CAPITA

Technical Note

Project	Tynybryn Footbridge and Culvert	**Project Number**	CS100270
Title	Tynybryn Footbridge Options Modelling Note		
Revision	V3.0	**Date**	09/12/2021
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1 Introduction

Capita have been appointed by Redstart, on behalf of Rhondda Cynon Taf Borough Council, to model the proposed option for a new footbridge and channel realignment on the River Ely in Tynybryn, Tonyrefail. This document sets out the method used for the assessment and the model results. This Technical Note follows on from *Tynybryn Footbridge Baseline Modelling Note* which outlines the approach and results to the development of the baseline model.

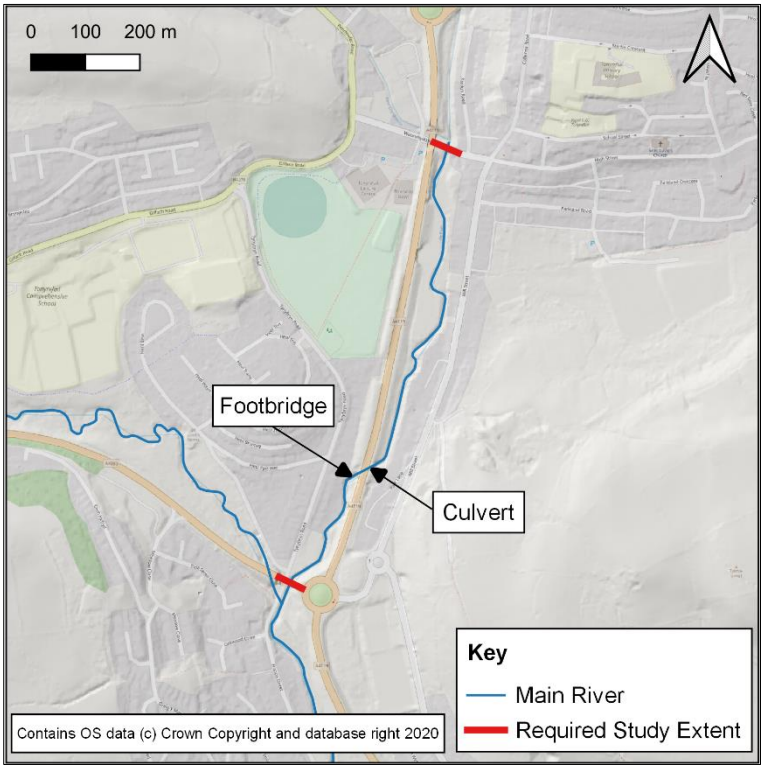
2 Scope

During Storm Dennis in February 2020, high flows and debris in the River Ely led to significant scour of key structures on the watercourse, notably the culvert beneath the A4119 (300761, 187615) and the concrete pedestrian footbridge downstream of the culvert (300726, 187596). Redstart, on behalf of Rhondda Cynon Taf Council, are looking at options to protect the structures and mitigate scour in the future. The scope of this current study is to assess possible options for mitigating scour and replacing the pedestrian footbridge with a bridge suitable for Active Travel at Tynybryn.

3 Study Area

The study area is the River Ely in Tonyrefail between Waunrhydd Road and the A4093 roundabout shown in Figure 1. The River Ely flows north to south. The Nant Erin tributary joins the River Ely just downstream of the A4093 roundabout.

Figure 1 Study extent



4 Data Available

The data available to establish the options model is listed in Table 1.

Table 1 Data available

Name	Data Type	Data Owner	Date	Comments
River Ely 1D Hydraulic Model	Flood Modeller (ISIS)	NRW	2020	Model developed during baseline stage of this study
Design Drawings	CAD	Redstart/ RCTBC	2021	GC3893-RED-78-XX-DR-S-0103-Cross Sections.pdf GC3893-RED-78-XX-DR-S-0102-0103-Hydrology.dwg Drawing with selected sections for new design.

5 Proposed Design

The proposed design comprises the following elements which are illustrated in Figure 2 and Figure 3:

- Demolition of the existing footbridge.
- Building of a new 4m wide footbridge at the same location, but at a shallower angle across the river channel to lessen the bends in the footpath either side of the bridge with a proposed soffit level of 116.39-116.59mAOD.
- Reducing the significant step at the culvert outlet by bringing the bed level up to within 350mm of the culvert invert using blockstone.

- Reshaping the channel profile between the culvert and footbridge replicating the trapezoidal shape of the culvert through the reach thus widening the channel. Downstream of the footbridge, the channel is widened but the banks steepened compared to the culvert profile to tie into the concrete retaining wall downstream.
- Lessening the angle of the bend downstream of the footbridge to mitigate scour.
- Inclusion of small blockstone weirs within the bed at 10m intervals rotated 15 degrees to dissipate energy, mitigate scour and support retention of bed material.
- Inclusion of baffles within the culvert to promote fish passage.
- Building of a temporary footbridge immediately downstream of the culvert outlet to maintain access to the medical centre. The soffit of the temporary bridge will be above the baseline modelled 1% AEP plus climate change water levels.
- Infilling of large scour hole upstream of culvert (this has not been modelled as will assume previous channel dimensions).

Figure 2 Plans of proposed option design downstream of culvert

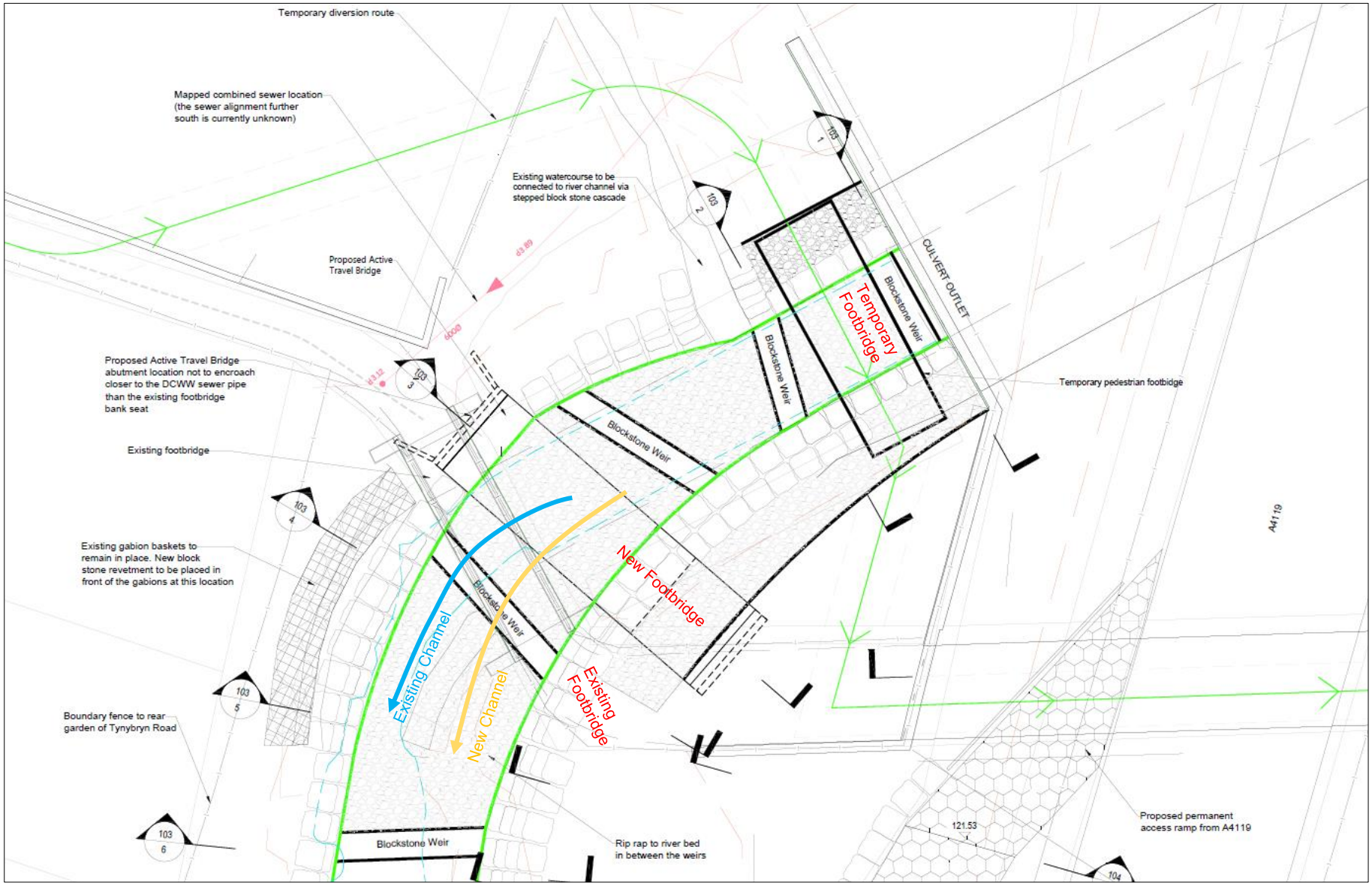
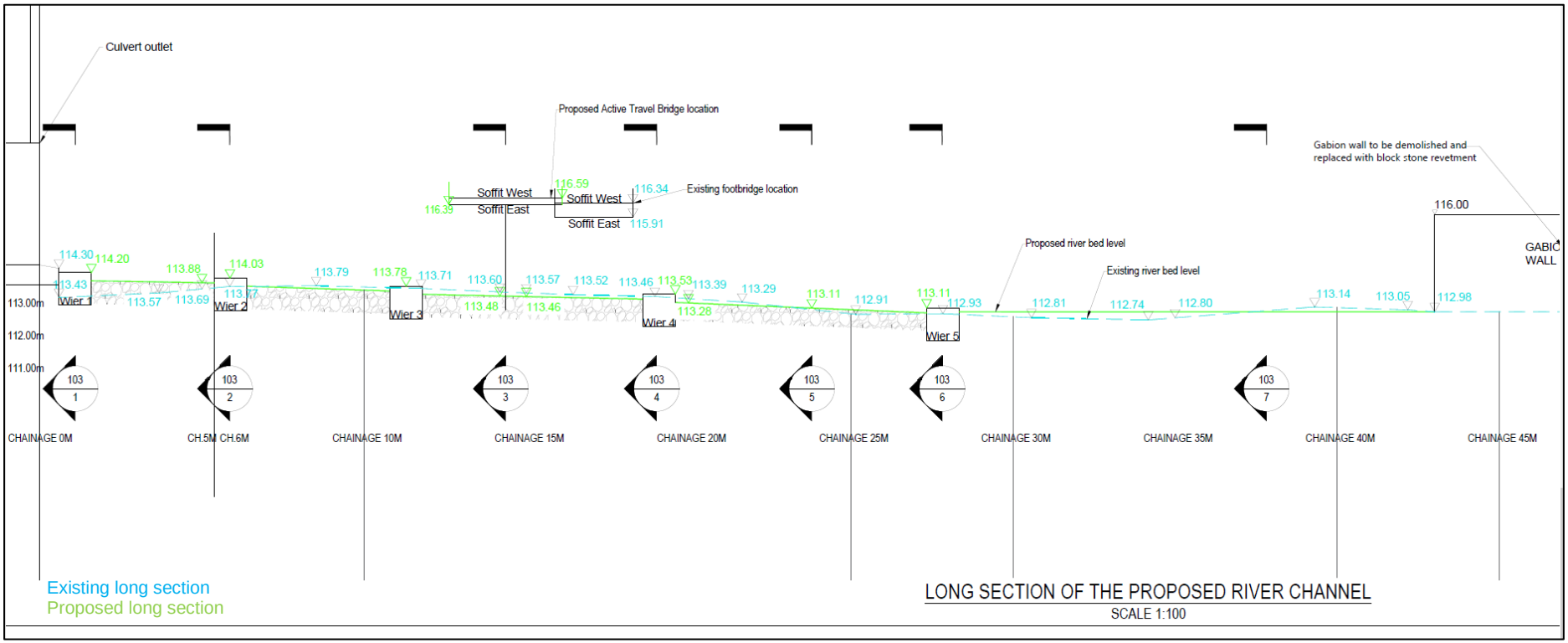


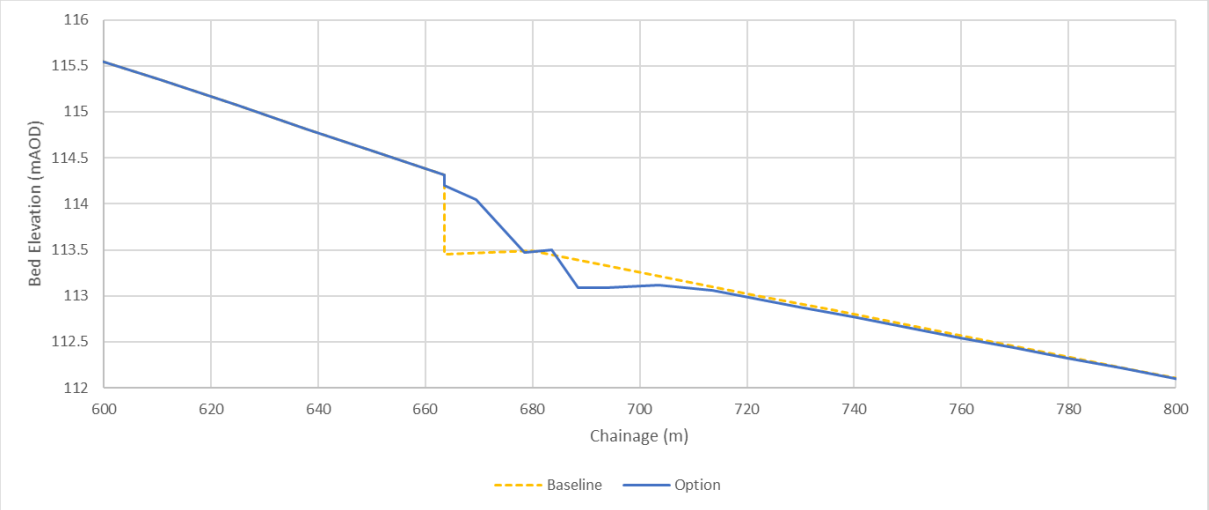
Figure 3 Long section showing difference between existing and proposed bed level and inclusion of small weirs



Section changes

Figure 3 shows an indicative long profile of the propose small blockstone weirs that will be embedded within the channel to create small steps to mitigate scour and promote retention of bed material. This has been generalised within the hydraulic model (shown in Figure 4) as the features are too small to include within the model. Figure 4 also shows the change from the existing bed profile downstream of the A4119 culvert.

Figure 4 Comparison of long section between baseline and proposed option



The change in cross sections between the baseline and proposed option are shown in the drawings in Appendix A.

Materials

It is proposed that the realigned and reshaped channel upstream of the footbridge will comprise rock armour blockstone supporting rip rap block armour on the bank slopes. The bank tops will be covered in erosion control matting to promote vegetation growth.

Downstream of the proposed footbridge both the channel bed will comprise rip rap and banks will comprise rock armour blockstone due to the steepness of the bank slopes. Further details of the proposed materials are shown in the drawings in Appendix A.

6 Model Update

The baseline 1D Flood Modeller model developed in September 2020 has been updated to reflect the proposed option. The updates are concentrated between the A4119 culvert and section ELY00850 which is 140m downstream of Tynybryn footbridge. The final model version is Tynybryn_057_Op.dat.

Updates to the model included:

- Colebrook White Friction factor within A4119 culvert (nodes A4119cu and A4119cd) increased to represent the inclusion of baffles on the culvert invert.
- Increased the bed level in the river section (Section 1 in drawings) immediately downstream of the culvert (node A4119d) to 114.2mAOD and reshaped the channel cross section.
- Replaced node A4119dIn1 with ELYOP02 and reshaped cross section based on Section 2 in drawings.
- Replaced node ELY00710 with ELYOP03 and reshaped cross section based on Section 3 in drawings

- Replaced bridge unit ELY00710bu with ELYOP03BRU (based on Section 3 in drawings) with soffit level at 116.39mAOD and assumed deck level 0.5m above at 116.89mAOD.
- Replaced the cross section at ELY00710d with ELYOP03DS, the downstream face of the new active travel bridge, to replicate the cross section beneath the bridge.
- Included new sections ELYOP04-08 based on Sections 4-8 in drawings.
- Created new interpolated sections between ELYOP08 to ELY00850.
- The temporary footbridge has not been included within the model as it will be a clear span construction with the soffit level designed to be above the baseline 1% AEP plus 70% climate change modelled water level.

The roughness values for each section between A4119cu and ELY00850 have been updated to reflect the materials being used in the proposed design. The Manning's n values for each material are shown in Table 2. Sensitivity testing on the roughness values has also been undertaken with the results discussed in Section 7.

Table 2 Roughness values used for updated sections

Material Type	Details	Manning's n value
Rip rap rock armour	Average 400mm diameter, ungrouted	0.040
Rock armour blockstone	Approximately 1.5t blocks	0.030
Erosion control matting	With some assumed light brush coverage	0.050
Bed material	Assumed existing material	0.040

7 Results

Options Model

The results show that the modelled water levels for the proposed option are reduced within the reach for all AEP events compared to the baseline model apart from at the downstream face of the culvert (A4119d) in the 50% and 20% AEP events where water levels are slightly higher. This is likely due to the increase in bed level at the outlet to mitigate scour.

Table 3 shows the difference in water levels between the baseline and option model for each modelled AEP event at selected nodes upstream of and through the study reach. The absolute levels from the Baseline model and Options model are shown in Table 4 and Table 5.

Table 3 Difference in water levels from baseline model (option minus baseline)

%AEP	Return Period	Difference in water level (m) from baseline model at selected nodes*					
		ELY00500ln3 100m u/s of culvert	**A4119u** U/s of culvert	**A4119d** D/s of culvert	**A4119dln1/ ELYOP02** Between culvert and fb	**ELY00710bu/ ELYOP03BRU** Footbridge	**ELY00850** 120m d/s of footbridge
50	2	0.00	-0.27	0.07	-0.08	-0.33	0.00
20	5	0.00	-0.22	0.01	-0.09	-0.30	0.00
10	10	0.00	-0.18	-0.02	-0.10	-0.28	0.00
5	20	0.00	-0.15	-0.04	-0.10	-0.24	0.00
4	25	0.00	-0.14	-0.04	-0.09	-0.23	0.00

3.3	30	0.00	-0.13	-0.04	-0.09	-0.22	0.00
2	50	0.00	-0.11	-0.04	-0.08	-0.18	0.00
1	100	0.00	-0.09	-0.03	-0.06	-0.13	0.00
0.5	200	0.00	-0.07	-0.02	-0.03	-0.07	0.00
0.1	1000	0.00	-0.03	-0.01	-0.02	-0.03	0.00
1+CC	100CC25	0.00	-0.06	0.00	-0.01	-0.04	0.00
1+CC	100CC70	0.00	-0.03	0.00	-0.01	-0.03	0.00

*negative value indicates reduction in water level compared to the baseline modelled level

Table 4 Absolute modelled water levels – Baseline model

%AEP	Return Period	Absolute water levels (mAOD)					
		ELY00500ln3 100m u/s of culvert	**A4119u** U/s of culvert	**A4119d** D/s of culvert	**A4119dln1/ ELYOP02** Between culvert and fb	**ELY00710bu/ ELYOP03BRU** Footbridge	**ELY00850** 120m d/s of footbridge
50	2	118.00	116.73	114.87	114.76	114.65	112.85
20	5	118.14	116.89	115.03	114.90	114.79	113.00
10	10	118.23	116.98	115.13	114.99	114.89	113.10
5	20	118.33	117.08	115.23	115.09	114.99	113.21
4	25	118.36	117.11	115.26	115.13	115.03	113.25
3.3	30	118.39	117.13	115.29	115.16	115.05	113.28
2	50	118.46	117.21	115.36	115.24	115.13	113.37
1	100	118.57	117.31	115.47	115.35	115.24	113.49
0.5	200	118.69	117.43	115.64	115.53	115.41	113.65
0.1	1000	118.98	117.75	115.90	115.79	115.67	113.86
1+CC	100CC25	118.74	117.48	115.59	115.48	115.36	113.61
1+CC	100CC70	118.97	117.74	115.91	115.81	115.69	113.87

Table 5 Absolute modelled water levels – Options model

%AEP	Return Period	Absolute water levels (mAOD)					
		ELY00500ln3 100m u/s of culvert	**A4119u** U/s of culvert	**A4119d** D/s of culvert	**A4119dln1/ ELYOP02** Between culvert and fb	**ELY00710bu/ ELYOP03BRU** Footbridge	**ELY00850** 120m d/s of footbridge
50	2	118.00	116.46	114.94	114.68	114.32	112.85
20	5	118.14	116.67	115.04	114.81	114.49	113.00
10	10	118.23	116.80	115.11	114.90	114.62	113.10
5	20	118.33	116.93	115.19	115.00	114.75	113.21
4	25	118.36	116.97	115.22	115.03	114.80	113.25
3.3	30	118.39	117.00	115.25	115.06	114.83	113.28
2	50	118.46	117.09	115.32	115.16	114.95	113.37
1	100	118.58	117.22	115.44	115.29	115.11	113.49
0.5	200	118.69	117.36	115.58	115.45	115.30	113.61

%AEP	Return Period	Absolute water levels (mAOD)					
		ELY00500In3 100m u/s of culvert	**A4119u** U/s of culvert	**A4119d** D/s of culvert	**A4119dIn1/ ELYOP02** Between culvert and fb	**ELY00710bu/ ELYOP03BRU** Footbridge	**ELY00850** 120m d/s of footbridge
0.1	1000	118.98	117.72	115.90	115.79	115.66	113.87
1+CC	100CC25	118.74	117.42	115.64	115.52	115.37	113.65
1+CC	100CC70	118.98	117.71	115.89	115.78	115.64	113.86

Sensitivity Testing

A sensitivity run, testing changes in roughness, have been undertaken on four AEPs: 20%, 2%, 1% plus 25% climate change and 1% plus 70% climate change. The tests were as follows:

1- Global roughness increased by 20% across study reach (culvert to ELYOP08)

2- Roughness decreased by 20% across study reach (culvert to ELYOP08)

The difference in maximum modelled water levels from the baseline and options model for selected nodes for Test 1 are shown in Table 6, with the results for Test 2 in Table 7. Where there is an increase in water level from either model up to 0.2m, this is highlighted in light blue with changes greater than 0.2m shaded in darker blue.

Table 6 Sensitivity test 1: Increased Manning's Roughness by 20%

INCREASED MANNINGs: 20%	%AEP	Return Period	Difference in water level (m) from baseline model at selected nodes*					
			ELY00500In3 100m u/s of culvert	**A4119u** U/s of culvert	**A4119d** D/s of culvert	**A4119dIn1/ ELYOP02** Between culvert and fb	**ELY00710bu/ ELYOP03BRU** Footbridge	**ELY00850** 120m d/s of footbridge
Difference from Baseline	20	5	0.00	-0.22	0.08	-0.01	-0.20	0.00
	2	50	0.00	-0.11	0.07	0.04	-0.06	0.00
	1+CC	100CC25	0.00	-0.06	0.14	0.13	0.11	0.00
	1+CC	100CC70	0.00	-0.03	0.21	0.22	0.22	0.00
Difference from Option	20	5	0.00	0.00	0.07	0.08	0.10	0.00
	2	50	0.00	0.00	0.11	0.12	0.12	0.00
	1+CC	100CC25	0.00	0.00	0.14	0.14	0.14	0.00
	1+CC	100CC70	0.00	0.00	0.22	0.23	0.25	0.00

Table 7 Sensitivity test 2: Decreased Manning's roughness by 20%

DECREASED MANNINGs: 20%	%AEP	Return Period	Difference in water level (m) from baseline model at selected nodes*					
			ELY00500In3 100m u/s of culvert	**A4119u** U/s of culvert	**A4119d** D/s of culvert	**A4119dIn1/ ELYOP02** Between culvert and fb	**ELY00710bu/ ELYOP03BRU** Footbridge	**ELY00850** 120m d/s of footbridge
Difference from Baseline	20	5	0.00	-0.22	-0.07	-0.19	-0.40	0.00
	2	50	0.00	-0.11	-0.18	-0.24	-0.37	0.00
	1+CC	100CC25	0.00	-0.06	-0.19	-0.23	-0.29	0.00
	1+CC	100CC70	0.00	-0.03	-0.23	-0.27	-0.30	0.00
Difference from Option	20	5	0.00	0.00	-0.08	-0.09	-0.10	0.00
	2	50	0.00	0.00	-0.13	-0.16	-0.19	0.00
	1+CC	100CC25	0.00	0.00	-0.19	-0.22	-0.25	0.00
	1+CC	100CC70	0.00	0.00	-0.23	-0.25	-0.28	0.00

The results shown in Table 6 and Table 7 indicate that the model is locally sensitive to changes in roughness value, particularly with increased water levels when roughness is increased. This change however does not have any impact upstream or downstream of the immediate subject reach meaning that any local adjustments or changes to materials should not affect river levels 100m upstream of the culvert or 120m downstream of the footbridge.

8 Conclusions

The proposed option for replacement of Tynybryn footbridge and associated works has been modelled in 1D in Flood Modeller software. The model geometry has been updated to reflect the proposed widening of the channel, new bridge design and bed changes. The roughness values of the culvert and affected reach have been updated to reflect the proposed materials.

The results of the modelling show that the water levels between the A4119 culvert and Tynybryn footbridge are reduced due to the channel widening and reshaping. The change in water levels is localised to immediately upstream of the culvert and 120m downstream of the footbridge. The soffit of the proposed footbridge (116.39mAOD) is well above the modelled 1% AEP plus 70% climate change water level (115.78mAOD).

Sensitivity testing has shown that the model is sensitive to changes in roughness within the study reach. Increasing roughness increases the maximum water levels of the proposed option, however these changes in water levels are localised to the affected reach and have no impact up or downstream. The water levels also stay below the soffit level of the proposed footbridge.

Appendices

Appendix A – Design drawings