been used excessively, with on interpolate every 10m. The interpolates have not caused any kinks in the conveyance plots so it is concluded that this is unlikely to impact results.	Acceptable - but does not meet best practice		N/A		
			B-31	Bank levels are interpolated between survey points rather than updated from the DTM. In some cases this can make the 1D bank 2m above the 2D level	Minor issue	In future, update bank levels from DTM in between surveyed cross sections if there is good confidence in the DTM levels.	This is addressed within the accompanying technical note	The consultant has justified their approach.	No further action required.
			B-32	Discharge coefficient of 1 and modular limit of 0.8 consistently used.	Acceptable		N/A		
			B-33	No inflow applied to the river reach link as inflow hydrograph has been used.	Acceptable		N/A		
	Watercourse structures	~ Bridges ~ Culverts ~ Screens ~ Weirs ~ Flap valves ~ Sluices	B-34	7 culverts have been modelled. The data flags suggested 6 of these 7 have been modelled from survey data and 1 from As Built drawings. The size and roughness looks sensible although I would recommend that Manning's n is used for fluvial culverts over Colebrook White.	Acceptable		N/A		
			B-35	Culvert inlets and outlets consistently used with appropriate coefficients applied.	Acceptable		N/A		
			B-36	1 bridge has been modelled. The bridge opening (flagged as survey data) and deck look sensible compared to the river cross section. Bank coefficient and discharge coefficient have been left as default.	Acceptable		N/A		
			B-37	Summary on none modelled: flap valve, orifice, pump, screen, weirs	Acceptable		N/A		
	Mesh	~ Mesh optimisation ~ Infiltration surfaces ~ Initial conditions ~ Rainfall applied to the mesh. Use of sub catchments ~ 1D/2D linking: bank lines, manhole flood types, inline banks	B-38	Max triangle area was $20m^2$ and minimum element was $10m^2$ which is appropriate for a model of this scale. The general roughness was 0.035 which is within typical range.	Acceptable		N/A		
			B-39	No mesh warnings have were produced.	Acceptable		N/A		
			B-40	No rainfall was applied to the mesh, despite rainfall being applied in the run set up. It is understood that this was a fluvial model, and therefore the rainfall was not required. However, clarification on why rainfall files have been included is required.	Clarification required	Clarify if rainfall was an intended inflow to this model.	Rainfall was only applied in a small sub catchment, with the model being predominantly fluvial.	Thank you for clarifying.	No further action required.
			B-41	1D-2D linking happens at bank lines which has been successfully achieved.	Acceptable		N/A		
	Mesh modifications	~ Representation of roads and buildings ~ Roughness	B-42	There is no representation of the conveyance in highways or the resistance caused by buildings.	Minor issue	Represent buildings, road, woodland, scrub as roughness zones in the 2D model.	This model covers a small area and this level of detail is not required in this instance	Thank you for clarifying.	No further action required.
			B-43	However, the raised highway embankment are represented in the DTM and therefore the mesh.	Acceptable		N/A		
	Scenarios	~ Do minimum (baseline) ~ Do nothing ~ Do something	B-44	Option 1a: Ditch re-alightment A Mesh Level Zone has been added over the existing watercourse. This adjusts the DTM elevation to give a minimum elevation of 16 mAOD and maximum elevation of 17.5 mAOD. A 3D view indicates that this level zone has lowered the existing embankment. There has been no modification of the ground levels to tie in worth the proposed bank heights. In some locations this can cause a 1m discrepancy between 1D and 2D bank level. This is not shown to impact 0.1% AEP results. The extended culvert has been connected to the proposed culvert with a break node. I would think it more likely that a manhole chamber would be installed to connect these. A manhole would have the potential to flood whereas a break node does not. However, the pipe is not surcharged at the peak of the 0.1% AEP event so this is not thought to impact results. The roughness of the proposed culvert has not been updated from default. The The new cross sections mainly look sensible but ARD1 - ARD4 all have left bank lower than the highest point, allowing for premature flooding (Figure 1). However, the max water level doesn't exceed left bank level in the 0.1% AEP event so this is not thought to impact results. The conveyance of the new cross sections is kinked at higher depths (Figure 2). However, the max water depth doesn't reach this level in the 0.1% AEP event so this is not thought to impact results.	Acceptable - but does not meet best practice		N/A		
			B-45	Option 1b: Ditch realignment + flow control A Mesh Level Zone has been added over the existing watercourse, as before (for comments see Option 1a). Pipe size of SA02USc.1 has been reduced from 1.35 to 1.2m in diameter. No other apparent changes made from Option 1a so same comments stand.	Acceptable - but does not meet best practice		N/A		
			B-46	Option 2: Viaduct A Mesh Level Zone has been added over the existing watercourse, as before (for comments see Option 1a). There is no apparent level change in the model to account for lowering the highway embankment which is present in the DTM JBA imported (no DTM provided). As a result, in some places there is a 9m miss match between the 1D and 2D bank levels modelled. In channel water levels do not exceed bank top during the 0.1% AEP so this is not impacting results. The open channel has been extended to replace the culvert. As per Option 1a, sections ARD1-ARD4 have lower left bank to the bank top (Figure 1). The same is true for ARD14-17 and ST02 US. Here channel flow does exceed bank top in the 0.1% AEP event (Figure 4) so this is impacting results. As per Option 1a, conveyance plots are kinked in at greater depths, which in this instance could impact the results as in channel depths exceed 1m.	Minor issue	Trim 1D cross sections to the highest point on the left bank. Update panel markers and channel roughness to smooth conveyance plots at deeper flows.	This is addressed within the accompanying technical note	The documentation states that the model has been updated	No further action required.
			B-47	Option 3: Viaduct There are no apparent changes between Options 2 and 3 so the same comments stand unless clarification of changes is provided.	Minor issue	Trim 1D cross sections to the highest point on the left bank. Update panel markers and channel roughness to smooth conveyance plots at deeper flows.	See response to B-47	The documentation states that the model has been updated	No further action required.
	Run parameters and output data	~ Results generated ~ Temporal resolution of results ~ Run parameters	B-48	Results saved at a 1minute interval which is high but acceptable.	Acceptable		N/A		
			B-49	Model is run for 12 hours which allows the full storm to pass	Acceptable		N/A		
			B-50	Run use a GPU card but don't link 1D and 2D calculations at minor timesteps.	Acceptable		N/A		
Runs									
	Model simulations	Model simulation runs ~ Existing (baseline) ~ Climate change ~ Sensitivity	B-144	The model has been run and reviewed for the baseline and options. All results use the 0.1& AEP event.	Acceptable		N/A		
			B-145	There were no sensitivity tests provided.	Minor issue	Run sensitivity tests	This is addressed within the accompanying technical note	The consultant has documented the model's sensitivity to downstream boundary, channel roughness and flow duration. This did not suggest any ammendments to the base model where required.	

Figure 1: Bank top higher than left bank

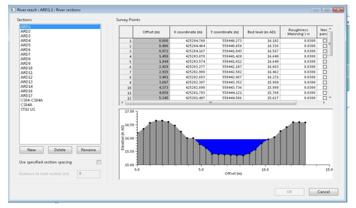
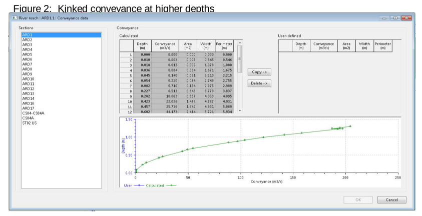


Figure 2: Kinked conveyance at higher depths



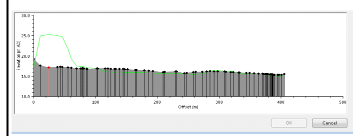
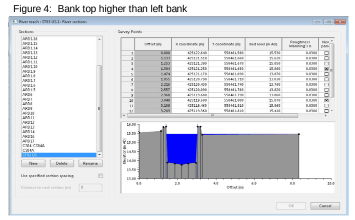


Figure 3: Bank level miss match

Figure 4: Bank top higher than left bank



Model results, interpretation, verification and stability									
Model results, interpretation, verification and stability	Model stability	~ zzd, eof, tlf ~ Model warnings and errors ~ Non-convergence ~ Mass balance ~ unrealistic oscillations (water level / flow / boundaries / dVol).	B-147	Total mass error = 0.0 m3	Acceptable		N/A		
			B-148	Volume balance error = 0.0 %	Acceptable		N/A		
			B-149	In channel flows raise and fall in a smooth hydrograph	Acceptable		N/A		
			B-150	Out of bank flows are generally stable	Acceptable		N/A		
			B-151	There is some instability at the downstream boundary due to the backing up of the River Team 0.1% AEP level but this is not impacting the results in the area of interest.	Acceptable		N/A		
	Sensitivity testing	~ Suitability of sensitivity testing undertaken ~ Results & interpretation of sensitivity testing	B-152	Sensitivity tests not provided for review	Minor issue	Run sensitivity tests	See response to B-145	Thank you for clarifying.	No further action required.
	Calibration / performance		B-153	No model performance testing was provided for review.	Minor issue	Use the model report to provide commentary on the sensibility of predicted flooding.	This is addressed within the accompanying technical note	Thank you for clarifying.	No further action required.

Acceptable
Acceptable - but does not meet best practice
Clarification required
Minor issue
Major issue
Recommendations

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