Llanmaes Flood Alleviation Scheme Flood Consequence Assessment Addendum Technical Note

18 February 2022

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Quality information

Prepared by	Checked by	Verified by	Approved by
Ralph Collard Flood Risk Engineer	Richard Moore Senior Consultant	Rob Sweet Associate	Athan Tzovaras Principal Engineer

Revision History

Revision	Revision date	Details	Authorized	Name	Position
P01	18 Feb 22	Final	AT	Athan Tzovaras	PM

Prepared for:

Vale of Glamorgan Council

Prepared by:

Ralph Collard
Flood Risk Engineer
T: 0117 901 7000
M: 07990074095
E: ralph.collard@Aecom.com

AECOM Limited
3rd Floor, Portwall Place
Portwall Lane
Bristol BS1 6NA
United Kingdom

T: +44 117 901 7000
aecom.com

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1. Introduction

AECOM have undertaken detailed hydraulic modelling since 2017 to support the submission of a Flood Consequence Assessment (FCA) for the Llanmaes Flood Alleviation Scheme planning application (2021/01082/RG3). Natural Resources Wales (NRW) have reviewed the Baseline and Proposed Option hydraulic model throughout the scheme development on four occasions with the latest being completed in November 2021[1].

This Technical Note has been produced following two meetings with NRW on the 19/01/2022 (Appendix A1) and 09/02/2022 (Appendix A2) to agree the evidence base required to address the comments raised in the November 2021 hydraulic model review. A detailed response to the specific requirements raised in the NRW model review is found in Appendix B. This document forms an addendum to the FCA and provides a response to each of the modelling comments provided by NRW alongside any required actions.

This Technical Note, which should be read in conjunction with the Llanmaes Flood Alleviation Scheme FCA[2] and Hydraulic Modelling Report[3], contains the following:

- Summary of the model updates in response to the November 2021 NRW review;
- Baseline Results following updates;
- Proposed Option Results following updates;
- New Sensitivity Analysis; and
- Conclusions.

2. Model Updates

The Baseline and Proposed Option hydraulic models have been updated in response to the comments raised by NRW (November 2021). The aim of these changes is to make the hydraulic model assessment more robust and improve the accuracy of the results. Additional sensitivity testing beyond that presented within the FCA has been undertaken on the flows from Boverton Brook and antecedent conditions at Frampton Ponds at the upstream extent of Llanmaes Brook, as requested by NRW.

The full details of the AECOM response to NRW comments can be found in Appendix B and a detailed summary of the hydraulic modelling files updated for this submission is provided in Appendix C and within a separately supplied Model Log. It is noted that for model review items where no action has been taken, justification is provided in the AECOM response (Appendix B) and not explicitly discussed in this report for brevity.

It was agreed with NRW at the meeting on 19/01/2022 (Appendix A1) that a subset of the design events and scenarios presented in the FCA could be used to fulfil the planning requirements of TAN15 following the model updates. Table 2-1 shows the scenarios and design events undertaken for the additional modelling presented in this Technical Note. It is noted that the 1.33% AEP event was simulated for the sensitivity simulations at the request of NRW as this is the standard of protection of the Boverton Brook Flood Alleviation Scheme and is considered to provide a suitable assessment of the downstream impacts of the Llanmaes Flood Alleviation Scheme.

[1] Natural Resources Wales November 2021, Llanmaes Flood Alleviation Scheme, Rev No. 1.0
[2] Vale of Glamorgan 2022, Llanmaes Flood Alleviation Scheme Flood Consequence Assessment, AECOM Bristol
[3] Vale of Glamorgan 2022, FCA Appendix C Llanmaes Flood Alleviation Scheme Hydraulic Modelling Report, AECOM Bristol

Table 2-1: Design Events and Scenarios Agreed With NRW

Scenario	Scenario	Design Event (% AEP)
Design Event	Baseline	1.33%, 1%, 1% + 30%CC, 0.1%
Design Event	Proposed	1.33%, 1%, 1% + 30%CC, 0.1%
Sensitivity - Boverton Brook Inflows	Baseline & Proposed	1.33%
Sensitivity- Frampton Ponds (50% Capacity)	Baseline & Proposed	1.33%
Sensitivity - Frampton Ponds (100% Capacity)	Baseline & Proposed	1.33%

2.1 Baseline Model Set Up

The Baseline model set up remains predominately the same as documented within Section 3 of the Hydraulic Modelling Report which accompanies the FCA. Minor improvements were made to the model in response to NRW comments (Appendix B) with full details of the GIS layers that have been updated and a description of the changes made found in Appendix C.

Table 2-2 summarises the model updates have been made to the Baseline hydraulic model in response to the NRW model review (November 2021) and references the model review or meeting agenda item that has been addressed.

Table 2-2: Baseline Model Updates

Model update Made	Model Review Item Addressed
Combined the ECF and TCF into a single control file to improve file management	Appendix B – Item 3
Updated the bc_database to include the 1.33% AEP (1 in 75yr) rainfall event	Appendix A1
Removed incorrect parameters in reporting lines (po lines)	Appendix B – Item 7
Updated culvert losses	Appendix B – Item 11
Removed cross section A6 near Frogland's Farm	Appendix B – Item 11
Adjusted the code and 2d_bc boundary layer at the south west corner of the catchment	Appendix B – Item 13
Improved the 1D-2D connection of the watercourse at the Llanmaes Village Green	Appendix B – Item 9, Item 14

Table 2-3 show the changes to the TUFLOW control files since the NRW review (November 2021).

Table 2-3: Baseline TUFLOW Control File Update

Scenario	Control File	NRW Reviewed Model (Dec 2021)	Baseline Update (Feb 2022)
Baseline	TCF	LlanFAS_BL_~s1~_~e1~_070.tcf	LlanFAS_BL_~s1~_~e1~_074
	ECF	LlanFAS_BL_~s1~_~e1~_070.ecf	
	TGC	LlanFAS_BL_2m_070.tgc	LlanFAS_BL_2m_074.tgc
	TBC	LlanFAS_070.tbc	LlanFAS_BL_072.tbc

During the November 2021 review NRW raised concerns that the surveyed culvert BOV_02_0042 was not present within the hydraulic model (Item 20 Appendix B). A review was undertaken of the September 2013 Boverton Brook survey[4] and it was found that there is a discrepancy between the naming convention used in the survey and that used in the hydraulic model. The surveyed culvert BOV_02_0042 is correctly represented within the model under the reference BOVE_0043C1 & BOVE_0043C2.

The Baseline and Proposed Option models have a rainfall boundary that only covers the Llanames Brook catchment meaning that there are no hydraulic inflows modelled on Boverton Brook. This is primarily to reduce the model simulation times to manageable levels. In the November 2021 hydraulic model review, NRW raised concerns that this does not accurately represent the flows at the Boverton Brook Railway Culvert and hence the flood risk to Boverton.

All of the Proposed Option design events presented in the FCA are shown to reduce flows on Llanmaes Brook post scheme. It was therefore agreed at the meeting with NRW 19/01/2022 (Appendix A1) that to assess the downstream flood risk to Boverton, the sensitivity simulation (as described in Section 7.4 of the FCA), which increases the rainfall boundary to include the Boverton Brook catchment, was an acceptable method of assessment (Appendix A1). A sensitivity simulation for the 1.33% AEP event was agreed (Appendix A1) and the results from this simulation are presented in Section 3.3 of this Technical Note. The Baseline and Proposed models therefore remain without model flows included on Boverton Brook and the rainfall boundary covers only the Llanmaes Brook catchment (Item 18, Appendix B).

It is considered that these changes discussed above are relatively minor adjustments to the model set up. Section 4 demonstrates that the Baseline model results remain commensurate with those presented in the FCA and do not alter the conclusions presented.

2.2 Proposed Option Model Set Up

The Proposed Option model set up remains predominately the same as documented within Section 5 of the Hydraulic Modelling Report which accompanies the FCA. The model updates include those which were made to the Baseline model (Table 2-2) and have been carried forward to the Proposed Option model alongside those which are specific to the Proposed Option model.

Table 2-4 summarises the model updates that have been made to the Proposed Option hydraulic model in response to the NRW model review (November 2021) and references the model review or meeting agenda item that has been addressed. It is noted that these are specific to the Proposed Option design and were not required for the Baseline model.

Table 2-4: Proposed Option Model Updates

Model update Made	Model Review Item Addressed
Improve Village Green channel representation	Appendix B – Item 17
Include roughness 0.033 for proposed design ditches	Appendix B – Item 10

[4] Storm Geomatics September 2013, Llantwit Major & Boverton Brook Survey, Ref: 2013s7420

Topography of the Village Green and channel representation was reviewed against the design and updated to ensure a consistent gradient. It is noted that the review highlights potential poor representation of the topography at the Village Green, specifically identifying a swale on the left bank of the watercourse (Item 21, Appendix B). This swale was stamped into the topographic layer to ensure that it was providing a sufficient gradient from the road to the watercourse (2d_zsh_LlanFAS_DD_Design_Patch_067). The irregular representation is caused by the orientation and size of the grid however this simplified representation is considered to sufficiently represent the design accurately and does not require updating. This was discussed and agreed during the meeting on 19/01/2022.

Table 2-5 show the changes to the TUFLOW control files since the NRW review (November 2021).

Table 2-5: Proposed Option TUFLOW Control File Update

Scenario	Control File	NRW Reviewed Model	Model Updated
Proposed Option	TCF	LlanFAS_DD_~s1~_~e1~_071.tcf	LlanFAS_DD_~s1~_~e1~_075
	ECF	LlanFAS_DD_~s1~_~e1~_071.ecf	
	TGC	LlanFAS_DD_2m_071.tgc	LlanFAS_DD_2m_075
	TBC	LlanFAS_DD_071.tbc	LlanFAS_DD_073

Section 4 demonstrates that the Proposed Option model results remain commensurate with those presented in the FCA and do not alter the conclusions presented.

2.3 Sensitivity Simulation Model Set Up

It was agreed with NRW at the meeting on the 19/01/22 (Appendix A1) that based upon the preliminary results presented at the meeting, the sensitivity simulations within the FCA were not required to be re-simulated completely. To improve the assessment of the downstream impacts of the proposed scheme, sensitivity simulations to include the Boverton Brook inflows and antecedent conditions at Frampton Ponds were undertaken (as discussed below). Full details of the GIS layers that have been updated and a description of the changes made can be found in Appendix C.

2.3.1 Boverton Brook

The hydraulic model updates for the Baseline and Proposed models described in this report were incorporated into the sensitivity models and the rainfall boundary was extended to include the entire Boverton Brook catchment (Appendix C). The Baseline and Proposed Option models were simulated for the 1.33% AEP design event to be commensurate with the design standard of protection of the Boverton Flood Alleviation Scheme. The methodology is consistent with that described within Section 7.4 of the Hydraulic Modelling Report accompanying the FCA.

2.3.2 Frampton Ponds

To assess the impact of antecedent catchment conditions it was agreed with NRW on the 19/01/22 (Appendix A1) that a sensitivity simulation would be undertaken applying a starting capacity of 50% and 100% to the flood storage area at Frampton Ponds (approximate NGR 297274, 169656).

A GIS analysis of the volume stored within Frampton Ponds was undertaken using the modelled spillway elevation (55.65m AOD) as the maximum capacity of the flood storage area. This provided a flood storage of approximately 10,000m^3 at 100% capacity. Initial water levels were set to 55.65m AOD (100% capacity) and 55.10m AOD (50% capacity) at the beginning of the design event. Figure 2-1 shows the location of the initial water levels applied at Frampton Ponds for the sensitivity simulation.

The sensitivity analysis was undertaken on both the Baseline and Proposed Option models and simulated for the 1.33% AEP event to assess the downstream impacts of the scheme at Llanames and Boverton.

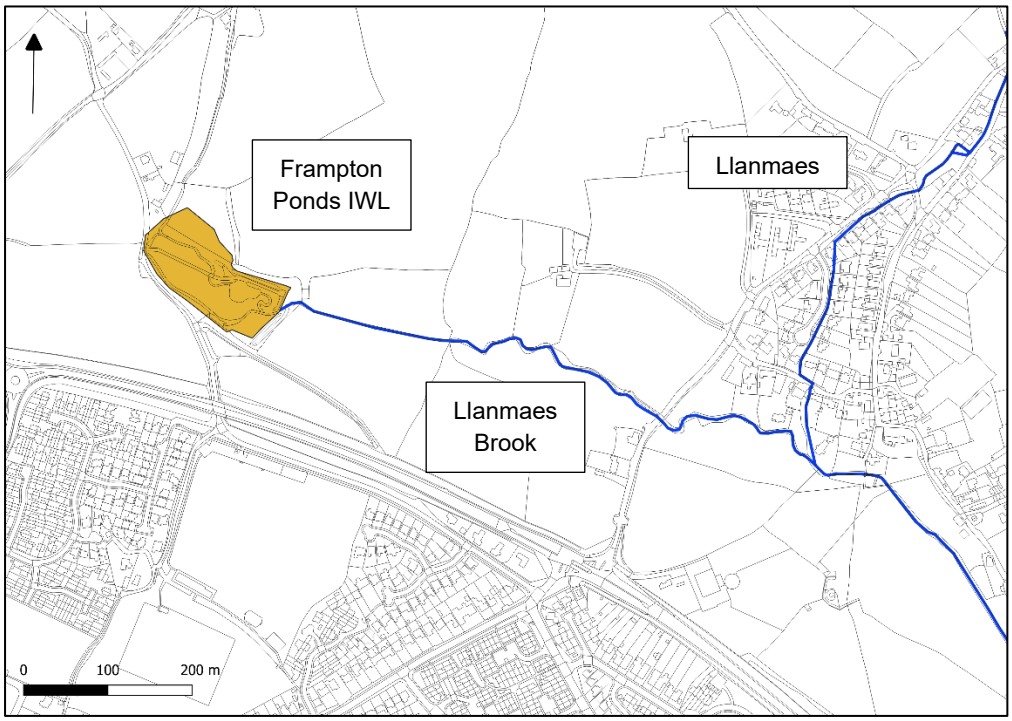


Figure 2-1: Frampton Ponds Initial Water Levels

2.4 Checks and Warnings

A review of checks and warnings for all re-simulated models was undertaken. Table 2-6 documents the checks and warnings that are not covered by Table 7-5 of the Hydraulic Modelling Report which accompanies the FCA.

Table 2-6: Checks/Warnings

Message Code	Message	Comment/Likely Impact Upon Results
WARNING 1313	No inlet culvert connected to Manhole "XXX". Manhole not used/applied.	No manhole is required at this location because it is where two independent pipes through the bunds are located and different invert levels
CHECK 1402	More than one culvert connected but could not create manhole at Node "XX"	No manhole is required at this location because it is where two independent pipes through the bunds are located and different invert levels
CHECK 2108	2D HX link applied more than once at cell.	Review of the check locations show that these are caused by the model grid cell size predominately where spills have been modelled in the 2D. The water level at these locations will be consistent with the bank HX line and therefore will not have a significant impact on the model results

It is noted that 'CHECK 1402' & 'WARNING 1313' are located at the outfall culverts to each of the flood storage bunds. Whilst these culverts are schematised in the same location, the upper culverts are intended as flood relief culverts with invert levels at a higher elevation. These checks and warnings relate to the creation of manholes to account for losses at junctions between 1D network lines. These culverts are not intended to be connected and therefore the creation of manholes is not required.

2.5 Model Health

The cumulative mass balance of all the simulated design hydraulic models remains within the accepted +/- 1% tolerance and is consistent with those reported within the Hydraulic Modelling Report that accompanies the FCA. It is noted that the cumulative mass balance of the Boverton Brook sensitivity simulations (Baseline and Proposed Option) exceeds the +1% tolerance after approximately 2.5hrs of simulation time to a maximum of c.2.3%. The source of this mass balance error is located on the neighbouring Nant-y-Stepsau watercourse to the east of

Boverton Brook and occurs after the peak of the event. It is therefore not considered to impact the conclusions of the model results.

The presence of 1D and 2D negative depths within the hydraulic model results for the Baseline, Proposed Option and Sensitivity Simulations is consistent with that described in the Hydraulic Modelling Report. These are present for a short period of time, in isolated areas and are not considered to significantly impact the conclusions of the model results.

Table 2-7 shows the number of 1D and 2D classic negative depths for each of the simulations in this Technical Note. 1D negative depths are present at the Boverton Brook Railway culvert however they appear for a short period of time at approximately 30 minutes into the model simulation. They do not impact the peak of the event and therefore are not considered to impact the hydraulic model results significantly.

It is noted that the number of 2D negative depths increases for the Boverton Brook sensitivity simulation compared to the design simulations. This is because there are a number 2D negative depths that occur on the adjacent Nant-y-Stepsau watercourse to the east of Boverton Brook which is included in the model boundary. These do not impact the results in the Boverton Brook catchment.

Table 2-7: Classic 1D and 2D Negative Depths

Scenario		1.33% AEP Negative Depths	1% AEP Negative Depths	1% AEP + 30%CC Negative Depths	0.1% AEP Negative Depths
Design Event	Baseline	1D = 28 2D = 1	1D = 18 2D = 0	1D = 18 2D = 1	1D = 14 2D = 0
	Proposed Option	1D = 26 2D = 2	1D = 24 2D = 0	1D = 32 2D = 1	1D = 19 2D = 1
Sensitivity Boverton Brook	Baseline	1D = 13 2D = 31			
	Proposed Option	1D = 15 2D = 18			
Sensitivity – Frampton Ponds 50%	Baseline	1D = 24 2D = 1			
	Proposed Option	1D = 21 2D = 1			
Sensitivity – Frampton Ponds100%	Baseline	1D = 25 2D = 1			
	Proposed Option	1D = 33 2D = 2			

3. Model Results

3.1 Comparison to FCA Results

Following the hydraulic model updates described in Section 2 the updated Baseline and Proposed Option hydraulic models were simulated for the 1.33%, 1%, 1% + 30% CC and 0.1% AEP events (as agreed with NRW). The updated model results were compared to those reviewed by NRW (November 2021) and presented within the FCA report to understand if the model updates result in any material change to the conclusions.

Figure 3-1 and Figure 3-2 show the 1% AEP + 30% Climate Change event maximum flood depth difference plot comparing the updated Proposed Option model results to those reviewed by NRW at Llanmaes and Boverton respectively. Within Llanmaes (Figure 3-1) there are minor reductions in maximum flood depths within the proposed ditches of between -0.01m to -0.10m due to the change in manning's roughness values and also within Llanmaes Village Green where there have been alterations to the 1D cross section profiles. At Boverton (Figure 3-2) there are minor changes to the maximum flood depths around the railway line due to the reduction in the 2d_bc layer but results are materially the same.

The results are similar for both the 1% AEP and 0.1% AEP events when compared to the previous November 2021 reviewed results (Appendix D). A comparison cannot be undertaken with the 1.33% AEP event because this was not simulated previously.

It can be concluded from these results that the Baseline and Proposed Option hydraulic modelling results have not materially changed from those presented within the FCA as a consequence of the model updates described in this report. Therefore the conclusions and outcomes presented within the FCA remain valid.

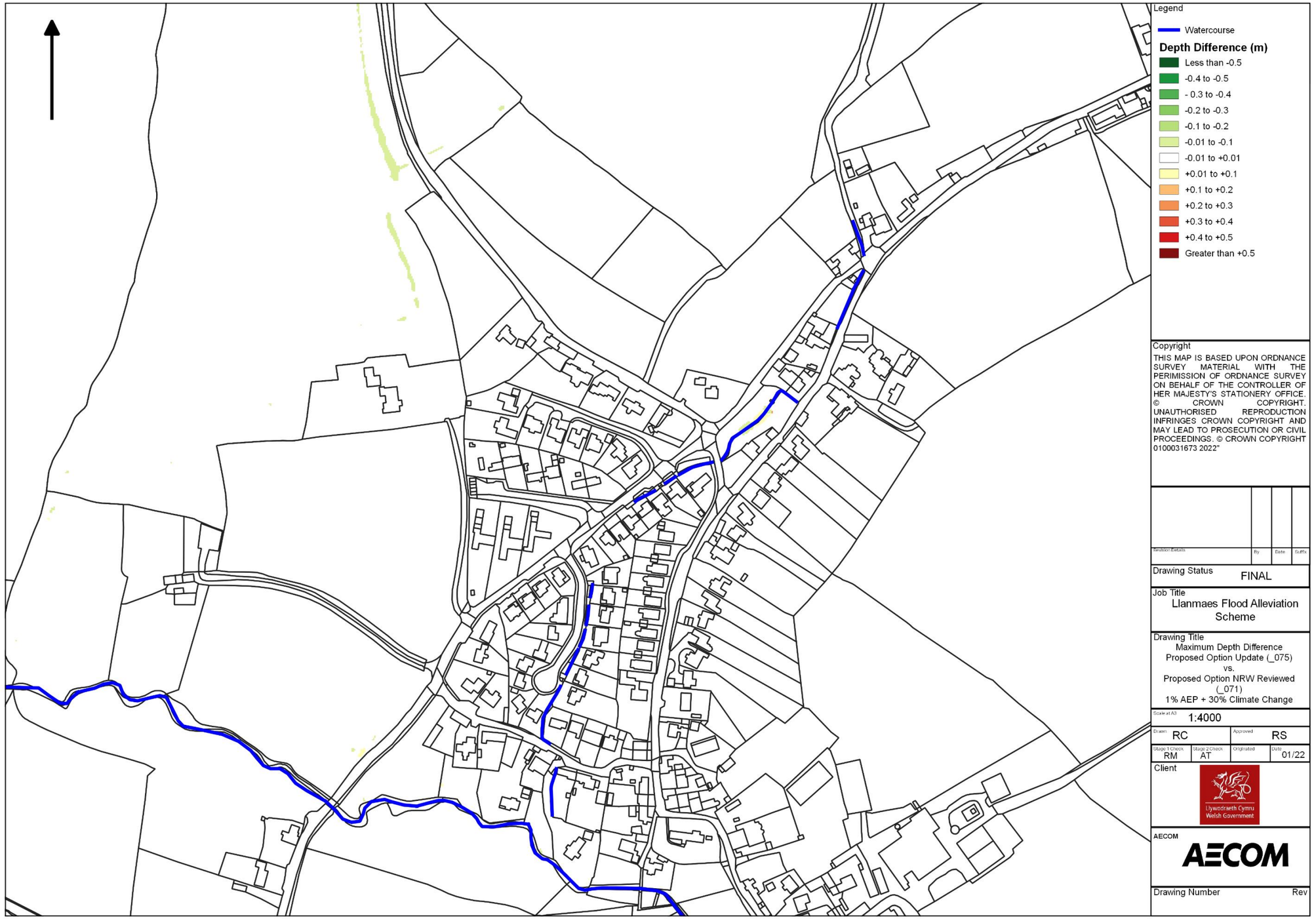


Figure 3-1: Maximum Depth Difference Plot, Llanmaes, 1% + 30%CC, Updated Proposed Option vs NRW Reviewed Proposed Option

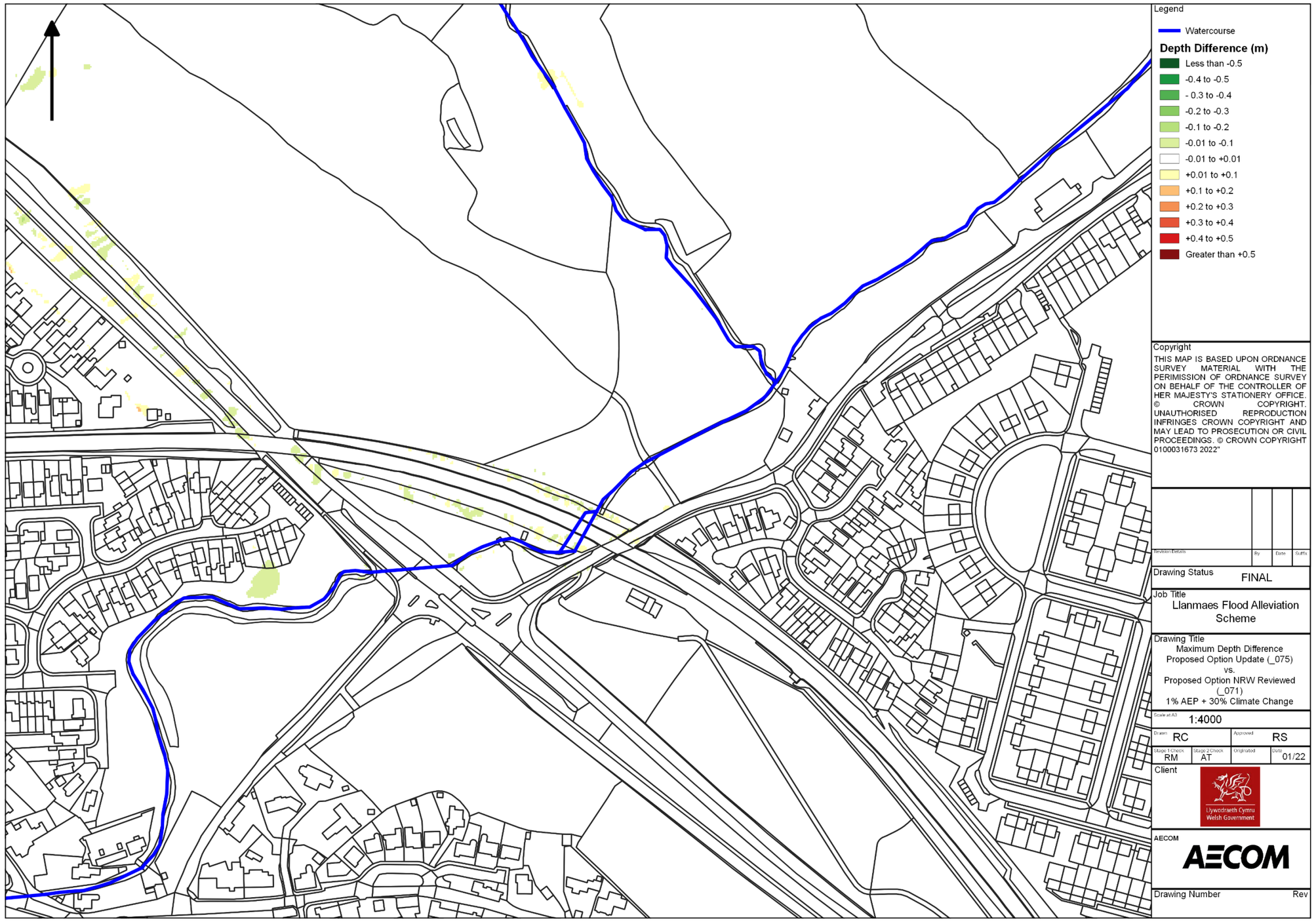


Figure 3-2: Maximum Depth Difference Plot, Boverton, 1% + 30%CC, Updated Proposed Option vs NRW Reviewed Proposed Option

3.2 Proposed Option Results

It is not considered necessary to describe the hydraulic model results again in this report as they are consistent with those presented within the FCA. For completeness the maximum depths maps and maximum depth difference plots for the re-simulated results are presented in Appendix E and Appendix F. Table 3-1 shows a comparison of the peak flows at the Boverton Brook Railway Culvert for the Baseline and Proposed Option. This location contains all flows passing into Boverton and therefore provides a proxy to assess the downstream impacts in Boverton of the Llanmaes Flood Alleviation scheme. Table 3-1 demonstrates that there is a reduction in peak flows downstream of the proposed scheme across all of the design events.

Table 3-1: Peak Flow Comparison at Boverton Brook Railway Culvert (Node Bov_042b)

AEP (%)	Baseline	Proposed Option	Difference
1.33%	4.0m^3/s	3.5m^3/s	-0.4m^3/s
1%	4.8m^3/s	3.9m^3/s	-0.9m^3/s
1% + 30% CC	8.4m^3/s	7.0m^3/s	-1.4m^3/s
0.1%	10.9m^3/s	10.6m^3/s	-0.3m^3/s

3.3 Sensitivity Results

3.3.1 Boverton Brook

The Boverton Brook sensitivity was re-simulated for the 1.33% AEP event with the updates made to the Baseline and Proposed Option models described in Section 2 of this report.

Figure 3-3 shows a comparison of the Baseline and Proposed Option flow hydrographs downstream of the Boverton Brook Railway Culvert and Figure 3-4 shows the maximum flood depths difference map between the Baseline and Proposed Option. Figure 3-3 shows that the peak flow is reduced from 6.7m^3/s (pink) to 6.2m^3/s (green) in the Proposed Option leading to an overall reduction in maximum flood depths of -0.01m to -0.10m at the Boverton Brook Culvert (Figure 3-4). This demonstrates that there is no detrimental impact downstream of the proposed scheme and remains consistent with the conclusions of the results presented within the FCA.

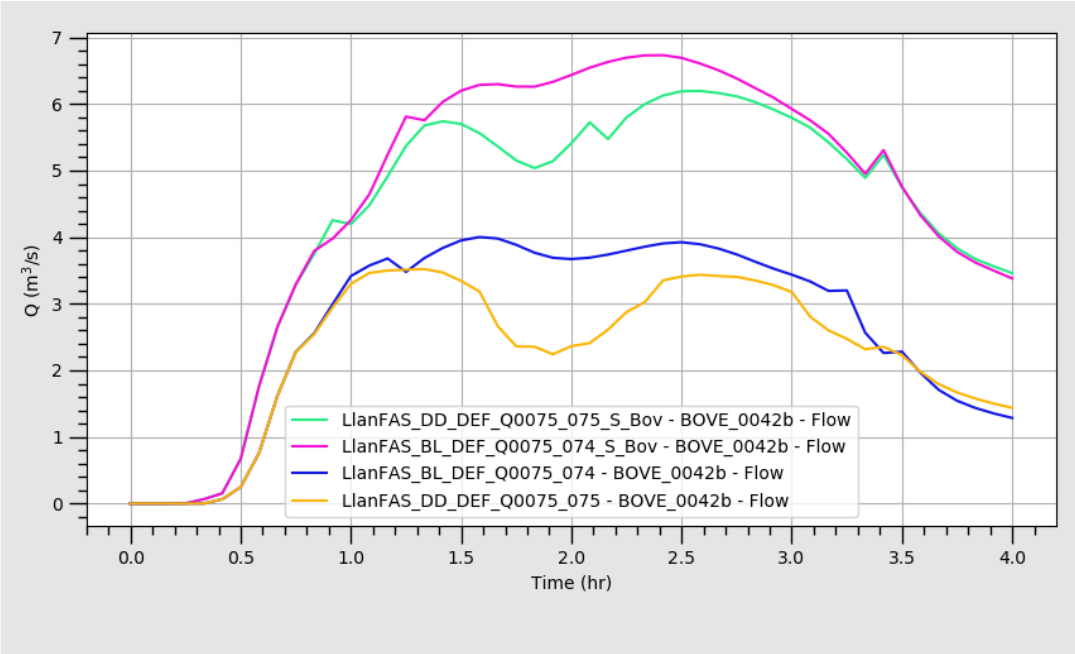


Figure 3-3: Boverton Brook Sensitivity Flow Comparison Downstream of Boverton Brook Railway Culvert ,1.33% AEP, (Node Bov_042b)

3.3.2 Frampton Ponds Antecedent Conditions

The Frampton Ponds sensitivity was simulated for the Baseline and Proposed scenario with a starting capacity set to 50% and 100% for the 1.33% AEP event to assess both the impact at Llanmaes and Boverton.

Hydraulic model results show that intuitively the peak flows on Llanmaes Brook increase for both the Baseline and Proposed Option scenarios as a greater volume of water enters Llanmaes Brook. However, when comparing the Baseline and Proposed Option results for the 50% and 100% capacity scenarios there remains an overall reduction in peak flows downstream of Llanmaes (Table 3-2). This, alongside the sensitivity of catchment percentage runoff presented within the FCA, builds confidence that the scheme remains robust under different antecedent catchment conditions.

Table 3-2: Frampton Ponds Sensitivity - Comparison of Peak Flows at Boverton Brook Railway Culvert (Node Bov_042b), 1.33% AEP

AEP (%)	Design Event (No capacity)	50% Capacity Frampton Ponds	100% Capacity Frampton Ponds
Baseline	4.0m^3/s	5.3m^3/s	6.1m^3/s
Proposed Option	3.5m^3/s	4.2m^3/s	5.4m^3/s

The maximum depth difference plot for Llanames, comparing the Baseline and Proposed Option for the 50% and 100% capacity sensitivity simulations, are shown in Figure 3-5 and Figure 3-6 respectively. There remains an overall reduction in maximum flood depths through Llanmaes with the areas of increased maximum flood depths on Llanames Brook remaining consistent with the results in the design event (Appendix F5). This demonstrates that the proposed scheme functions well under different antecedent conditions and the conclusions of the FCA are still valid.

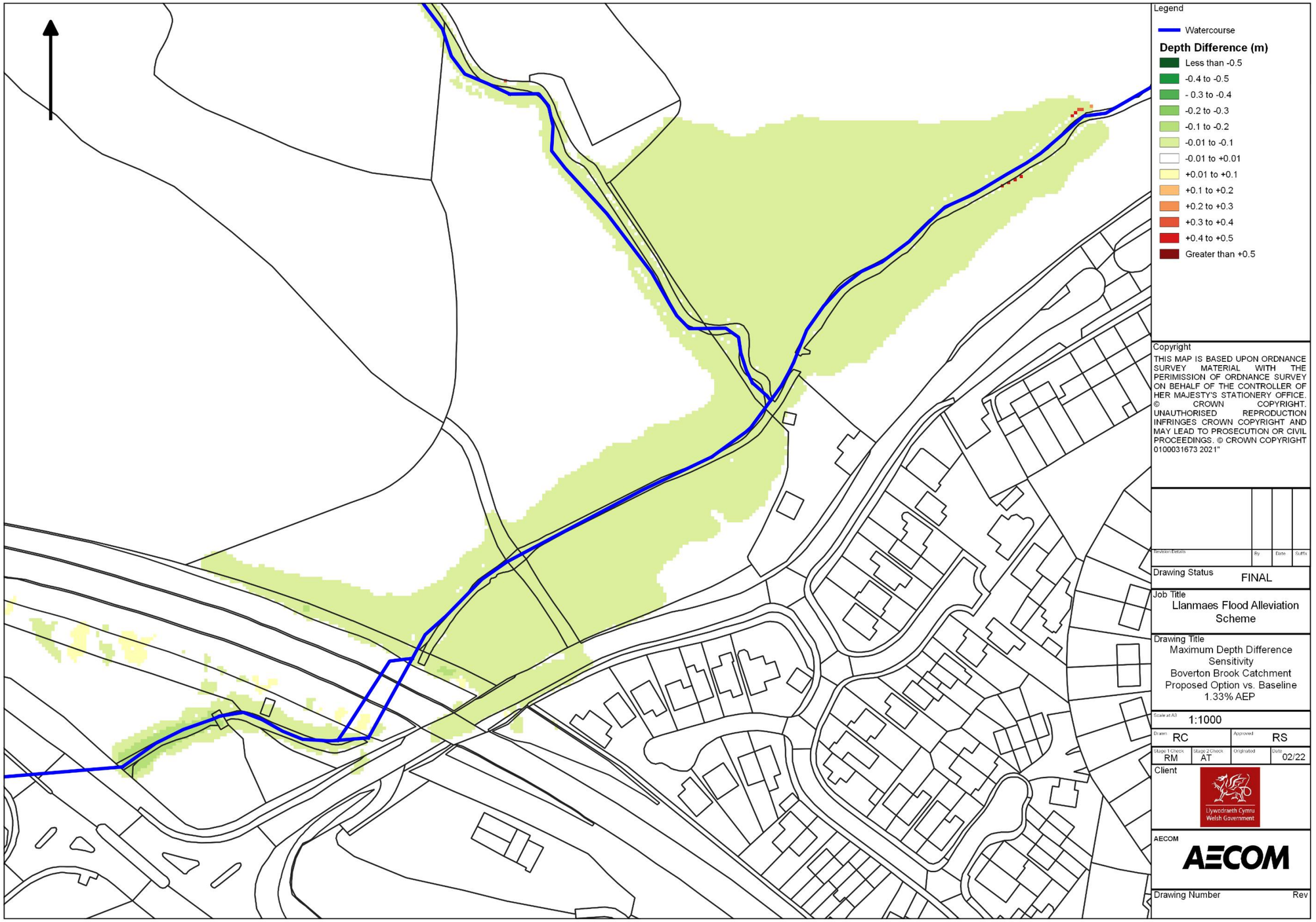


Figure 3-4: Maximum Depth Difference - Boverton Brook Sensitivity, 1.33% AEP

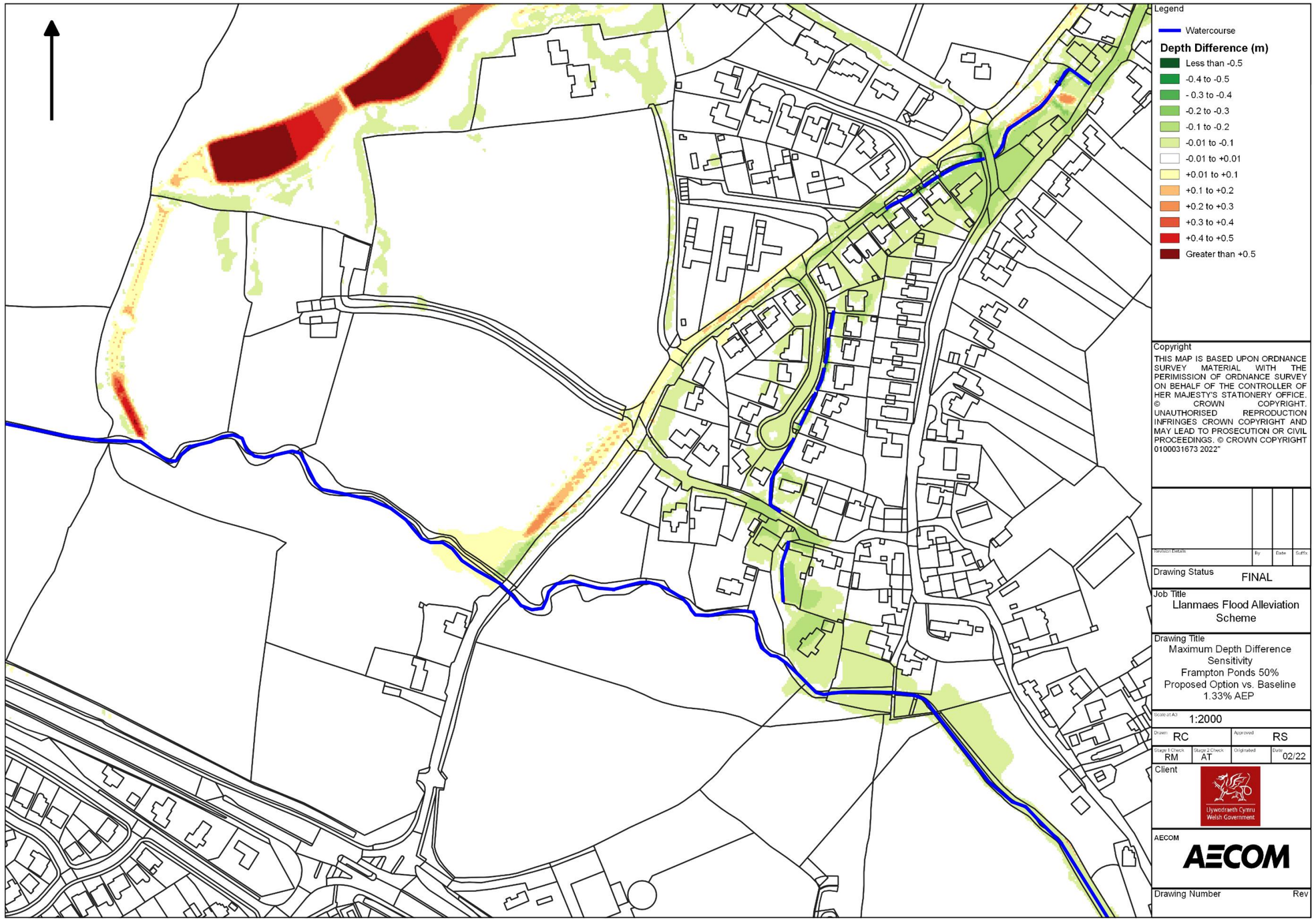


Figure 3-5: Maximum Depth Difference – Frampton Ponds Sensitivity, 50% Capacity, 1.33% AEP

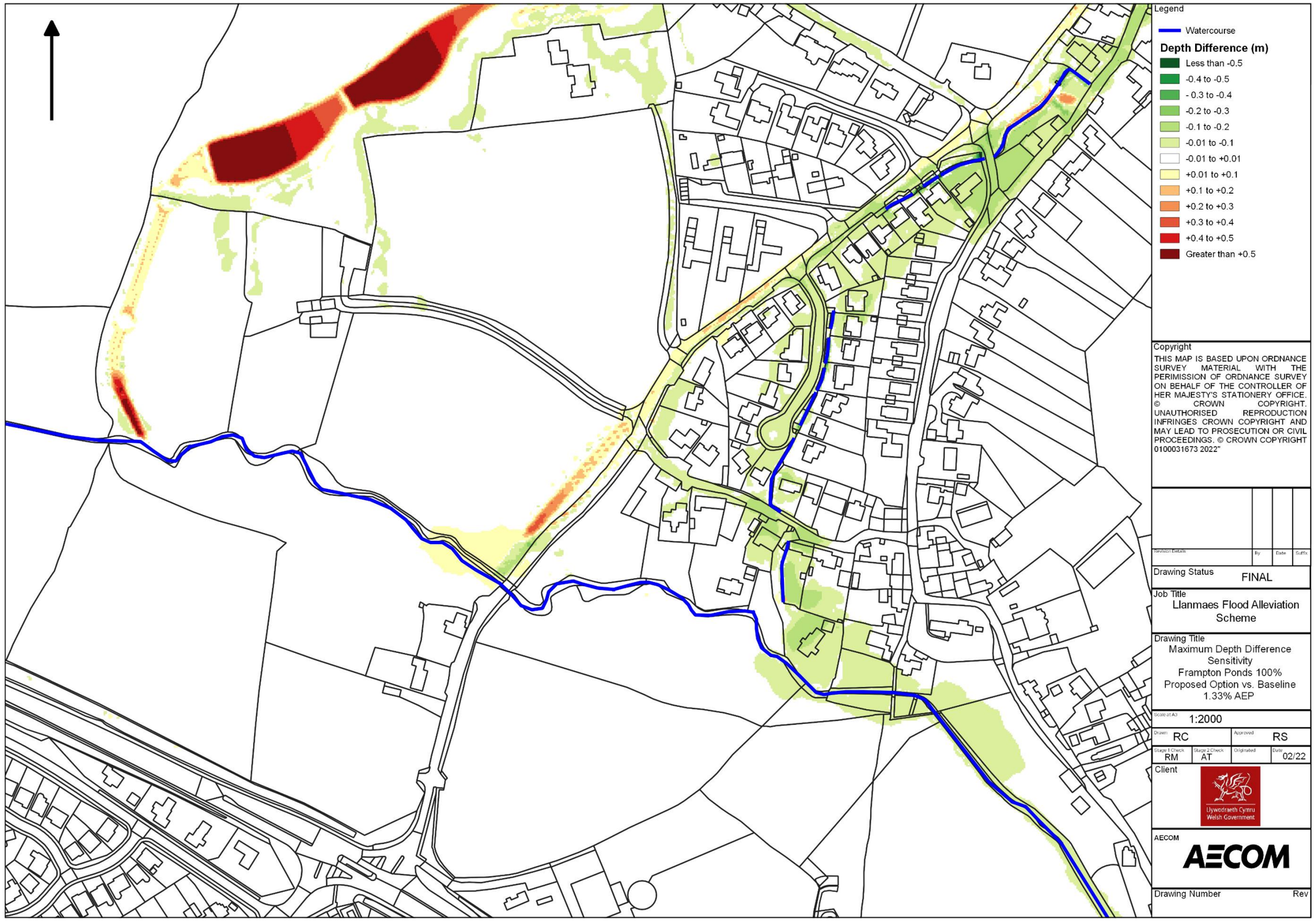


Figure 3-6: Maximum Depth Difference – Frampton Ponds Sensitivity, 100% Capacity, 1.33% AEP

4. Conclusions

This Technical Note has been produced to document the additional hydraulic modelling undertaken to support the Llanmaes Flood Alleviation Scheme planning application following NRW's review of the Baseline, Proposed Option and Sensitivity models in November 2021. The methodology set out in this technical note was agreed during consultation with NRW on two occasions (Appendix A1 and A2) to address their concerns with the hydraulic model assessment and ensure the conclusions are robust.

The Baseline and Proposed Option models were updated and simulated for the 1.33%, 1%, 1% + 30%CC and 0.1% AEP events. The hydraulic model results have been shown to be commensurate with those presented within the FCA with no material change to the conclusions.

The two additional sensitivity simulations that were suggested by NRW for Boverton Brook and Frampton Ponds were simulated for the 1.33% AEP using the updated Baseline and Proposed Option models as a foundation. Both these sensitivity simulations show that the scheme does not have a detrimental flood risk impact downstream.

It can be concluded that the hydraulic model updates undertaken for this Technical Note do not change the conclusions presented within the FCA and therefore the assessment remains valid.

Appendix A – NRW Meeting Minutes

A.1 NRW Meeting 19/01/2022

Minutes

Meeting name
Llanmaes Flood Alleviation

Meeting date
19/01/2022

Location
Microsoft Teams

Project number
60160078

Subject
NRW- Flood Model Review Meeting

Time
12:00

Project name
Llanmaes FAS

Attendees
Clive Moon (CM)- VoGC Project Manager
Huw Morgans (HM)- VoGC Deputy Project Manager
Annabelle Evans (AE)- Development Planning Advisor at NRW
Barry Cox (BC)- NRW FCA Lead
Filippo Scimone (FS) -NRW Flood Risk Analysis Modelling Specialist advisor
Athan Tzovaras (ATz)- AECOM Project Manager
Ralph Collard (RC) - AECOM Lead Modeller
Mark Davin (MD)- AECOM Technical Lead

Ref	Description of meeting notes	Action By
1.	ATz and CM introduce the scheme and current position it is. Currently at planning stage. Planning committee due on the 26/01/22. Tenders received for review and the aim is to start works on site in March 2022.	
2.	BC – Not reviewed the FCA yet because NRW are not happy with the model, FRAP have been submitted where outfalls into Llanmaes Brook but further review can be triggered until the hydraulic modelling is signed off by NRW Flood Risk Analysis Team	
1.	FS – Involved in the NAR, main concern that we do not increase hydraulically anything on Boverton Brook. NRW would like to be able have confidence that the results are proving the above and can confidently input to the FCA.	
2.	RC – Requested clarity on the concerns raised in the model review about the representation of the culverts for the scheme, particularly at Bund 1. FS - confirmed that the Checks and Warnings had not been sufficiently documented and therefore concerned that the representation may be incorrect. Ideally, they would be removed but if not should be documented correctly with justification on why these remain and have no impact to model results. RC - has reviewed the culverts through the bunds and believes that they are functioning correctly. This will be clearly documented and justified in the next submission. **ACTION –** AECOM to fully document checks and warnings in subsequent submission.	RC/MD
3.	RC – discussion of the representation of Boverton Brook in the model and previous correspondence with Richard Wicks in Jan 2019. FS highlighted concerns with the channel running dry and not correctly representing flows in to Boverton. The model must stand	

	up to scrutiny and therefore it is likely that this will be questioned should that come to pass. RC – Asked for NRW for a pragmatic approach and to simulate for a reduced number of simulations. NRW agreed that this could be simulated as a sensitivity and agreed that the 1.33% AEP (1 in 75yr) event was appropriate to demonstrate that the flows on Boverton Brook have been considered. **ACTION** – AECOM to simulate Baseline and Proposed with the Boverton Brook catchment included to the 1.33% AEP event (1 in 75yr). Results will be documented in a Technical Note	RC/MD
4.	RC – discussion of the representation of the Village Green. FS concern was making sure the modelled representation is as accurate as possible. RC has amended the incorrect cross sections and is confident it now is correctly representing the scheme at the Village Green. **ACTION** – AECOM to document changes made to the Village Green	RC/MD
5.	RC – Highlighted that the Amber comments have been considered and will be documented in the next submission. RC states that these changes have a relatively minor impact on the overall results and due to the large number of simulations AECOM request that only a select number of design events are simulated. FS and BC agreed that 75yr, 100yr, 100yrCC and 1000yr would be sufficient demonstrate the current and existing flood risk at planning. This could be presented in a technical note as an addendum to the FCA rather than re-writing the entire FCA . **ACTION** – AECOM to update the model with NRW comments and simulate for the 75yr, 100yr, 100yrCC and 1000yr events. Results will be documented in a Technical Note	RC/MD
6.	RC – A final sensitivity was raised for Frampton Ponds. The current model begins with this empty and RC accepts that a sensitivity to assess the impact of the capacity of the pond would be sensible. BC and FS state that the Baseline and Proposed model could be simulated for the 75yr event with a half full and completely full starting capacity. The results will be documented in the Technical Note. **ACTION** – Simulate 75yr sensitivity for the Frampton Ponds with a half full and completely full scenario. Both Baseline and Proposed will be simulated. Results will be documented in a Technical Note	RC/MD
7.	FS – Raised concern about the incorrect specification of the boundary layer and code layer at the SW extent of the Llanmaes Catchment. RC stated that the model has been adjusted in this area and further documentation will be provided to demonstrate this does not impact the model results in this area.	
8.	Together with the above agreed model simulations, it was agreed that all the results and responses to be combined in the Technical note, supplementary to the issued Flood model / flood model report and FCA.	AECOM- NRW For Info
9.	Timescales. CM enquired on potential timescales as this review will impact the forecasted starting date of the construction, as the resolve of NRW comments will be part of the pre-commencement condition on the planning applications	

10.	Timescales NRW: Technical Note review – NRW Flood Risk Analysis Team - 1 week FCA review-BC- 1 week Preparing Planning Response to VoGC- AE- 3 days (minimum) Forecasted timescale – approx. 2.5 weeks AECOM : Forecasted timescale to issue technical note – approx. 4weeks. Agreed to look and arrange a meeting first week of Feb, to expediate any question that may come out at the next submission it would be sensible to have a pre-submission meeting. **ACTION** – AECOM to arrange a pre-meeting with NRW prior to submission of the model and Technical Note.	All ATz

A.2 NRW Meeting 09/02/2022

Minutes

Meeting name
Llanmaes Flood Alleviation

Meeting date
09/02/2022

Location
Microsoft Teams

Project number
60160078

Subject
NRW- Flood Model Review Meeting

Time
12:30

Project name
Llanmaes FAS

Attendees
Clive Moon (CM)- VoGC Project Manager
Huw Morgans (HM)- VoGC Deputy Project Manager
Annabelle Evans (AE)- Development Planning Advisor at NRW
Barry Cox (BC)- NRW FCA Lead
Filippo Scimone (FS) -NRW Flood Risk Analysis Modelling Specialist advisor
Athan Tzovaras (ATz)- AECOM Project Manager
Ralph Collard (RC) - AECOM Lead Modeller

Ref	Description of meeting notes (January 18 2022)	Meeting Notes (February 09 2022)
1.	ATz and CM introduce the scheme and current position it is. Currently at planning stage. Planning committee due on the 26/01/22. Tenders received for review and the aim is to start works on site in March 2022.	
2.	BC – Not reviewed the FCA yet because NRW are not happy with the model, FRAP have been submitted where outfalls into Llanmaes Brook but further review can be triggered until the hydraulic modelling is signed off by NRW Flood Risk Analysis Team	
1.	FS – Involved in the NAR, main concern that we do not increase hydraulically anything on Boverton Brook. NRW would like to be able have confidence that the results are proving the above and can confidently input to the FCA.	
2.	RC – Requested clarity on the concerns raised in the model review about the representation of the culverts for the scheme, particularly at Bund 1. FS - confirmed that the Checks and Warnings had not been sufficiently documented and therefore concerned that the representation may be incorrect. Ideally, they would be removed but if not	

	should be documented correctly with justification on why these remain and have no impact to model results. RC - has reviewed the culverts through the bunds and believes that they are functioning correctly. This will be clearly documented and justified in the next submission. **ACTION –** AECOM to fully document checks and warnings in subsequent submission.	RC presented tables within the model log that record the checks and warnings from the latest model simulations. This will be presented in the Technical Note.
3.	RC – discussion of the representation of Boverton Brook in the model and previous correspondence with Richard Wicks in Jan 2019. FS highlighted concerns with the channel running dry and not correctly representing flows in to Boverton. The model must stand up to scrutiny and therefore it is likely that this will be questioned should that come to pass. RC – Asked for NRW for a pragmatic approach and to simulate for a reduced number of simulations. NRW agreed that this could be simulated as a sensitivity and agreed that the 1.33% AEP (1 in 75yr) event was appropriate to demonstrate that the flows on Boverton Brook have been considered. **ACTION** – AECOM to simulate Baseline and Proposed with the Boverton Brook catchment included to the 1.33% AEP event (1 in 75yr). Results will be documented in a Technical Note	RC presented the hydraulic model results for the Boverton Brook Sensitivity simulation. Hydrographs show that there remains a reduction in peak flows downstream of Boverton Brook Railway culvert and is consistent with the reporting in the FCA.
4.	RC – discussion of the representation of the Village Green. FS concern was making sure the modelled representation is as accurate as possible. RC has amended the incorrect cross sections and is confident it now is correctly representing the scheme at the Village Green. **ACTION** – AECOM to document changes made to the Village Green	RC presented the changes made to the Village Green cross sections to demonstrate a consistent profile and constant gradient. FS happy that this appears to have addressed NRW concerns but will be reviewed at submission.
5.	RC – Highlighted that the Amber comments have been considered and will be documented in the next submission. RC states that these changes have a relatively minor impact on the overall results and due to the large number of simulations AECOM request that only a select number of design events are simulated. FS and BC	RC presented comparison of the latest model results compared to those previously reviewed by NRW (Nov 2021). These show minimal difference with the previous results and therefore the results presented in the FCA remain valid. RC stated that rather than re-describe all of the results in the Technical Note this will be used to demonstrate that the results presented in the

	agreed that 75yr, 100yr, 100yrCC and 1000yr would be sufficient demonstrate the current and existing flood risk at planning. This could be presented in a technical note as an addendum to the FCA rather than re-writing the entire FCA . **ACTION** – AECOM to update the model with NRW comments and simulate for the 75yr, 100yr, 100yrCC and 1000yr events. Results will be documented in a Technical Note	FCA remains valid. FS agreed that this was a sensible approach. BC highlighted that whilst all results did not need to be presented in the body of the Technical Note they should be included in an Addendices
6.	RC – A final sensitivity was raised for Frampton Ponds. The current model begins with this empty and RC accepts that a sensitivity to assess the impact of the capacity of the pond would be sensible. BC and FS state that the Baseline and Proposed model could be simulated for the 75yr event with a half full and completely full starting capacity. The results will be documented in the Technical Note. **ACTION** – Simulate 75yr sensitivity for the Frampton Ponds with a half full and completely full scenario. Both Baseline and Proposed will be simulated. Results will be documented in a Technical Note	RC described the methodology for undertaking the antecedent conditions at Frampton Ponds sensitivity. The channel begins dry as per the design events. Results were presented and show that there is minimal downstream impact. FS agreed this methodology was sensible and requested that results are presented at the Boverton Brook Railway Culvert.
7.	FS – Raised concern about the incorrect specification of the boundary layer and code layer at the SW extent of the Llanmaes Catchment. RC stated that the model has been adjusted in this area and further documentation will be provided to demonstrate this does not impact the model results in this area.	
8.	Together with the above agreed model simulations, it was agreed that all the results and responses to be combined in the Technical note, supplementary to the issued Flood model / flood model report and FCA.	RC presented a draft template for the Technical Note and described what was required. FS and BC agree that the presentation in the FCA did not need updating as they are reassured that the results indicate the previous reviewed results remain valid.
9.	Timescales. CM enquired on potential timescales as this review will impact the forecasted starting date of the construction, as the resolve of NRW comments will be part of the pre-commencement condition on the planning applications	

10.	Timescales NRW: Technical Note review – NRW Flood Risk Analysis Team - 1 week FCA review-BC- 1 week Preparing Planning Response to VoGC-AE- 3 days (minimum) Forecasted timescale – approx. 2.5 weeks AECOM : Forecasted timescale to issue technical note – approx. 4weeks. Agreed to look and arrange a meeting first week of Feb, to expediate any question that may come out at the next submission it would be sensible to have a pre-submission meeting. **ACTION** – AECOM to arrange a pre-meeting with NRW prior to submission of the model and Technical Note.	

Appendix B – Hydraulic Model Review Response

Comments Register

Project Information	Project: Llanmaes Flood Alleviation Scheme			
Title / Project Number	Llanmaes FAS			
AECOM Project Manager	Athan Tzovaras			
Client	Vale of Glamorgan County Council			

Modelling Comments	Item Checked	NRW Comments	AECOM Response	AECOM Action
Model	1	For future reviews supply only the final model files, removing redundant/superseded files.	Agreed only the final model files will be supplied	Remove superseded files from submission
Model	2	File naming not consistent, apply consistent file naming convention within the model and follow recommendation within TUFLOW Manual.	Acknowledged. Results files were provided in a different format to allow ease of review of check and results files. Future submissions will ensure that the log files are located in the standard TUFLOW structure so model files can be loaded in correctly.	Provide all files in standard TUFLOW folder structure
Model	3	Consider reducing the number of control files by the use of “IF…ELSE statement” and fully use of event scenario variables.	Acknowledged. The control files have been retained from the approach of the received model. To reduce the number of control files the TCF and ECF will be combined.	Combine ECF and TCF to reduce the number of control files
Model	4	Consider combining similar GIS Layers that have the same function and hence reducing the number of GIS layers e.g. stability layers.	Acknowledged. Where possible GIS layers have been retained from the received model to make clear where features have been updated or modified. It is agreed that improvements could be made in the number of layers but this could be resolved by better commentary and recording of the GIS layers within the model log. Combining GIS layers at this stage may lead to further confusion in the model layers and so will not be undertaken.	Commentary in model control files updated and list of updated files provided
Model	5	Consider reducing the model size, to help aid model QA.	It is acknowledged that a reduction in the model size would be beneficial however, the hydraulic model performs well with good stability. Changing the model size may introduce model stability issues and therefore will not be undertake at this stage. The model domain size may be reduced to improve the size of the results and check files to aid the QA process.	Reduce the 2D domain size to within the limits of the coded area.
Model	6	Consider providing additional information on the derivation of the storm duration and hyetographs.	This is provided within the model report.	No Action

Model	7	Consider updating attributes within the PO GIS layer to remove “QV” attribute, as this does not appear to be outputting any additional results within the 2d po results file.	Acknowledged. This will be updated for future model simulations.	Update PO line attribute data to remove "QV" attribute
Model	8	Consider the use of latest TUFLOW HPC/GPU modelling version to improve run times and reduce the grid resolution to 1 meter.	The grid cell resolution has been discussed following previous reviews (January 2019). The 2m grid resolution provides suitable detail to assess the flood risk to and from the scheme whilst maintaining manageable simulation run times and therefore no changes will be made to the model grid resolution.	No action
Model	9	When removing bridges ensure that HX lines are also amended e.g. bridge removed at Village Green.	The 1D-2D linking has been reviewed at the Village Green within the Baseline scenario. It was found that the HX linking was not applied correctly. To improve the representation the cross section L_FAS_009 was removed and the 1d-2d linked reach goes from L_FAS_008 to L_FAS_010_Rev1. This was considered representative because the channel cross sections US and DS of the bridge are effectively the same.	Improved the 1D-2D linking at the Village Green in the Baseline model
Model	10	Manning’s values have not been altered for the new proposed ditches and storage ponds. The modeller must consider whether these values are still appropriate and document reasoning.	The Proposed Option ditches were assigned a manning's value of 0.04 (Natural Surface) as similar to the surrounding fields. It is agreed that the ditch is likely to be maintained and potentially have less resistance than the surrounding fields therefore a manning's value of 0.033 was chosen. The storage areas remain part of the open fields and therefore it was not considered appropriate to alter the manning's value upstream of the bunds.	Updated Manning's values of proposed ditches in the Proposed Option model
Model	11	Confirm entry and exit losses are as intended for all culverts and are all populated with appropriate values.	Entry and exit losses have been reviewed and updated within the limits of the model that will impact the results. The 1d_nwke_UNKN_050 is downstream of the B4265 and will not impact the results of this study.	Entry/Exit losses updated from FRC_EAST_01.
Model	12	Ensure GIS building layers are consistent for all scenario runs.	Acknowledged. Buildings layer will be consistent across all model simulations	Update buildings layer to be consistent for all model simulations.
Model	13	Review and update 2d_bc_LlanFAS_040, currently the boundary layer extends inside of the 2d code layer.	The 2d_bc boundary is located along the west side of the B4265 which forms the western boundary of the Llanmaes Brook rainfall catchment. No rain falling on the west side of the B4265 will flow into the Llanmaes Brook catchment and therefore this will not affect the model outcomes. To ensure clarity the code layer will be reduced to match the 2d_bc boundary	Reduce code layer along the B4265 to match the 2d_bc layer
Model	14	Review and update 2d_zln_LLANFAS_Banks_042 to remove or connect zpts.	Dangling zpts have been reviewed with the Baseline and Proposed Option model. These will be removed where found.	Dangling zpts have been removed from the Baseline and Proposed Option model
Model	15	Review 2d negative depths and document justification impact these have in the model if any.	Documentation of 2D negative depths will be provided within the Technical Note. It is noted that a small number of 2D negative depths are isolated at the western extent of the NAR present for an short period of time in the model simulation. This is likely caused by the steep change in topography due to the NAR cutting. Given the small number of 2d negative depths and location upstream of Boverton Brook and west of Llanmaes Village these will not impact model results.	Add detail of 2D negative depths to the Technical Note.
Model	16	Review 1d negative depths for sensitivity run “S_50pcPRfor”, document justification what impact these have in the model if any.	1D negative depths are located in two locations within the hydraulic model. The first is within Llanmaes Village (L_FAS_038.2) and the second at the downstream extent of the model on Boverton Brook (BOVE_0042a). The reasons for the 1d negative depths in Llanmaes is explained within the modelling report. The area is at a location of steep change in channel slope combined with the entrance to a culvert beneath South Road. Improvements were made to the model to address this and are documented in the model report. It is acknowledged that for the 50%PR Sensitivity simulation the number of negative depths is larger than other simulations and will be discussed in the model report.	Updated model report to include discussion of 1d negative depths for the 50%PR sensitivity simulation
Model	17	Review the topography applied at the Village Green and the proposed cross sections applied at this location as this may impact storage and flood mechanism at this location.	The cross section data for the proposed design was provided by the design team and reflects the specific topography of the Village Green and watercourse channel. Elevations of the bed appear to have been incorrectly specified and therefore will be updated accordingly. The reviewer has highlighted the schematisation of the Village Green topography to be poorly represented. The design includes a swale on both the left and right bank of the watercourse to improve conveyance from the highway to the watercourse. This was provided within the design asc (20201027_west_rd_and_ditch_trim) however due to the grid resolution and orientation a topo patch had to be included to ensure that the flow path was consistent along both swales (2d_zsh_LlanFAS_DD_Design_Patch_067). This is an approximation because of the grid resolution but it is considered that this provides suitable representation of the design as intended.	Review and update topography of the watercourse at the Village Green and update where required by the design

Model	18	Review and update model 1d inflows, Boverton Brook does not have a 1d inflow and therefore is currently running dry, this is incorrect must be amended.	It is acknowledged that the current set up does not include flows on Boverton Brook and this is explained within the modelling report. To address this details were sent to Richard Wicks in Jan 2019 to explain the reasoning for this. To recap the assessment has shown that the flows on Llanmaes Brook are reduced due to the Llanmaes FAS scheme using the pluvial modelling of Llanmaes Brook. A sensitivity assessment has been carried out to extend the rainfall catchment to include all of Boverton Brook to the B4265 and simulated for a range of events. This is different to the approach taken in the previous explanation to Richard Wicks which added a 1d inflow for Boverton Brook and only extended the rainfall catchment to south of Boverton Brook. The reason for this is to remove the uncertainty between the fluvial and pluvial inflows inherent between the NAR model and the current Llanmaes FAS model. These simulation take c. 25hrs to complete and therefore it was not deemed practical to undertaken these for all baseline, detailed design, blockage and sensitivity simulations. Agreed with NRW at meeting 19/01/2022 that only 1.33% AEP event required to be simulated. It was also agreed that a sensitivity simulation on the antecedent conditions at Frampton Ponds would be undertaken.	1.33% AEP Boverton Brook sensitivity simulated and recorded within the Technical Note. 50% capacity and 100% capacity of Frampton Pond Sensitivity undertaken for 1.33% AEP event.
Model	19	For the FAS ensure all culverts are applied and operating correctly, especially for Bund1.	Both the primary and overflow culverts from each of the FAS bunds are read into the model correctly however it is acknowledged that the checks and warnings have not been adequately addressed in the modelling report. These are not considered to impact the functioning of the bunds as intended and flow is conveyed through the culverts at the appropriate design level.	Updated the model report addressing checks and warnings for the FAS culverts

Additional Comments Extracted From November 2021 Report

Model	20	The modeller must document the reasoning why BOVE_02_0042 being omitted and review the missing attributes for the entry and exit losses of all culverts ensure these are populated.	A review of this culvert found that there is a discrepancy in the naming of the modelled structure and that of the 2013 surveyed structure. BOVE_02_0042 is included in the model as BOVE_02_0042C1 & BOVE_02_0042C2	No action
Model	21	We note that the topography changes for the proposed scheme are now imported as “ERSI II asc” text files. These appear to have been imported correctly into the model to amend the topography. As this data is created externally to the hydraulic model it is not therefore possible to review if the data is correct prior to importing in the hydraulic model. However, we do note that an area in the Village Green may not have been correctly created and this is highlighted in Figure 6, this area will require reviewing and amended as necessary	Topography of the Village Green and channel representation was reviewed against the design and updated to ensure a consistent gradient. It is noted that the review highlights potential poor representation of the topography at the Village Green, specifically identifying a swale on the left bank of the watercourse (Item 21, Appendix B). This swale was stamped into the topographic layer to ensure that it was providing a sufficient gradient from the road to the watercourse (2d_zsh_LlanFAS_DD_Design_Patch_067). The irregular representation is caused by the orientation and size of the grid however this simplified representation is considered to sufficiently represent the design accurately and does not require updating. This was discussed and agreed during the meeting on 19/01/2022.	Text added to the Technical Note
Model	22	The files have previously been reviewed with the exception of 1d_cs_LLANFAS_035. Two additional bridges have been added within this layer and one bridge HW reference has been re-named. In addition, all bridge structures have been updated from B type structure to BB type structures, with the exception of two bridges which are located downstream of the study area (1d_nwke_AFON_050). This review focuses on the model upstream of the B4265. As stated within the previous review, there is little need to the model to extend downstream of the B4265, it would aid in QA if the model was cut down, however, this will have no impact on the results. NRW previous review recommended that “T” was assigned to the UCS attribute and “0” is assigned to “n_or_n_F”. It is noted that this has been adopted across the majority of the features, however this has not been applied consistently across all the layers used within the model. It is noted that following the previous review form loss has been updated to 0.001, where required, with the exception of BOVE_0033BW, which has a form loss of 0.01. This structure is located downstream of the B4265; therefore, it is unlikely to affect the results within Llanmaes."	It is agreed that structures outside of the Boverton Brook catchment will not impact the conclusions of the hydraulic modelling. No updates have been made to these structures.	No action
Model	23	It is noted that fields relating to culvert losses have been updated however, in some cases a further review is needed for example, entry and exit losses have not been applied to the culverts within 1d_nwke_UNKN_050.	This culvert is located on a tributary of Boverton Brook downstream of the area of interest. This does not impact the model results and therefore will not be updated.	No action

Appendix C – Detailed Model File Updates

Baseline Model

	NRW Reviewed Model (Nov 2021)	AECOM February 2022 Updates	Comment
TCF	LlanFAS_BL_~s1~_~e1~_070.tcf LlanFAS_BL_~s1~_~e1~_070.ecf	LlanFAS_BL_~s1~_~e1~_074.tcf	Combined ECF into TCF + updated control files + 1D domain
	LlanFAS_BL_2m_070.tgc	LlanFAS_BL_2m_074.tgc	Updated GIS files (see below)
	LlanFAS_070.tbc	LlanFAS_BL_072.tbc	Added BL suffix for clarity + updated GIS files
	bc_dbase_LlanFAS_001	bc_dbase_LlanFAS_074	Updated the rainfall profiles (LlanFAS_60min_074_0,3RC.csv) to include the 75yr event
	StA_Com_60min_002_0,3RC.csv	LlanFAS_60min_074_0,3RC.csv	Added the 1.33% AEP rainfall event
	2d_po_LlanFAS_070	2d_po_LlanFAS_BL_072	Added BL suffix for clarity and removed erroneous parameters
	1D Domain		
	1d_nwke_BOV_EXT_FLOOD_RELIEF_033	1d_nwke_BOV_EXT_FLOOD_RELIEF_072	Updated losses for culvert FRC_EAST_01
	1d_nwke_LLANFAS_042	1d_nwke_LLANFAS_072	Removed reach L_FAS_009 to homogenise channel
	1d_xs_LLANFAS_Drainage_Ditches_040	1d_xs_LLANFAS_Drainage_Ditches_072	Removed cross section A6 from near Frogland's Farm
	1d_xs_LLANFAS_042	1d_xs_LLANFAS_072	Updated representation at the Village Green. Removed Cross Section L_FAS_009.csv as cross section US and DS are essentially the same so not required and avoids unnecessary HX connection issues
	1d_WLL_LLANFAS_035	1d_WLL_LLANFAS_072	Extended WLL lines at the Village Green where channel updates have been made
TGC	Grid Size = 5800,4700	Grid Size = 5800,4500	Reduced domain size to improve simulation time
	2d_code_LlanFAS_039	2d_code_LlanFAS_072	Adjusted code boundary in SW corner of Llanmaes Brook catchment to follow railway line
	2d_code_LlanFAS_Channel_035	2d_code_LlanFAS_Channel_072	Adjusted code layer to match new HX connection
	2d_zln_LLANFAS_Banks_042	2d_zln_LLANFAS_Banks_072	Removed disconnected zpts. Removed Village Green Bridge and connected 2d_zln along Village Green
	2d_zsh_LlanFAS_Ditch_Bank_040	2d_zsh_LlanFAS_BL_Ditch_Bank_074	Removed dangling zpts
	2d_zsh_StA_Com_Frog_Flowpath_022	2d_zsh_LlanFAS_BL_Frog_Flowpath_074	Removes dangling zpt maintains same elevation
TBC	2d_bc_LlanFAS_039	2d_bc_LlanFAS_072	Truncated SW boundary to match to code layer
	2d_rf_LlanFAS_039	2d_rf_LlanFAS_072	Moved RF boundary in line with the Code change at SW corner of Llanmaes catchment
	2d_hxi_LlanFAS_035	2d_hxi_LlanFAS_072	Extend HX connection to remove bridge at Village Green (near XS L_FAS_010)

Proposed Option Model

	NRW Reviewed Model (Nov 2021)	AECOM February 2022 Updates	Comment
TCF	LlanFAS_DD_~s1~_~e1~_071.tcf		
	LlanFAS_DD_~s1~_~e1~_071.ecf	LlanFAS_DD_~s1~_~e1~_075.tcf	Combined ECF into TCF + updated control files + 1D domain
	LlanFAS_DD_2m_071.tgc	LlanFAS_DD_2m_075.tgc	Updated GIS files (see below)
	LlanFAS_DD_071.tbc	LlanFAS_DD_073.tbc	Updated GIS files (see below)
	bc_dbase_LlanFAS_001	bc_dbase_LlanFAS_074	**Same as Baseline Model Update**
	StA_Com_60min_002_0,3RC.csv	LlanFAS_60min_074_0,3RC.csv	**Same as Baseline Model Update**
	2d_po_LlanFAS_070	2d_po_LlanFAS_BL_072	**Same as Baseline Model Update**
	2d_po_LlanFAS_065	2d_po_LlanFAS_DD_073	Added DD suffix for clarity no change to the GIS layer parameters
	BOV_020.tmf	LlanFAS_DD_073.tmf	Added material ID 1 with Mannings Roughness of 0.033 for representation of the design ditches
	1D Domain		
	1d_nwke_BOV_EXT_FLOOD_RELIEF_033	1d_nwke_BOV_EXT_FLOOD_RELIEF_072	**Same as Baseline Model Update**
	1d_nwke_LLANFAS_DD_057	No changes made to 1d_nwke_DD from previous submission	N/A
	1d_nwke_LLANFAS_DD_USStorage_Drainage_068	1d_nwke_LLANFAS_DD_USStorage_Drainage_073	Updated losses for culvert Di1_Agr_04
	1d_xs_LLANFAS_Drainage_Ditches_040	1d_xs_LLANFAS_Drainage_Ditches_072	**Same as Baseline Model Update**
	1d_xs_LLANFAS_DD_057	1d_xs_LLANFAS_DD_073	Updated Bed Elevations of L_FAS_DD_10a, 10b, 10c and 10d to ensure constant gradient
	1d_WLL_LLANFAS_DD_058	No changes made to WLL layer from previous submission	N/A
TGC	Grid Size = 5800,4700	Grid Size = 5800,4500	**Same as Baseline Model Update**
	2d_code_LlanFAS_039	2d_code_LlanFAS_072	**Same as Baseline Model Update**
	2d_code_LlanFAS_Channel_035	2d_code_LlanFAS_Channel_072	**Same as Baseline Model Update**
	2d_zln_LLANFAS_DD_Banks_048	2d_zln_LLANFAS_DD_Banks_073	Removed disconnected zpts
	2d_zsh_LlanFAS_Ditch_Bank_040	2d_zsh_LlanFAS_BL_Ditch_Bank_074	**Same as Baseline Model Update**
	2d_zsh_StA_Com_Frog_Flowpath_022	2d_zsh_LlanFAS_BL_Frog_Flowpath_074	**Same as Baseline Model Update**
	2d_zsh_LLANFAS_DD_Kerb_063	2d_zsh_LLANFAS_DD_Kerb_075	Removed dangling zpt
	None present	2d_mat_LLANFAS_DD_Ditches_073	Material layer for design ditches to set Manning's value to 0.033
TBC	2d_bc_LlanFAS_039	2d_bc_LlanFAS_072	**Same as Baseline Model Update**
	2d_rf_LlanFAS_039	2d_rf_LlanFAS_072	**Same as Baseline Model Update**
	2d_hxi_LlanFAS_DD_057	No changes made to 2d_hxi layer from previous submission	N/A

Boverton Brook Sensitivity Simulation Baseline

Baseline model LlanFAS_BL_~s1~_~e1~_074.tcf carried forward for simulation. All changes documented in the Baseline Model Updates have been applied here. Only the specific changes for the sensitivity simulation have been included within the table.

	NRW Reviewed Model (Dec 2021)	AECOM Feburary 2022 Updates	Comment
TCF	LlanFAS_BL_~s1~_~e1~_060_S_Bov.tcf LlanFAS_BL_~s1~_~e1~_060_S_Bov.ecf	LlanFAS_BL_~s1~_~e1~_074_S_Bov	Combined ECF into TCF + updated control files
	LlanFAS_BL_2m_060_S_Bov.tgc	LlanFAS_BL_2m_074_S_Bov.tgc	Updated code layers (see below)
	LlanFAS_042_S_Bov.tbc	LlanFAS_BL_072_S_Bov.tbc	Updated 2d_bc layer (see below)
TGC	2d_code_LlanFAS_Bov_001	2d_code_LlanFAS_072_S_Bov	Match changes to Baseline at SW corner of Llanmaes catchment.
	2d_mat_LLANFAS_building_035	2d_mat_LLANFAS_building_070	Building layer consistent with Baseline simulation
TBC	2d_bc_LlanFAS_Bov_041	2d_bc_LlanFAS_072_S_Bov	Match changes to Baseline at SW corner of Llanmaes catchment

Boverton Brook Sensitivity Simulation Proposed Option

Proposed Option model LlanFAS_DD_~s1~_~e1~_075.tcf carried forward for simulation. All changes documented in the Proposed Option Model Updates have been applied here. Only the specific changes for the sensitivity simulation have been included within the table

	NRW Reviewed Model (Dec 2021)	AECOM Feburary 2022 Updates	Comment
TCF	LlanFAS_DD_~s1~_~e1~_068_S_Bov.tcf LlanFAS_DD_~s1~_~e1~_068_S_Bov.ecf	LlanFAS_DD_~s1~_~e1~_075_S_Bov.tcf	Combined ECF into TCF + updated control files
	LlanFAS_DD_2m_067_S_Bov.tgc	LlanFAS_DD_2m_075_S_Bov.tgc	Updated code layers
	LlanFAS_DD_066_S_Bov.tbc	LlanFAS_DD_073_S_Bov.tbc	Updated 2d_bc layer
TGC	2d_code_LlanFAS_Bov_001	2d_code_LlanFAS_072_S_Bov	**Same as Baseline Model Update**
	2d_mat_LLANFAS_building_035	2d_mat_LLANFAS_building_070	**Same as Baseline Model Update**
TBC	2d_bc_LlanFAS_Bov_041	2d_bc_LlanFAS_072_S_Bov	**Same as Baseline Model Update**

Frampton Ponds – Baseline

Not previously reviewed by NRW. Baseline model LlanFAS_BL_~s1~_~e1~_074.tcf carried forward for simulation. All changes documented in the Baseline Model Updates have been applied here. Only the specific changes for the sensitivity simulation have been included within the table.

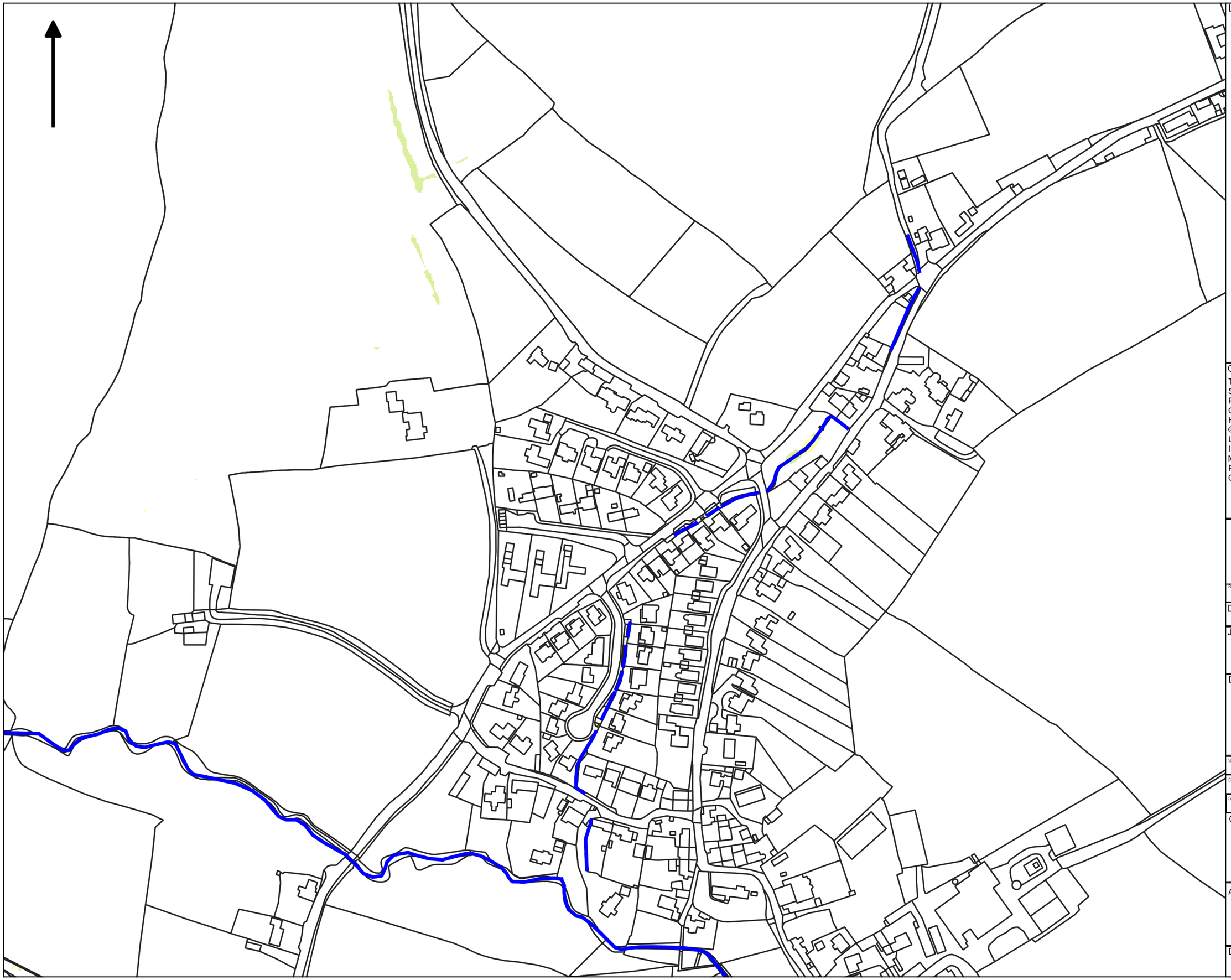
	50% Capacity	100% Capacity
TCF	LlanFAS_BL_~s1~_~e1~_074_S_FSA50pc.tcf	LlanFAS_BL_~s1~_~e1~_074_S_FSA100pc.tcf
	LlanFAS_BL_2m_074.tgc	LlanFAS_BL_2m_074.tgc
	LlanFAS_BL_072.tbc	LlanFAS_BL_072.tbc
	2d_IWL_LLANFAS_Frampton_074_S_FSA50pc	2d_IWL_LLANFAS_Frampton_074_S_FSA100pc

Frampton Ponds – Proposed Option

Not previously reviewed by NRW. Proposed Option model LlanFAS_DD_~s1~_~e1~_075.tcf carried forward for simulation. All changes documented in the Proposed Option Model Updates have been applied here. Only the specific changes for the sensitivity simulation have been included within the table.

	50% Capacity	100% Capacity
TCF	LlanFAS_DD_~s1~_~e1~_075_S_FSA50pc.tcf	LlanFAS_DD_~s1~_~e1~_075_S_FSA100pc.tcf
	LlanFAS_DD_2m_075.tgc	LlanFAS_DD_2m_075.tgc
	LlanFAS_DD_073.tbc	LlanFAS_DD_073.tbc
	2d_IWL_LLANFAS_Frampton_074_S_FSA50pc	2d_IWL_LLANFAS_Frampton_074_S_FSA100pc

Appendix D – Comparison to November 2021 NRW Reviewed Model Results



Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option Update (_075) vs. Proposed Option NRW Reviewed (_071) 1% AEP

Scale at A3: 1:4000

Drawn	Approved
RC	RS

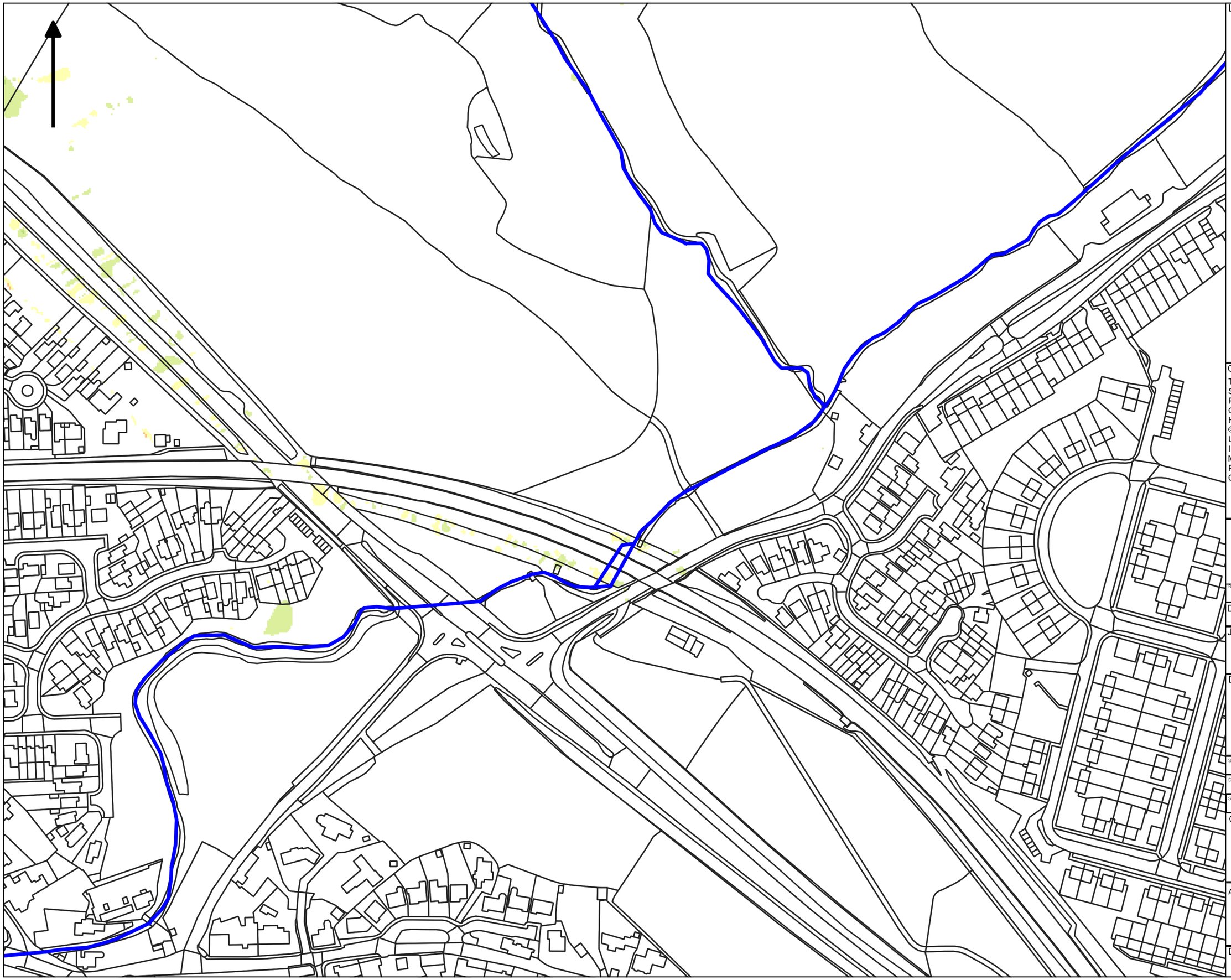
Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		01/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: D1

Rev



Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option Update (_075) vs. Proposed Option NRW Reviewed (_071) 1% AEP

Scale at A3: 1:4000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		01/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: D2

Rev:

Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option Update (_075) vs. Proposed Option NRW Reviewed (_071) 1% AEP + 30% Climate Change

Scale at A3: 1:4000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		01/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: D3

Rev

Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option Update (_075) vs. Proposed Option NRW Reviewed (_071) 1% AEP + 30% Climate Change

Scale at A3: 1:4000

Drawn	Approved
RC	RS

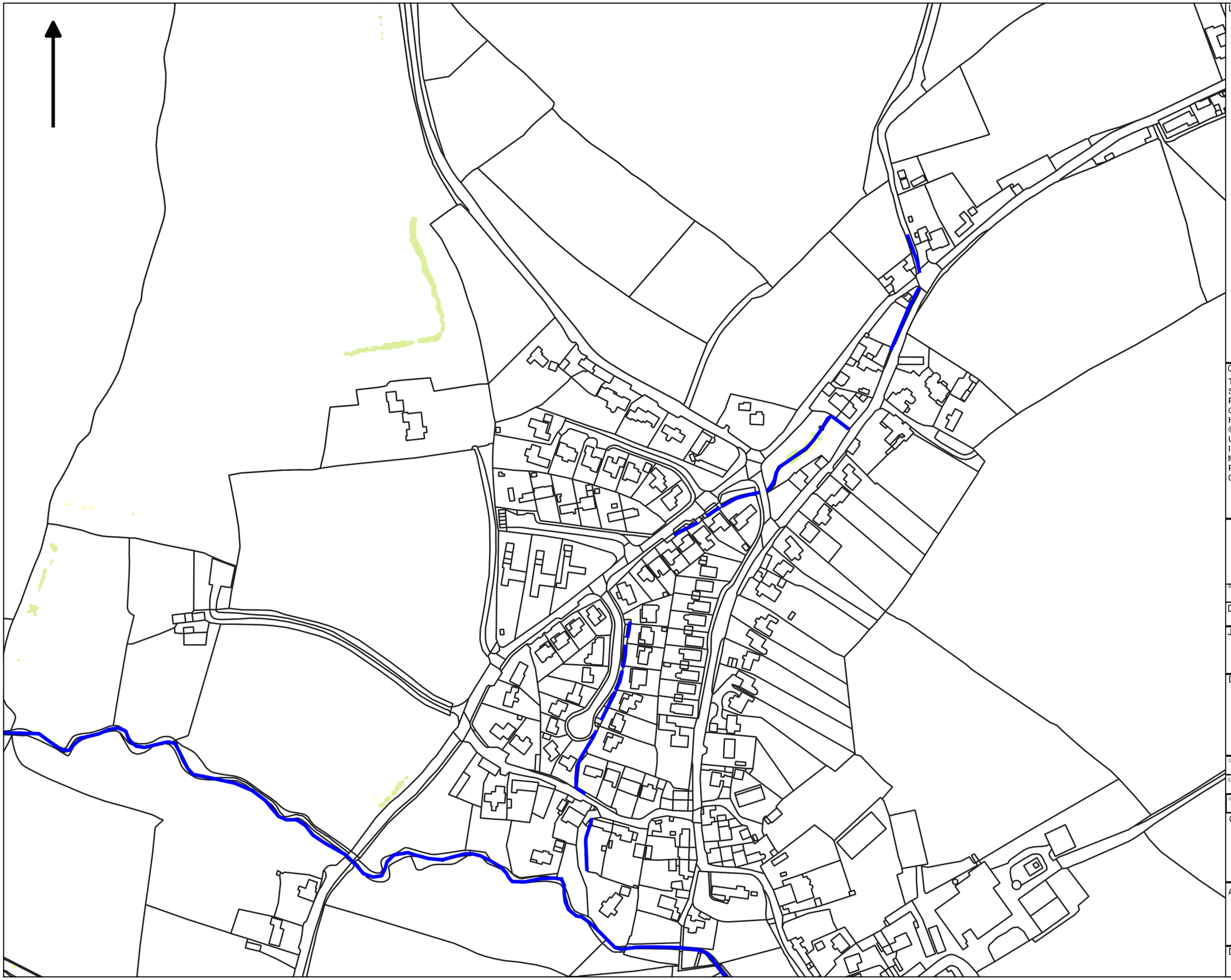
Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		01/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: D4

Rev:



Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option Update (_075) vs. Proposed Option NRW Reviewed (_071) 0.1% AEP

Scale at A3: 1:4000

Drawn	Approved		
RC	RS		
Stage 1 Check	**Stage 2 Check**	**Originated**	**Date**
RM	AT		01/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: D5

Rev

Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option Update (_075) vs. Proposed Option NRW Reviewed (_071) 0.1% AEP

Scale at A3: 1:4000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		01/22

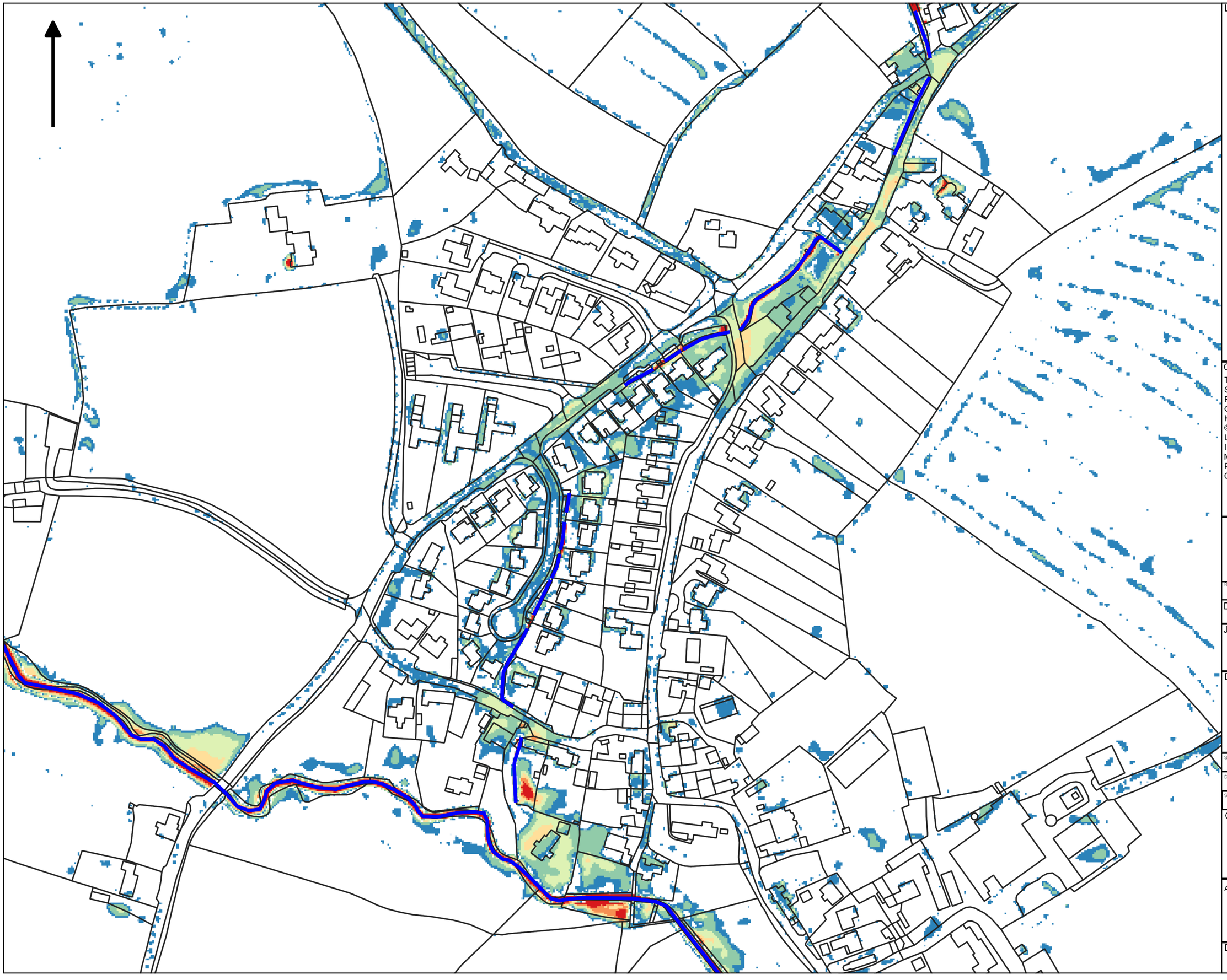
Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: D6

Rev

Appendix E – Baseline Model Results



Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Baseline 1.33% AEP

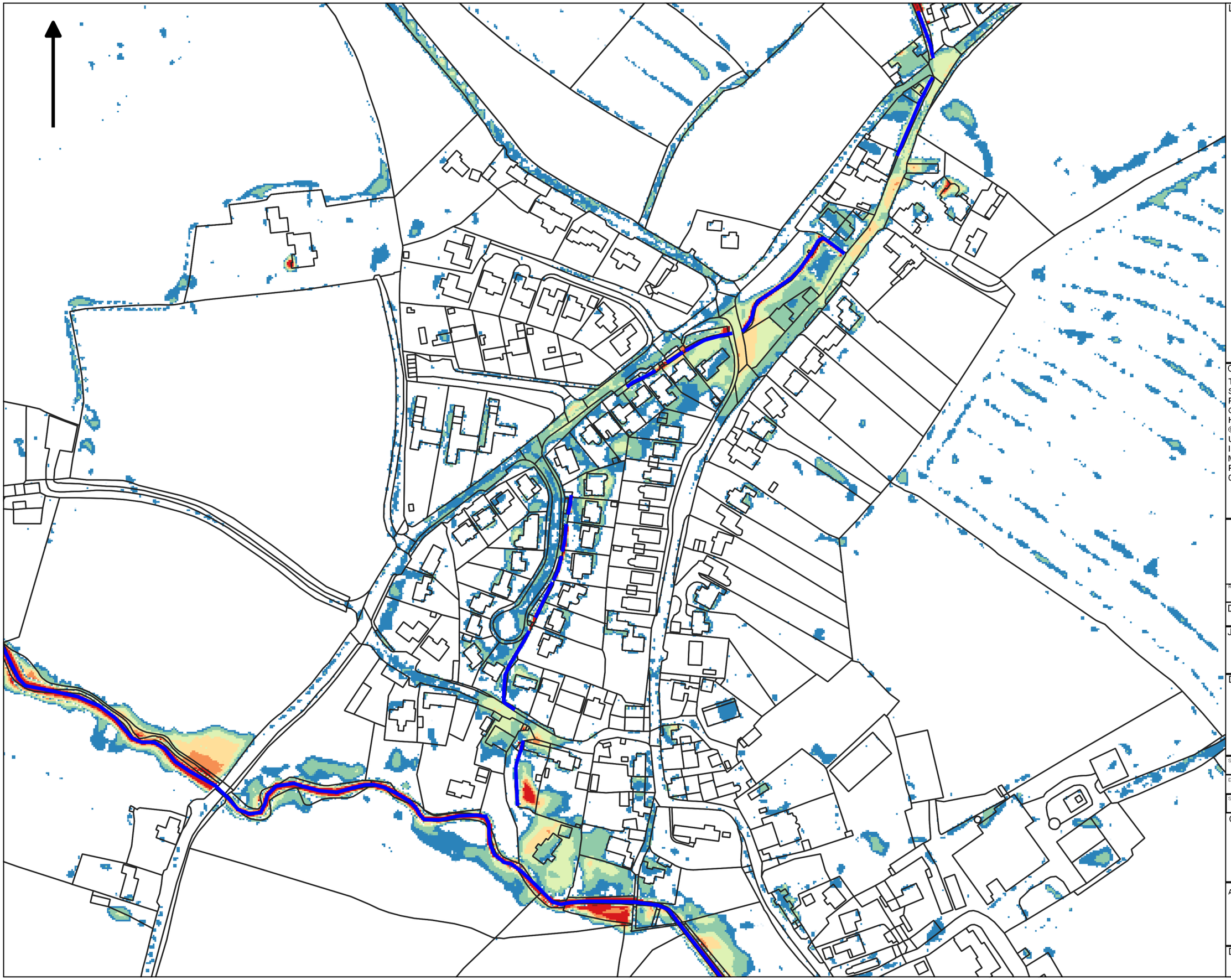
Scale at A3			
1:2000			
Drawn: RC		Approved: RS	
Stage 1 Check: RM	Stage 2 Check: AT	Originated	Date: 02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: E1

Rev



Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Baseline 1% AEP

Scale at A3: 1:2000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: E2

Rev:

Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Baseline 1% AEP + 30% Climate Change

Scale at A3: 1:2000

Drawn	Approved
RC	RS

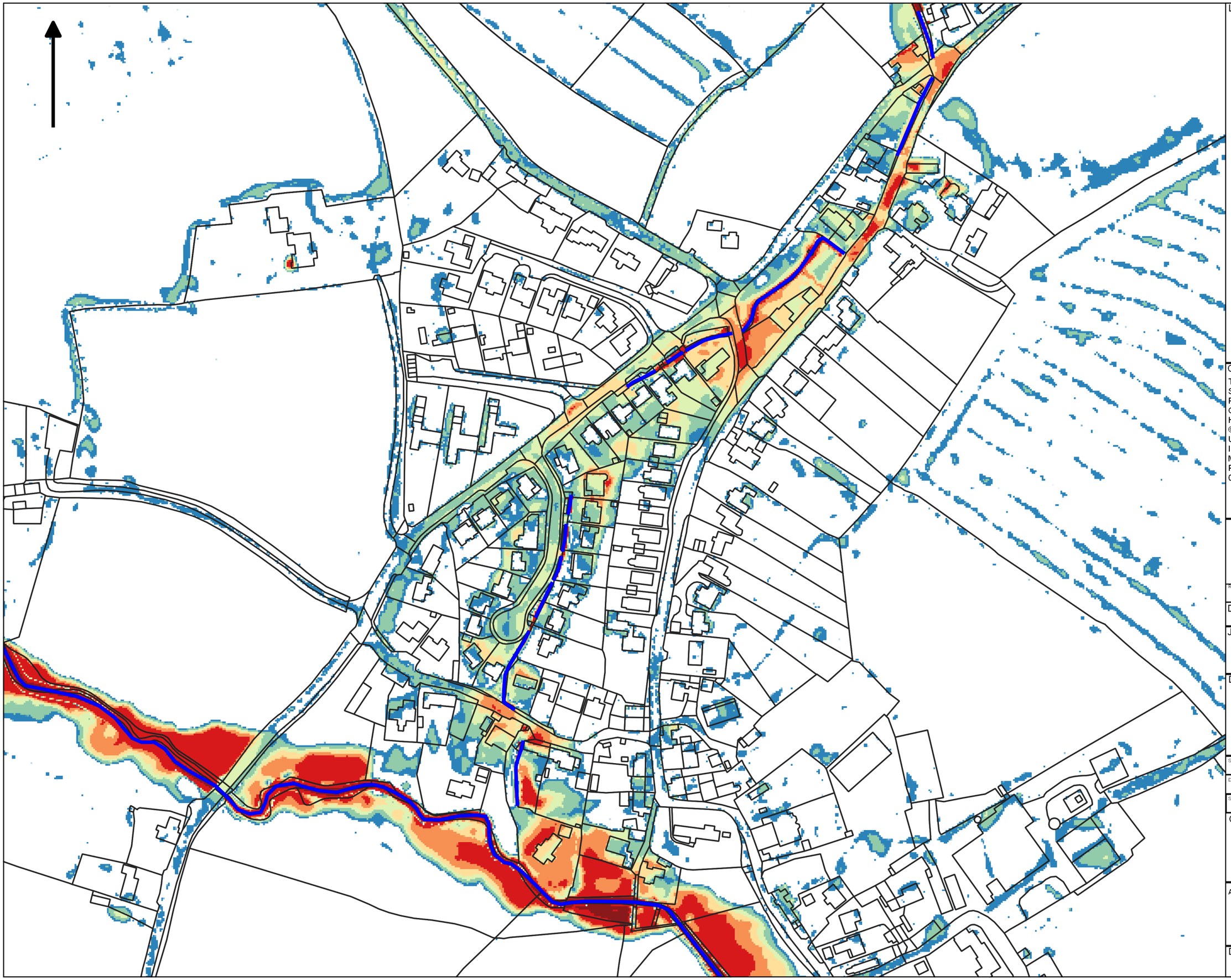
Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: E3

Rev



Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Baseline 0.1% AEP

Scale at A3: 1:2000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

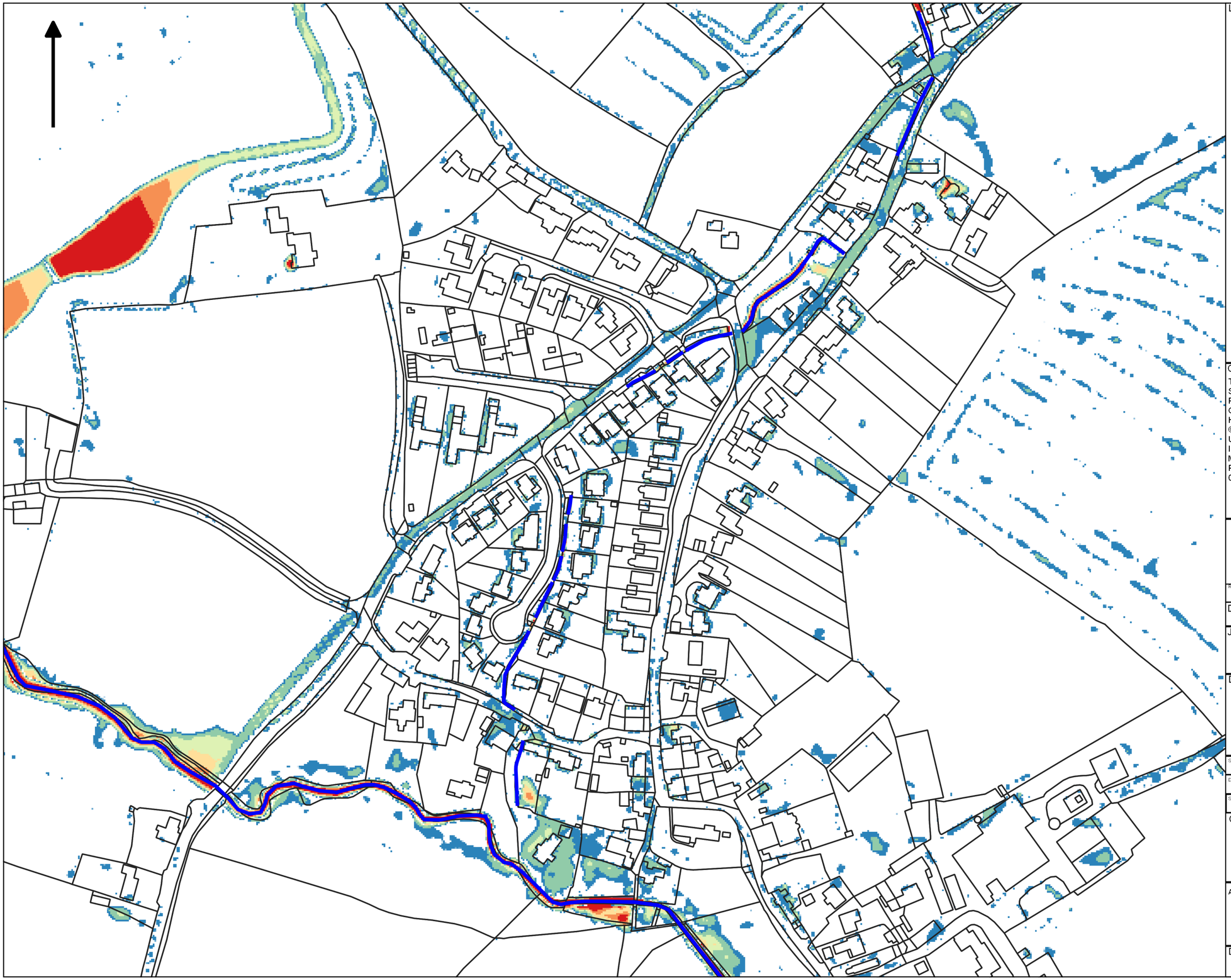
Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: E4

Rev

Appendix F – Proposed Option Model Results



Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Proposed Option 1.33% AEP

Scale at A3: 1:2000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F1

Rev

Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Proposed Option 1% AEP

Scale at A3: 1:2000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F2

Rev

Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Proposed Option 1% AEP + 30% Climate Change

Scale at A3: 1:2000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F3

Rev

Legend

Watercourse

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 1.00
- > 1

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Flood Depth Proposed Option 0.1% AEP

Scale at A3: 1:2000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F4

Rev

Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option vs. Baseline 1.33% AEP

Scale at A3: 1:4000

Drawn	Approved
RC	RS

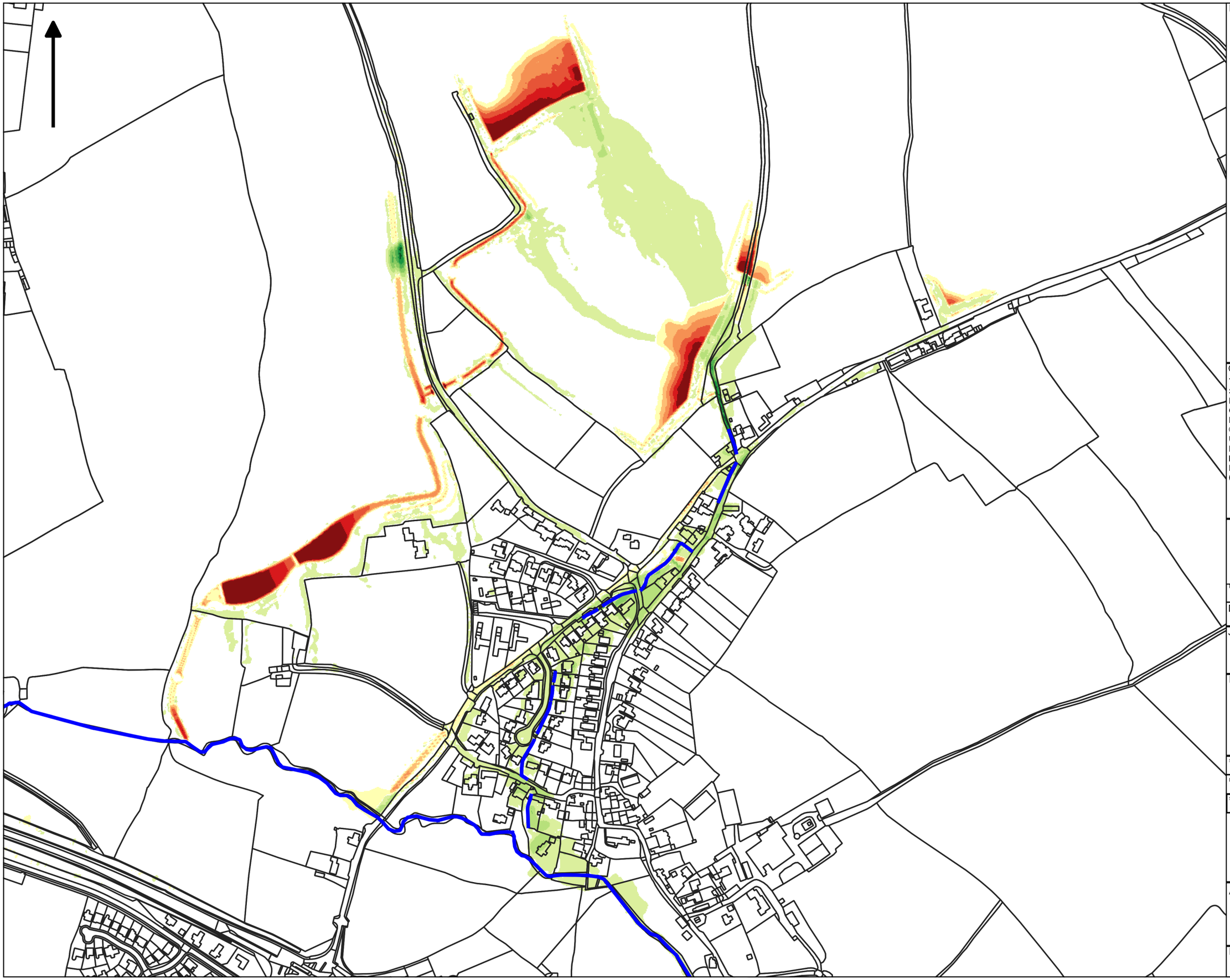
Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F5

Rev



Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option vs. Baseline 1% AEP

Scale at A3: 1:4000

Drawn	Approved
RC	RS

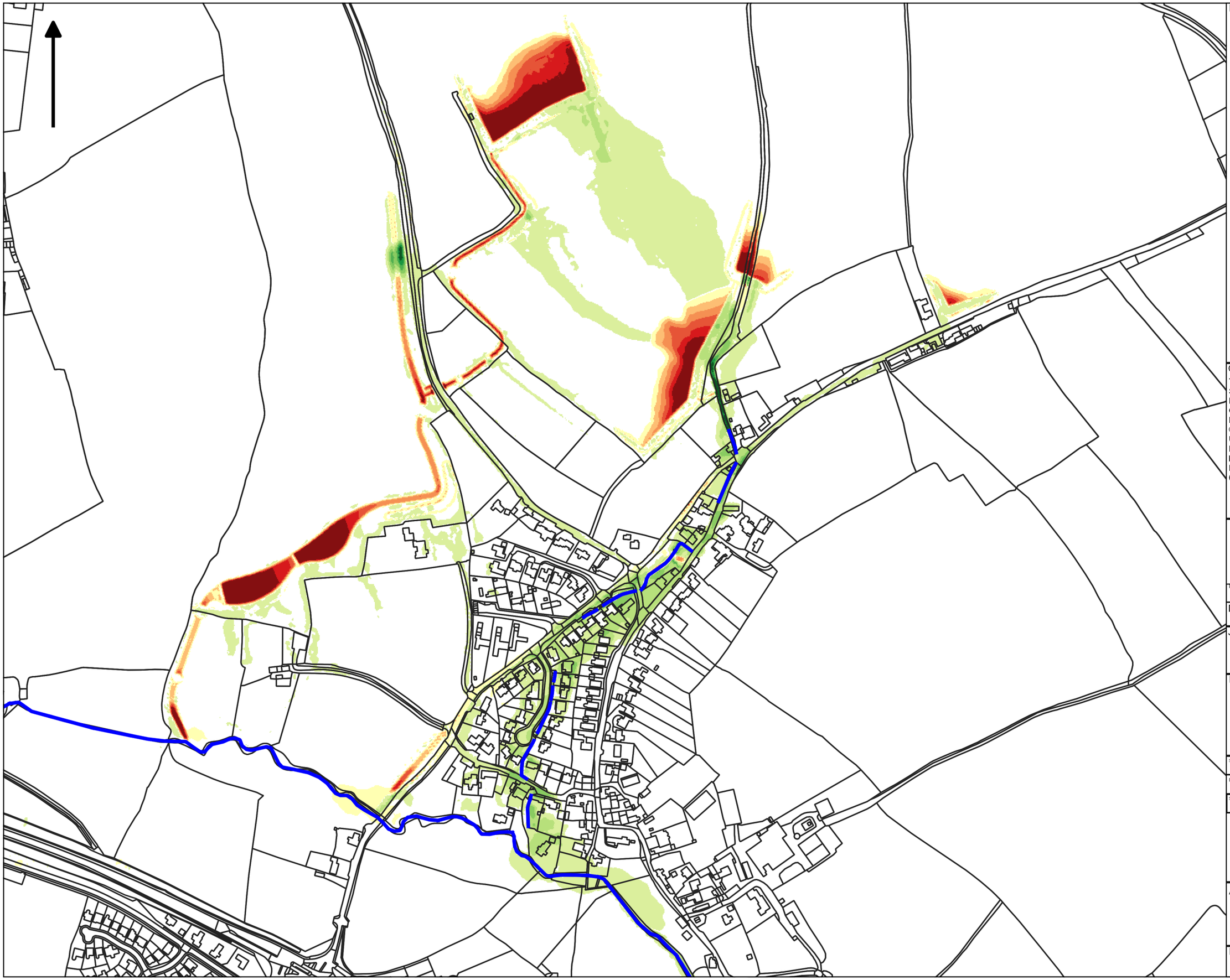
Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F6

Rev



Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option vs. Baseline 1% AEP + 30% Climate Change

Scale at A3: 1:4000

Drawn	Approved
RC	RS

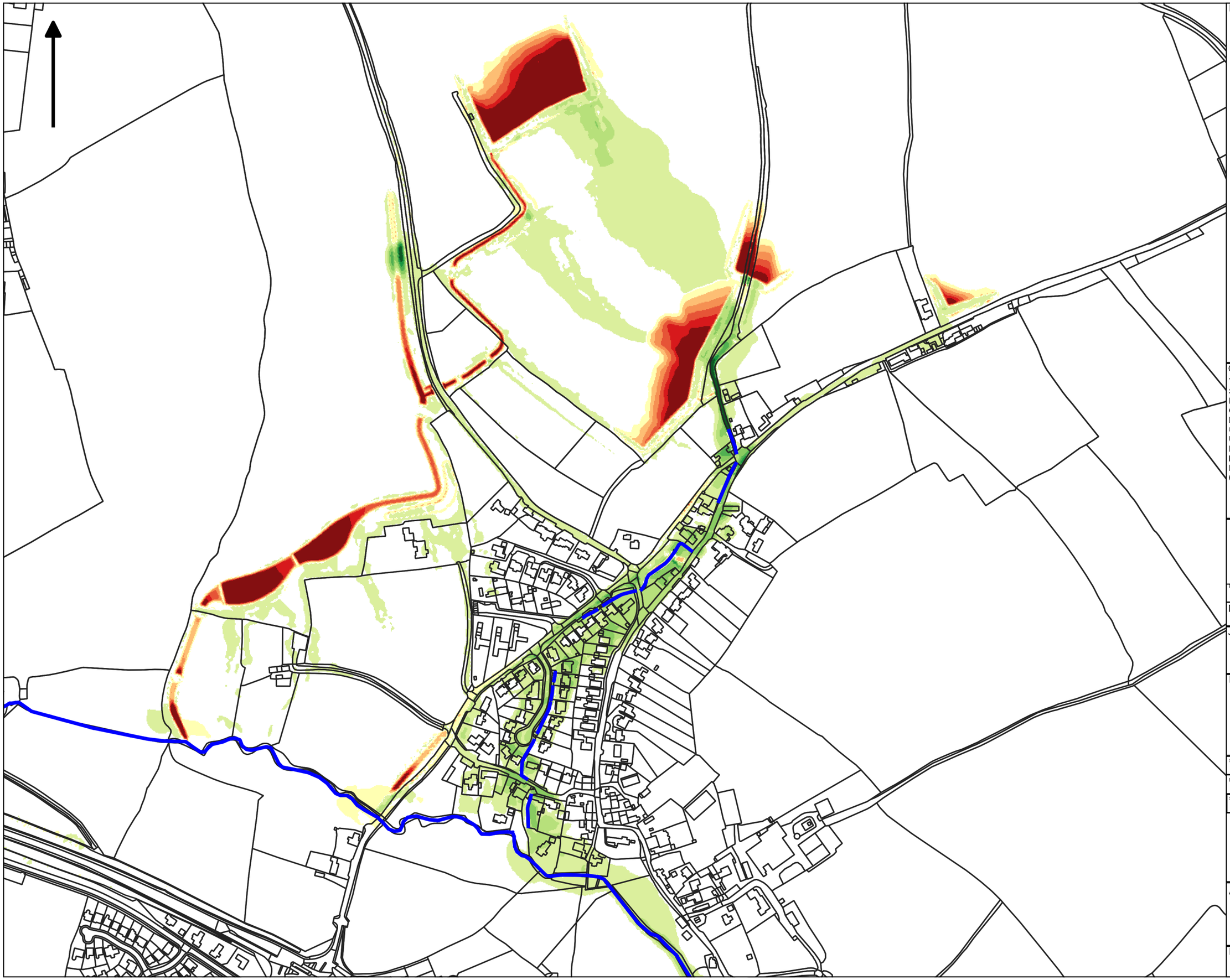
Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F7

Rev



Legend

Watercourse

Depth Difference (m)

- Less than -0.5
- -0.4 to -0.5
- - 0.3 to -0.4
- -0.2 to -0.3
- -0.1 to -0.2
- -0.01 to -0.1
- -0.01 to +0.01
- +0.01 to +0.1
- +0.1 to +0.2
- +0.2 to +0.3
- +0.3 to +0.4
- +0.4 to +0.5
- Greater than +0.5

Revision Details	By	Date	Suffix

Drawing Status: FINAL

Job Title: Llanmaes Flood Alleviation Scheme

Drawing Title: Maximum Depth Difference Proposed Option vs. Baseline 0.1% AEP

Scale at A3: 1:4000

Drawn	Approved
RC	RS

Stage 1 Check	Stage 2 Check	Originated	Date
RM	AT		02/22

Client: Llywodraeth Cymru Welsh Government

AECOM

Drawing Number: F8

Rev:

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