



NRW Flood Model Comments Response to NRW

PROJECT NUMBER	7005-3561
DATE	May 2021
PROJECT NAME	Leckwith Quays
CLIENT	Phil Worthing
DOCUMENT REFERENCE	70053561-C-Mem02-00

INTRODUCTION

NRW have provided a set of comments (11/03/2021) on the hydraulic model submitted as part of the planning application. This memorandum sets out WSP's responses to each of these comments in turn.

GENERAL COMMENTARY

NRW have undertaken a partial review of the model and supplied data but may have misinterpreted its purpose. NRW mention reviewing the refined baseline and VarB models only but discuss both detailed drawings of the proposed bridge and a full understanding of impacts, something which can only follow detailed design. Whilst we do not agree with all of the points raised, NRW have valid points worth further explanation and evidence. Some of these items may have a minor-negligible effect on the results; however, it is our opinion that the overall findings and conclusions of the modelling and FCA remain sound.

In the first instance it is worth reiterating the purpose of the FCA and modelling. To provide a wide scale understanding of the hydraulic system, its interaction to and from the proposed development and a potential solution worth pursuing. This understanding is both logical and consistent and whilst the findings set out in NRW's review identify a couple of points whereby the precision of the findings may be subject to minor-negligible revision the overall conclusions remain sound namely:

- There is an existing choke point in the river at the historic bridge.
- The proposals in their original form locally increase water levels.
- The ground level of the proposal needs to be raised to be compliant with TAN15, but this is a practicable quantum.
- The proposed bridge structure would benefit from a wider aperture to prevent introducing an additional flow constriction upstream of the historic bridge.
- The inclusion of bypass culverts which relieve the choke point in the river has the potential to solve the problem of increased water levels resulting from the proposals subject to further design.

SPECIFIC RECOMMENDATIONS TO EACH ITEM RAISED

This section of the memo provides additional commentary and detail to each of the items raised by NRW in their review commentary.

■ **Item Number One**

NRW recommends that single *.MIF files are used rather than breaking the files into point, line and regions.

We agree with NRW's definition of this item as unlikely to change the model outcome, other than this we have no further comment.

■ **Item Number Two**

It is recommended that the latest version of the software is used.

The NRW model was simulated using an older version of the software, the 2018-03-AD version used for this project to date was released in March 2019. No significant changes in moving to more recent engines are anticipated, noting however that such a change did break NRW's provided model as described in the FCA. We consider that the software engine utilised is sufficiently current to support the FCA, but later modelling may use new software engines in accordance with WSP's licencing and upgrade schedules.

■ **Item Number Three**

NRW recommends that the cell size is reviewed and updated as required, with a focus on the Ely Paper Mill site and the A4232 bridge.

The cell size was agreed as appropriate with NRW in the DAS, please refer to the agreed minutes for evidence of this. The nested grid in the refined model shows a limited effect from this transition we consider an 8 m cell size sufficient to capture a strategic site such as Leckwith Quay as previously agreed. Therefore we do not intend to review the cell size. No decision has been finalised by the project team on whether the 4 m nested grid will be retained or the previously agreed 8 m grid reverted to in future modelling or not.

■ **Item Number Four**

WSP must provide justification on why "model surcharged bridge as orifice flow" has not been adopted within the model.

This parameter has not been included as it was not in either of the baseline models and this alteration has been objected to in previous NRW reviews. We suggest that this parameter can be included (subject to model stability) for any structure NRW may now consider it appropriate for in any future simulations, if explicitly identified. We do not consider that the inclusion or omission of this parameter will effect the findings of the current modelling bearing in mind its purpose.

■ **Item Number Five**

The file 2d_zIn_7005-3561_Lek_PropInfrastructurePatch_001a_L.mif must be reviewed and updated to ensure it only makes changes to the model within the redline boundary.

It is unclear why NRW consider this to have any influence on results as it is a replication of a feature which crosses both domains, typically it is better to avoid duplicating features unnecessarily to avoid errors.

■ **Item Number Six**

The timesteps used within the model must be reviewed and updated.

The timestep in the 1D domain is auto-corrected by Tuflow to match the 2D domain where the 2D domain is lower. As set out in the FCA, NRW's documentation on the model timestep does not match that in the model and records provided. As this is auto-corrected by the software it will not affect model results. The FCA presumes that the error was in NRW's reporting and that the 1s 2D timestep was intentionally

applied. Additionally, please could NRW confirm whether it is implied that the original error is with their documentation or their supplied model. Setting the 1D timestep to match the 2D timestep in any subsequent models can be undertaken, following clarification.

■ Item Number Seven

NRW require additional justification on the update of Cardiff Bay from 2D to 1D.

The FCA sets out a number of issues with the representation of Cardiff Bay and the difference between the Baseline & Refined Baseline models (noting that NRW have only considered the refined model) which suggest improved performance and suitable representation.

To recapture points from the FCA:

In order to represent Cardiff Bay in the 1D domain the resulting model surface from the 2D model was extracted and contoured, replicating the current representation. These contours were used to represent a reservoir unit in FMP which was then connected to both rivers, the tidal sluice gates and overspill points to allow the transfer of water into the 2D domain. These overspill points take their elevation from the LiDAR and are located along: Ferry Road (85 m wide at 7.85 m AOD), Roath Basin (26 m, 7.68 m AOD), Stuart Street (60 m, 7.3 m AOD), Havana Street North (31 m, 7.64 m AOD), Havana Street South (30 m, 7.90 m AOD) and Landsea Gardens (40 m, 7.35 m AOD).

The model as supplied by NRW was disinclined to initialise under the latest software engine without forcing its settings via the *'default = Pre 2017'* command. This command changes a number of settings, deprecating them to those which would have been applied when the VDM was built. The most probable reason for this disinclination is due to the manner the command changes the implementation of 'SX' connections. Both of the rivers connect into Cardiff Bay at their downstream end via these 'SX' links, spread over each cell across the mouth of both rivers. It follows that this command alters how the initial interchange of water between domains is applied at the start of the model; when the stability issues (crashes) otherwise occur within latest engine. It should also be noted that the value in the *2d_iwl* for the bay differs by 0.1 m from that specified in the FMP model which may have amplified these initial instabilities. These explanations would also explain why the Refined Baseline /Existing models (and those based on it) do not require restart files.

NRW will also note from the provided results files which represent the Bay as a 2D feature the striations and mottling across the bay in even low return period events when coloured against NRW's 5 mm difference criteria. Such mottling patterns are not typically indicative of a good performing model and introduce additional noise when trying to understand outcomes. Additionally, it is noted that large volumes of (static) water in the 2D domain can mask MB errors when considering model performance. Therefore, the representation of the bay in the 2D domain being an aspect which is not a focus for this project given its controlled nature and relation to the site it can be considered an unnecessary burden assuming that suitable 1D representation can be agreed.

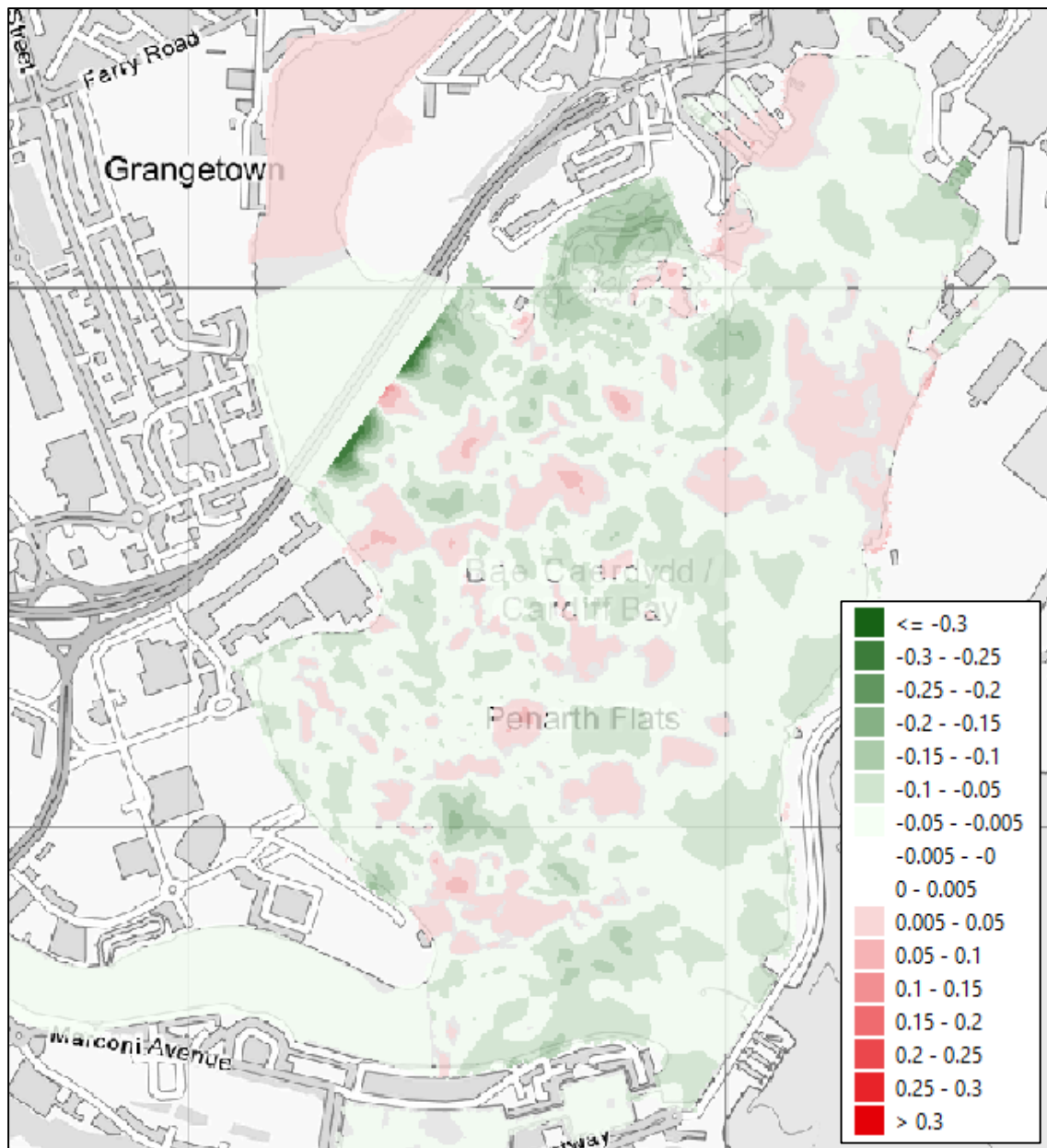


Figure 7.1: Stage difference centred on Cardiff Bay in 2D Representation.

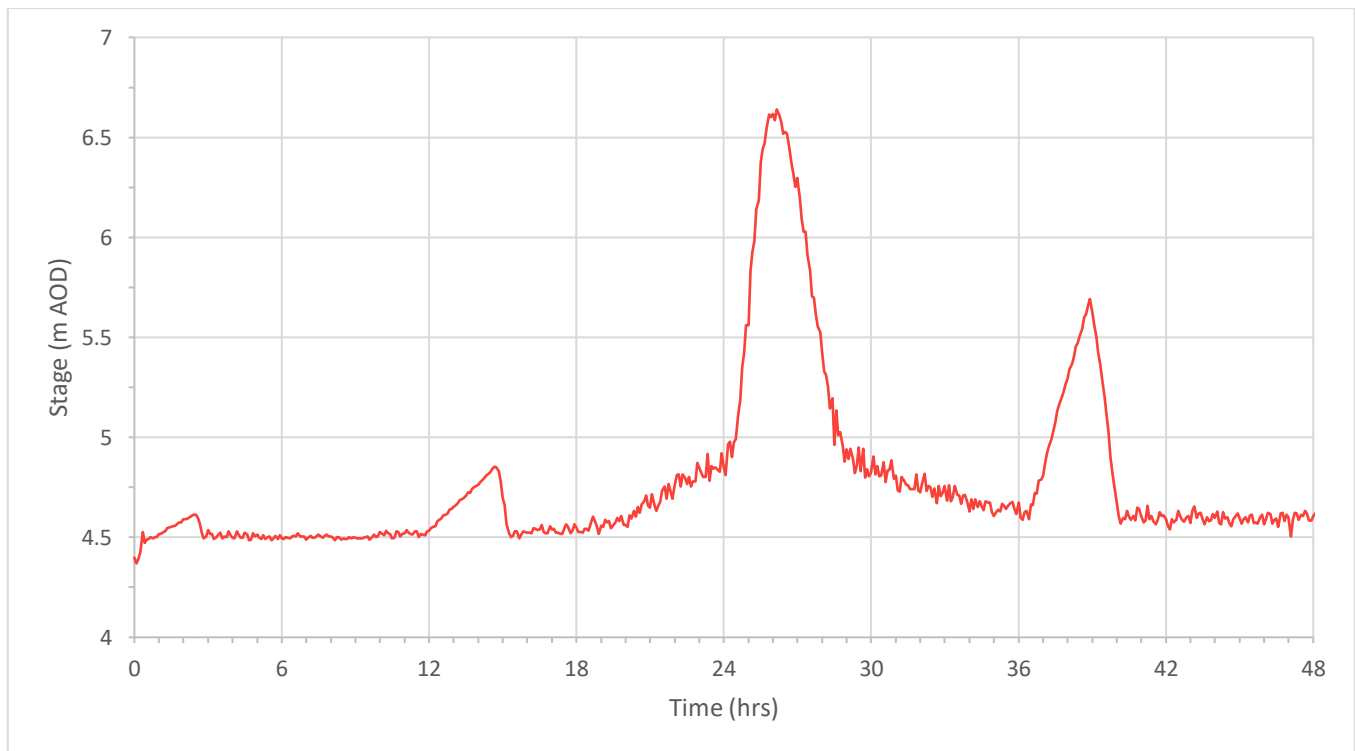


Figure 7.2: 2D Stage extract from NRW provided VDM results for random point in Cardiff Bay.

The above plot shows the change in water level for a randomly selected point in Cardiff Bay from the results directly supplied by NRW, noting the oscillations particularly around the peak water level.

As noted in the FCA as the conversion from the Baseline to the Refined Baseline resulted in a limited change in maximum stage levels through the site of interest as a result of the model refinements, with differences tending to a couple of centimetres if not a couple of millimetres. Therefore, this change is considered appropriate and a suitable representation of Cardiff Bay is not anticipated to significantly alter the conclusions of the modelling. Given the above explanation setting out why the 1D representation is preferable it is our consideration that this representation should be inherited into any future modelling for this project.

■ **Item Number Eight**

The representation of the A4232 bridge must be reviewed and updated as required.

This bridge was not included in either provided model nor has any of NRW's supporting information (e.g. topographic survey) been provided. In our opinion the modest increase in depth is not likely significant when considering the soffit (from observed data) and remembering that the bridge was originally omitted from NRW's model, presumably for being sufficiently higher than the maximum predicted flood level. If NRW can provided supporting information we can review the representation of this bridge.

■ **Item Number Nine**

The representation of the B4267 road bridge.

The Leckwith Quay FCA reports that the existing B4267 road bridge is a single span concrete arch bridge across the channel and includes nine additional spans over the western bank. NRW require confirmation that all but one of these arches are blocked, as these have not been included within the model. NRW understand that a 1D rectangular culvert has been used to represent one of the arches on the western bank. NRW recommends that WSP review the full section of this bridge which is represented in the 2D domain. NRW recommend WSP consider representing the openings in the 2D domain, through the use of zsh.

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In addition to the topographical survey provided in the submission we have provided below two screenshots from Google Earth. Based on this information we concur with the representation in both NRW supplied models as having these arches as wholly blocked. We added a flowpath through the one arch which remains clear for access in the same fashion as the other underpasses within the provided model (i.e. a culvert). We consider the representation of this underpass to be satisfactory and have no bearing on the model results. If NRW insist on a free flowing zsh stamped into the topography this change can be made in any future model simulations.



Figure 9.1: Google Earth view looking upstream at Existing Bridge



Figure 9.2: Google Earth view looking downstream at Existing Bridge

■ Item Number Ten

and representation of the Leckwith Road as it passes under the A4232 must be reviewed and updated as required.

The representation of the Leckwith Road underpass was improved such that the representation better corresponded with real world data. One of the NRW models had no underpass at this location and the other a 1D-2D link directly to the opposite side of the embankment meaning there was no 2D overland flowpath or volume through the structure. Modelled in the same fashion as the other underpasses within the model we consider this configuration a significant improvement over the licenced model and entirely suitable for the purposes of this study. If NRW can be explicit as to their preferred 2D representation, presumably a zsh as suggested for the access underpass onsite, this change can be made in any future model simulations.

■ Item Number Eleven

The width of the 1D cross sections and position of the corresponding HX lines, differ in a number of locations, this must be reviewed and updated.

We acknowledge that misalignments between 1D & 2D channel widths have been inherited from the NRW licenced models. We note that the information supplied within the licence did not include survey information or correctly geocordinated FMP section data to readily check and amend any such misalignments. The project team understands that additional survey of the watercourse will be required along this reach in order to fully inform the detailed bridge design and this will be used to update and improve any future models. If NRW can provide supporting information they may hold (e.g. original survey of the Ely) this would be beneficial. Whilst the project team accepts that mismatches between 1D/2D channel widths may have a minor effect on local results, the essential findings of the strategic model hold true.

■ Item Number Eleven-A

Within the proposed version of the model the 'Distance to Next Section' has been change for ELY32400, ELY32550 and ELY32550D. NRW question the changes applied.

The overall reach of the river does not change, however bridges do not have an associated length. Therefore, the options are to either shorten the watercourse or increase the chainage upstream or downstream. As illustrated in the table below the upstream chainage was increased as opposed to either the downstream (between the two bridges) or omitting the chainage/volume entirely.

Table 11.A.1: Chainage through key reach.

Label	Chainage (m)	
	Baseline	Proposed
ELY32100	150	150
ELY32250	150	150
ELY32400	150	155
ELY32550	10	0
ELY32550D	-	5
ELY32560U	0	0
ELY32560D	12	12
ELY32572U	0	-
ELY32572D	8	8
ELY32575W	0	0
ELY32580	10	10
ELY32590	110	110
ELY32700	140	140
ELY32840	150	150
ELY32990	140	140
ELY33130	160	160
Total	1190	1190

■ **Item Number Twelve**

Implementation of the hydrology must be reviewed and updated.

We can confirm that the flows applied to the model were as supplied by NRW. Future models can be run with revised flows if desirable and provided.

■ **Item Number Thirteen**

WSP must review and update the implementation of the proposed bridge and any associated culverts. In addition, detailed drawings of the proposed bridge must be supplied.

The bridge is at an outline design stage, therefore full details are not yet available. As much relevant detail as is available has been provided in the GA drawing and FCA. The modelling has simulated an outline design with a number of options. These options include the opinion from the outline design team that it may be feasible to widen the aperture from the initial design by the amount applied in Variations A and B as well as bypass culverts being a potentially feasible option. The modelling identifies that bypass culverts combined with the larger aperture may be an eventual solution to mitigating the effects of the proposal. We concur that the final design will need to be supported by detailed drawings and suggest that an NRW condition to the effect that a future model build including detail design drawings would be appropriate.

With regards to the configuration of the culverts we suggest that if future modelling is undertaken NRW will be asked to confirm whether the specific configuration of culvert representation decided upon (out of the many valid methods) meets their preference in this instance. In the current configuration a spill and orifice were used at either end, as preliminary testing found that the culvert inlet / outlet losses were unstable and the USBPR unit inbuilt flood relief culverts was considered to potentially underestimate losses along the substantial length of the culvert, essentially modelling them as a broadcrested weir (undrowned)/ orifice (drowned). It is our position that for the purposes of the modelling this representation investigating the effects of a theoretical structure is appropriate.

With regards to blockages on the culvert, once these have been suitably designed an assessment as to their potential for blockage during a flow event can be agreed with NRW and, if necessary, modelled.

With regards to the appropriateness of building the culverts. Bypass culverts and channels are not an unusual feature and have been implemented in other FAS in Wales. We are entirely clear that the detailed design of these culverts may result in necessary deviations from their current theoretical representation. We would suggest that a condition to the effect that a final model of the detailed design of the bridge and associated infrastructure would be appropriate.

With regards to the observation that ‘they pass very little flow’. It is fully accepted that the total peak flow of 4.5 cumecs in the 1000yr event (254 Megalitres volume) may appear to be insignificant when compared to the flow passed through the Historic Bridge (175 cumecs) at only 2.5%. However, when considering the peak flow out of the upstream floodplain into Cardiff, which in the original proposal was some 55 cumecs occurring between 20 and 30 hours in the simulation; then the release of 254 Megalitres from the floodplain which also delays the driving flow spreading out over Cardiff, reduces the peak, the whole curve and brings forward the severance of the flowpath, then the resulting effect becomes significant. This can be seen in the figure below which shows one of the PO over spills (SAN1) into Cardiff.

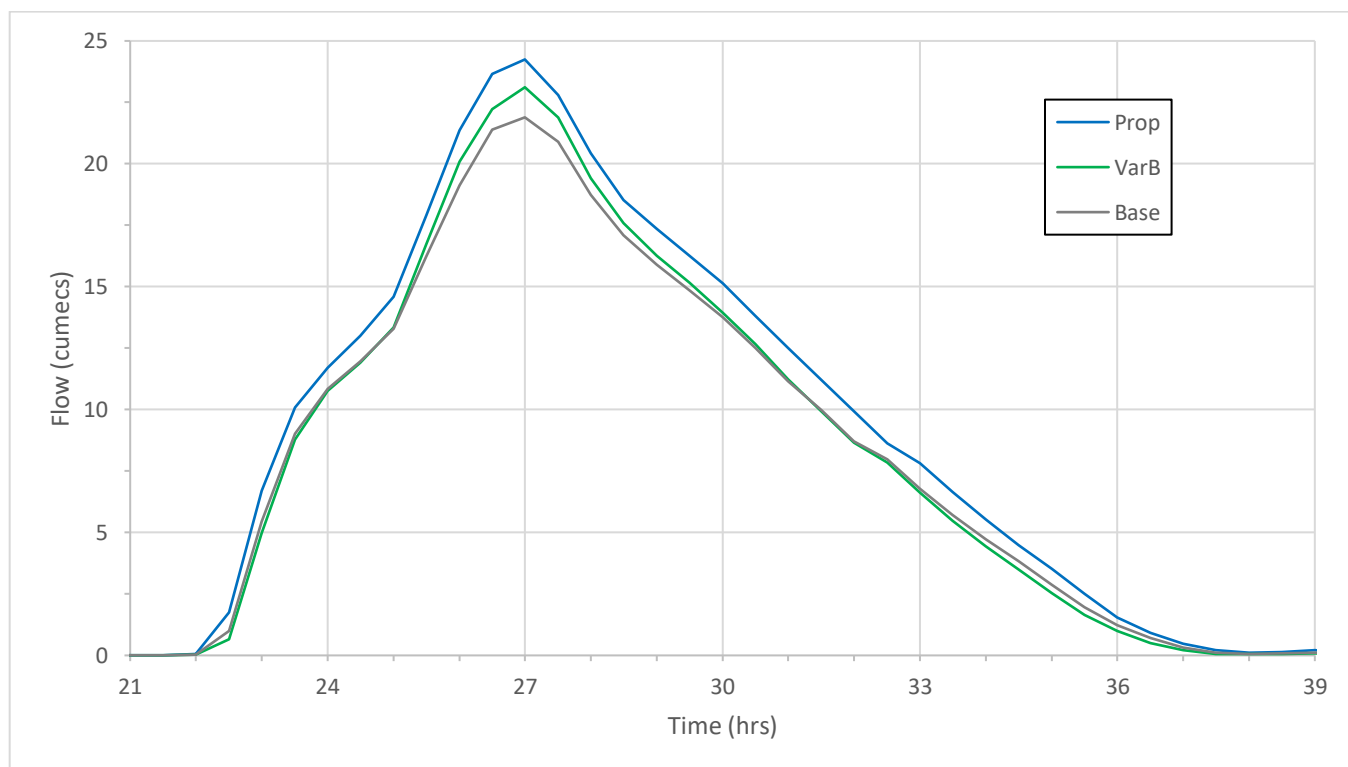


Figure 13.1: Sanitorium Park Overspill into Cardiff (SAN1) Hydrograph

The above figure more clearly shows the effect of the culverts on the floodplain, whilst the VarB peak flow remains higher than the baseline it is reduced from the initial proposal, additionally it can be seen that the

rising and falling limbs show less floodplain flow in VarB compared to the baseline with a later start and earlier termination. This is a logical consequence of the bypass culverts.

■ Item Number Fourteen

WSP must ensure the defences at Leckwith Quay and the flood compensation area at Ely Paper Mill are included within the model.

All defence information in the provided models remain within the WSP model and this information has only been updated with on site topographical survey data. The representation of the Paper Mills defences and compensation area are as set out in its accompanying report and as per those provided the model. Therefore, we consider that the results of the model are suitable for the purposes of this study.

■ Item Number Fifteen

The modeller must ensure any files which previously incorporated data from the old LiDAR are updated using the latest LiDAR, for example, 2d_zln_7005- 3561_Lek_ELY_Defences_007_P.MIF.

It is not clear which values in this data set or *all* of the other data sets are from old LiDAR and which are from topographical land and channel surveys (data not supplied NRW but which would supersede new LiDAR where present). We would suggest that whilst small features in proximity to the site may have a negligible effect on the model results, updating the whole of the Cardiff model is far outside the scope agreed and what is reasonable for this study. If NRW can explicitly identify which information in proximity to the reach of interest is obsolete LiDAR and which is not then this is something which future modelling can look to update (excepting where it may be superseded by later topo surveys). Given that this change from old to newer LiDAR are expected to have an effectively negligible effect on the overall results we consider that the conclusions of this project to date remain valid.

■ Item Number Sixteen

The implementation of the current survey data for the site must be reviewed and updated.

It is recognised that there are gaps in the available topographical coverage, in these places it is more accurate to have 'holes' relying on the underlying LiDAR than to presume the ground surface. The identified section cuts through the lower road, up into a higher 'display area' noted on the topo provided and back down towards the road. Given the transition from the available 2D/3D topo points (see provided data in submission), to a 3D surface as read into a grid with a 4m or 8m cell size a perfect representation of the site does not result; however, it is more accurate than the underlying LiDAR. Therefore, we consider that the findings of the model remain valid. If NRW consider that LiDAR would instead be preferable to the available topo we would be happy to revert to this in any future modelling.

■ Item Number Seventeen

The representation of buildings in the model must be updated.

These improvements can be made to the final set of model simulations representing the final scheme; however, given the limited onsite flooding in the extreme event this will have a negligible effect on the results and the findings of the overall model remain valid.

In the wider model the applied roughness values for buildings are as inherited from the licenced models to ensure consistency. This value can be increased to 0.7 in any future models if NRW consider that it is more important to be compliant with their current position on building roughness values than it is to be consistent with the previous model build / findings. Again, we consider that the value provided in the NRW licenced models is suitable for a strategic model of this nature and hence the findings of this project remain valid.

■ Item Number Eighteen

The representation of the proposed scheme (both Manning's n and topography) must be updated in the model to ensure it is representative of the proposed scheme.

Noting that the proposed surface performed suitably when read in the original 8 m cell size and that according to the design team the footbridge towards the southern end of the site is no longer included, we concur that these improvements should be made to any future set of model simulations. However, given the limited amount of onsite flooding in the extreme event and the limited change noted in the reach of interest and in the wider area from the move to the refined model we consider that this will have a negligible effect on the results and the overall findings of the model remain valid.

■ Item Number Nineteen

The undefended, blockage and sensitivity versions of the model must be run in the final version of the model.

Undefended, blockage and sensitivity models were simulated. It is noted in the FCA that the refined baseline model only showed minor changes to the results and hence we consider that the previous findings of these models are adequate to understand the hydraulic regime to a level suitable to support the purpose of the FCA. The project team wholly accepts that a full set of simulations (inc. undefended, blockage and sensitivity) will need to be included once the detailed design of the bridge etc is resolved.

■ Item Number Nineteen-A

NRW also note that the file 2d_zln_7005-3561_Lek_ELY_Defences_007_P.MIF doesn't appear to be applied in the undefended version of the model. NRW advise this is reviewed by the modeller to ensure that the only change between the defended and undefended versions of the model is the removal of the required defences. undefended, blockage and sensitivity versions of the model must be run in the final version of the model.

NRW will additionally note that this representation is inherited from the provided model. Therefore, we consider that the representation is suitable for this project.

■ Item Number Twenty

Blockage must be applied for the full duration of the model run.

We consider that the representation of the blockage is suitable and the overall findings of the model remain valid. The application of the blockage after the baseflow is more realistic and reduces the number of restart and initial condition files required and hence is generally preferable. However as previously identified the project accepts that a full set of simulations (inc. undefended, blockage and sensitivity) will need to be included once the detailed design of the bridge is resolved. If this is a matter on which NRW insist on 'for simplicity' then this representation of the blockage can be undertaken for any future modelling.

Additionally, we would like NRW to clarify whether in their opinion, recommending additional events (i.e. 1000yr blockage) over and above those agreed to in the DAS is reasonable. We would suggest that we have undertaken the scenario and event configurations agreed and as such do not intend to undertake additional scenario/event combinations at this stage.

■ Item Number Twenty-One

A full suite of final model files must be provided which must include a full set of results and log files, the file name must be clear and use return period.

We suggest we have supplied sufficient information regarding results and log files, with supporting information in the FCA, comparative to that supplied by NRW. We advise that a difference in naming convention does not open the findings of the results to challenge. The project team accepts that additional information will be submitted once the bridge design proposals are progressed further. If the naming convention is something on which NRW insist upon Morris/Q1000 nomenclature can be switched, it is patently not something which has any effect on the results or outcomes.

■ Item Number Twenty-One-A

A review of the messages has been undertaken for the baseline version of the model. These messages must be reviewed, and the model updated to ensure that it is operating as the modeller intended. Justification should be provided for any remaining unresolved messages.

Messages have been reviewed throughout the model build process, although improvements have been made many are inherited from the licenced models. These have been checked and are found to be acceptable on balance. Justification can be provided for any remaining unresolved messages as part of any future modelling.

■ Item Number Twenty-Two

NRW does not consider the current modelling to be suitable to support the FCA. The current model has limitations that mean it is currently not suitable to inform NRW on any changes to flood risk at the site or any potential third-party impacts. Until the model has been updated to address the recommendations raised within this review the model results cannot be used to support the FCA.

We suggest that the purpose of the FCA and model may have been misunderstood whilst reviewing a subset of the provided data. The FCA and modelling in their entirety provides a wide scale understanding of the hydraulic system, its interaction to and from the proposed strategic development in line with the agreements in the DAS and identifies a potential solution worth pursuing. This understanding is both logical and consistent and whilst the findings set out in NRW's review identify a couple of points whereby the precision of the findings may be subject to minor-negligible revision, the overall conclusions remain sound namely:

- There is an existing choke point in the river at the historic bridge.
- The proposals in their original form locally increase water levels.
- The ground level of the proposal needs to be raised to be compliant with TAN15, but this is a practicable quantum.
- The proposed bridge structure would benefit from a wider aperture to prevent introducing an additional flow constriction upstream of the historic bridge.
- The inclusion of bypass culverts which relieve the choke point in the river has the potential to solve the problem of increased water levels resulting from the proposals subject to further design.

The NRW model review discusses a *full* understanding of the *detailed* bridge design and *full* understanding of the implications of the model as not being available and not being definable to a satisfactory level of confidence to NRW. The project team fully accepts this is a consequence of the stage the design has reached. We suggest that this full understanding is something which will be required as the design is finalised and is a suitable condition at this juncture. We thank NRW for undertaking a review of the modelling undertaken to date and request the additional clarification on the relevant points noted above. We trust that WSP's additional clarification on the above points and the holistic purpose of the hydraulic model is useful to NRW.