

Afon Gwenfro Western Gateway FCA Modelling

Final Report

September 2010

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
Initial Draft Report (18/12/09)		Paul Sleeman
Draft Report (22/09/10)	Model & report update based upon revised design detail	Robert Browning
Final Report (27/09/10)	Minor Updates.	Robert Browning

Contract

This report describes work commissioned by Paul Sleeman on behalf of Wrexham County Borough Council, by a letter dated 5th November 2009. Krista Davies of JBA Consulting carried out this work.

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Purpose

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Executive Summary

This document describes the modelling work that has been undertaken to identify the change in flood risk from the River Gwenfro that may arise as a result of proposed changes to the existing structures running underneath the dismantled railway and Croesnewydd Road. Two options were also considered regarding changes to ground levels in this area:

1. Croesnewydd Road will be raised on an embankment above the existing levels; this option includes the modifications to the culverts. The new embankment stretches for approximately 100m to the south of the culvert and 150m to the north.
2. As above but also including a new proposed link road running along the course of the disused railway and intersecting with Croesnewydd Road a short distance to the north of the new structure on the Afon Gwenfro.

The key outcomes from the study are:

- The 1% and 1%+CC events show only very localised water level changes in the vicinity of the revised structures between scenarios.
- In the 0.1% AEP event the flow path along the disused railway from Croesnewydd Road to the hospital has been cut off and an additional $1.8\text{m}^3/\text{s}$ passes through the Croesnewydd Road culvert as a result. This has some local implications on flows and levels but the impact does not continue into the hospital site and Wrexham town centre.
- Adding the proposed link road causes some additional local changes in flood extent but again these do not propagate further downstream. No flood water is predicted to flow across the new link road provided that the road level is configured at or above 96.05mAOD.
- A peak water level of 93.43m is modelled at the inlet of the new Croesnewydd Road culvert during a 0.1% AEP design event compared to the proposed new soffit level of 93.69mAOD. No water is predicted to flow over the raised Croesnewydd road.

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Abbreviations

Abbreviation	Meaning
AEP	Annual Exceedance Probability
ASTSWF	Areas Susceptible to Surface Water Flooding
CEH	Centre for Ecology & Hydrology
DTM	Digital Terrain Model
DEM	Digital Elevation Model
LIDAR	Light Detecting and Ranging
TUFLOW	2 Dimensional Modelling Software

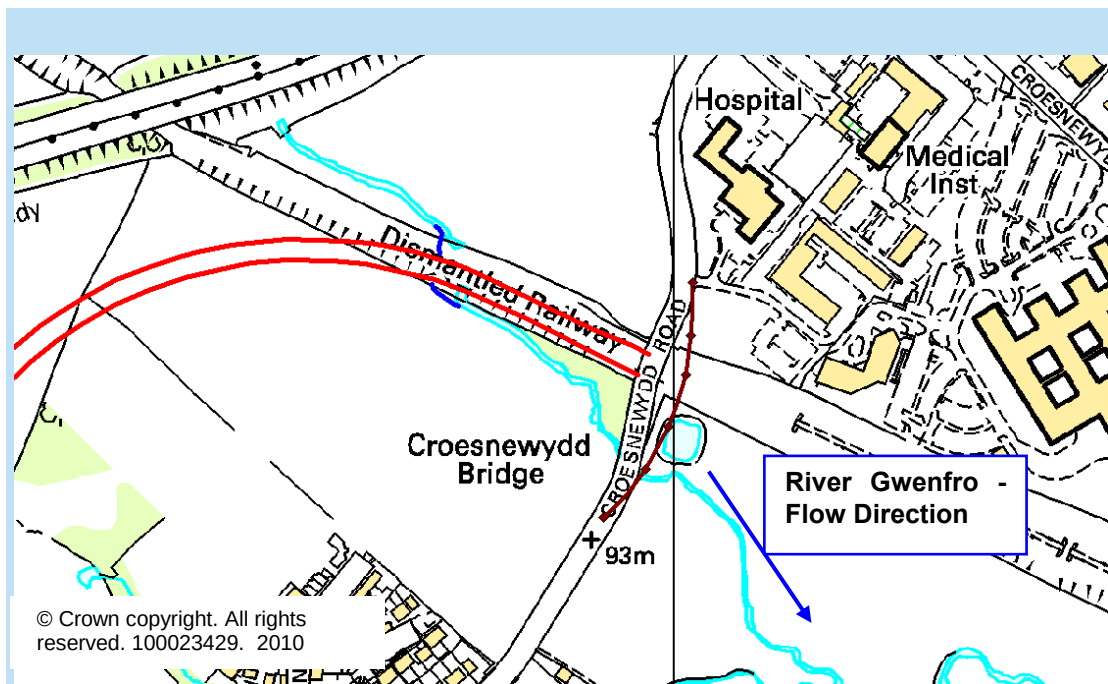
1. Introduction

1.1 Purpose and Scope of Study

This document describes the modelling work that has been undertaken to identify the change in flood risk from the River Gwenfro that may arise as a result of proposed changes to the existing structures running underneath the dismantled railway and Croesnewydd Road (Figure 1-1). This data will be used as part of a Flood Consequence Assessment (FCA) that will be submitted by Wrexham County Borough Council (WCBC) to support their proposal for a new spine road. The study will assess the impact of proposed changes to the structures during the 1%, 1% plus climate change and 0.1% AEP events.

The modelling work undertaken has used the existing ISIS-TUFLOW model of the River Gwenfro developed by JBA Consulting for Environment Agency in 2008 as part of a Floodplain Mapping Study. The study used a 1D ISIS model to represent the Afon Gwenfro river channel and a 2D TUFLOW model to improve the representation of the floodplain. The modelling extends downstream of the A483 road crossing, through Wrexham to the confluence of the Afon Gwenfro with the Afon Clywedog at Kings Mills. Further details about the model can be found within the Afon Gwenfro Modelling Report¹.

Figure 1-1: Proposed Changes to the Croesnewydd Road Area



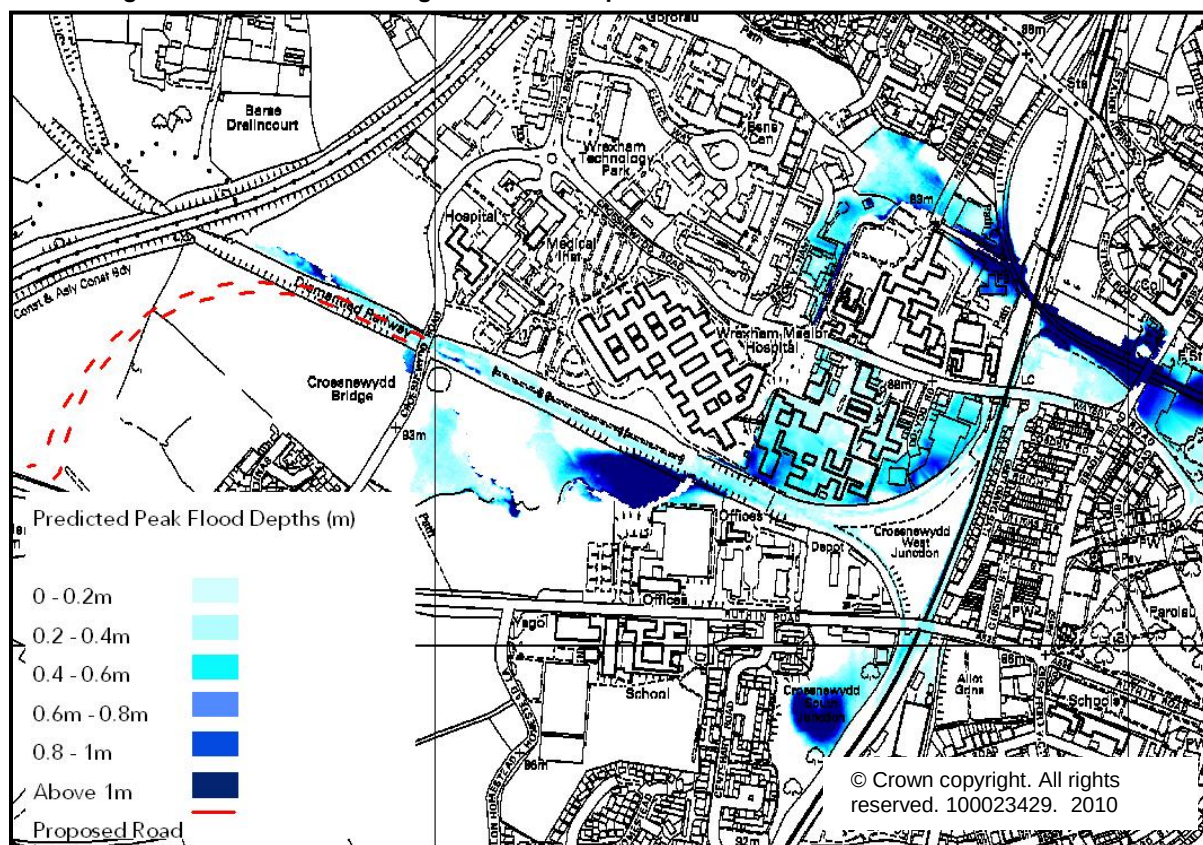
- 1) Replacement culvert under disused railway - Blue.
- 2) Replacement culvert under Croesnewydd Road, including realignment slightly downstream and raising of road - Brown.
- 3) Additional link road on line of disused railway - Red.

¹ Environment Agency Wales. Afon Gwenfro Flood Risk Mapping Study, Final Report (February 2009).

1.2 Existing Flood Risk

The existing flood risk during the 0.1% AEP event in the vicinity of the proposed road crossing is shown in Figure 1-2 below.

Figure 1-2 Predicted Existing Case Flood Depths for the 0.1% AEP Event



This shows that there is only a limited flood risk identified to the area upstream of Croesnewydd Road although the dismantled railway is shown to be an important flow route during the event, conveying floodwater downstream.

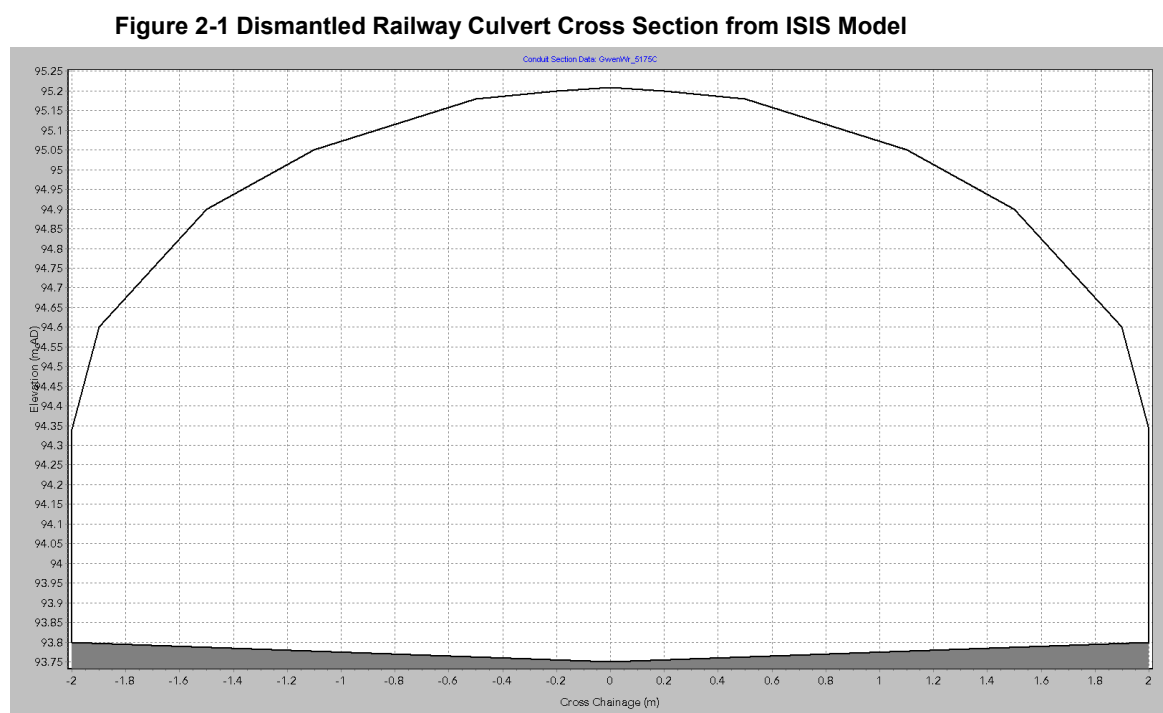
2. Updating the model

The sections below describe the existing representation of both structures within the model and the updates made to represent the proposed culverts.

2.1 Culvert underneath the Dismantled Railway

2.1.1 Existing case representation

Within the model, the culvert running underneath the dismantled railway is modelled as a 27m long culvert using a culvert inlet and outlet unit and symmetrical conduit units to define the barrel of the structure. This is shown in Figure 2-1 below.



The representation of the structure within the model compares favourably to the existing structure information provided on the proposal drawings prepared by WCBC, although the opening area has been calculated as 5.22m² compared to the 3.0m² detailed in the proposal drawings, this is shown in Figure 2-2 overleaf. The modelled area was based on site survey used in the Environment Agency model so has been retained with a 5.22 m² opening for this modelling exercise.

2.1.2 Representation of the Proposed Diversion Channel

The model has been updated to include a short diversion channel that will divert the Gwenfro away from its original course approximately 20m upstream of the existing structure to the new culvert that will be at a different alignment. A short reach of diversion channel is also needed at the downstream face. The geometry of the diversion channel has been defined using cross section drawings provided by WCBC. These are shown in Figure 2-3 to Figure 2-5 below.

Figure 2-2 Proposed Culvert at Dismantled Railway

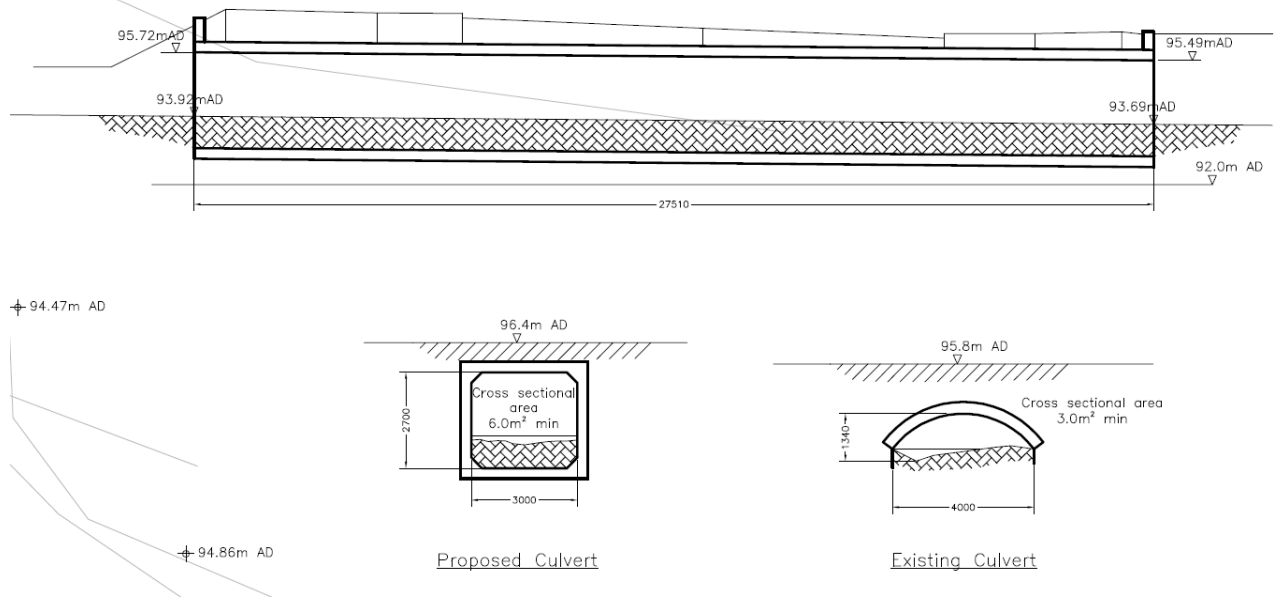


Figure 2-3 Location of Diversion Channel Sections

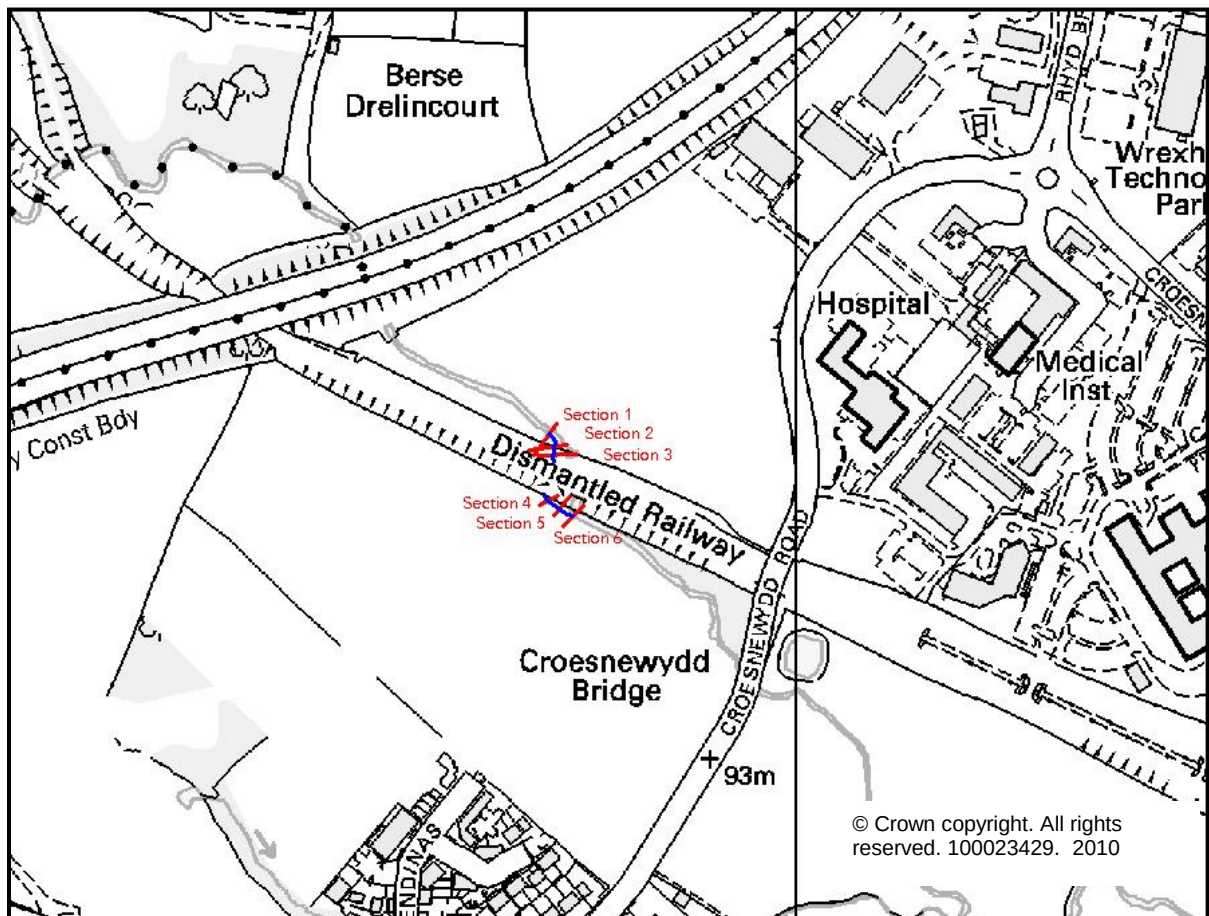


Figure 2-4 Proposed Diversion Channel Sections Upstream of the Dismantled Railway (looking upstream)

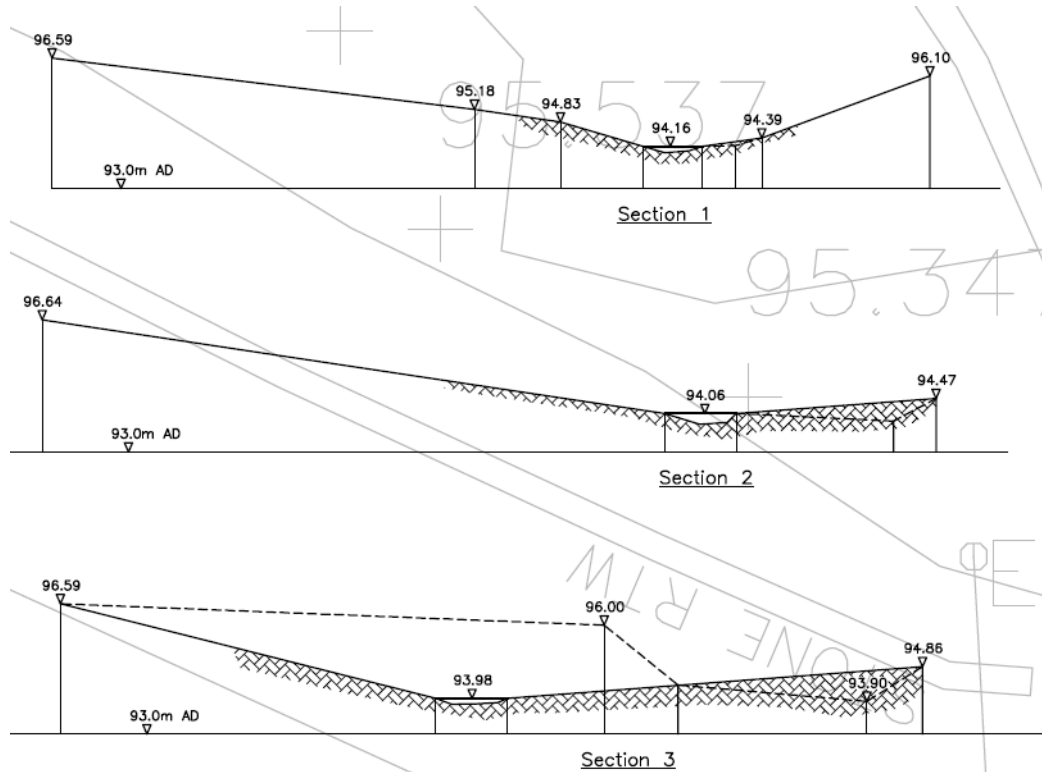
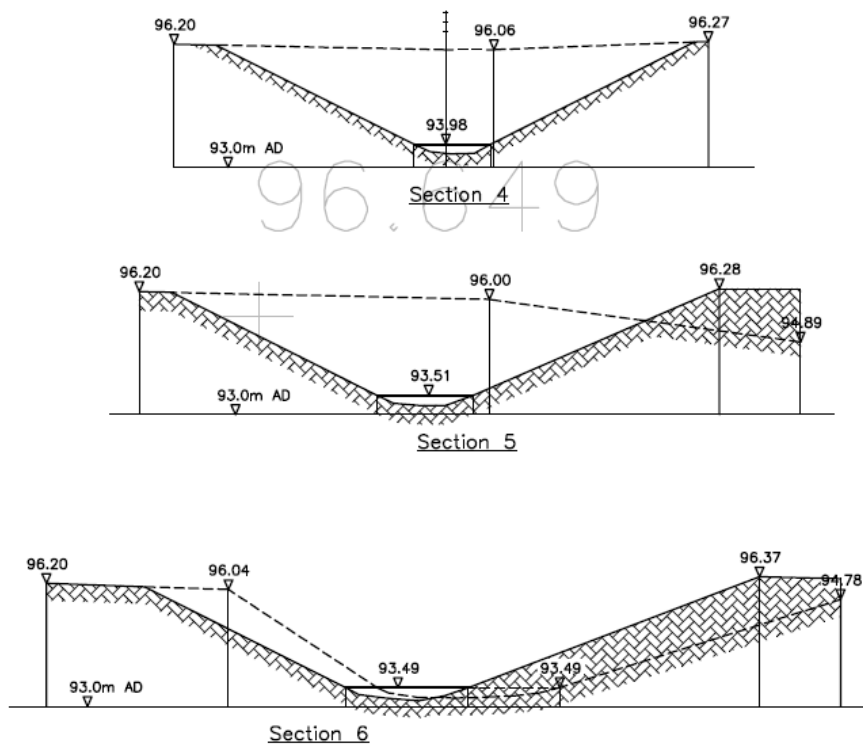


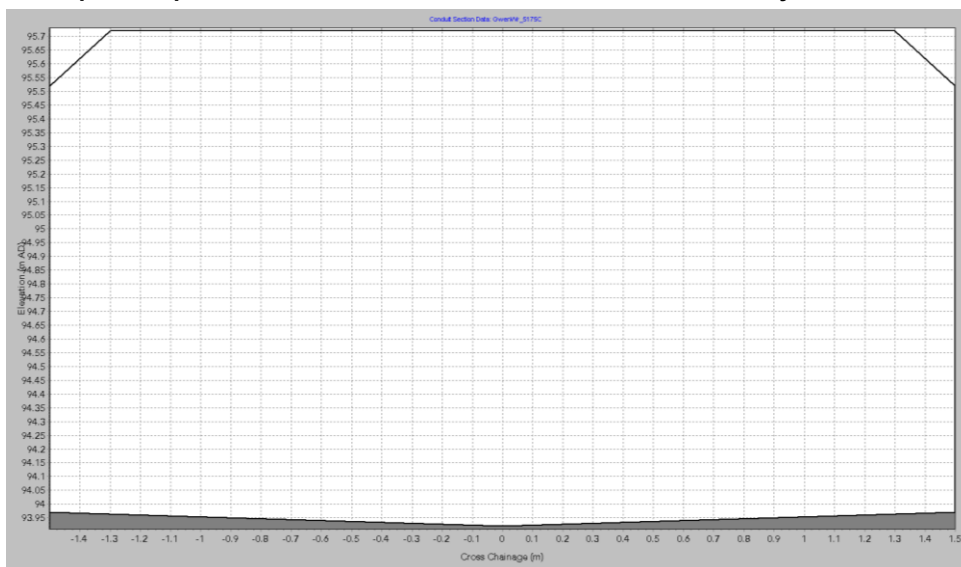
Figure 2-5 Proposed Diversion Channel Sections Downstream of the Dismantled Railway (looking upstream)



2.1.3 Representation of the Proposed Culvert

The proposed culvert underneath the dismantled railway has been included in the model by updating the geometry data within the symmetrical conduit units used to define the barrel of the existing culvert and replacing the culvert inlet unit already included in the model with an orifice unit. The proposed culvert width and the invert and soffit levels marked on the proposed long section (shown in Figure 2-2) have been used to define the 27.5m long culvert. The upstream face of the culvert barrel included in the model is shown in Figure 2-6 below.

Figure 2-6 Proposed Upstream Face of the Culvert at the Dismantled Railway included in the ISIS Model

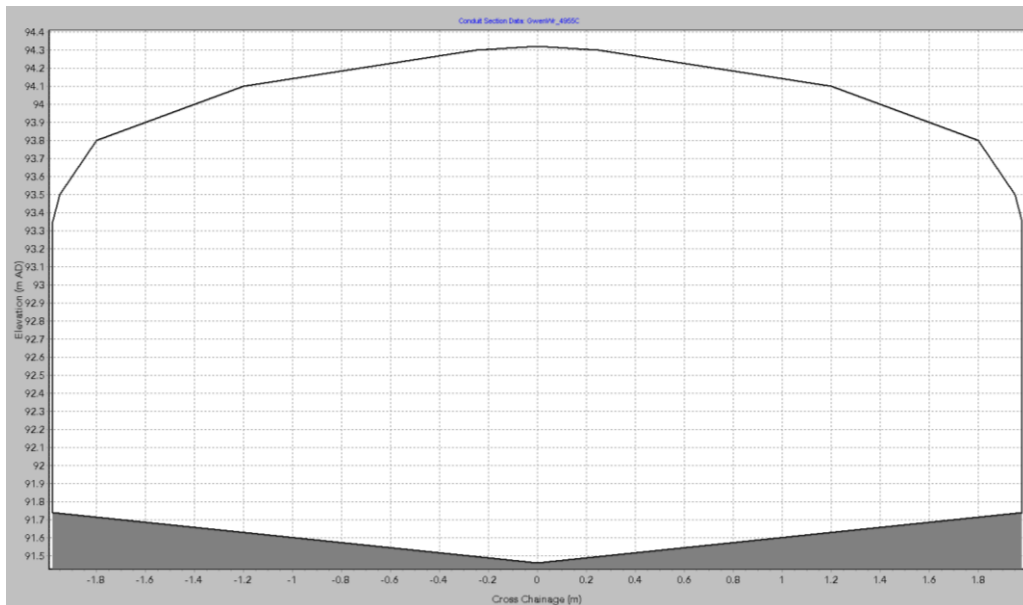


2.2 Croesnewydd Road Culvert

2.2.1 Existing case representation

Within the existing ISIS model, the Croesnewydd Road crossing is modelled as a culvert using culvert inlet and outlet units and symmetrical conduit sections. The geometry of the structure included in the model is shown in Figure 2-7 below. It is 8m long. The cross sectional area of the structure has been calculated as 9.62m².

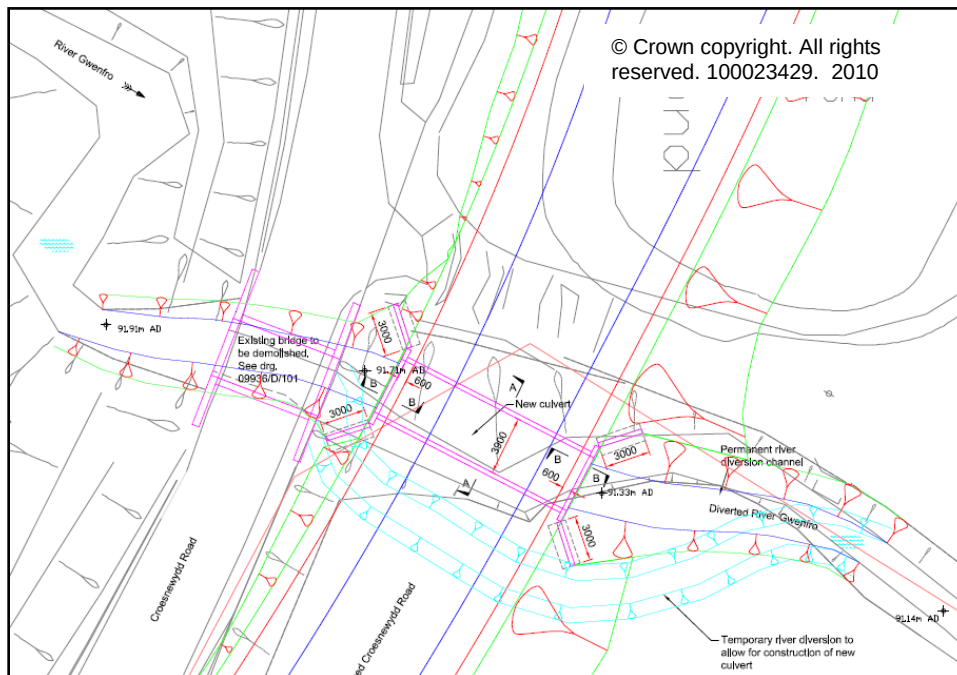
Figure 2-7 Croesnewydd Road Culvert Cross Section from ISIS Model

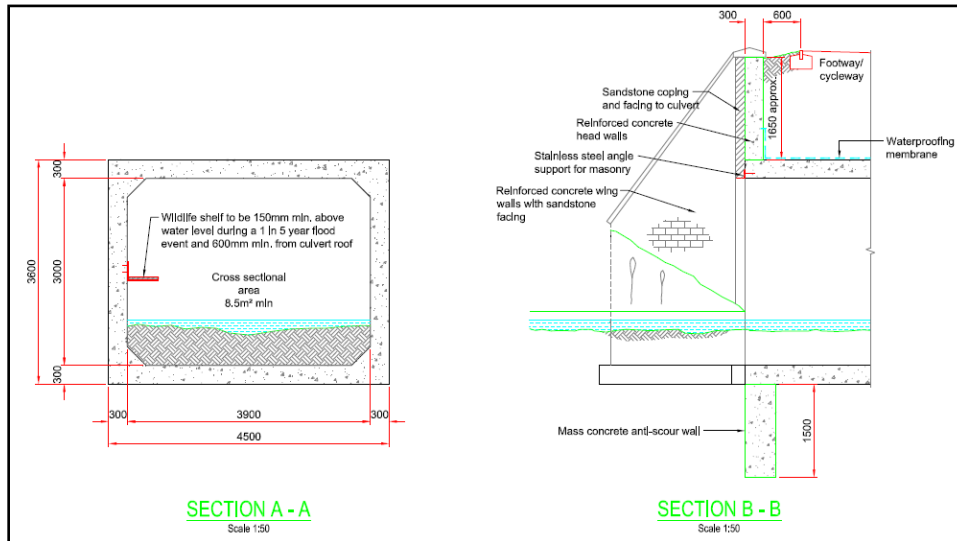


2.2.2 Proposed Culvert and Embankments

A new culvert and embankment is proposed to replace the existing Croesnewydd culvert. The new structure would be immediately downstream of the existing culvert and Croesnewydd Road would be on an embankment, eventually tying into a new link road along the route of the disused railway. The planned new culvert is shown in Figure 2-8.

Figure 2-8 Croesnewydd Road Culvert Cross Section taken from WCBC Proposal Drawings

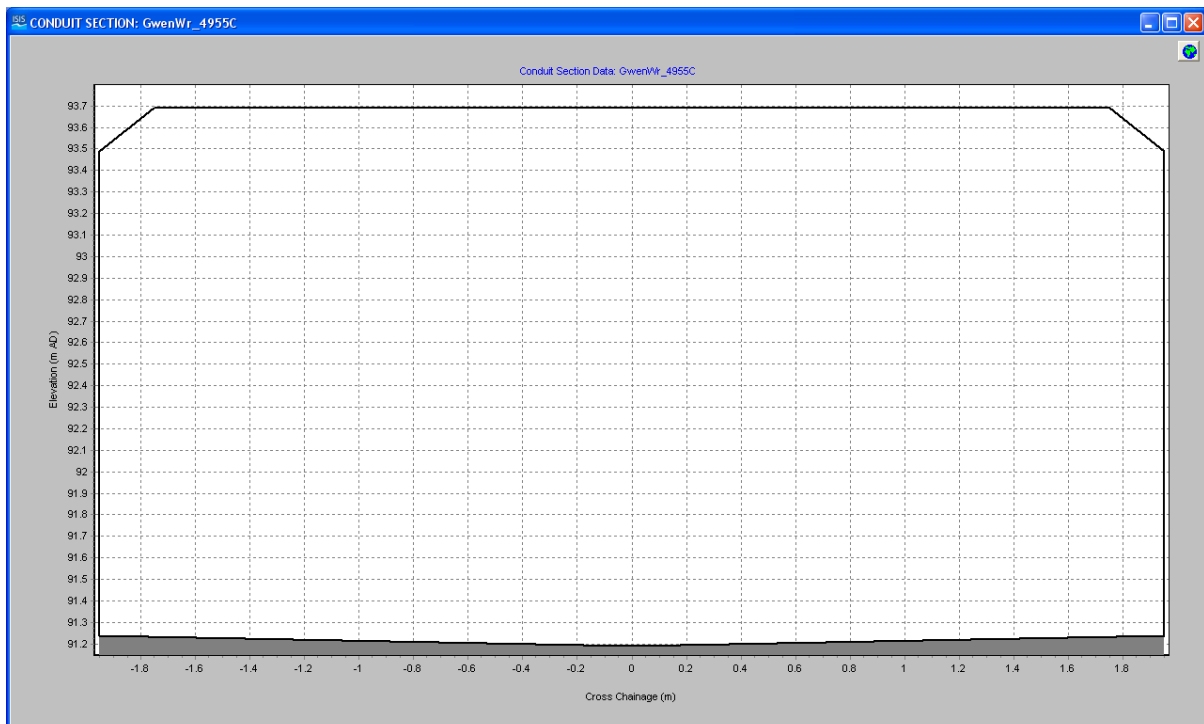




2.2.3 Representation of the Proposed Culvert and Embankments

To reflect the proposed culvert at Croesnewydd Road, the geometry of the existing culvert has been updated using the information provided by WCBC in Figure 2-9. The ISIS model has been updated to represent the new position and dimensions of the Croesnewydd Road culvert. The new culvert in the ISIS model has a height of 2.5m, width of 3.9m and a length of 14m. The culvert cross section is shown in Figure 2-9.

Figure 2-9 Proposed Upstream Face of the Culvert at Croesnewydd Road included in the ISIS Model



The TUFLOW model of the floodplain has been amended to link to the updated ISIS model and to consider two scenarios to represent the proposed embankments:

1. Croesnewydd Road has been raised on an embankment above the existing levels; this option represents the modifications to the culverts discussed above. The new embankment stretches for approximately 100m to the south of the culvert and 150m to the north.
2. As above but also including a new proposed link road running along the course of the disused railway and intersecting with Croesnewydd Road a short distance to the north of the new structure over the Afon Gwenfro.

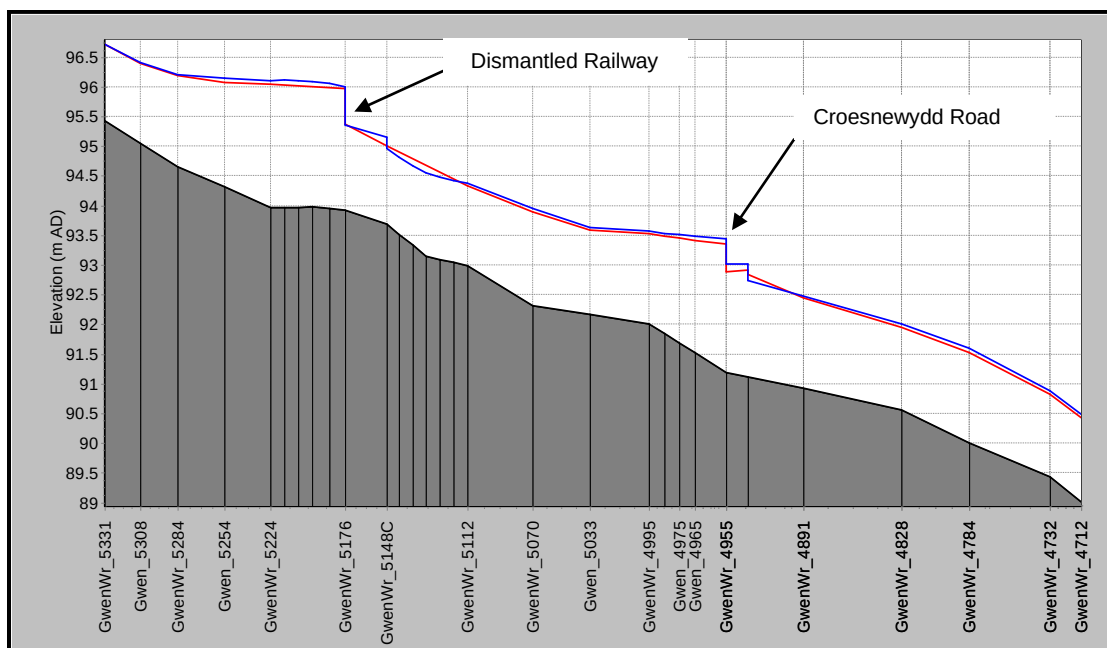
3. Model Results

The models containing the proposed culverts at the dismantled railway and Croesnewydd Road have been linked to the 2D TUFLOW model of the floodplain that includes the new height and alignment of Croesnewydd Road and have run for the 1%, 1% plus climate change and 0.1% AEP events. These events have also been run with the additional link road in place. The model results have then been compared to the model with the existing structures in place. The results are discussed below.

3.1 Local Impacts on Water Levels and Flows

Predicted peak water levels in the River Gwenfro during the 0.1% AEP event for the existing and proposed cases are shown in Figure 3-1. This long section shows that there are some localised changes in peak water levels as a result of the proposed new road structure. There are small (up to 80mm) local increases in water levels upstream of both Croesnewydd Road and, when the link road is raised, the dismantled railway, which result from the obstruction of the existing flow routes by the new embankments. The new culvert inlet at Croesnewydd Road is predicted to have a peak water level of 93.43mAOD compared to the culvert soffit level of 93.69mAOD.

Figure 3-1 Predicted Peak Water Levels in the River Gwenfro for the 0.1% AEP Event
(Red - existing risk; Blue - Croesnewydd and Link Road option)



There is no impact on flows through the Croesnewydd Culvert during the 1% AEP and 1% plus climate change events (Table 3-1). In these cases there are small localised changes in water level close to the structures resulting from the changes to the structures but no changes further upstream or downstream.

For the 0.1% AEP event there is a 1.6-1.8m³/s increase in flow through the Croesnewydd Road culvert as the flow route along the railway is cut off in the option models. The impacts of this further downstream are discussed in Section 3.3.

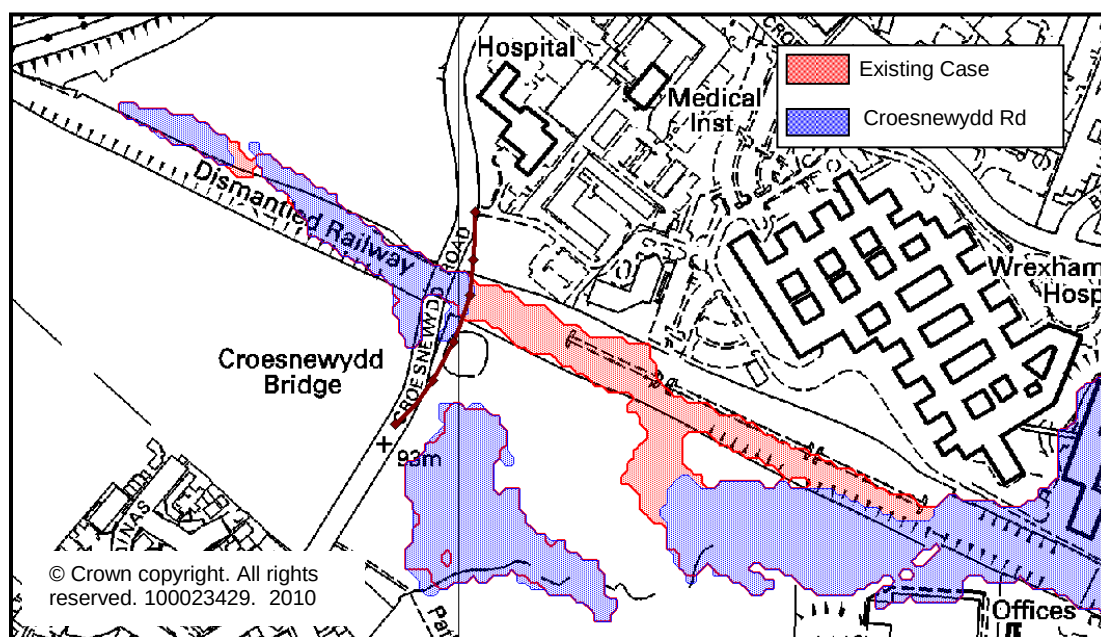
Table 3-1: Flows through Croesnewydd Road Culvert (m3/s)

	1% AEP Event	1% AEP+CC Event	0.1% AEP Event
Existing Case	9.9	11.9	15.4
Croesnewydd Road Only	9.9	11.9	17.2
Croesnewydd Road and Link Road	9.9	11.9	17.0

3.2 Local Impacts on Flood Extents

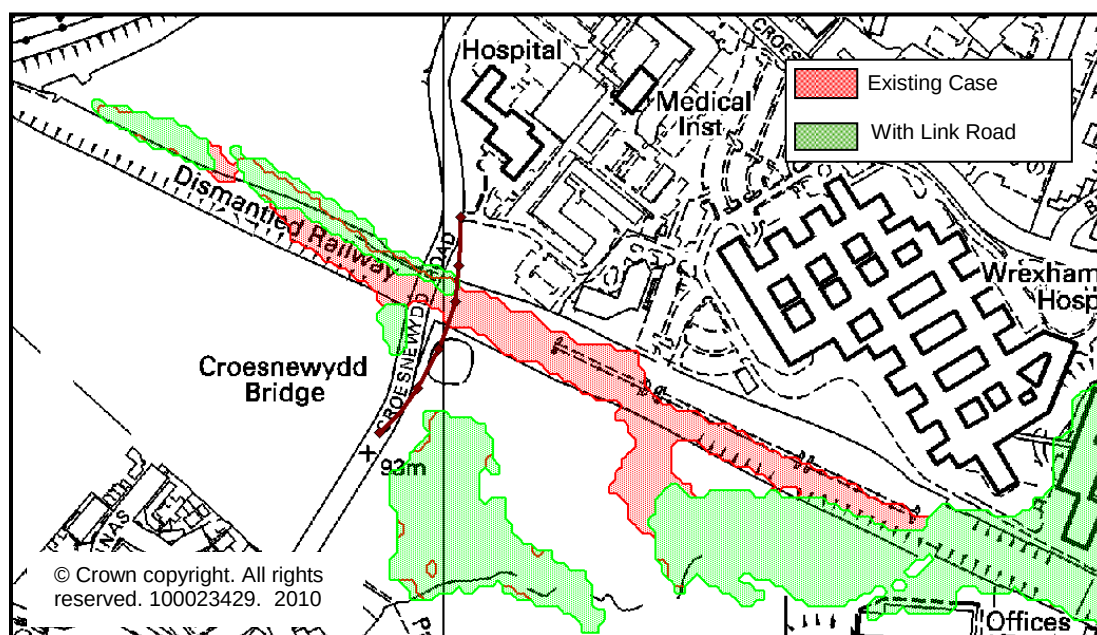
The new alignment and increased elevation of Croesnewydd Road stops the flow of water along the disused railway towards the hospital in the 0.1% AEP event (Figure 3-2). This leads to a slight increase in the flood extent both upstream and downstream of the Croesnewydd Road crossing, the latter being due to the additional flow that passes through the new proposed culvert. For the 1% and 1%+CC events there are only very localised changes in flood extent close to the structures.

Figure 3-2 Predicted Flood Extents for the 0.1% AEP Event - Existing case and with new Croesnewydd Road embankment and culvert



When the new link road is added to the model this produces only minor additional changes to the local flood outline in the vicinity of the roads (Figure 3-3). In addition, it should be noted that, provided that the link road is constructed to have a minimum elevation of 96.05m AOD between the railway culvert and Croesnewydd Road, then no overtopping of the proposed link road should occur as floodwater will remain ponded on the northern side of the link road. For the 1% and 1%+CC events there is essentially no difference in the flood extents as a result of the link road.

Figure 3-3 Predicted Flood Extents for the 0.1% AEP Event - With new Croesnewydd Road culvert and link road added



3.3 Downstream impacts on water levels

For the 0.1% AEP event the flows under Croesnewydd Road increase in the proposed scenarios by up to $1.8 \text{ m}^3/\text{s}$ (i.e. from $15.4 \text{ m}^3/\text{s}$ to up to $17.2 \text{ m}^3/\text{s}$) leading to some additional flooding in the vicinity of the road crossing. However, as the floodwater that would travel along the disused railway under existing conditions would rejoin the Gwenfro upstream of the hospital site, the water levels and flows are almost identical to the existing case in the vicinity of the hospital site (Figure 3-4 & Table 3-2). During the 0.1% AEP event, the impact of the proposed road arrangement downstream within Wrexham town centre is shown to be negligible. As such the changes to the flow regime following development remain fairly localised with more water being retained in the river channel rather than flowing along the disused railway as in the existing case.

Figure 3-4 Predicted Peak Water Levels in the River Gwenfro for the 0.1% AEP Event
(Red - existing risk; Blue - Croesnewydd and Link Road option)

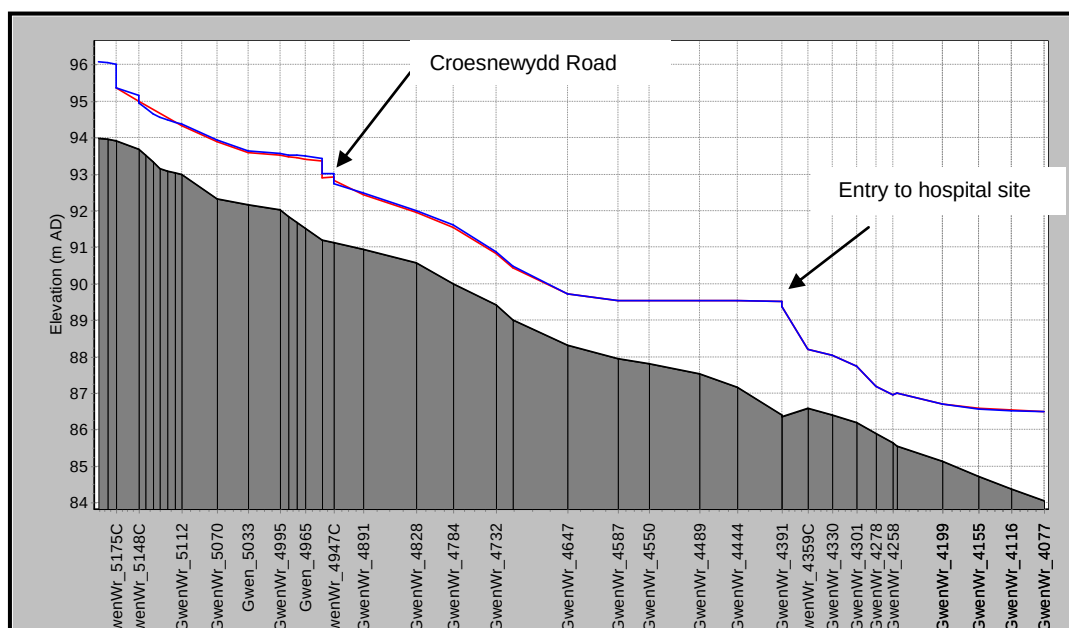


Table 3-2: 0.1% AEP Event Water levels and flows at various locations in Wrexham

		Maesgwyn Road Bridge (3771)	Inlet to Brook Street Culvert (3033)	Rivulet Road Culvert (2358)
Existing Case	Flow (m ³ /s)	11.0	17.1	11.6
	Level (mAOD)	83.14	76.81	72.59
Croesnewydd Road Only	Flow (m ³ /s)	11.0	17.1	11.6
	Level (mAOD)	83.14	76.81	72.59
Croesnewydd Road and Link Road	Flow (m ³ /s)	11.0	17.0	11.6
	Level (mAOD)	83.14	76.80	72.59

3.4 Downstream impacts to flood extents

Predicted flood extents from the 2D TUFLOW model for the 1%, 1% plus climate change and 0.1% AEP events are shown in Figures 3-5 to Figure 3-7 for both the existing case and the developed case in which both the link road and Croesnewydd Road have been raised. These show that downstream there are only localised and very minor variations to the flood extents as a result of the proposed development.

Figure 3-5 Predicted Flood Extents for the 1% AEP Event Downstream of the Proposed Development

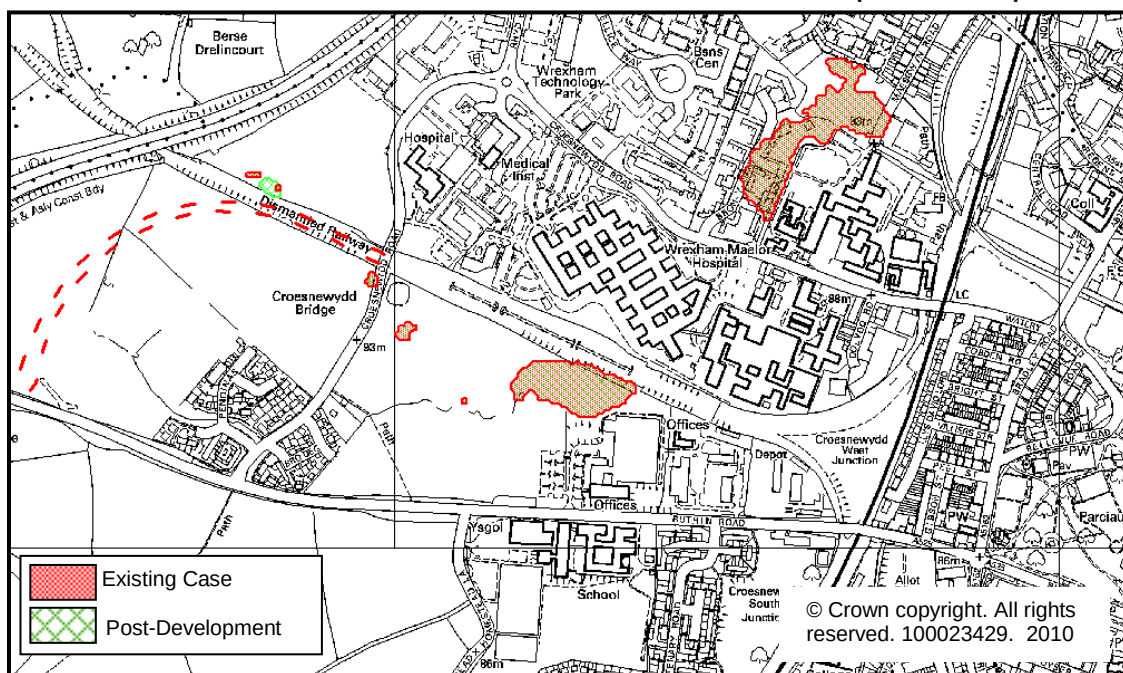


Figure 3-6 Predicted Flood Extents for the 1% Plus Climate Change AEP Event Downstream of the Proposed Development

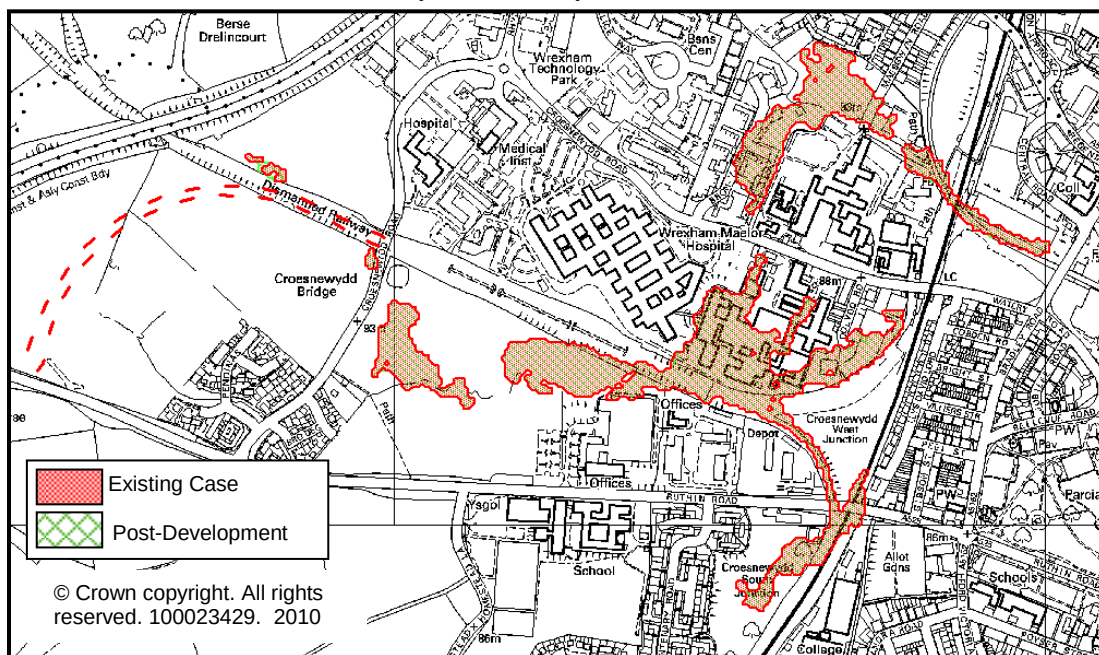
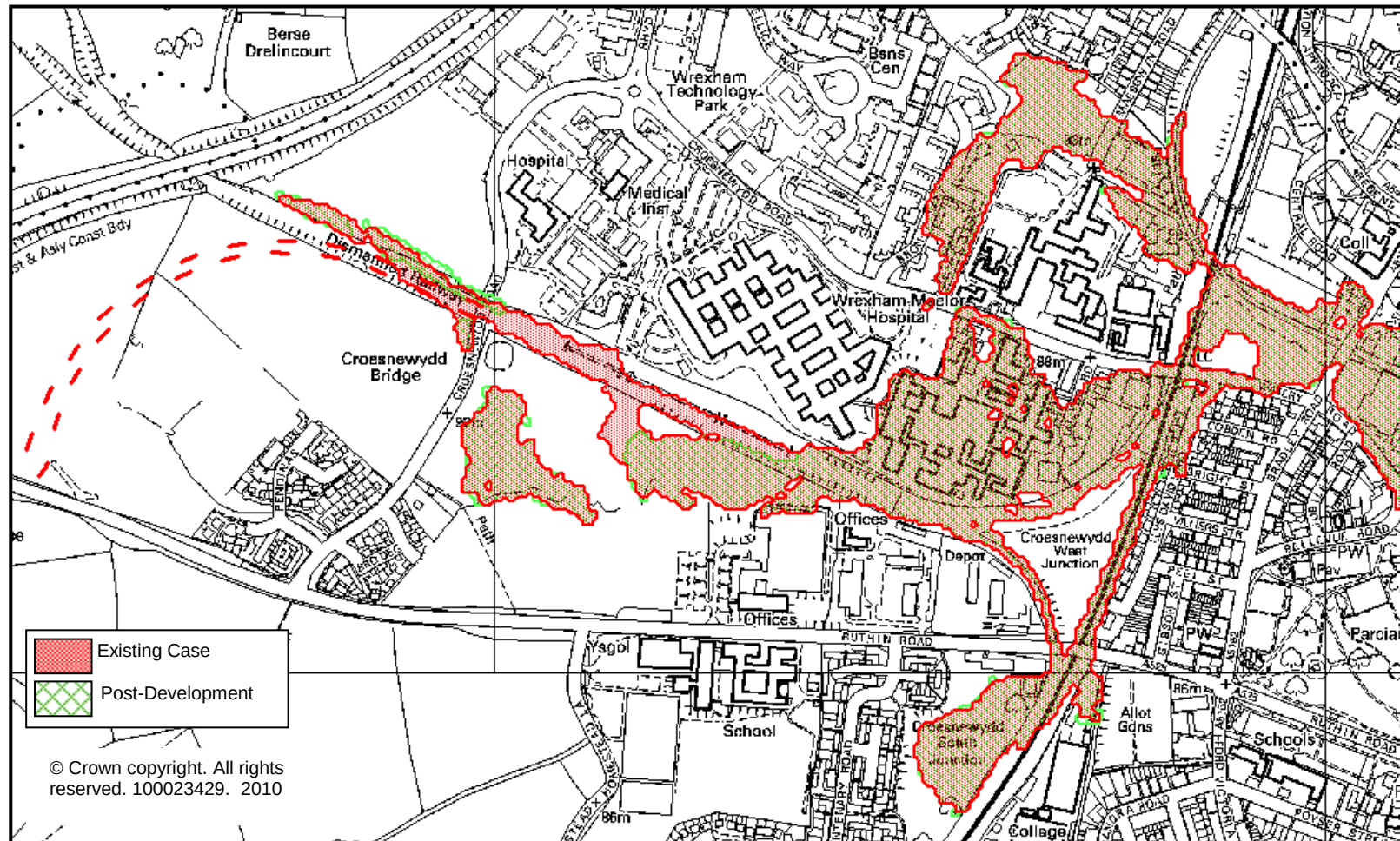


Figure 3-7 Predicted Flood Extents for the 0.1% AEP Event Downstream of the Proposed Development



4. Conclusions

Modelling work has been undertaken to identify the change in flood risk from the River Gwenfro that may arise as a result of proposed changes to the existing structures running underneath the dismantled railway and Croesnewydd Road. Two options were considered regarding changes to ground levels in this area:

1. Croesnewydd Road will be raised on an embankment above the existing levels; this option will also require a new culvert to replace the one at the existing location. The new embankment would stretch for approximately 100m to the south of the culvert and 150m to the north.
2. As above but including a raised new link road running along the course of the disused railway and intersecting with Croesnewydd Road a short distance to the north of the new structure on the Afon Gwenfro.

The key outcomes from the study are:

- For the 1% and 1%+CC events only very localised water level changes in the vicinity of the proposed structures are predicted.
- In the 0.1% AEP event the flow path along the disused railway from Croesnewydd Road to the hospital is cut off and this results in an additional flow of up to 1.8m³/s through the culvert underneath Croesnewydd Road. This has some local implications on flows and levels downstream but the impacts do not continue into the hospital site and Wrexham town centre.
- Adding the proposed link road causes some additional localised changes in flood extent between the disused railway culvert and Croesnewydd Road but once again this scenario does not propagate any changes further downstream into Wrexham. No flood water is predicted to flow across the new link road provided that the road level is configured at or above 96.05mAOD.
- A peak water level of 93.43mAOD is modelled at the inlet of the new Croesnewydd Road culvert during a 0.1% AEP design event compared to the proposed new soffit level of 93.69m. No water is predicted to flow over the raised Croesnewydd road.



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