CAPITA

Commercial in Confidence

Rother Valley Railway

Hydraulic Modelling Report – FRA Addendum

March 2021

Quality Management

Job No	CS099746
Project	Rother Valley Railway
Location	Robertsbridge
Title	Hydraulic Modelling Report – FRA Addendum
Document Ref	CS0099746_RPT_MOD_01
Issue / Revision	V1.0
Date	08/03/2021
Prepared by	Chris Johncock
Check By	Suzanne Callaway
Authorised By	Jack Southon

Revision Status / History

Rev	Date	Issue / Purpose/ Comment	Prepared	Checked	Authorised
V1.0	08/03/2021	For Information	CJ	SC	JS

General Disclaimer

This report has been prepared by Capita Property and Infrastructure Limited (Capita) in favour of Rother Valley Railway Ltd ("the Client") and is for the sole use and benefit of the Client in accordance with the agreement between the Client and Capita dated 3rd March 2020 under which Capita's services were performed. Other than in respect of liability which cannot be excluded by law, Capita accepts no liability to any other party in respect of the contents of this report. This report is confidential and may not be disclosed by the Client or relied on by any other party without the express prior written consent of Capita.

Whilst care has been taken in the construction of this report, the conclusions and recommendations which it contains are based upon information available and standards applicable at the time the report was created, and may include information provided by third parties ("Third Party Information"). Capita has for the purposes of this report relied upon and assumed that the Third Party Information is accurate and complete and has not independently verified such information for the purposes of this report. Capita makes no representation, warranty or undertaking (express or implied) in the context of the Third Party Information and no responsibility is taken or accepted by Capita for the adequacy, completeness or accuracy of the report in the context of the Third Party Information on which it is based.

Contents

1.	**INTRODUCTION**	**1**
1.1	Background	1
1.2	Scope	1
1.3	Study Area	2
2.	**DATA COLLECTION**	**3**
2.1	Input Data	3
2.2	Existing Model	3
2.3	Channel Survey	4
3.	**MODEL UPDATE**	**5**
3.1	Hydrology	5
3.2	Hydraulic Model	6
4.	**MODEL SIMULATIONS**	**13**
4.1	Summary	13
4.2	Final Scenarios	13
5.	**MODEL CALIBRATION AND VALIDATION**	**14**
5.1	Model Calibration	14
5.2	Flow Reconciliation	16
6.	**MODEL RESULTS**	**18**
7.	**MODEL STABILITY**	**22**
7.1	Flood Modeller Convergence Plots	22
7.2	TUFLOW Mass Balance and Volume Checks	23
8.	**SENSITIVITY TESTING**	**24**
9.	**ASSUMPTIONS AND LIMITATIONS**	**26**
9.1	Introduction	26
9.2	Key Assumptions in the Hydraulic Model	26
9.3	Limitations	26
10.	**CONCLUSION**	**28**

1. Introduction

1.1 Background

This report describes the additional modelling undertaken for Rother Valley Railway in relation to the additional environmental information requested by the Inspector. The results of the modelling are reported in the Flood Risk Assessment Addendum Report (March 2021).

The original Flood Risk Assessment (FRA) for the proposed reinstatement of the Rother Valley Railway between Robertsbridge and Udiam (Bodiam) was completed in 2014. Following discussions with the Environment Agency and updates to the proposed scheme design, a new Flood Risk Assessment was completed in June 2016. The 2016 FRA encompassed amendments to the original scheme including changes to the track elevation, sections of viaduct and the proposed culverts through the railway embankment. The June 2016 FRA superseded the earlier 2014 FRA. The route is approximately 3.5 km and will link the existing railway between Bodiam and Robertsbridge. Planning permission for the reinstatement of the railway line from Robertsbridge to Udiam was approved in 2017.

On 19 April 2018 Rother Valley Railway Limited (RVR) applied to the Secretary of State for Transport for the Rother Valley Railway Order, providing RVR the powers to construct, maintain and operate the Rother Valley Railway. A public inquiry has been called and the Inspector requested further environmental information relating to the Environmental Statement. This includes an update to the flood risk analysis. An addendum to the 2016 FRA was prepared and submitted to the Inspector on 8th March 2021.

This report provides a technical record of the updates to the Rother Valley Railway hydraulic model.

1.2 Scope

Following a request from the Public Inquiry Inspector the flood estimation calculations and climate change allowances used in the 2016 FRA have been updated. The flood model has been run with these updates.

The Environment Agency has been consulted throughout the process of updating the flood risk information. The Environment Agency has been consulted regarding:

- whether the climate change guidance for fluvial flooding had been updated based on the revised UKCP18 climate projections
- the proposed methodology for updating the flood risk information
- the updated flood flow estimation calculations

The modelling was undertaken between December 2020 and March 2021. As of March 2021 the Guidance on Flood Risk Assessments: climate change allowances published on the GOV.UK website has not been updated to include guidance for fluvial flooding based on the revised UKCP18 climate projections. The 2016 FRA was based on the 20% climate change allowance, which was agreed with the Environment Agency at the time the FRA was produced. However, this is lower than the currently published guidance based on UKCP09 climate projections (Higher Central estimate 45%, Upper End estimate 105%). Therefore, the assessment of fluvial flood risk documented in the FRA Addendum report and this technical note apply the currently published Climate Change Allowance Guidance based on UKCP09.

Modelling was previously undertaken as part of the 2016 FRA to understand the influence the Rother Valley Railway scheme would have on the surrounding River Rother floodplain. The model used to inform the 2016 FRA was reviewed and approved for use by the Environment Agency.

As part of the modelling for the Addendum FRA, minor updates were made to the 2016 model in addition to applying the latest flow estimates and climate change guidance.

1.3 Study Area

The proposed development is the reinstatement of the Rother Valley Railway between Northbridge Street, Robertsbridge and Junction Road, Udiam (NGR TQ7380024010 to TQ7710024270). The route is approximately 3.5 km and will link the existing railway between Bodiam and Robertsbridge (Figure 1-1). The reinstated section of the railway runs along a section of the River Rother. The River Rother is approximately 56km in length, from its source near Rotherfield in East Sussex, to where it flows into the English Channel at Rye.

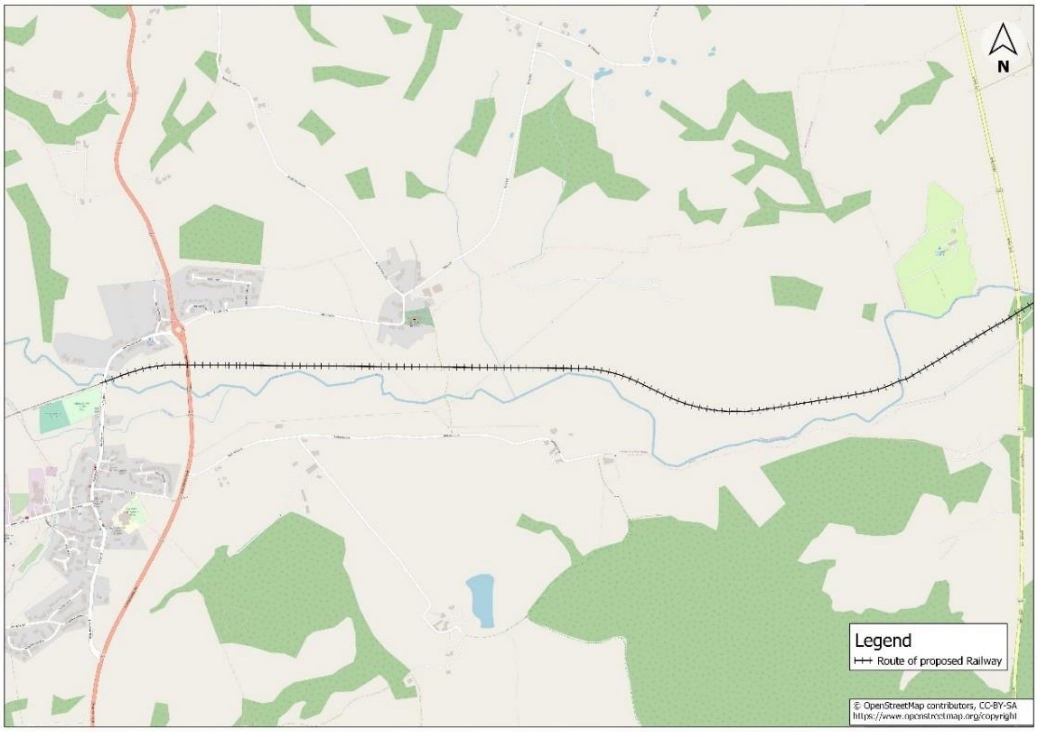


Figure 1-1 Proposed route of reinstated railway

2. Data Collection

2.1 Input Data

The input data used in the hydrology and model was collected from various sources and reviewed as required. The main input data used in the model is detailed in Table 2-1. Further details of the data used in the flood estimation calculations are provided in the Flood Estimation Calculation Record[1].

Table 2-1: Input Data

Data Received	Provided by	Comments
Rother Model (2016 version)	Licenced by the Environment Agency	The model is based on the 2016 Rother Valley Railway model. The model is a 1d/2d Flood Modeller/TUFLOW model. The model consists of a reach of the River Rother from upstream of Etchingham to just downstream of the Kent Ditch confluence.
LIDAR	https://data.gov.uk	2m Resolution LIDAR covers the entire modelling extent. This data was downloaded through the Government open data site (2020). Meta data shows the LIDAR covering the model extents was flown between 2017 and 2019.
Gauge Data	Environment Agency	Gauge data was provided for Udiam (15 minute flow data 2015 to 2020)

2.2 Existing Model

The 2016 Rother model is a 1d/2d multi-domain Flood Modeller (FM)-TUFLOW model. The 2d model was separated into two domains with a 20m and 5m resolution grid respectively. The finer 5m resolution covered the middle reach of the River Rother, the River Darwell and the majority of the River Dudwell. The upper and lower reaches of the model are covered by the 20m resolution domain.

The inflow hydrographs are input into the model using several point and lateral inflow nodes. The flow between the Flood Modeller 1D and TUFLOW 2D domain is transferred via a combination of HX boundaries and SX boundaries. The SX boundaries were implemented in the original 2011 Environment Agency version of the model along some reaches of the channel to solve model stability issues[2]. Some of these SX boundaries were retained in the 2016 model.

[1] Rother Valley Railway, Flood estimation calculation record: Rother Valley, Capita, 2021

[2] Environment Agency (2011) River Rother Final Hydraulic Modelling, ABD and Hazard Mapping Report. Hyder.

2.3 Channel Survey

No additional channel survey was carried out for this project. Model cross sections have been retained from the 2016 Rother model.

3. Model Update

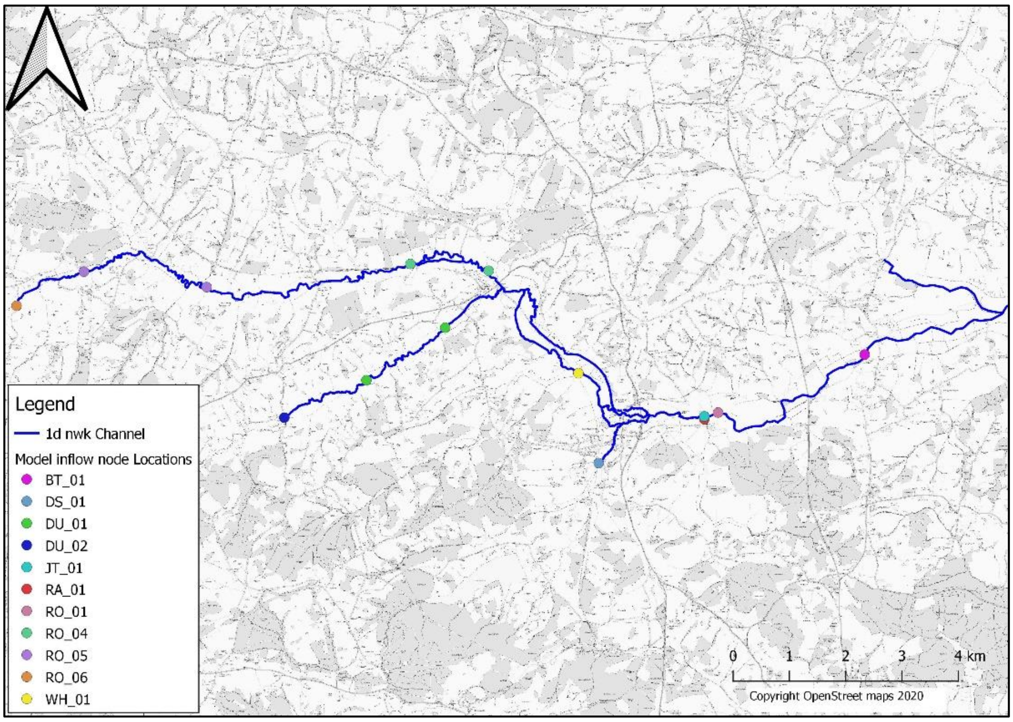
This chapter will focus on the updates made to the 2016 FM-TUFLOW model. The details of the 2016 model are provided in the Rother Valley Railway Modelling Report (June 2016).

The Environment Agency reviewed and approved the 2016 modelling. The Environment Agency has reviewed the updated flood estimation calculations undertaken as part of the addendum to the Flood Risk Assessment.

3.1 Hydrology

The latest flood estimation calculation methods were used to update the existing Rother Valley hydrology. Details of the flood estimation calculation and justification of the design flows used in the modelling can be found in the RVR Calculation Record[3]. The location of model inflow nodes was updated as part of the hydrological and hydraulic modelling update (Figure 3-1). Lateral inflow nodes were updated, using sub-catchment maps and LIDAR to identify the percentage of flow assigned to the channel node. The inflows were reconciled at the Udiam gauge, comparing peak flow and hydrograph shape. A 36.5 hour storm duration was selected, because this duration gives the best fit to the average observed hydrograph shape at Udiam gauge.

Figure 3-1: Inflow Node Locations



[3] Rother Valley Railway, Flood estimation calculation record: Rother Valley, Capita, 2021

The initial conditions in the 2021 model were updated. This had the benefit of correcting the initial conditions in the 2011 model which were set higher than recommended in the upper reaches of the model. This was not resolved in the 2016 model because it was in an area outside the main study area and did not impact on the model results in the key area of interest.

3.2 Hydraulic Model

3.2.1 LIDAR

The LIDAR used as the basis for the 2D TUFLOW model domains, was updated with the latest available 2m resolution LIDAR from the Government Open Data website. The LIDAR covering the study area was flown between 2017 and 2019. LIDAR patches were removed from the model as they were no longer required.

3.2.2 Model Domain

The TUFLOW grid was updated so that the finer 5m domain covered a greater portion of the model (Figure 3-2; Figure 3-3), including the main study area for the Rother Valley Railway scheme. The 5m domain in the 2021 version of the model includes the lower reaches of the model to the downstream boundary. This facilitates the calculation of water level within the 2D model domain at a finer horizontal grid resolution. This update to a finer resolution in the lower section of the model was possible without significantly increasing model run times due to the advancement in computer processors over recent years. Increasing the model resolution, increases model run times but not to an excessive degree and in turn allows a more detailed representation of floodplain topography and flooding flow paths/mechanisms.

Figure 3-2: Model 2D Domain Schematic - 2016 Modelling

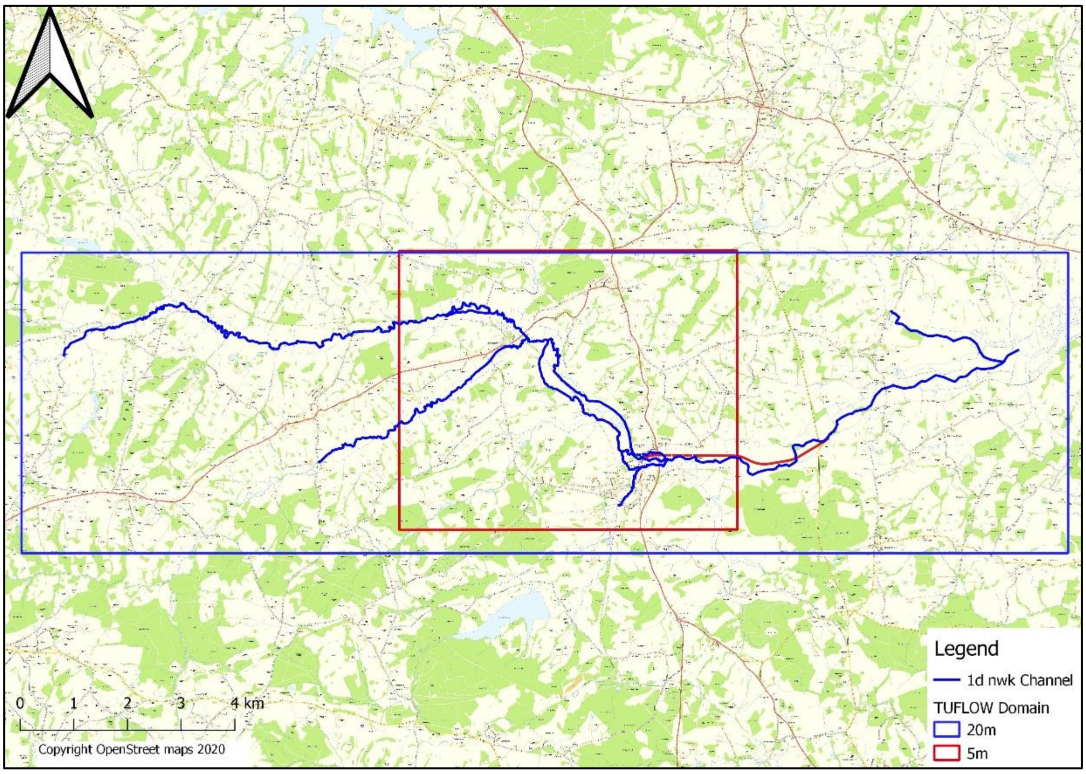
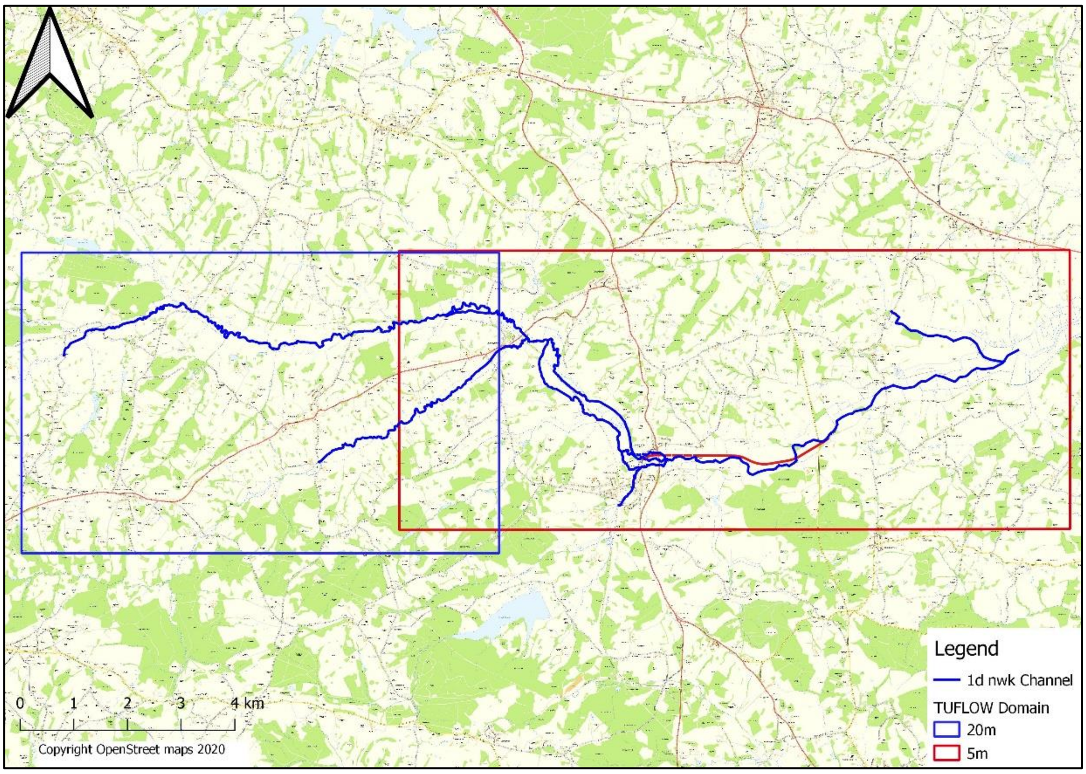


Figure 3-3: Model 2D Domain Schematic - 2021 Modelling



In order to apply the change in grid resolution and amend the areas covered by the 20m and 5m domains, a number of model files were updated including the 2D/2D boundary, code and hxi layers, layer defining river banks, the layers representing the proposed railway and culverts under the proposed embankment. These amendments were to make sure that the correct files were applied to the correct domain. In some cases this simply involved combining separate files for the 20m and 5m domains into one new file that is only applied to the new larger 5m domain.

3.2.3 Downstream Boundary (2D HQ Slope)

As a result of amending the model grid resolution within the lower reach of the model, some stability errors were reported at the downstream boundary. Minor updates were made to the location of the downstream boundary based on the local topography to improve model stability (Figure 3-4). The downstream 2d_bc HQ (Water level/Flow Relationship) boundary slope value (2d_bc ‘b’ attribute) was also updated to resolve model stability issues at the downstream boundary. The value was increased from 0.0002 to 0.0007. This has a minimal impact on the upstream floodplain as the embankment within the floodplain at the boundary acts as a control on the amount of flow reaching the downstream boundary. A sensitivity test on the downstream boundary was carried out and is documented in Chapter 8.

To improve the model stability the DSembankment shape file was also updated. The DSembankment shapefile defines the length and width of the embankment close to the downstream extent of the model. It required updating due to the finer grid resolution.

Additional material patches, which are used to define the 2D floodplain roughness, were added across floodplain ditches near the downstream boundary to increase roughness and improve model stability.

Figure 3-4: Downstream HQ Boundary Representation

3.2.4 1d/2d Boundary – HX Boundary

The 1d/2d boundary representation along the channel was updated in some locations from an SX to a HX boundary. SX boundaries were used in the original Environment Agency 2011 modelling and some were retained in the 2016 model to improve model stability along the 1D/2D interface. An HX connection is the preferred approach for connecting the 1D channel to the 2D domain (floodplain) and therefore this was updated in the model. Amendments were made to the 1D and 2D elements of the model to accommodate the change in method from SX to HX connections. Figure 3-5 shows the location of SX connections in the 2016 model. Figure 3-6 shows the updated schematisation with the majority of SX connections replaced by HX connections. The SX connections were retained along a small section of channel in Northbridge Street

The HX boundaries 'a' value was updated. The 'a' value provides additional energy losses across the banks between the 1d and 2d model domains as a Form Loss Coefficient (FLC). This is used to represent energy losses as the water is forced to change direction as it flows from the river to the floodplain or from the floodplain to river. Adding a form loss can also improve model stability. The parameter value is typically between 0 and 0.5. An 'a' value of 0.2 was applied in the updated 2021 version of the model.

Figure 3-5: 1d/2d Representation upstream of Robertsbridge - 2016 Model

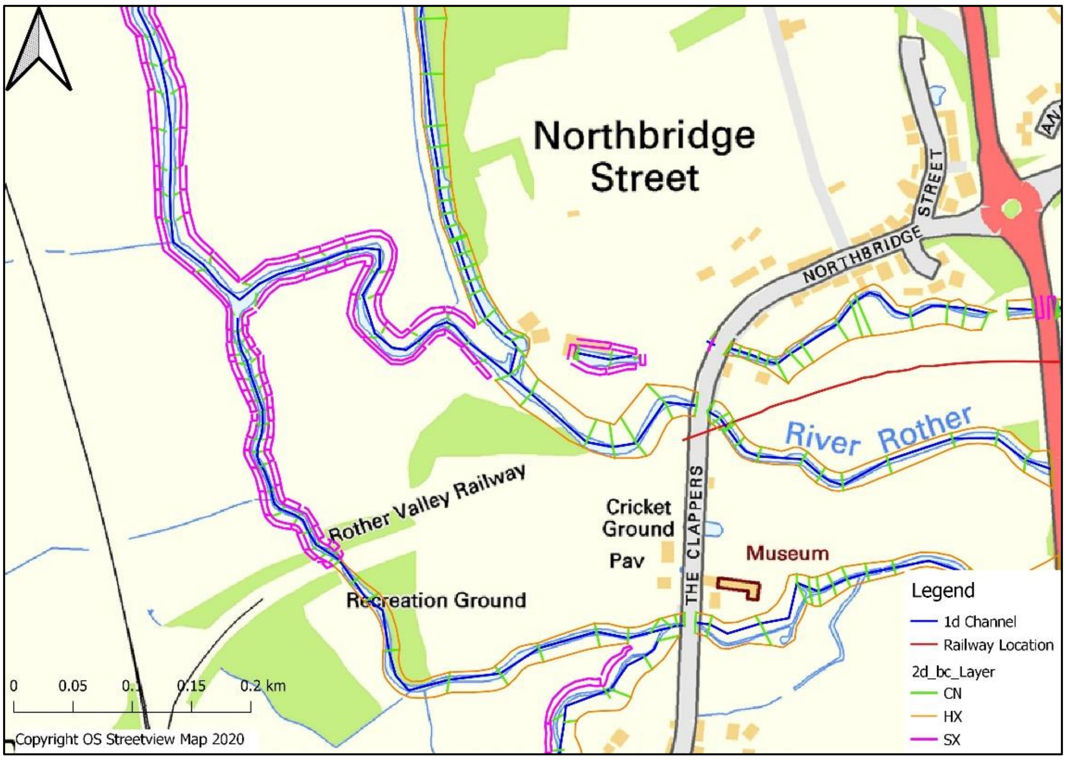
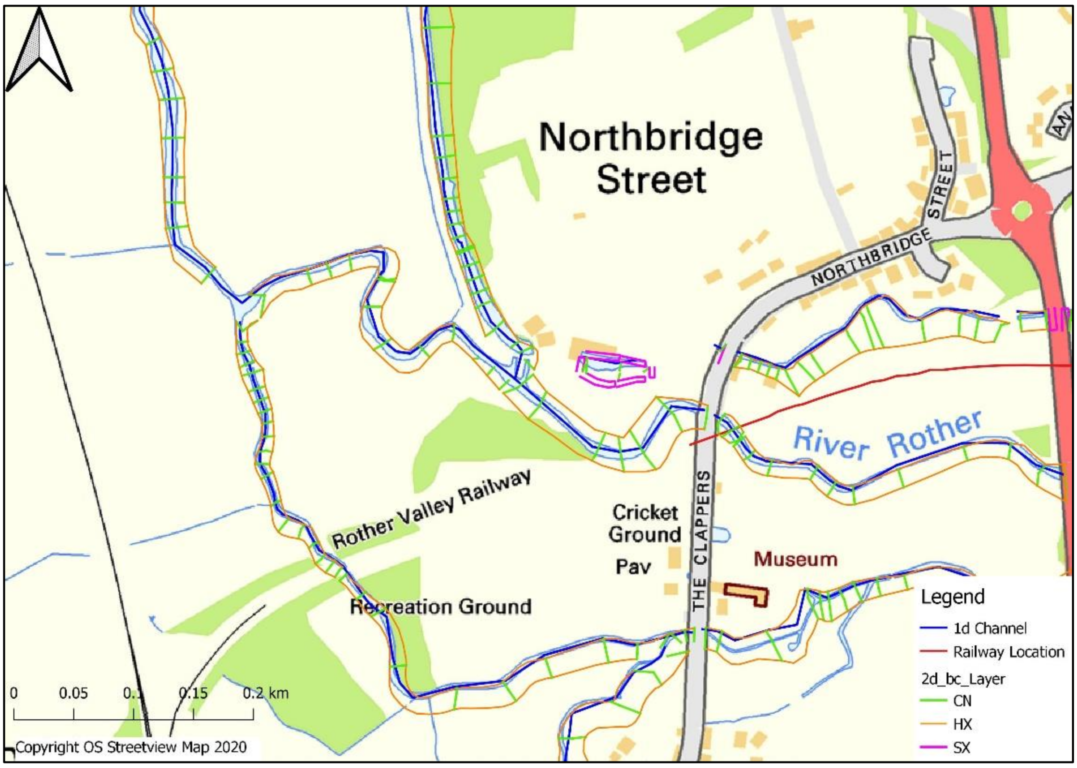


Figure 3-6: 1d/2d Representation upstream of Robertsbridge - 2021 Model



3.2.5 Culvert SX connections

Several floodplain culverts through the proposed railway embankment are represented in the model. These culverts are represented by 1D elements and are connected to the floodplain (2D domain) via SX connections. Where the grid resolution was increased from 20 m to 5 m, a slight change was applied to several SX connections. It was appropriate in the 2016 version of the model to apply the SX connection to one cell in some locations, where the grid resolution was 20 m. On updating the grid resolution to 5 m it was necessary to apply the SX connection to multiple cells to make sure that the 1D culvert and not the gird cell size was the control on flow. Therefore, where required the SX connections where updated from a point in a single cell to a line covering three cells.

3.2.6 Lower Reach Bank Levels

Where the model domain was updated from 20 m to 5m the representation of the defence embankments was checked. It was identified that in some locations the LIDAR indicated a greater variation in defence crest level than was applied by the defences layer in the model due to the distance between elevation points. Some minor updates were made based on LIDAR to supplement the elevation points. This amendment was applied to the Baseline and ‘with railway’ versions of the model.

3.2.7 Structures

Some minor changes were made to a few structures. In the baseline model br4649u was changed from an orifice unit to a USBPR bridge unit as this provided a better representation than the orifice unit of the channel under the bridge, particularly for the lower flow events. The model results were compared between the different schematisations. The representation using an orifice unit predicts a higher maximum flood level than the USBPR unit immediately upstream of the structure. The difference in the predicted baseline maximum flood levels is small upstream of The Clappers (model node br4684u).

In the 5% AEP flood event the maximum flood level predicted upstream of The Clappers adjacent to the cricket pitch is approximately 50 mm lower when an USBPR unit is used compared to the Orifice unit.

In the 1% AEP flood event the maximum flood level predicted upstream of The Clappers adjacent to the cricket pitch is approximately 70 mm lower when an USBPR unit is used compared to the Orifice unit.

In the 0.1% AEP design event the difference in maximum flood level predicted upstream of The Clappers adjacent to the cricket pitch is negligible. The USBPR representation was taken forward in the final version of the 2021 model.

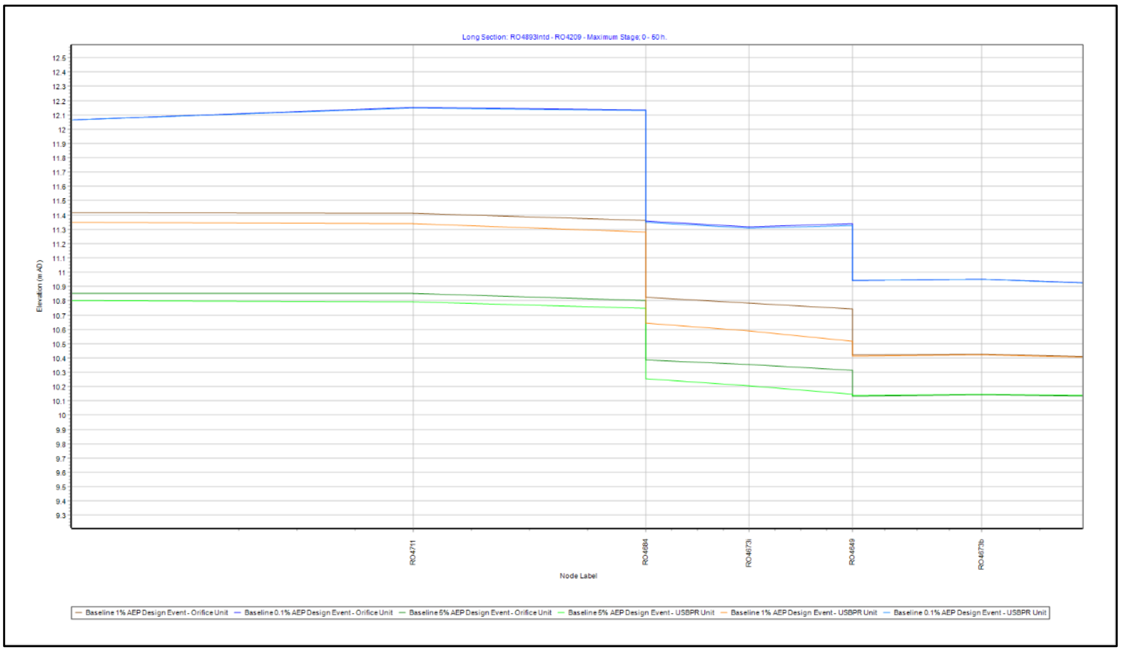


Figure 3-7: Modelled flood levels at br4649u; comparing representation of Bridge

Minor amendments were also made to structures in the 'with railway' model. The invert levels of RR_C1150 and RR_C3675 were adjusted slightly.

3.2.8 Defences downstream of The Clappers/Northbridge Street

Directly east of The Clappers the location of the proposed embankment intersects with the existing EA flood defence. Following discussions between Rother Valley Railway and the Environment Agency, it is proposed to replace the existing flood defence embankment with a flood wall to enable the Environment Agency to access and maintain the defences. An access path is proposed between the proposed railway embankment and the flood defence wall.

Within the TUFLOW domain, Z-shapes and Z-lines were used to represent the proposed changes to the defence and ground levels along the access path from The Clappers/Northbridge Street.

4. Model Simulations

4.1 Summary

Following the updates to the inflows to the model (flow estimation calculations) and the amendments to the model detailed in section 3.2, a series of model simulations were undertaken. Two scenarios were simulated, the Baseline and the Proposed Scheme 'with railway'. The results were compared and used to update the Flood Risk Analysis as detailed in Flood Risk Addendum Report[4]. A sensitivity test was also simulated to check the amendments to the downstream boundary did not impact on the model results in the study area. The scenario naming is summarised in Table 4-1.

Table 4-1: Model Run ID Parameters

Model Run ID	Scenario
~e1~	Used to specify the design event and climate change scenario
~s1~	Used to specify the scenario, flags below.
Rail	Scenario with the reinstated Rother valley Railway Line
Base	Baseline scenario
SEN1	- 20% Downstream Boundary Slope Value
SEN2	+ 20% Downstream Boundary Slope Value

4.2 Final Scenarios

The scenarios were simulated for a range of design events (Table 4-2). The simulations included 'future' scenarios for the 2080s epoch using the Higher Central and Upper End climate change allowances based on the current guidance.

Table 4-2: Design Events Simulated- Baseline and Reinstated Railway Runs

Design Event	Scenario	Final simulation number (ief and tcf)
5%	Baseline	869
1%	Baseline	869
1%+45CC (45% climate change allowance)	Baseline	869
1%+105CC (105% climate change allowance)	Baseline	869
0.1%	Baseline	869
5%	Rail	867
1%	Rail	867
1%+45CC (45% climate change allowance)	Rail	867
1%+105CC (105% climate change allowance)	Rail	867
0.1%	Rail	867
1%+45CC	SEN1	867
1%+45CC	SEN2	867

[4] Rother Valley Railway, Flood Risk Assessment Addendum, March 2021, Capita.

5. Model Calibration and Validation

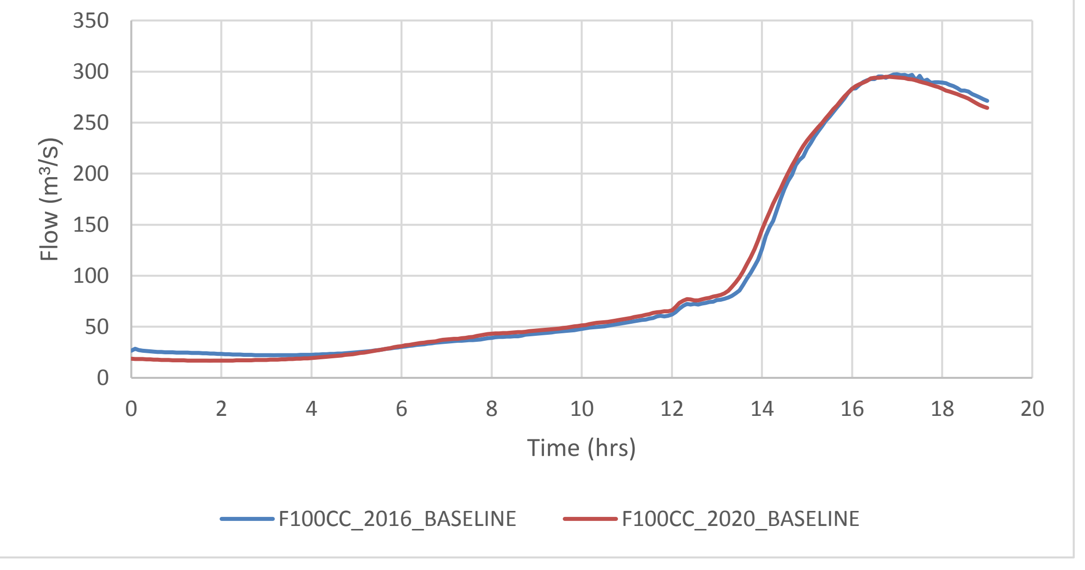
5.1 Model Calibration

The previous 2016 model cited that the 2011 modelling calibrated the model to the 13th October 2000, 30th October 2000 and 6th November 2000 events. The 2011 report stated that the 12th October 2000 calibration event agreed well with the flood outline and flow/stage at the Udiam gauge. Modelled peak stage was within 60mm of the observed peak. Model tolerance is within a range of 150mm.

The current 2021 model is essentially the same as the previous 2016 and 2011 modelling, with the most significant update being the extension of the 5m domain downstream of Robertsbridge to the downstream boundary. The impact of the domain change was assessed by running the 2016 and 2021 baseline models with the (2016) 1% AEP with climate change inflows and comparing the results. The comparison was made prior to updating the inflow nodes in the 1D model and therefore the updated model is referred to as the 2020 Baseline in the figures below.

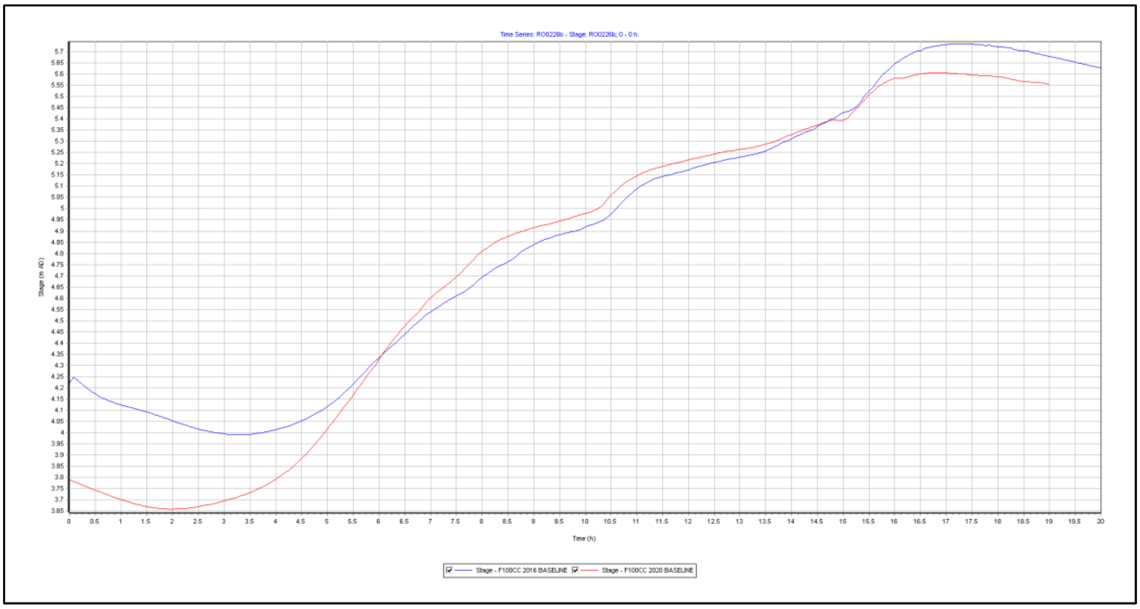
The Udiam gauge is located downstream of the B2244 on the River Rother. In the 2011 and 2016 modelling the Udiam gauge was located within the 20m model domain. In the current modelling the gauge is located within the extended 5m domain. The representation of the banks and floodplain is more detailed within the 2021 modelling, which has a small impact on stage at the gauge. The shape and peak flow at the Udiam gauge (model node: RO226b) for the 2016 and 2021 model match well, with peak modelled flows of 297.3 m^3/s and 294.8m^3/s respectively (Figure 5-1).

Figure 5-1: Modelled Peak Flow (1% AEP with climate change) at the Udiam Gauge



The timing of the peak stage is similar for both the 2016 and 2021 model with a modelled peak stage of 5.74 mAOD and 5.61 mAOD respectively. The differences in peak stage are due to the banks and floodplain within the lower reaches of the model being more refined in the 2021 model. The difference between the 2016 and 2021 model is within the model tolerance of 150mm.

Figure 5-2: Modelled Peak Stage at the Udiam Gauge



The long section plot below extends from upstream of The Clappers to the confluence downstream of the A21 (Figure 5-3). This shows that upstream of The Clappers the difference in predicted maximum water level is less than 20 mm between the 2016 and 2021 versions of the model. The maximum stage downstream of The Clappers is approximately 60mm higher in the 2021 model compared to the 2016 model.

Figure 5-3: Maximum Stage Long Section - Robertsbridge

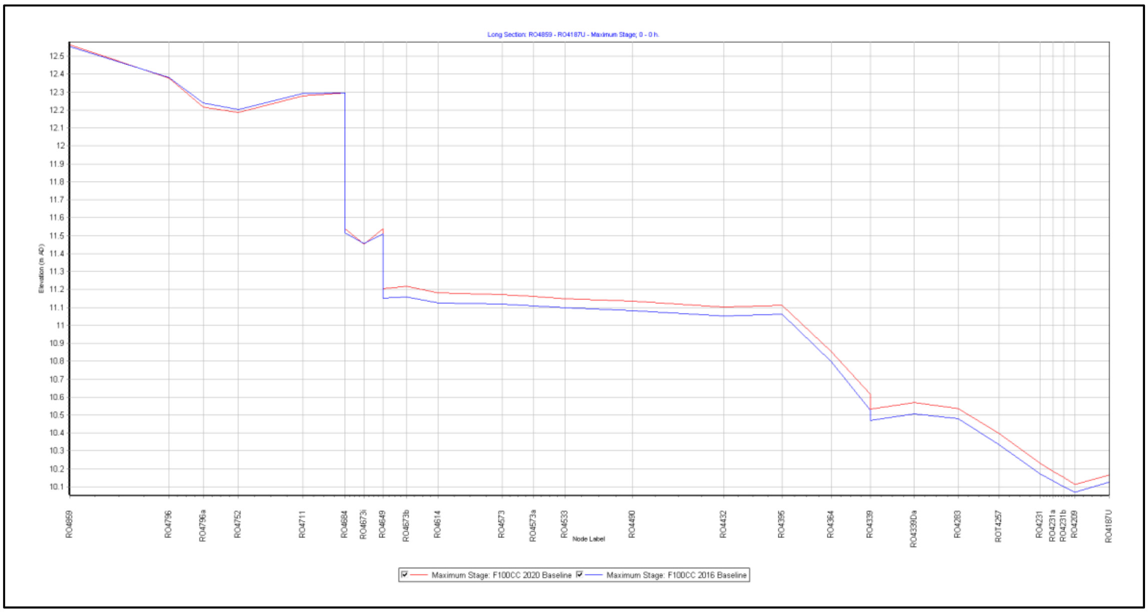
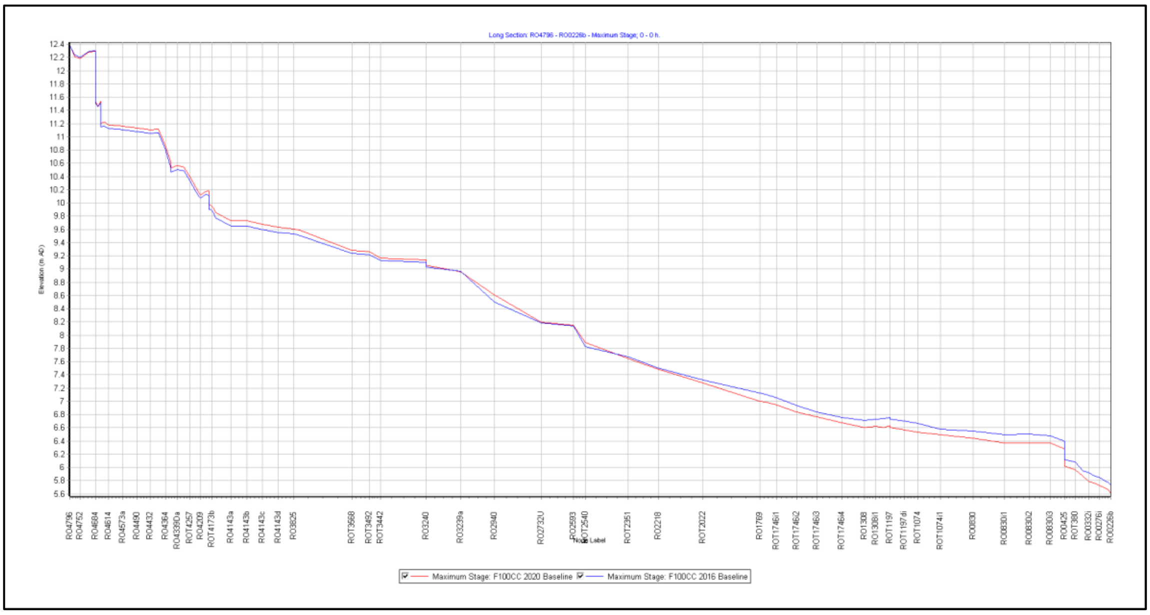


Figure 5-4 is shows the long section between Robertsbridge and the Udiam gauge. The long section shows that the 2021 modelled stage is higher from Robertsbridge to Robertsbridge Abbey, whilst the 2016 modelled stage is higher from Robertsbridge Abbey to the Udiam gauge. The cross over point occurs approximately at model node RO3239a. This node is in close proximity to the 2d/2d boundary between the 5m Domain and the 20m Domain in the 2016 model. This boundary does not exist in the 2021 model.

Figure 5-4: Maximum Stage Long Section - Robertsbridge to Udiam Gauge



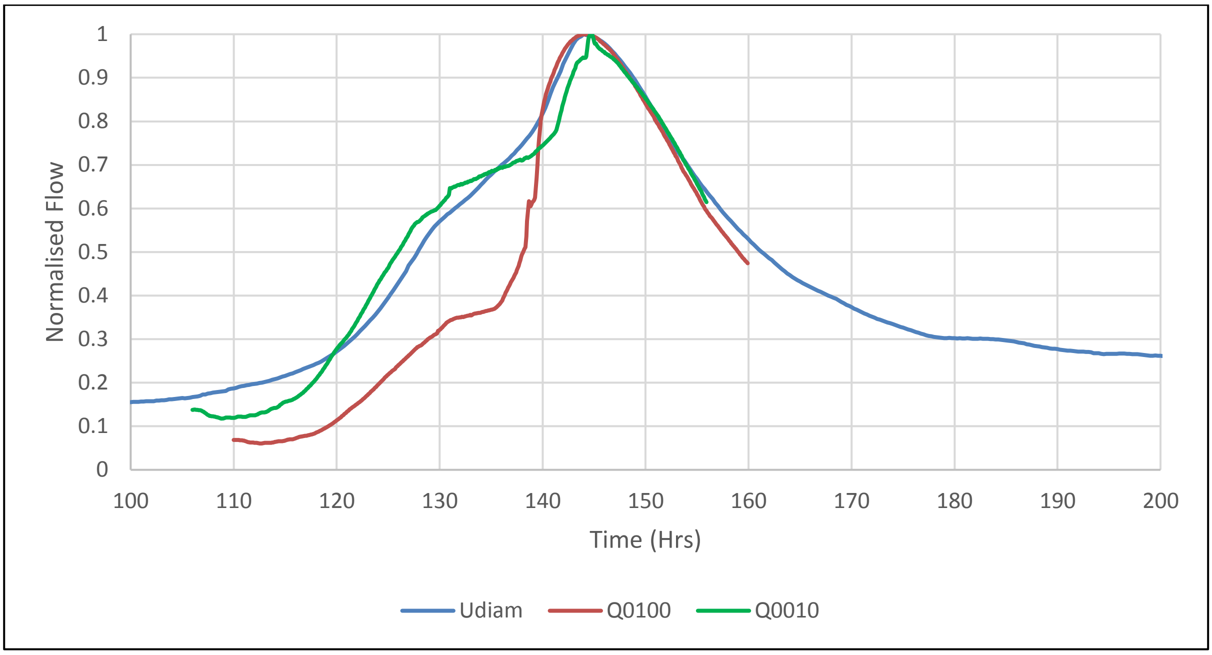
5.2 Flow Reconciliation

Model flow was reconciled at the Udiam gauge (Figure 5-5). The updated flood estimation calculations predicted a peak flow at the Udiam gauge of 138m³/s for the 1% AEP design event. The peak flow extracted from the model at Udiam Gauge was 138.5m³/s for the 1% AEP design event, indicating that the model provides a good represents of the river and floodplain.

The flows predicted by the model at the Udiam gauge for the 10% AEP and 1% AEP flow hydrographs was normalised. This was done to allow comparison of hydrograph shape against an average hydrograph consisting of 28 previous annual maximum (AMAX) events. The normalised hydrographs were shifted when plotted so that the peaks were coincident with the average hydrograph to enable the shapes to be compared.

The peak of the normalised 1% AEP modelled flow matches the shape of the averaged hydrograph well, as does the recession limb. The shape of the rising limb does not match as well. This may be due to the average hydrograph being based on AMAX events, the majority of which were much smaller than the 1% AEP design event. In the larger design flood events, the model predicts water will back up behind the B2244, Junction Road, before overtopping the road to the north.

Figure 5-5: Normalised Flows at Udiam Gauge



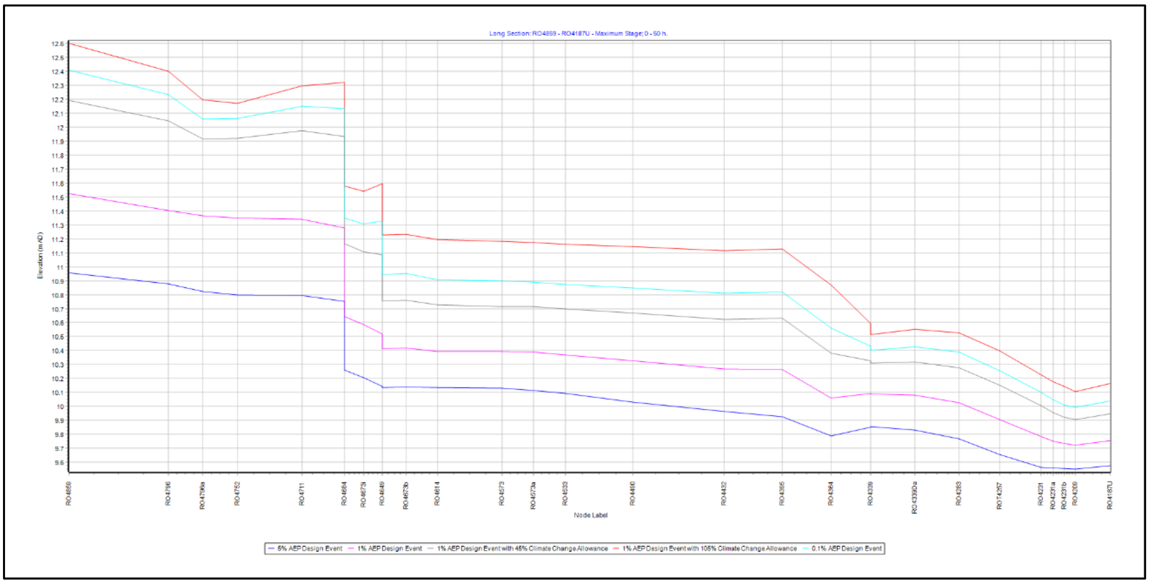
The 10% AEP normalised flow time series generally has a similar shape to the average AMAX hydrograph, though towards the peak of the event the 10% AEP normalised flow is lower than the average AMAX. In general, the model shape is similar and provides additional confidence in the model schematisation.

6. Model Results

The model results will briefly be discussed within this section, for a more comprehensive analysis of the baseline and 'with railway' results refer to the Rother Valley Railway Flood Risk Assessment Addendum[5].

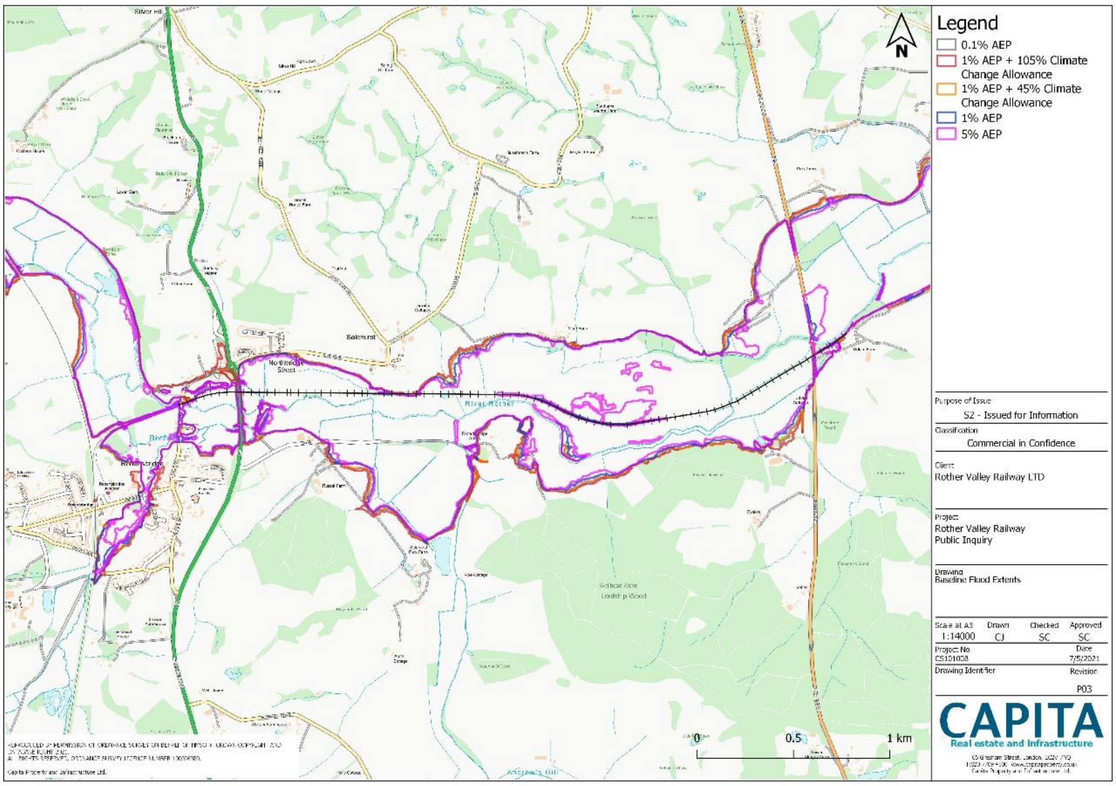
Modelled results show that the topography of the River Rother catchment is well defined, constraining flow within its valley. The maximum modelled water levels in the channel increase by up to 1.6m between 5% AEP and the 1% AEP+105%CC design events (Figure 6-1), whilst the predicted flood extents remained fairly similar through the Robertsbridge area (Figure 6-2). As the floodplain becomes less constrained downstream of the A21, the difference in maximum flood depths predicted in the 1D element of the model between the 5% AEP and 1%AEP+105%CC decreases to approximately 0.8m. Floodplain extents increase slightly as the magnitude of flood event increases, however there is a only a small variation in flood extent for the more extreme events due to the well-defined valley.

Figure 6-1: Peak Stage Long Section through Robertsbridge - Baseline



[5] Rother Valley Railway, Flood Risk Assessment Addendum, March 2021, Capita

Figure 6-2: Baseline Flood Extents



The impact of the scheme is small through Robertsbridge with the Baseline and 'with railway' scenarios having similar flood extents (Figure 6-3). Comparison of the maximum flood levels predicted for the 1% AEP+45%CC event shows that predicted flood levels in the 'with railway' scenario upstream of The Clappers are between 0.01 m and 0.07 m lower than the Baseline. Between 'The Clappers' and the A21 the maximum predicted flood levels are generally between 0.01 and 0.03m higher in the 'with railway' scenario compared to the Baseline. The difference in maximum predicted flood level between the A21 and Junction Road varies with both increases and decreases predicted in the 'with railway' scenario compared to the baseline as shown in Figure 6-4.

Difference in maximum water level maps for the full suite of design flood events simulated are provided in Appendix B1 of the Flood Risk Assessment Addendum Report[6]. The maps show that for the 5% AEP design event the difference in maximum water level between the Baseline and 'with railway' scenarios is generally +/- 0.01 m. The areas where slightly more variation (+0.05m to -0.10 m) in maximum water level is predicted between the scenarios, is around the A21 and between Robertsbridge Abbey and Austin's Bridge (which is located approximately 500m upstream of Junction Road). There are also some small isolated areas immediately adjacent to the proposed railway where a larger variation in water levels is predicted.

[6] Rother Valley Railway, Flood Risk Assessment Addendum, March 2021, Capita

Figure 6-3: 1% AEP with 45% allowance for climate change Flood Extents Comparison

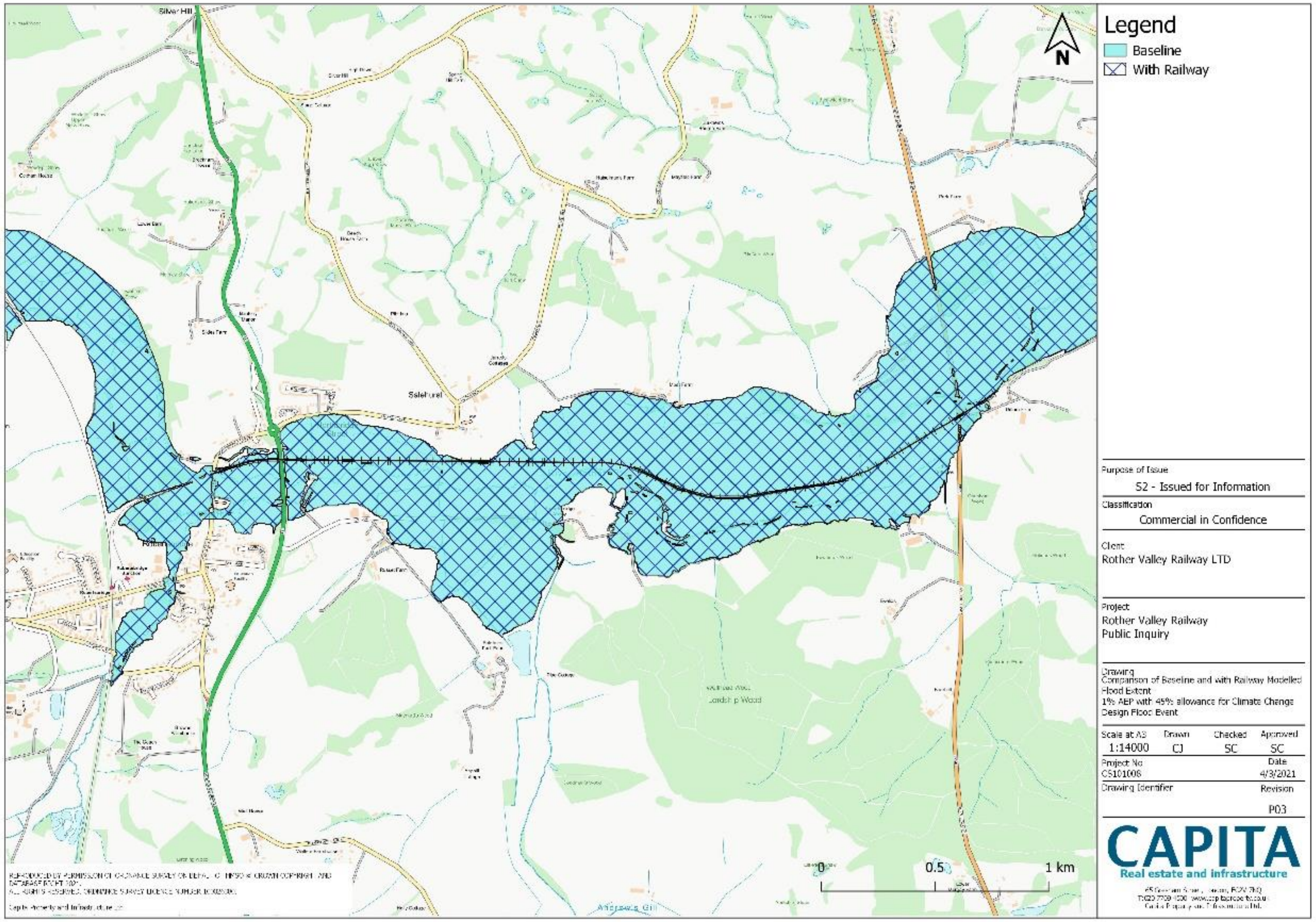
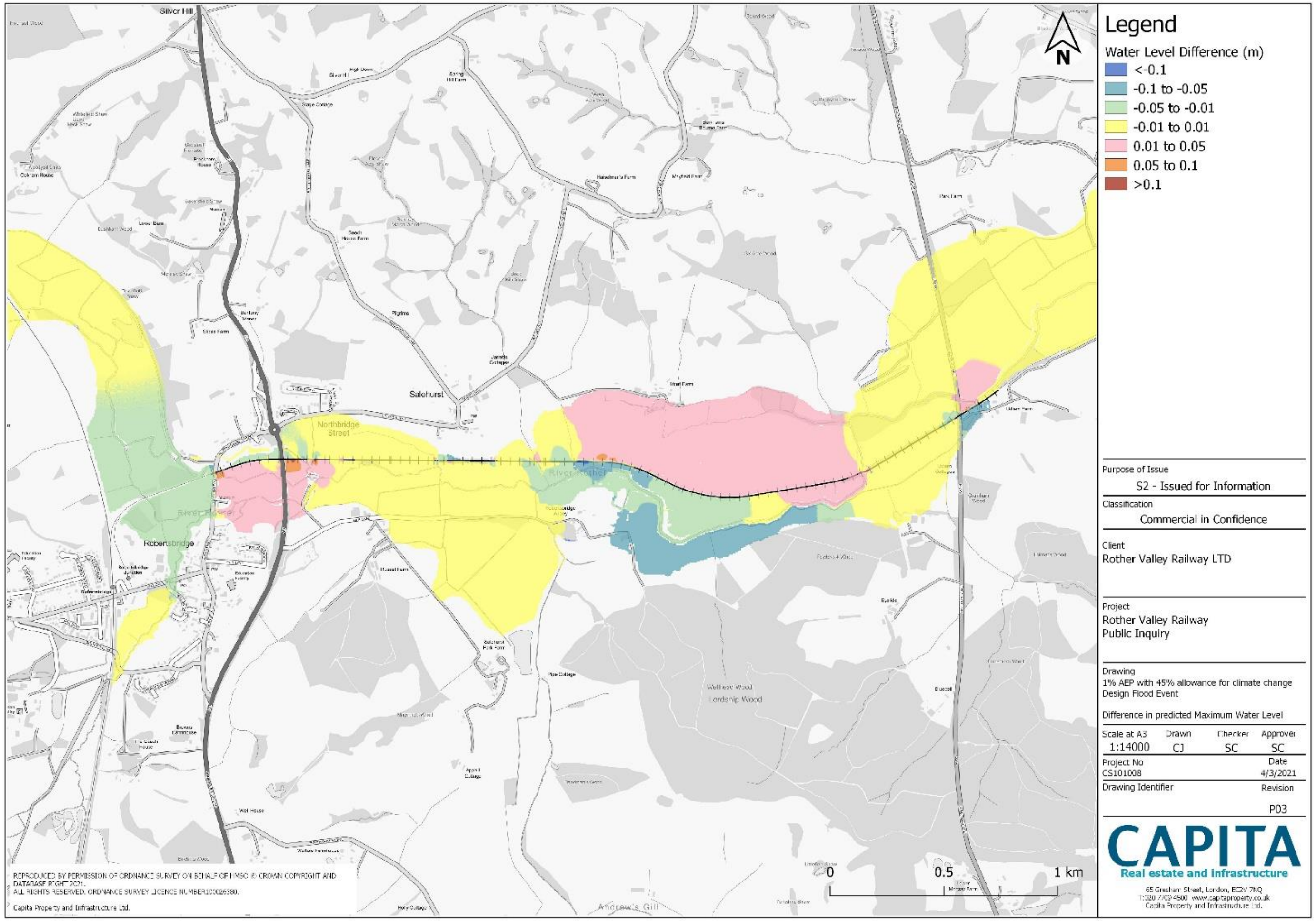


Figure 6-4: Difference in Maximum Water Level between Baseline and 'With Railway' scenarios - 1% AEP with 45% Climate Change Allowance



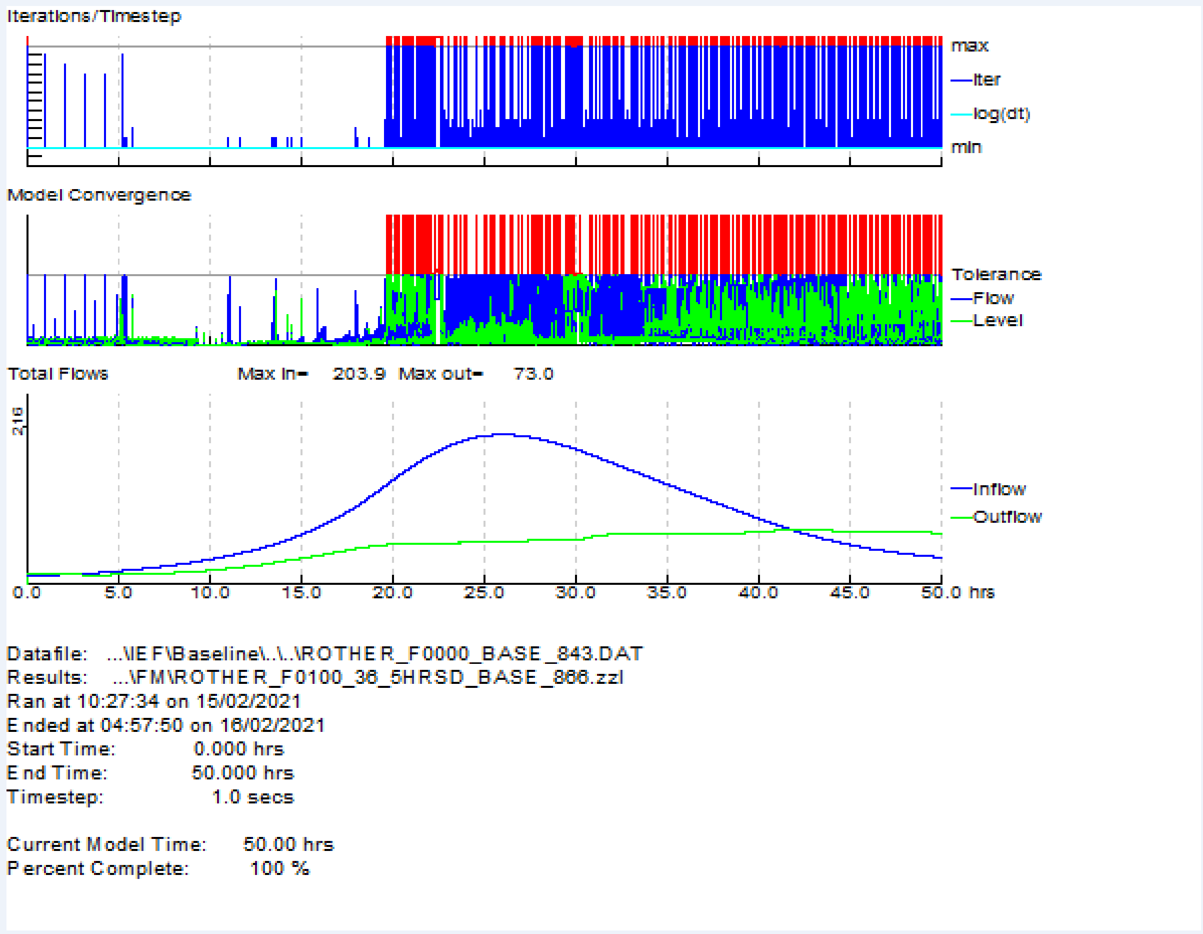
7. Model Stability

7.1 Flood Modeller Convergence Plots

Stability in Flood Modeller is assessed by examining the convergence plots and warning messages output by the model during simulation.

The convergence plot shows that from approximately 20 hours, there is intermittent periods of non-convergence occurring (Figure 7-1). The .zzd file highlights the nodes pump_us and pump_ds as the nodes causing the instability. The nodes refer to a pump represented in the model at Robertsbridge, on the Mill Stream to the north and running parallel to the River Rother. The poor convergence is caused by the pumps turning on and off, resulting in oscillations in flow and stage through that reach. The rules in the current model are consistent with the previous 2011 and 2016 modelling. The impact on flow and stage across the channel reach is minimal, with the channel showing no signs of influencing the 2d flood extents. Overall, the model stability is good.

Figure 7-1: Flood Modeller Diagnostic Plot Output - 1%AEP Baseline



7.2 TUFLOW Mass Balance and Volume Checks

Stability in TUFLOW is assessed by examining mass balance plots created during the model simulation. The TUFLOW 2D Mass balance is within +/-1% for the majority of the simulation (Figure 7-2). The mass error drops to -1.2% at 8.5 hours and increases to above -1% by 10 hours. This fall in mass balance can be attributed to the initial transfer of flow from the 1d into the 20m grid 2d model domain.

The dvol plot shows the change in total volume within the 2D domain during the simulation (Figure 7-3). The dvol curve is smooth for the majority of the simulation except for a small dip around 30 hours.

Figure 7-2: 2D Mass Balance Plot - Baseline 1% AEP

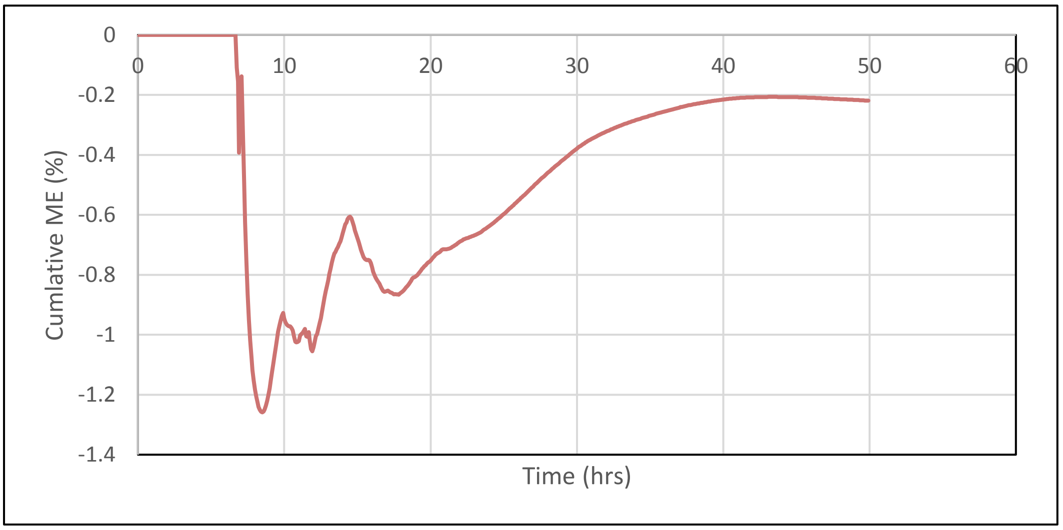
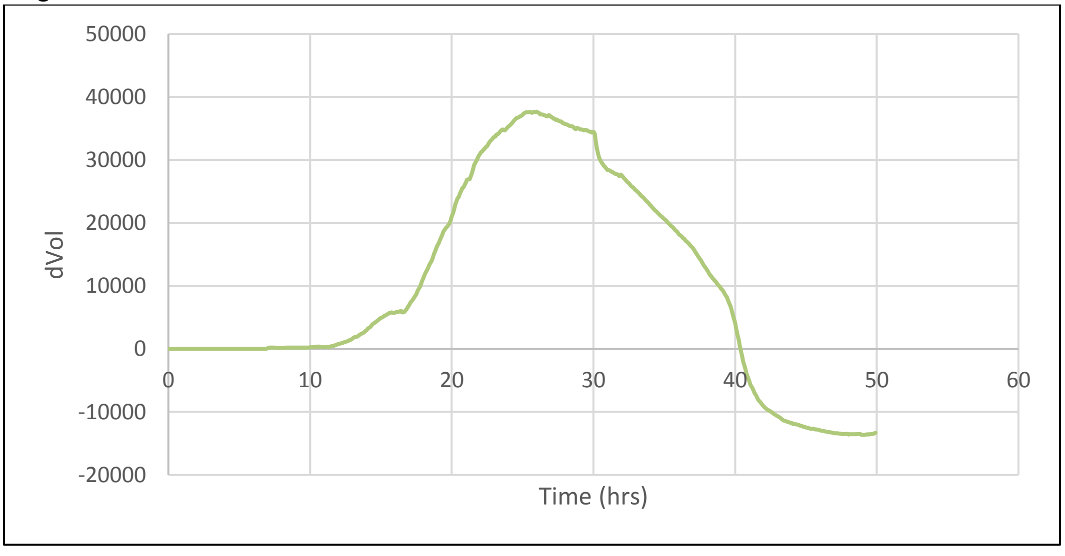


Figure 7-3: : 2D dVol Plot - Baseline 1% AEP

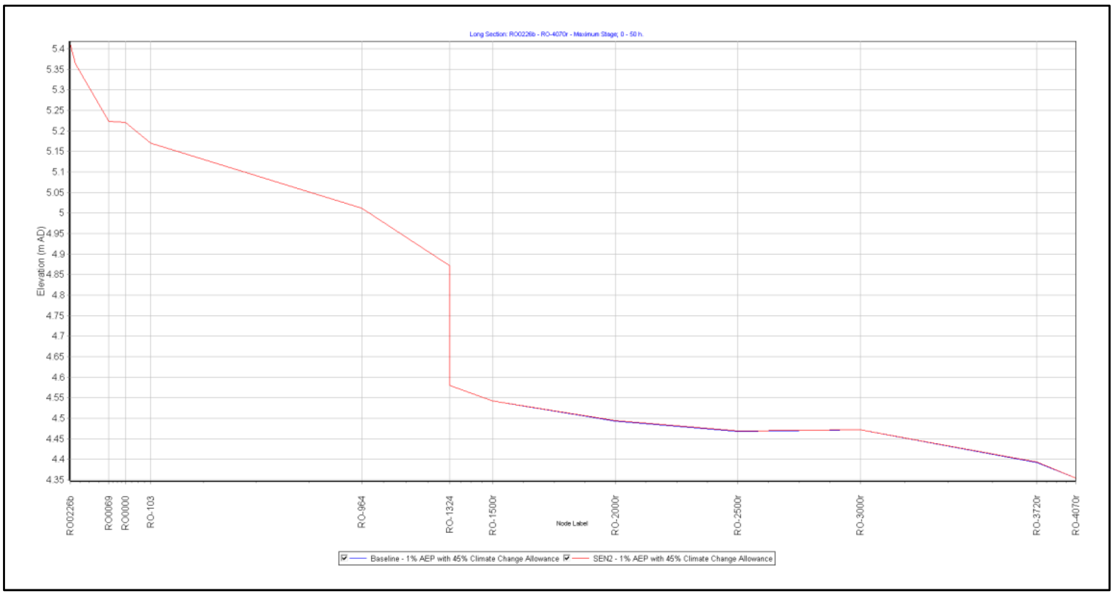


8. Sensitivity Testing

As part of the model updates, the slope used to generate the 2d HQ boundary was increased from 0.0002 to 0.0007 to aid model stability. This change in slope is not significant and remains a relatively flat gradient. The 1D Normal Depth boundary remained unchanged with a slope value of 0.0002. A sensitivity test was undertaken using the 1%AEP+45%CC event on the HQ boundary. Model simulations were carried out with the boundary slope adjusted by - 20% (SEN1) and +20% (SEN2). The model crashed in the -20% slope scenario which sets the downstream HQ boundary slope to 0.00058. The instability leading to the model simulation failure was located between the floodplain embankment and downstream boundary. The +20% sensitivity scenario (SEN2) results were compared to the Baseline.

The 1D long section shows little to no variation in peak water level between the Baseline and SEN2 scenario (Figure 8-1). This is expected as the 1d downstream boundary was not part of the sensitivity test.

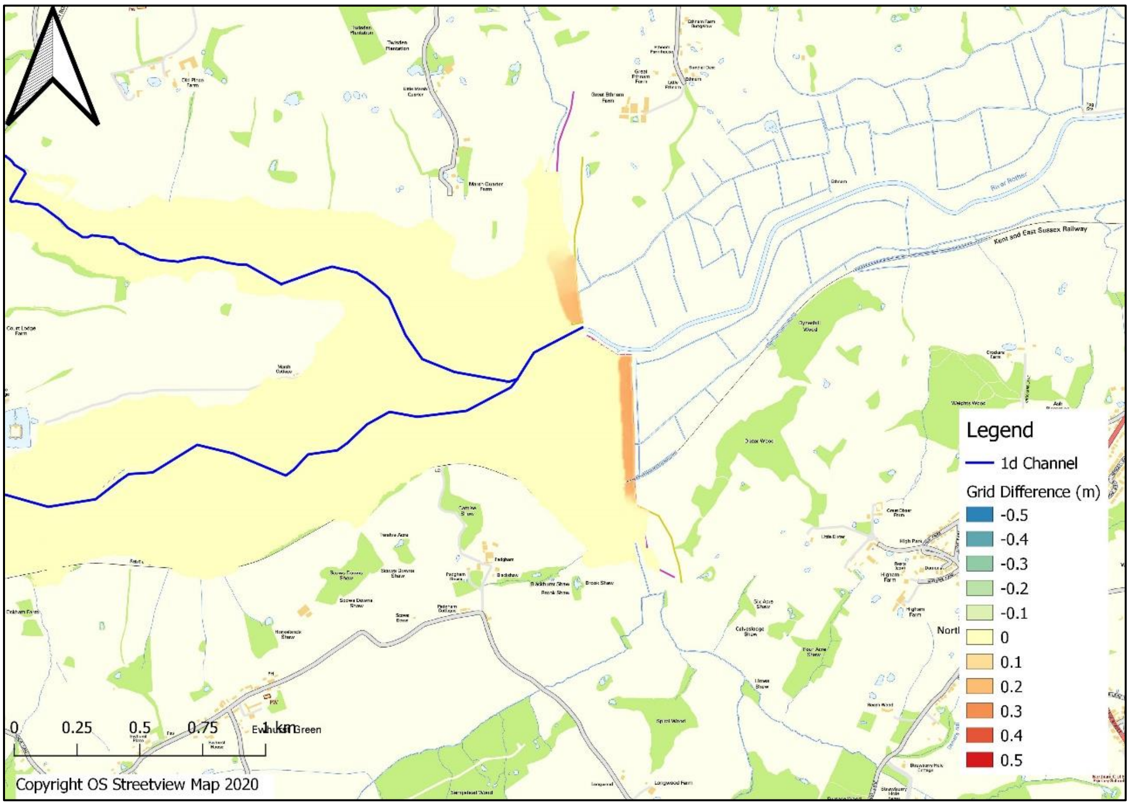
Figure 8-1: Comparison of Long Section - Udiam Gauge to Downstream Boundary



Comparison of the maximum water levels in the floodplain close to the downstream boundary shows a difference of up to 300 mm and 200 mm in the South and North floodplains respectively (Figure 8-2). The increase is broadly limited to the area between the downstream HQ boundary and the floodplain embankment. Upstream of the embankment the predicted maximum water level is essentially the same between both scenarios.

The floodplain embankment elevation is approximately 4.2 mAOD in the North floodplain and 4 mAOD in the South floodplain. The ground levels between the floodplain embankment and HQ boundary are approximately 2 mAOD. The embankment is acting as a control, preventing floodplain flow from reaching the 2d HQ downstream boundary in flood events up to and including the 1% AEP design event. In larger flood events the floodplain embankment is overtopped.

Figure 8-2: Difference Maximum Water level between SEN2 and the Baseline scenario



The sensitivity test demonstrates that the model results upstream of the floodplain embankment and not overly sensitive to the 2D HQ boundary and the increase in slope from 0.0002 to 0.0007 is not significant. The floodplain embankment has a more significant impact on controlling floodplain water levels than the HQ boundary. The change in the downstream boundary does not impact on the model results in the main study area. This analysis provides confidence in the approach adopted for the downstream boundary.

9. Assumptions and Limitations

9.1 Introduction

Several assumptions have been made during the model build and are described below. Limitations have been outlined in section 9.3

9.2 Key Assumptions in the Hydraulic Model

Assumption	Comments
Cell Size	The multi domain model consists of a 20m and 5m cell size which represents the 2D floodplain and flow across the model extent. The cell size is considered suitable for representing floodplain and flow paths within the study area.
Manning's Roughness	The Manning's '*n*' values applied across the model extent are consistent with the values used in the 2016 model.
Model Timestep	Standard modelling practice is for 1D timestep to be ½ of the 2D timestep. In addition to this the 2D timestep is typically ½ the grid cell size. The Flood Modeller timestep was set at 1 second and the 2D timestep was set to 2 seconds.
Downstream Boundary	The downstream boundary location and connection to the 1D model domain is consistent with the 2016. Some minor amendments were made to the orientation of the downstream boundary location based on local topography, to aid model stability.
HX Boundary 1D/2D	The HX boundary type is considered a more appropriate approach to representing the interface between the river channel (modelled in 1D) and the floodplain (modelling in 2D). The SX connections along the riverbanks were updated to HX connections. The stability of the model was checked to confirm this did not have an adverse impact on model stability.
Bank representation	The defences layer in the lower reach of the model was defined using a limited number of elevation points, these were supplemented with elevation points based on LIDAR to improve the representation of the embankments.

9.3 Limitations

This section highlights the limitations off the modelling approach used and any restrictions that might apply to the specific model that was constructed.

- The model grid resolution is considered suitable given the nature of the floodplain. However, the results should be interpreted in the context of the relevant (5 m or 20 m) spatial discretisation.

- The model does not specifically include all small watercourses and tributaries. However, inflows from these are accounted for within the hydrological estimates.

- The ‘with railway’ scenario is based on the available design drawings. The invert levels of floodplain culverts may be refined at detailed design stage. However, this is not anticipated to significantly impact the conclusions of the modelling.

10. Conclusion

On 19 April 2018, Rother Valley Railway Limited (RVR) applied to the Secretary of State for Transport for the Rother Valley Railway (Bodiam to Robertsbridge Junction) Order under the 1992 Act. A Public Inquiry has been called and the Inspector requested further environmental information relating to the Environmental Statement. This included an update to the flood risk analysis.

The updated assessment of flood risk has included updates to the flow estimation calculations and the incorporation of the latest climate change guidance. The flood model has been updated to include the revised design flows and allowances for climate change. Other than these updates the most significant update to the model was the extension of the 5 m domain downstream of Salehurst.

This report describes the updates made to the multi-domain 2016 FM-TUFLOW model of the River Rother. The updated model results have informed and are reported in the Flood Risk Assessment Addendum (2021).

Comparisons were made between the 2016 and 2021 model, to understand the impact of updating the lower reach 20 m domain to a 5 m domain. Results found that the impact on 1D and 2D peak water level were negligible and within model tolerance. A sensitivity run was carried out on the update to the 2D HQ boundary and demonstrated that the downstream boundary has limited and localised influence on predicted flood levels.

The 2021 version of the Rother model provides a suitable representation of the study area, which enables the impact of the proposed Rother Valley Railway on flood risk to be assessed.