Dinas Powys Active Travel Route

Flood Consequences Assessment

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Contents

1 INTRODUCTION

1.1 Background

1.1.1 Arcadis Consulting (UK) Limited ('Arcadis') has been commissioned by Vale of Glamorgan Council ('the Client') to undertake a Flood Consequences Assessment (FCA) for the proposed active travel route between Biglis Roundabout, Barry and Dinas Powys (referred to hereafter as 'the scheme').

1.1.2 The Welsh Government Development Advice Map (DAM)[1] classifies the site as being located in Zone C2, meaning it is located in a floodplain without significant flood defence infrastructure.

1.1.3 The FCA has been informed by detailed fluvial and tidal flood modelling undertaken to assess the risk to the proposed scheme and to help develop flood mitigation measures to ensure the development is safe and doesn't impact third party flood risk.

1.1.4 The FCA has been undertaken in accordance with Planning Policy Wales (PPW) Technical Advice Note 15 – Development and Flood Risk (TAN15)[2] and documents the approach taken to assess all sources of flood risk to the Site.

1.2 Aim and Objectives

1.2.1 Key objectives of the FCA are to:

- Undertake a desktop assessment of flood risk from all sources for the proposed active travel route.
- Consult with relevant stakeholders to collect baseline flooding data.
- Obtain river channel survey data in order to update the existing Natural Resources Wales (NRW) flood model.
- Undertake hydrological modelling for a range of annual exceedance probability (AEP) events to produce up to date flood hydrographs for application in the flood model.
- Update the existing NRW flood model and undertake detailed fluvial and tidal flood modelling to define baseline and post development flood risk.
- Produce a TAN15 compliant FCA report.

1.3 Terminology

1.3.1 Flood risk is a product of both the likelihood and consequences of flooding. Throughout this report, flood events are defined according to their likelihood of occurrence. Floods are described according to an 'annual chance', meaning the chance of a particular flood occurring in any one year. This is directly linked to the probability of a flood. For example, a flood with an annual chance of 1 in 100 (a 1 in 100 chance of occurring in any one year on average), has an annual exceedance probability (AEP) of 1%.

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[1] Welsh Government, TAN 15 Development and Flood Risk – Development Advice Map, https://gisgeoext.cyfoethnaturiolcymru.gov.uk/Geocortex/Viewers/Html5Viewer_4145/index.html?viewer=FloodRisk/

[2] Welsh Assembly Government, 2004, Planning Policy Wales, Technical Advice Note 15: Development and Flood Risk

1.4 Limitations

1.4.1 This report has been prepared for the Client in accordance with the terms and conditions of appointment. Arcadis cannot accept any responsibility for any use of or reliance on the contents of this report by any third party. The copyright of this document, including the electronic format shall remain the property of Arcadis.

1.4.2 This report has been compiled from several sources, which Arcadis believes to be trustworthy. However, Arcadis is unable to guarantee the accuracy of information provided by others. The report is based on information available at the time. Consequently, there is a potential for further information to become available, which may change this report’s conclusion and for which Arcadis cannot be responsible.

2 SITE OVERVIEW

2.1 Site Description

2.1.1 The proposed scheme is approximately 2 km in length and runs from the southeast of the roundabout known as Biglis roundabout, where Cardiff Road (A4055), A4231, and Sully Moors Road (B4267) meet, at approximate National Grid Reference (NGR) ST 14510 69140 to Dinas Powys (NGR ST 15642 71036). The route moves in a northeast direction and runs parallel to the south (and then east) of Cardiff Road. It intersects with the junction of Cardiff Road and Green Lane before crossing over Green Road. Continuing north, it merges back to the east of Cardiff Road and continues north until reaching a crossing at the entrance of Parc Bryn-y-Don. From there, it moves from the southeast to the northwest and into Heol Y Frenhines, reconnecting with Cardiff Road before utilising an existing signalised crossing to access St Cadoc's Avenue. The route then links with the existing shared route opposite St Teilo Close (NGR ST 15636 71035).

2.1.2 There are a number of watercourses in the vicinity of the scheme. The northern end of the route runs parallel to East Brook along St Cadoc's Avenue. The route runs parallel with the River Cadoxton for much of its length crossing it twice using existing highway bridges and a third time on a new proposed crossing. At the southern end the route runs parallel to unnamed watercourse near Biglis roundabout.

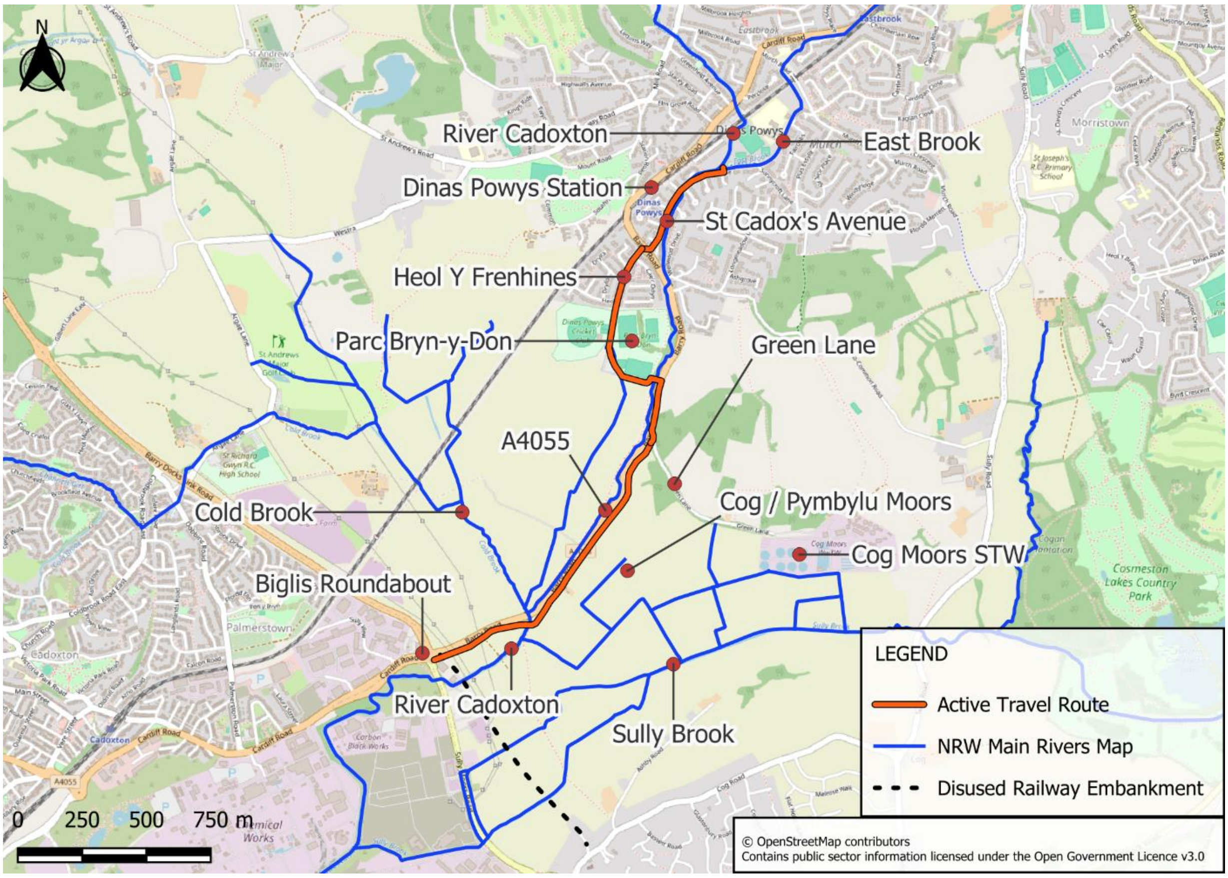

Figure 2-1 Scheme Location

2.2 Proposed Development

2.2.1 The proposals aim to improve the attractiveness and safety of walking and cycling routes to key facilities and employment in the Vale of Glamorgan.

2.2.2 The proposed scheme is to provide a shared cycle and footpath between Barry (from Biglis Roundabout) and Dinas Powys, connecting to existing National Cycle routes in Barry and Penarth, and further proposed routes across the Vale of Glamorgan. The scheme aims to promote active travel and reduce congestion by making cycling more attractive to commuters.

2.2.3 The northern section from Dinas Powys, along St Cadoc’s Avenue, Heol Y Frenhines and through Parc Bryn-Y-Don to the A4055 will use existing highway with amendments to road marking but no changes to ground levels.

2.2.4 The southern section of the scheme runs alongside the A4055 for a short distance before diverting off onto a newly constructed section that runs through agricultural land to the south of the A4055. This section of route will be embanked to raise it out of the floodplain.

2.2.5 A new bridge crossing of the River Cadoxton is proposed, consisting of a 12 m wide single span structure with a soffit level of 7.70 metres Above Ordnance Datum (mAOD) (to give 0.55 m freeboard above the 1 in 100 (1%) plus climate change peak fluvial flood level). Further cross drainage will be provided in the form of two 1 m by 0.5 m box culverts to the north of the new River Cadoxton crossing and four 300 mm circular culverts to the south of the new River Cadoxton crossing.

2.3 Site Topography

2.3.1 The proposed scheme runs across the low-lying Cog / Pymbylu Moors area, with ground levels as low as 5.4 mAOD in some areas. Higher levels are recorded at either end of the route; with ground levels at Biglis roundabout in the order of 7 mAOD and levels at Dinas Powys ranging between 9 and 21 mAOD.

2.3.2 The majority of the section of the A4055 that runs through the moors is elevated above the surrounding land, with levels typically 1 to 2 m above the surrounding ground. The A4055 road elevations increase in an easterly direction, with the lowest elevations near Biglis roundabout, where elevations are approximately 7.2 mAOD, raising up to 8.1 mAOD at the existing River Cadoxton bridge crossing and 9.7 mAOD at the junction with Green Lane.

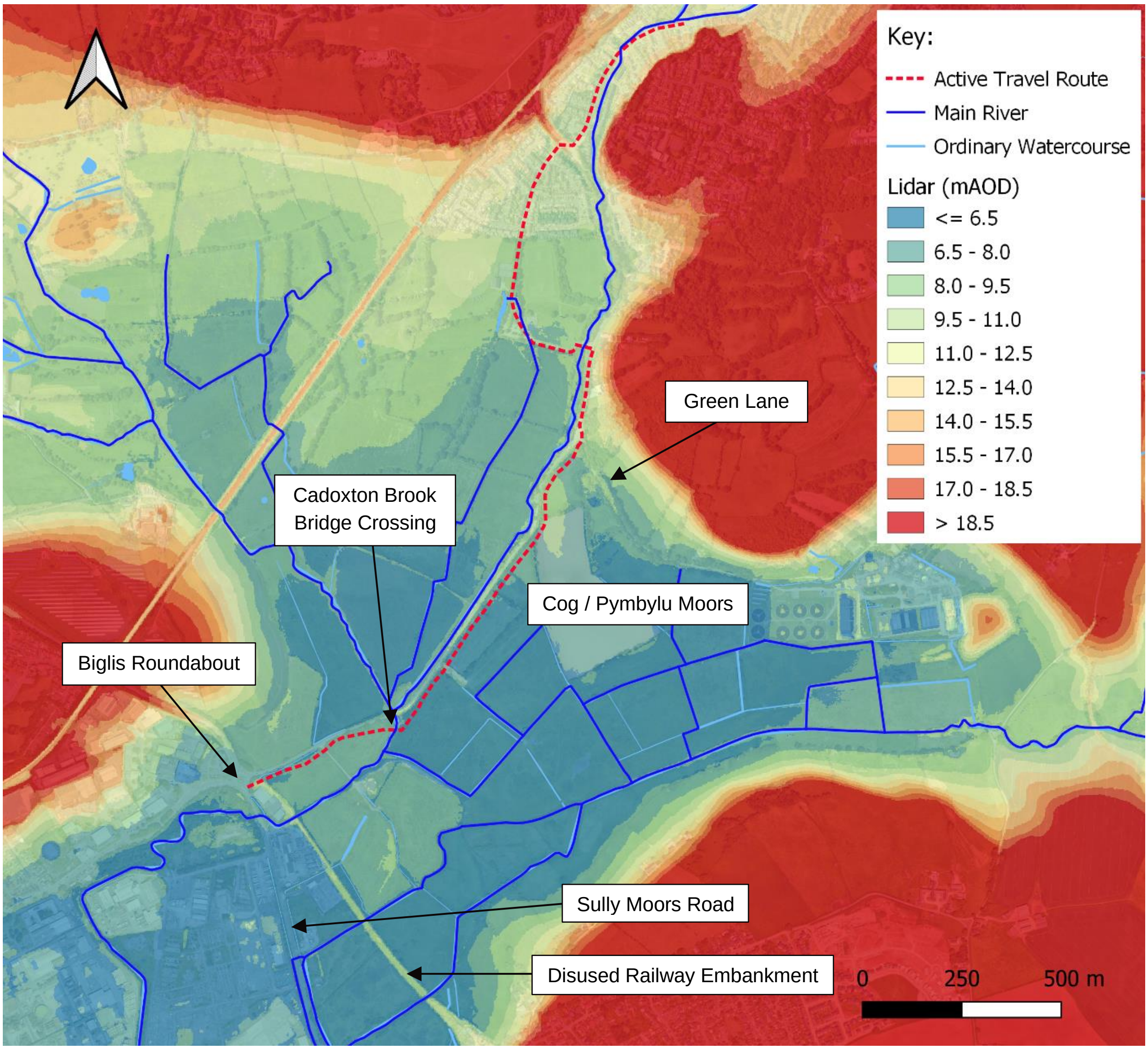

Figure 2-2 Site Topography

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2.4 Historical Flooding

2.4.1 The NRW Recorded Flood Extents[3] define the maximum extent of all recorded individual historical flood event outlines resulting from rivers, the sea and groundwater springs, and shows areas of land that have previously been subject to flooding in Wales. The map (Figure 2-3) shows a historic flood event from 27th January 1995, with the source of flooding being a main river exceeding its channel capacity.

Figure 2-3 NRW Historic Flood Extents

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2.4.2 Additional flood history information was supplied by NRW along with the flood models, as summarised in Table 2-1.

[3] NRW Flood and Coastal Erosion Risk Maps. https://flood-risk-maps.naturalresources.wales/?locale=en

Table 2-1: Flood history information

Date	Comment
Oct 1998	Widespread flooding of the industrial areas around Sully Moors Road. Some flooding of property adjacent to the watercourse in Dinas Powys.
Sept 1999	Widespread flooding of the industrial areas around Sully Moors Road. Some flooding of property adjacent to the watercourse in Dinas Powys.
24 Nov 2012	Affected properties in both Dinas Powys and around Sully Moors Road. There were no reports of internal property flooding at either location. In the Sully Moors Road area it was reported that floodwaters resulted in the closure of Sully Moors Road.
23 Dec 2012	Flooding to commercial properties lining Sully Moors Road, which were flooded externally and internally. Sully Moors Road and Hayes Road were closed to cars for a period of two days.
28 Oct 2013	Within Dinas Powys, floodwaters overtopped the footbridge at the confluence of the River Cadoxton and the East Brook but there were no reports of external or internal property flooding.

2.4.3 The Vale of Glamorgan Local Flood Risk Management Strategy[4] (LFRMS) notes historic flood events in October 1998 and October / November 2000 which affected Dinas Powys but did not specify the locations affected in any further detail.

2.4.4 Vale of Glamorgan Council, the Lead Local Flood Authority (LLFA), provided the following information of historical flooding at the site:

> *'On 23rd December 2020 there was widespread flooding in Dinas Powys and across the moors. Caer-Odyn and St Cadoc's Avenue were both badly flooded and Parc Bryn-y-Don was underwater as well.'*

2.4.5 The LLFA supplied the Section 19 report for the December 2020 event and notes that the Vale of Glamorgan Council identified that; 98 properties flooded internally, and 22 outbuildings and 74 gardens flooded across Dinas Powys through a combination of surface water and fluvial flooding.

[4] Vale of Glamorgan Council (December 2013). Local Flood Risk Management Strategy

2.5 Existing Flood Defences

2.5.1 The NRW flood maps show that the proposed scheme benefits from tidal defences. There is a tidal flood defence located on the River Cadoxton at the point it discharges to the coast (NGR: ST 13151 67249).

2.5.2 There is a short length of flood defence located along the left bank of the River Cadoxton, immediately upstream of the B4267, Sully Moors Road (NGR: ST 14566 69045). However, according to the NRW flood map, this does not provide a benefit to the proposed scheme.

2.5.3 Immediately south of Dinas Powys, there is a short length of flood defence located along the right bank of the River Cadoxton (NGR: ST 15422 70545). The flood map indicates that this provides protection to the properties located in the Cae'r Odyn area, between Heol Y Frenhines and the Cadoxton River.

2.5.4 Further information on the areas benefitting from the flood defences is given in Section 4.

3 TAN15 DEVELOPMENT AND FLOOD RISK

3.1 TAN15 Approach

3.1.1 TAN15 provides guidance to local planning authorities in determining planning applications with regard to flood risk and provides an interpretation of how this guidance applies specifically to a site. It *'provides a framework within which risks arising from both river and coastal flooding and from additional run-off from development in any location can be assessed'*. This *'precautionary framework should be used for both forward planning and development control purposes'*. Its operation is governed by:

- A Development Advice Map (DAM) containing three zones (A, B and C with subdivisions C1 and C2) which should trigger the appropriate planning tests in relation to Sections 6 and 7 and Appendix 1 (TAN15, para 3.2).
- Definitions of vulnerable development and advice on permissible uses in relation to the location of development and the consequences of flooding (TAN15, para 3.2).
- The approach is therefore a staged one:
  1. Categorisation of a site within TAN15 Flood Zones.
  2. Application of the TAN15 precautionary framework and determination of whether the proposed development is 'justified' in that zone (TAN15 Section 6 Test).
  3. Assessment of flooding consequences (TAN15 Section 7 Test and Appendix 1) and production of a Flood Consequences Assessment (FCA) report for submission alongside a planning application.

3.2 Flood Zone Categorisation

3.2.1 The TAN15 DAM is shown in Figure 3-1. This shows the scheme to be located within Flood Zone C2 (i.e. within the extreme flood extent (1 in 1000 (0.1%) AEP) and without significant flood defence infrastructure). The northern extent of the scheme is located within Flood Zone C1 (within the extreme flood extent (1 in 1000 (0.1%) AEP) and served by significant infrastructure, including flood defences).

3.2.2 The DAM is used alongside PPW and TAN15 to direct appropriate new development with respect to flood risk. TAN15 states that:

- Zone A - '*Used to indicate that justification test is not applicable and no need to consider flood risk further*.'
- Zone B - *'Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (1 in 1000 (0.1%)) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.'*
- Zone C1 – '*Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.'*
- Zone C2 - '*Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.'*

3.2.3 The proposed scheme would come under the TAN15 'less vulnerable development' classification and, therefore, is an appropriate development type for this area. However, as the site is within Zone C2, justification of its location is required and an FCA is required to demonstrate whether the development can proceed in line with the requirements of TAN15.

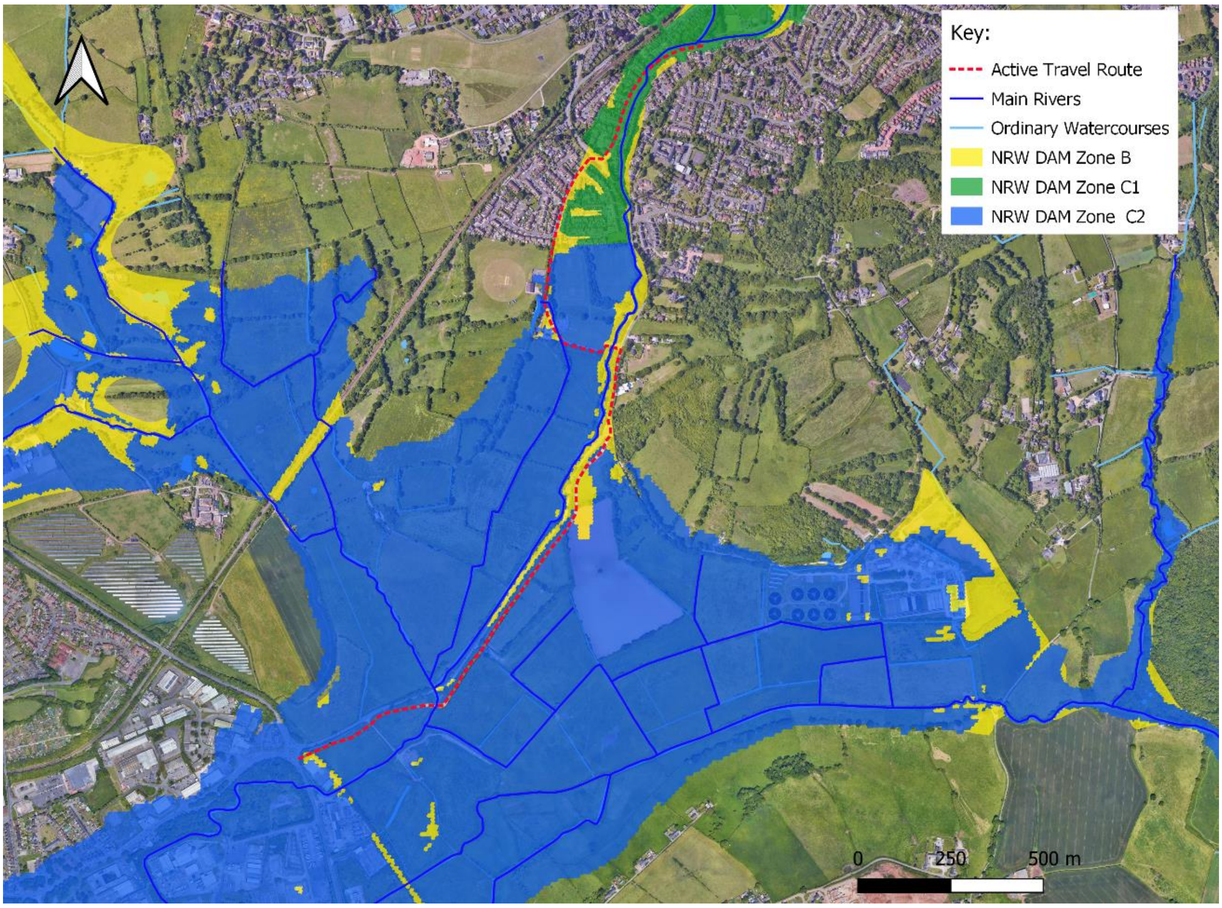

Figure 3-1 Development Advice Map

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3.3 Application of the Justification Test

3.3.1 The TAN15 DAM highlights that the proposed scheme is located within a flood risk area and, as a result, there is a requirement to justify the proposed location of development. Paragraph 6.2 of TAN15 states that new development should only be permitted within Zone C1 and C2 if determined by the Planning Authority to be justified in that location.

3.3.2 The first part of the TAN15 Justification Test states that:

'*Development, including transport infrastructure, will only be justified if it can be demonstrated that:'*

i. 'Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement' or,

ii. Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region'.

3.3.3 In September 2014, the Welsh Government introduced the Active Travel (Wales) Act 2013 which makes it a legal requirement for local authorities in Wales to map and plan for suitable routes for active travel within certain settlements, as specified by Welsh Government.

3.3.4 Furthermore, the active travel route will be of strategic importance, improving the attractiveness and safety of walking and cycling routes to key facilities and employment in the Vale of Glamorgan and provide an active travel link to Cardiff, aiming to reduce the congestion on the busy corridor between, Barry and in Dinas Powys. It is therefore considered that the development would pass the justification test given its significance both at a local and national level, as outlined above.

4 SOURCES OF FLOOD RISK

4.1 Overview

4.1.1 This section considers flood risk from the range of possible sources listed in Table 4-1.

Table 4-1: Sources of Flooding

Source of Flooding	Description
Flooding from rivers (fluvial)	Floodwater originating from a nearby watercourse when the amount of water exceeds the channel capacity of that watercourse.
Flooding from the sea (tidal)	High tides, storm surges and wave action, often acting in combination, flooding low-lying coastal land.
Flooding from surface water (pluvial)	Flooding caused by intense rainfall exceeding the available infiltration and/or drainage capacity of the ground.
Flooding from groundwater	Flooding caused when groundwater levels rise above ground level following prolonged rainfall.
Flooding from sewers	Flooding originating from surface water, foul or combined drainage systems, typically caused by limited capacity or blockages.
Flooding from reservoirs, canals, and other artificial sources	Failure of infrastructure that retains or transmits water or controls its flow.

4.2 Flooding from Rivers

Catchment Overview

4.2.1 The proposed scheme is located within the catchment of the River Cadoxton, with the river flowing adjacent to the route before discharging to the sea approximately 2.7 km to the southwest. Two tributaries join with the River Cadoxton in the study area; the East Brook which joins in Dinas Powys and the Cold Brook which joins approximately 400 m northeast of Biglis roundabout. There is also the Sully Brook and associated drainage ditches within the Cog / Pymylu moors area that drain to the River Cadoxton.

4.2.2 The River Cadoxton is crossed by the A4055 twice within the study area and there are several road bridges and footbridges that cross the river in Dinas Powys.

Fluvial Flood Mapping

4.2.3 The NRW Flood Risk Assessment Wales (FRAW) map[5] shows areas which would be affected by flooding from rivers, taking flood defences into account. The FRAW map (Figure 4-1) shows that there is varying flood risk along the active travel route, with some sections being within the 'high risk' flood extent, meaning there is a chance of flooding of greater than 1 in 30 (3.3%).

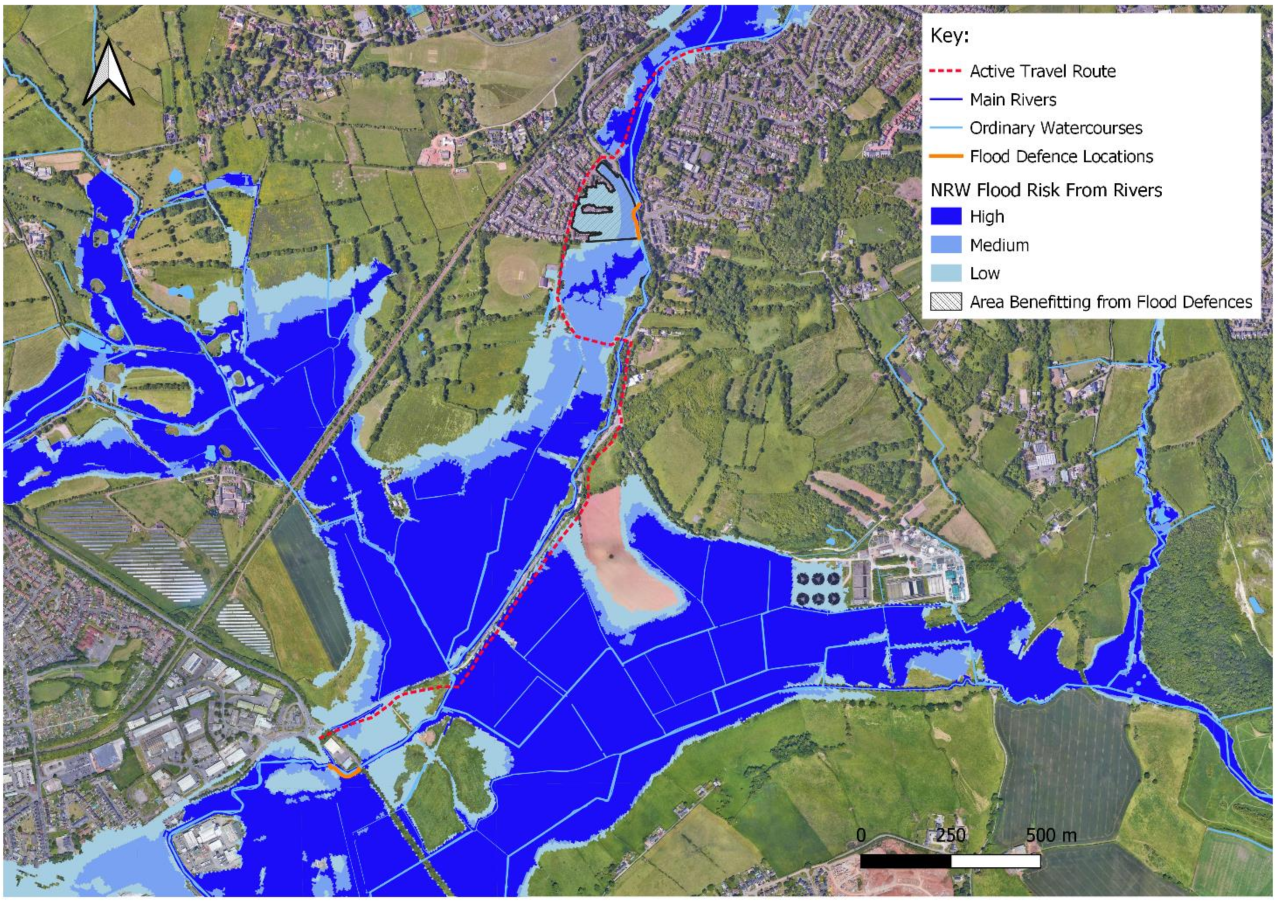

Figure 4-1 NRW FRAW Map - Flood Risk from Rivers (present day risk)

4.2.4 The NRW Flood Maps for Planning shows the potential extent of flooding assuming no defences are in place and includes the potential impact of climate change. The map (Figure 4-2) identifies the scheme as being located in Zones 2 and 3, defined as areas with an annual chance of flooding between 1 in 1000 (0.1%) and 1 in 100 (1%) and greater than 1 in 100 (1%), respectively.

[5] Flood Risk Assessment Wales Map, Natural Resources Wales, 2021 http://data.wales.gov.uk/apps/floodmapping/ - accessed July 2021

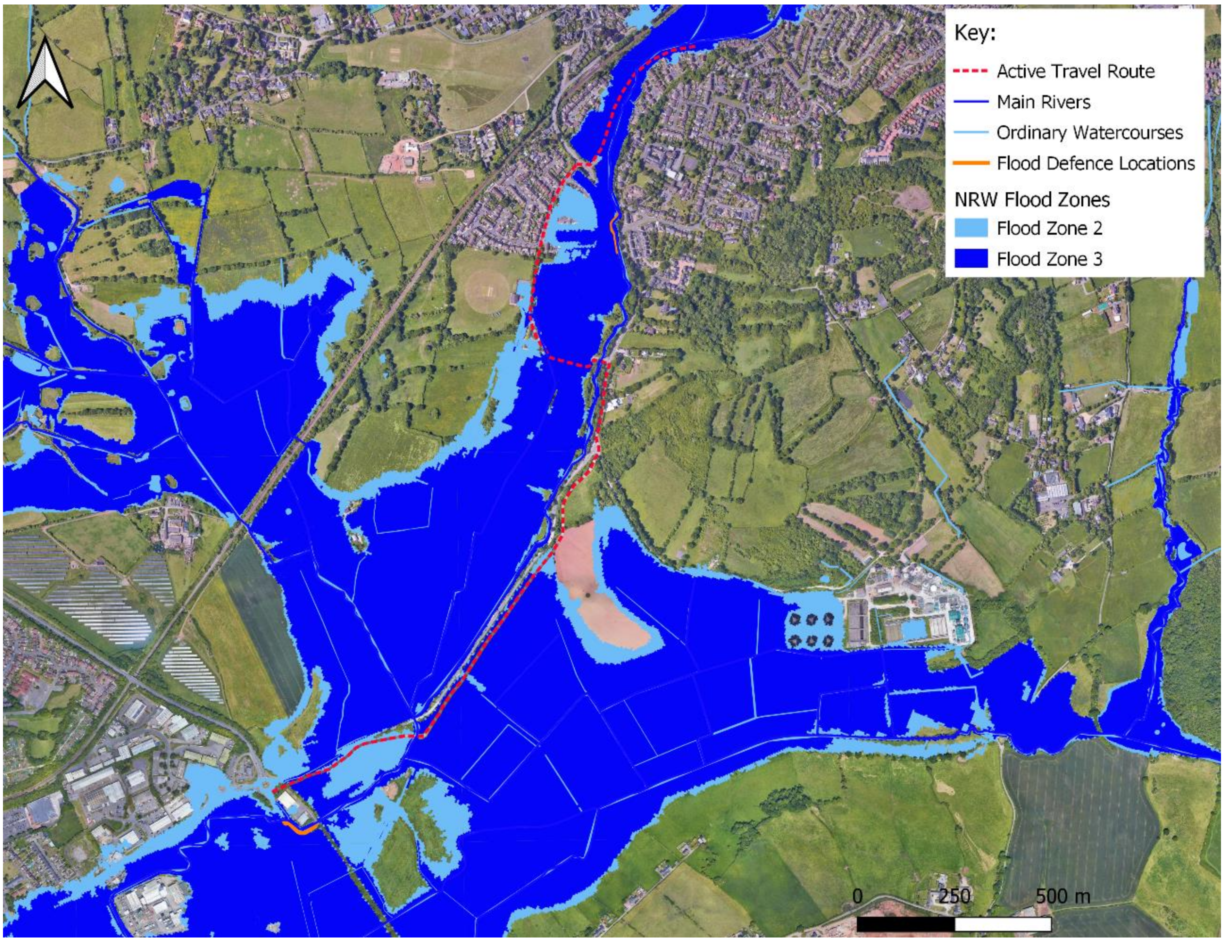

Figure 4-2 NRW Flood Map for Planning - Rivers (including effects of climate change)

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4.2.5 Due to the high level of flood risk, detailed flood modelling of the scheme has been undertaken and is discussed in Section 5.

4.3 Flooding from the Sea

4.3.1 The scheme is situated approximately 1 km from the coast. The FRAW map (Figure 4-3) shows that the southern section of the scheme, to Parc Bryn-Y-Don, is at low risk of flooding from the sea, equivalent to an annual chance of flooding between 1 in 1000 (0.1%) and 1 in 200 (0.5%).

4.3.2 As depicted by the hatched areas in Figure 4-3, the area at 'low risk' of flooding from the sea benefits from flood defences.

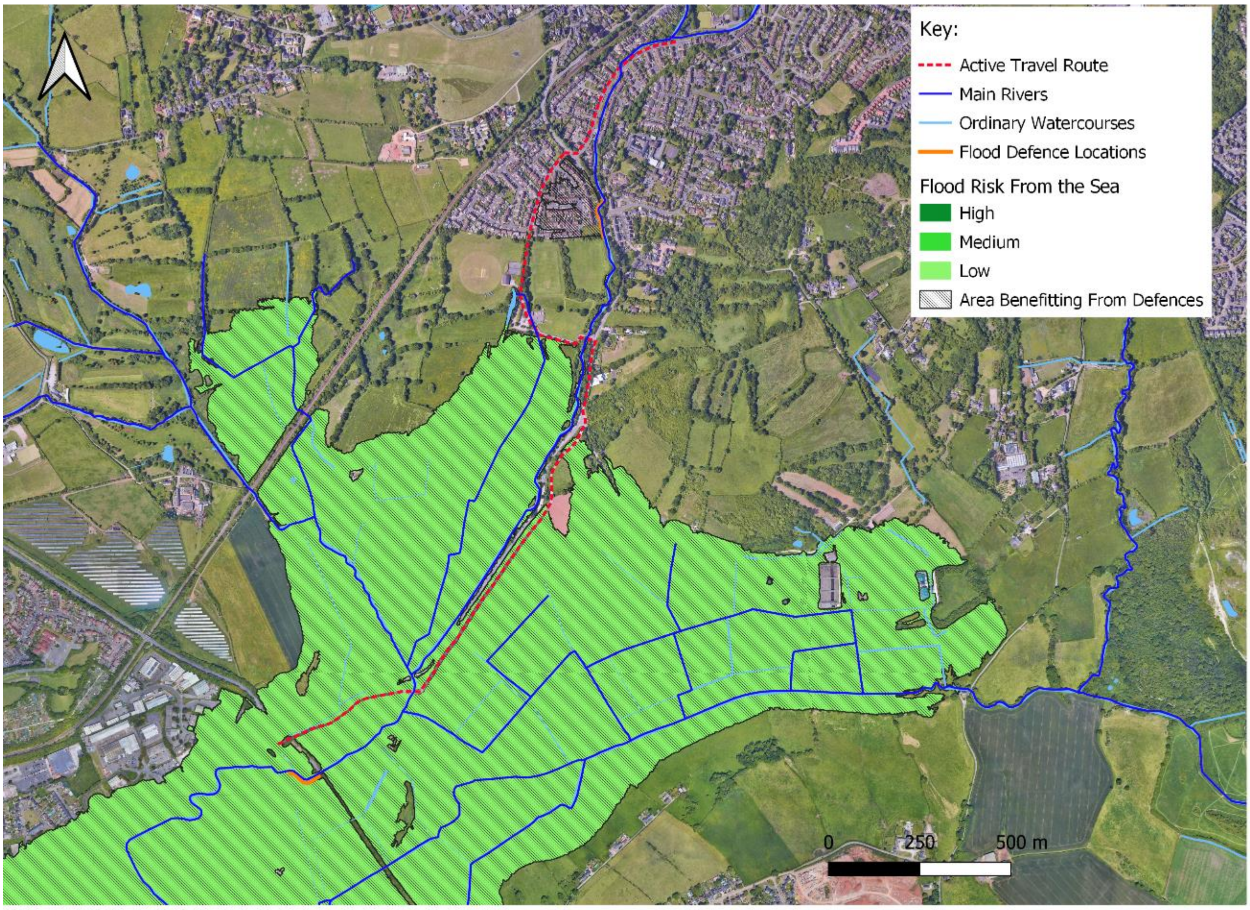

Figure 4-3 NRW FRAW Map - Flood Risk from the Sea (present day risk)

4.3.3 The Flood Map for Planning (Sea) (Figure 4-4), which includes the potential effects of climate change, shows that the scheme as being located in Zone 3, therefore, has an annual chance of flooding greater than 1 in 200 (0.5%).

4.3.4 The NRW flood map for planning indicates that the flood defences provide a standard of protection to the site of 1 in 1000 (0.1%), as depicted by the hatched areas in Figure 4-4.

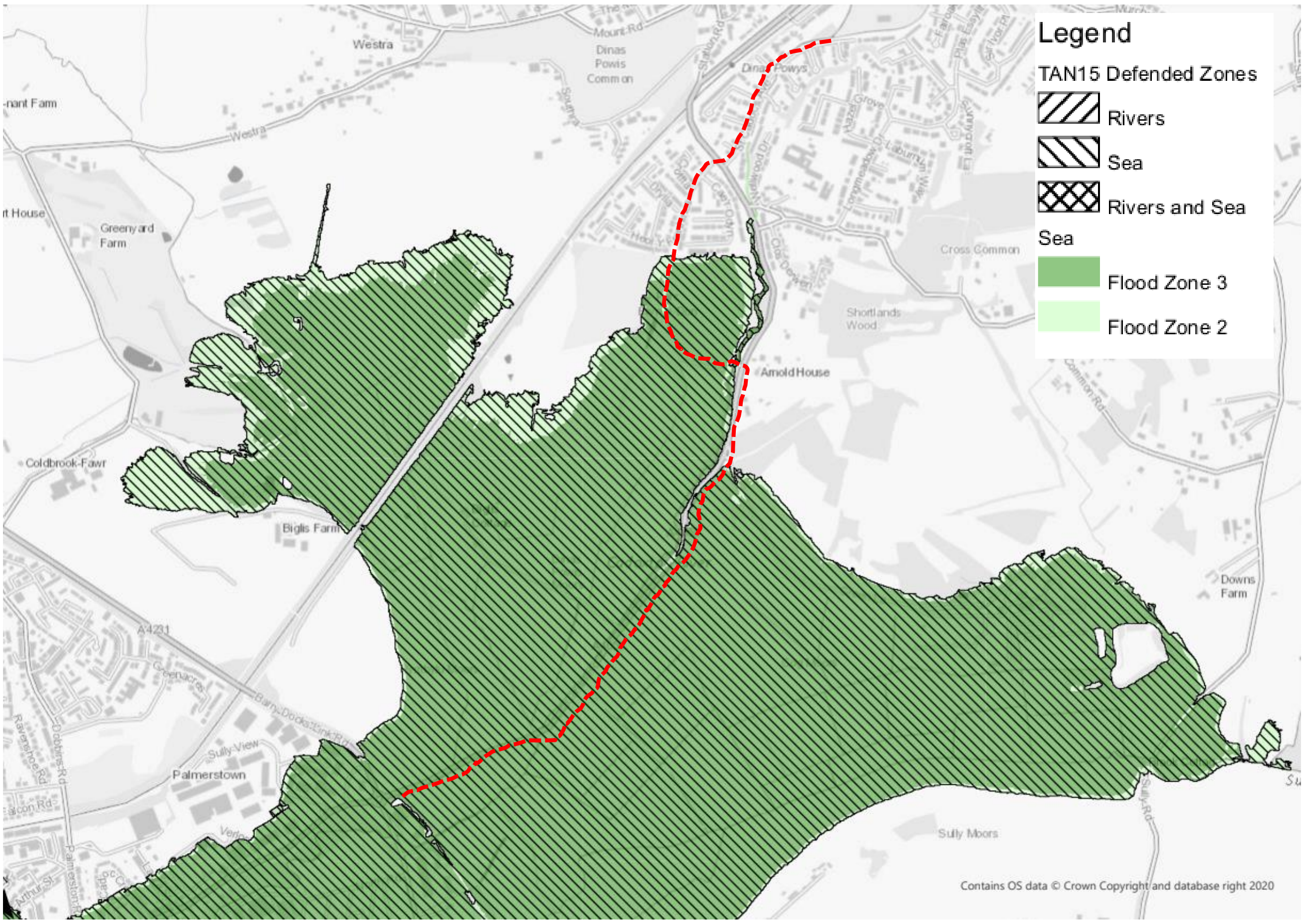

Figure 4-4 NRW Flood Map for Planning -Sea (including effects of climate change)

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4.3.5 While the NRW flood maps indicate the existing tidal defences provide a high standard of protection to the site, detailed flood modelling of the scheme has been undertaken to confirm the risk and the findings are discussed in Section 5.

4.4 Flooding from Surface Water

4.4.1 Flooding from surface water is a potential risk during short, intense rainstorm events or longer duration storms, when the capacity of underlying soils and drainage systems is exceeded, and rainfall runs overland to pond in depressions within the landscape. It is important that due consideration is given to changes in surface water runoff patterns as a result of the development proposals.

4.4.2 The NRW FRAW surface water flood map (Figure 4-5) provides a general indication of areas that may be at risk of surface water flooding. It shows that the vast majority of the proposed scheme is at 'very low' risk of surface water flooding, with an annual chance of less than 1 in 1,000 (0.1%), with the exception a small area of 'high risk' within Park Bryn-Y-Don.

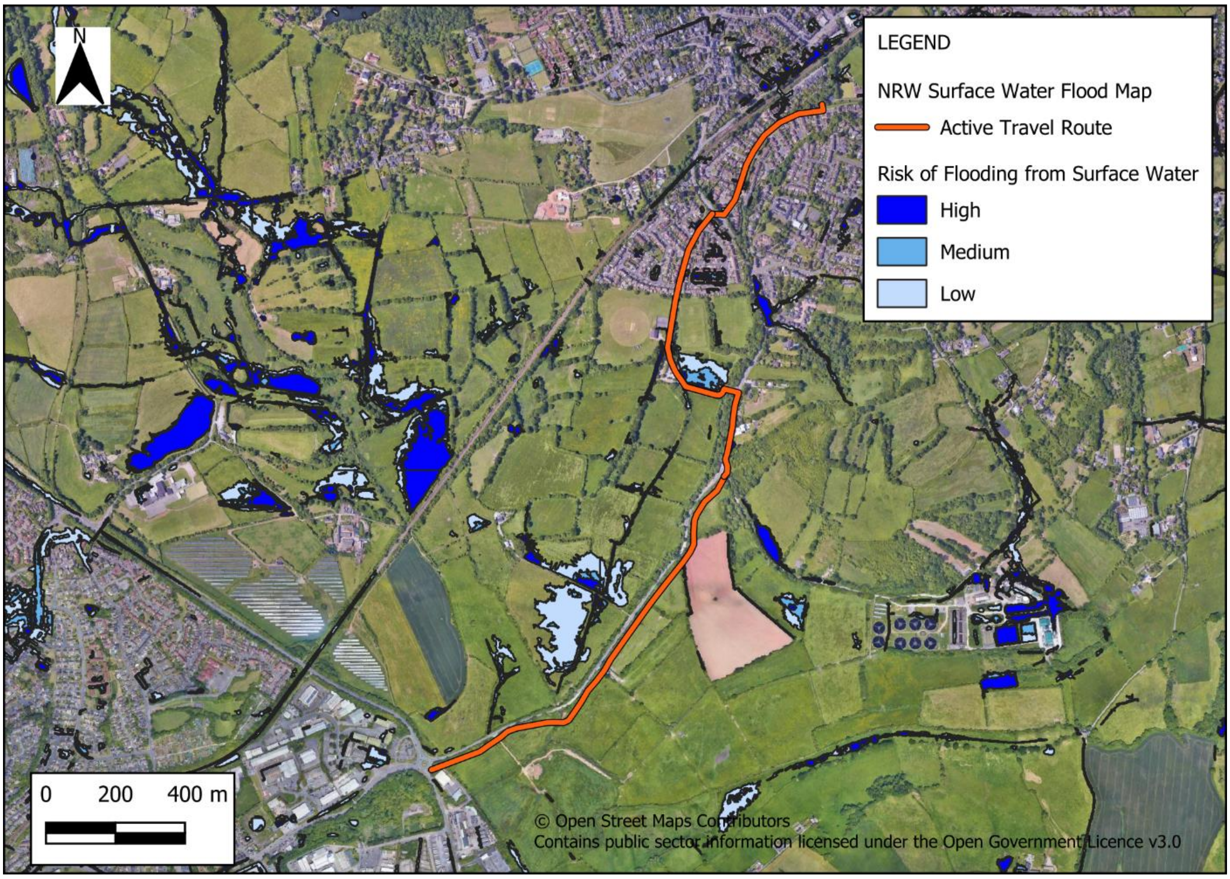

Figure 4-5 NRW FRAW Flood Map - Surface Water & Small Watercourses (present day risk)

4.4.3 The Flood Map for Planning (surface water and small watercourses) (Figure 4-6), which includes the potential effects of climate change, shows that the majority of the scheme would be at very low risk over the development lifetime. There are some localised areas of high risk in Parc Bryn yr Don and St Cadoc's Avenue.

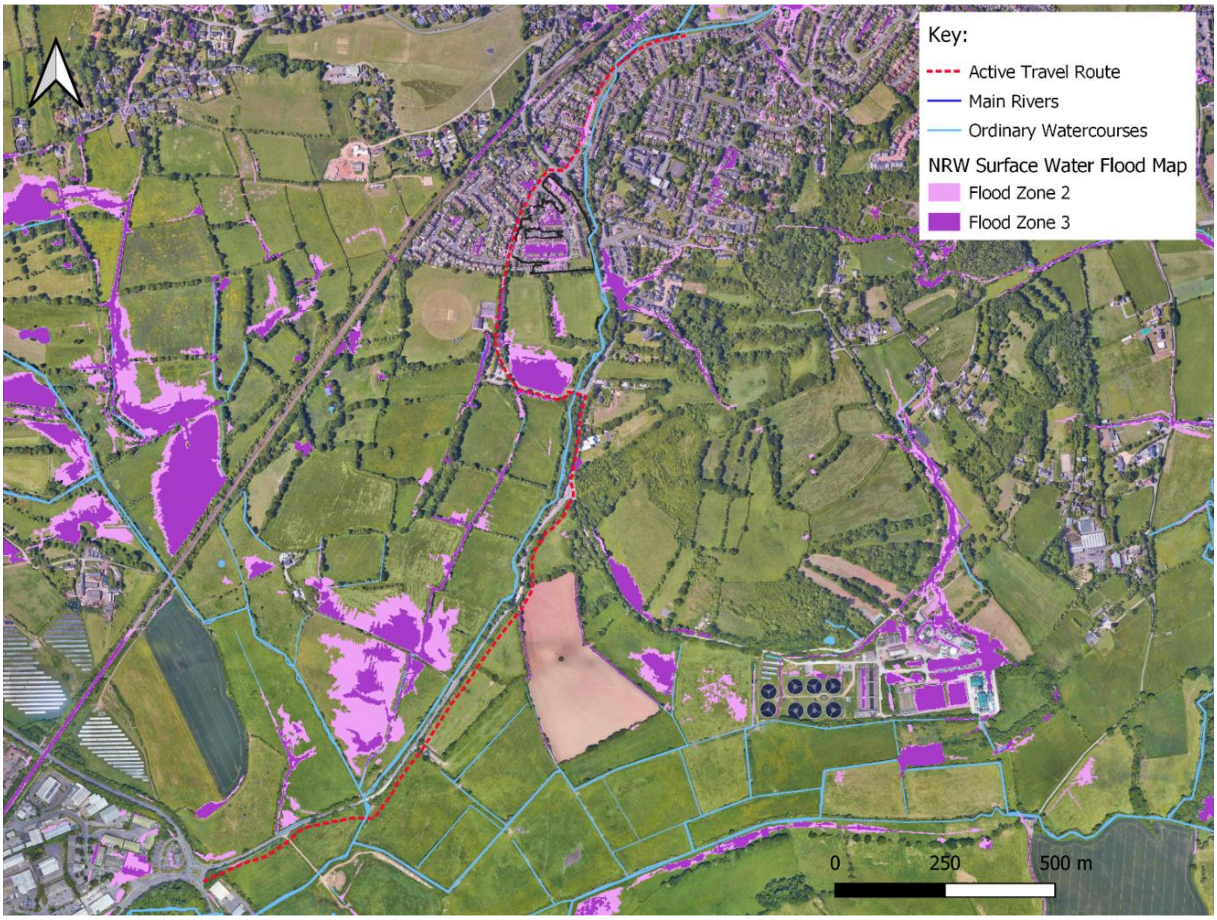

Figure 4-6 NRW Flood Map for Planning - Surface Water and Small Watercourses (including effects of climate change)

4.4.4 There are no changes to the land type for more than half the scheme, where it routes along existing highways and paths. The southern section will be constructed on an embankment which will be part paved. This section of the scheme will likely result in an increase in impermeable land coverage which could result in an increase in surface water runoff. A separate surface water drainage strategy has been developed to mitigate this and is detailed in a standalone report[6].

4.5 Flooding from Groundwater

4.5.1 Groundwater flood risk is not as well-defined as other sources of flooding, and an assessment of risk often requires consideration of geological conditions. Groundwater flooding can occur from two general mechanisms: (i) 'clearwater flooding', where the water table in unconfined aquifers rises above the ground surface, associated with permeable bedrock such as chalk and common in areas where 'winterbourne' streams are present, which may run dry for much of the year; and (ii) 'river-groundwater interaction', where river levels interact with permeable superficial deposits along river valleys, potentially flooding areas away from the river without necessarily overtopping the river banks.

[6] Biglis to Dinas ATR, Surface water drainage Strategy, Arcadis 2024. Ref: 10058585-ARC-XX-050-RP-C-00001

4.5.2 According to BGS mapping, the full extent of the scheme is underlain by Mercia Mudstone Group - Mudstone. The bedrock is overlain with superficial deposits of Alluvium - Clay, Silt, Sand and Gravel. The bedrock is classified as a 'Secondary B' aquifer on account of its low permeability; therefore, the risk from clearwater flooding is considered to be low. However, given the permeable nature of the superficial deposits, there may be a risk of flooding from river-groundwater interaction.

4.5.3 The Vale of Glamorgan LFRMS states that groundwater flood risk in the Vale is currently poorly understood with very little historic evidence available. The LFRMS report includes maps showing areas that are susceptible to groundwater flooding which indicate that there is a risk of groundwater flooding in the low-lying Cog / Pymylu moors area.

4.5.4 Given the fact that the section of the active travel route that passes through the low-lying moors area will be embanked, the risk from ground water flooding is considered to be low.

4.6 Flooding from Artificial Sources

4.6.1 The NRW flood maps illustrate the potential flood extent if large, raised reservoirs were to fail and release the water that they hold. The scheme is not within an area predicted to be at risk of reservoir flooding.

4.6.2 No other artificial sources, such as canals, small reservoirs or lakes/ponds, that could pose a flood risk to the site have been identified.

5 DETAILED FLOOD MODELLING

5.1 Fluvial and Tidal Flood Modelling

5.1.1 As discussed above, the only two sources of flooding that require further detailed investigation are fluvial and tidal flooding. In order to assess flooding from these sources a hydraulic model has been developed. A summary of the modelling process and subsequent results is presented below to support this FCA.

5.1.2 An existing 1D/2D model supplied by NRW has been used for this study. The model is a 1D/2D ESTRY-TUFLOW model dated 2015 and was created for a flood modelling and mapping study of the area on behalf of NRW.

5.1.3 The supplied model was reviewed prior to undertaking the study, and a modelling approach created that is documented in an inception report[7]. The inception report included a summary of the available data and proposed updates to the hydrology and hydraulic modelling. A summary of the modelling work undertaken to support the FCA is presented below.

5.1.4 Due to the age of the existing model, the primary recommendation was to collect check survey of the key structures and channel areas relevant to this study. This survey data was collected in January 2024, and the model updated accordingly. A comparison of the 2024 check survey against the 2015 model data indicated minimal change to the channel geometry and this provided confidence that the data within the existing model is still valid. New river channel data was also collected for Sully Brook, the ditches in Cog Moors and ditches adjacent to Sully Moors Road to improve the model quality.

5.1.5 The model was updated to use the latest TUFLOW software which enabled the use of the adaptive mesh size approach (Quadtree), and Highly Parallelised Compute (HPC) solver. Using Quadtree allowed optimisation of the model resolution to better represent the scheme area.

5.1.6 Detailed hydrological modelling was undertaken to produce updated inflows to the flood model and the tidal boundary was updated based on current guidance. Full details of the flood modelling and hydrological analysis are provided in a standalone report[8].

5.1.7 The tidal boundary in the model has been based on the Mean High-Water Spring (MHWS) tide curve included with the 2015 model. The MHWS curve has been uplifted for sea level rise to 2099 (i.e., 75 year design life of the scheme) and a storm surge component from the Newport donor location used to uplift the MHWS tide to the 1 in 200 (0.5%) and 1 in 1000 (0.1%) extreme still water levels, based on the Environment Agencies Coastal Flood Boundary data and guidance[9]. The resulting peak water levels used in the model scenarios are given in Table 5-1.

Table 5-1: Tidal boundary peak water levels

Scenario	Peak Water Level (mAOD)
MHWS (2024)	5.62
MHWS (up to 2099)	6.38
1 in 200 (0.5%) (up to 2099)	8.25
1 in 1000 (0.1%) (up to 2099)	8.60

[7] Dinas Powys Active Travel Route Flood Modelling, Inception Report, Arcadis 2023. Ref: 10048848_ARC_XX_ZZ_RP_DH_0001_P02
[8] Dinas Powys Active Travel Route Hydraulic Modelling Report, Arcadis 2024. Ref: 10058585-ARC-AT-260-TR-CW-00002
[9] Coastal flood boundary conditions for the UK: update 2018, SC060064/TR7, Environment Agency May 2019.

5.1.8 A schematic of the updated model is presented in Figure 5-1.

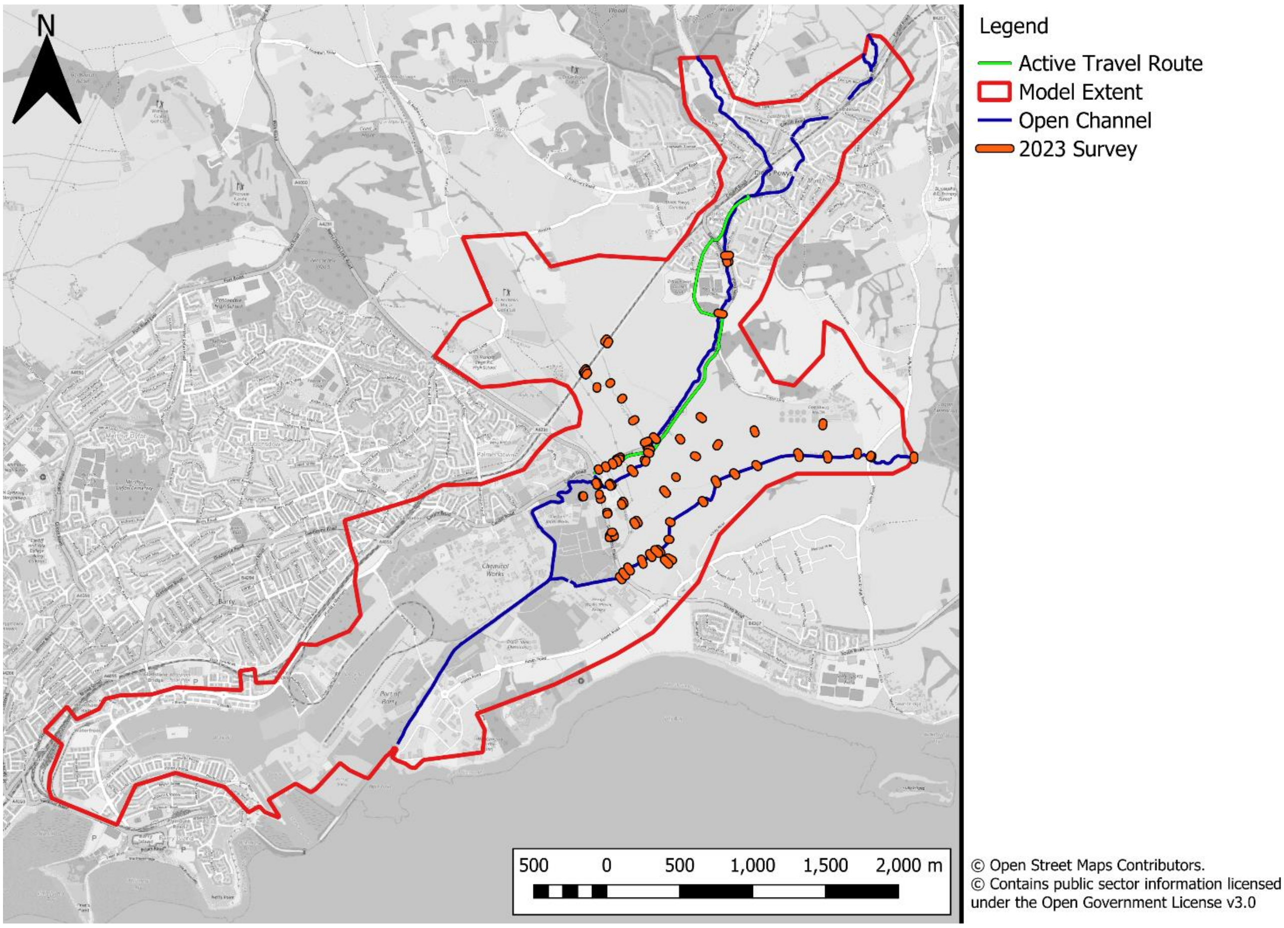

Figure 5-1 Model Schematic

5.1.9 The existing NRW flood model underwent a detailed validation and calibration process in 2015 which compared the predicted flooding against the available historic flood information. It is understood that limitations in the ability to reconcile recorded rainfall with river flows and flood extents led to a hybrid approach in which the flood event was approximated to an AEP and the modelled flooding for that event compared to the recorded extents. The same method has been used to validate the 2024 model and the predicted flooding compared to both the 2015 model results and recorded flood outlines. The 2024 model shows good agreement with the 2015 modelled flooding with slightly larger flood extents predicted in the 1 in 100 (1%) and 1 in 1000 (0.1%) events in the updated 2024 model primarily due to the larger flood hydrograph volumes that were applied following the hydrology updates.

5.1.10 Since the 2015 study there has been one new notable flood event which occurred in December 2020. The Section 19 report equated this event to between a 1 in 10 (10%) and 1 in 20 (5%). The modelled flooding has been compared to the extents for similar events and matches moderately well noting that the Section 19 report notes some of the flood sources as being surface water not fluvial.

5.1.11 The hydraulic model is considered to give a good representation of the flood mechanisms within the scheme area. Uncertainty has been assessed using standard sensitivity testing of the model. The model shows only minor sensitivity to roughness coefficients and is moderately sensitive to the inflow volume and downstream boundary conditions applied. This is to be expected in a location where tidal locking occurs and floodwater can pond. The model is considered robust and suitable for assessing the impact both to, and resulting from, the proposed scheme.

5.1.12 The model includes the three flood defences located within the study area. The modelling approach for the undefended scenarios is unchanged from the 2015 model i.e. the flood embankments have been removed in addition to the tidal flap on the River Cadoxton outfall.

5.1.13 A critical storm assessment was caried out as part of the hydrological analysis and the resulting design storm applied to the model has a duration of 25 hours. The critical duration assessment is detailed in the hydrology calculation record which is appended to the modelling report (10058585-ARC-AT-260-TR-CW-00002).

5.1.14 A peak river flow climate change allowance of +30% has been adopted in the assessment of fluvial flood risk for the 1 in 100 (1%) event, in line with current Welsh Government guidance[10]. The allowance of +30% is the central estimate for the predicted increase in peak river flows for catchments within the West Wales River Basin District to the 2080's epoch. The tidal boundary adopted in the 2015 model has been updated to include storm surge and sea level rise using the latest Welsh Government climate change guidance. The future climate change scenario applies a sea level rise up to 2099 equating to the 75-year design life required for infrastructure.

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[10] Welsh Government climate change guidance https://www.gov.wales/climate-change-allowances-and-flood-consequence-assessments

5.1.15 The model has been run for a range of fluvial and tidal return periods for both the baseline and with scheme models along with sensitivity testing, as set out in Table 5-2.

Table 5-2: Modelled design flood scenarios and sensitivity scenarios

Scenario	Description
Fluvial Model	
20% AEP	1 in 5 annual chance fluvial flood event with MHWS tidal boundary
10% AEP	1 in 10 annual chance fluvial flood event with MHWS tidal boundary
5% AEP	1 in 20 annual chance fluvial flood event with MHWS tidal boundary
3.33% AEP	1 in 30 annual chance fluvial flood event with MHWS tidal boundary
2% AEP	1 in 50 annual chance fluvial flood event with MHWS tidal boundary
1% AEP	1 in 100 annual chance fluvial flood event with MHWS tidal boundary
1% AEP CC30*	1 in 100 annual chance flood event plus 30% uplift in flows to account for climate change, fluvial flood event plus MHWS tidal including sea level rise to 2099 (75 year development lifetime)
0.1% AEP	1 in 1000 annual chance fluvial flood event with MHWS tidal boundary
0.1% AEP CC30	1 in 1000 annual chance flood event plus 30% uplift in flows to account for climate change, fluvial flood event plus MHWS tidal including sea level rise to 2099 (75 year development lifetime)
Tidal Model	
0.5% AEP Tidal plus climate change*	1 in 200 annual chance tidal flood event - MHWS tide plus surge and sea level rise to 2099 (75 year development lifetime). Run with 1 in 2 annual chance fluvial flood event.
0.1% AEP Tidal plus climate change*	1 in 1000 annual chance tidal flood event - MHWS tide plus surge and sea level rise to 2099 (75 year development lifetime). Run with 1 in 2 annual chance fluvial flood event.
Sensitivity Scenarios	
1% AEP Manning's 'n' sensitivity	1% AEP flow +/-30% Manning's 'n' roughness
1% AEP Flow sensitivity	1% AEP flow +/-20% Flow
1% AEP Tidal boundary sensitivity	1% AEP flow MHWN tidal boundary and MHWS noncoincident tide. Testing the impact of lower tidal levels and tidal timing relative to fluvial peak timing.
3.33% AEP 50% Blockage test	1 in 30 annual chance fluvial flood event with MHWS tidal boundary
1% AEP 50% Blockage test	1 in 100 annual chance fluvial flood event with MHWS tidal boundary

**Includes defended and undefended scenarios for the design events.*

5.2 Proposed Scheme Modelling

5.2.1 For reporting purposes, the route description has been split in two; the northern section covering the Dinas Powys to south of Parc Bryn-Y-Don and the southern section from Parc Bryn-Y-Don south to Biglis roundabout.

5.2.2 As the section of the route north of Parc Bryn-Y-Don follows existing roads and pathways through Dinas Powys, with no changes proposed to the existing ground levels, no model changes are required to represent the post development scenario.

5.2.3 The southern section of the route runs adjacent to the A4055 for a short distance before routing onto a new raised embankment that runs parallel to the A4055 approximately 20m to the southeast. The raised embankment varies in height above surrounding land along its length. The embankment ties in with existing ground levels at either end, reaching up to 1.7m high at the River Cadoxton crossing. The location of the embanked section of the active travel route, and example cross section profiles, are shown in Figure 5-2 and Figure 5-3, respectively.

5.2.4 A new crossing of the River Cadoxton is proposed approximately 40m downstream of the existing A4055 River Cadoxton bridge. The new crossing has 12m wide abutments and a flat soffit set at 7.70mAOD, approximately 0.55m above the 1 in 100 (1%) plus climate change flood level. The bridge crossing details are shown in Figure 5-4.

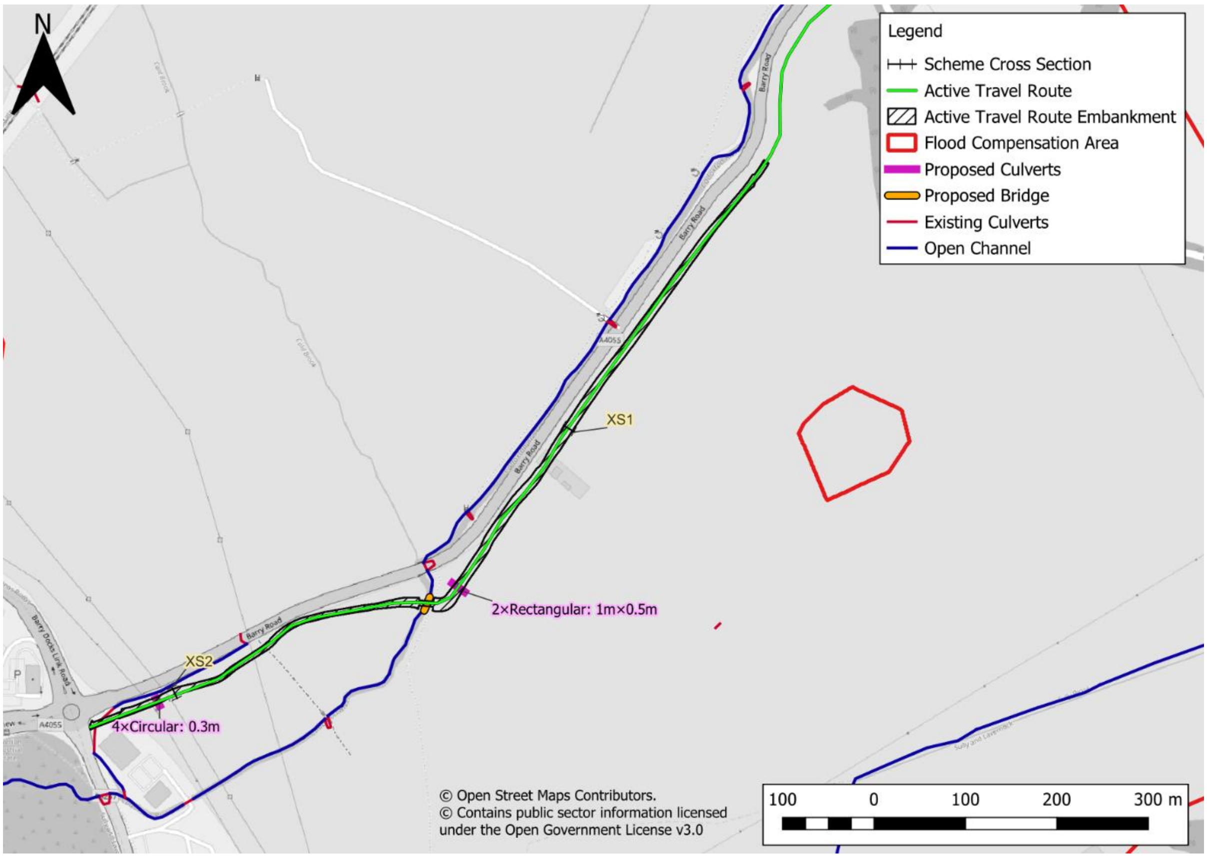
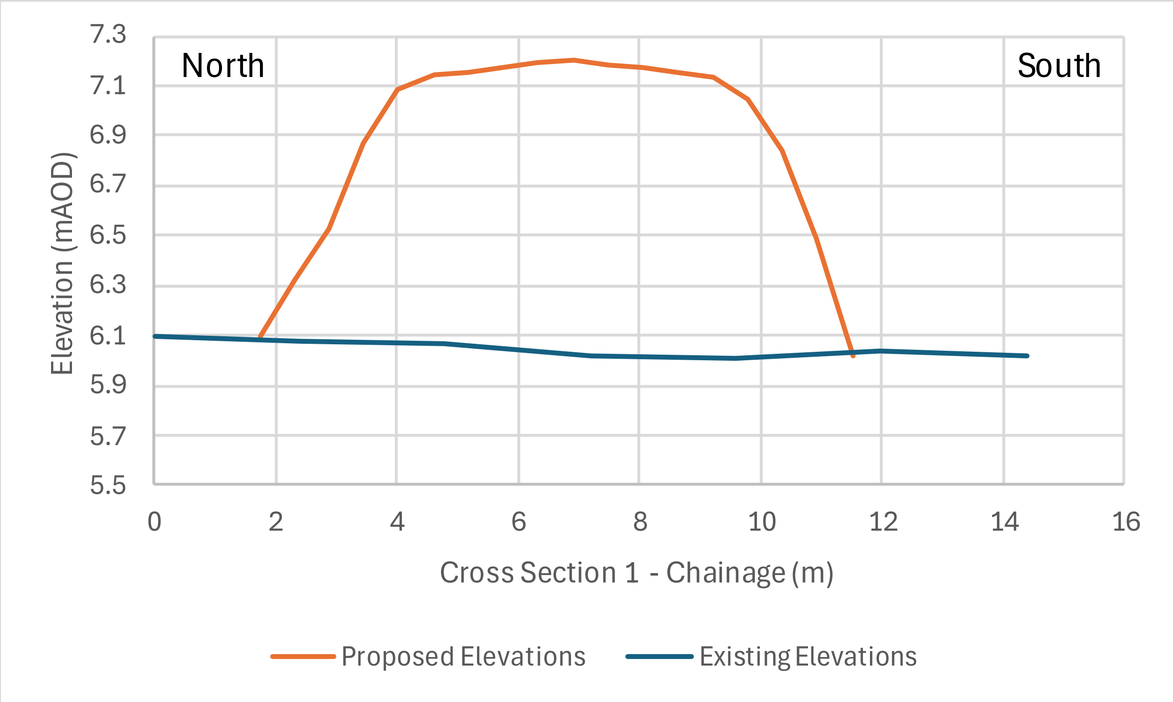


Figure 5-2: Proposed Scheme



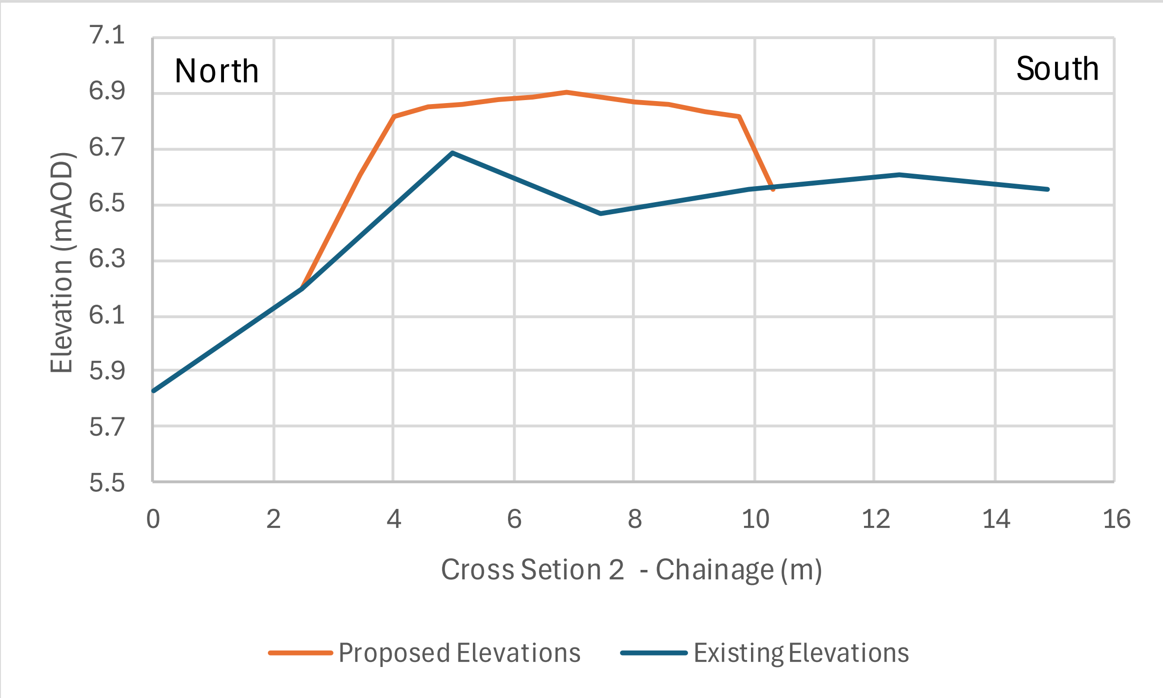


Figure 5-3: Indicative Embankment Cross Sections

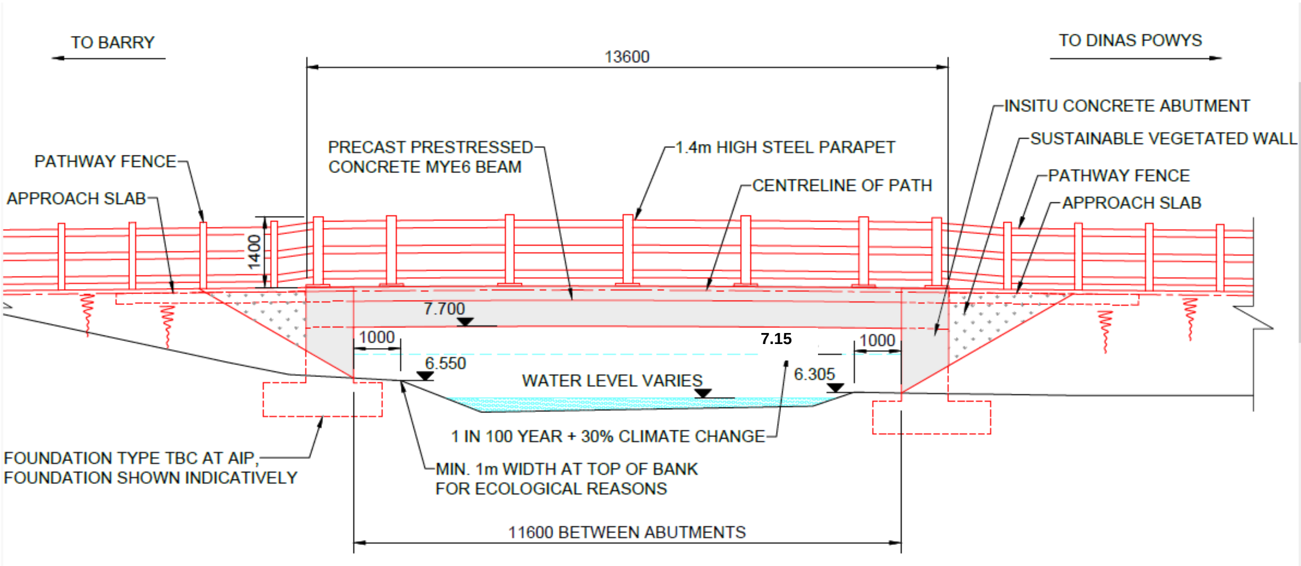


Figure 5-4: Proposed Bridge Crossing

Flood Mitigation Measures Incorporated into the Scheme Design

5.2.5 The raised embankment will result in a loss of floodplain storage. To mitigate this, the scheme includes a flood compensation area. The lost volume has been calculated on a level for level basis and will be replicated by excavating an area of raised land at the margin of the floodplain. The flood compensation area is designed to be a passive system connecting to an existing ditch.

5.2.6 Culverts through the embankment are proposed in order to allow floodplain flow to pass through. The indicative structure locations and sizes are shown in Figure 5-2.

5.2.7 The new bridge crossing over the River Cadoxton has been designed with 0.55m freeboard above the 1 in 100 (1%) plus climate change peak water level, thus reducing the risk of a blockage occurring.

5.3 Model Results

5.3.1 The hydraulic model has been run for a range of return periods, as listed in Table 5-2. For the purposes of this FCA, reporting focuses on the four design events: 1 in 100 (1%) plus climate change and 1 in 1000 (0.1%) fluvial events, and the 1 in 200 (0.5%) and 1 in 1000 (0.1%) tidal events, both including sea level rise up to 2099 (i.e., 75-year design life).

5.3.2 Model results have been presented for peak flood depths and extents, flood hazard and as depth difference maps. Flood hazard has been assessed using the default TUFLOW output which is based on the value of the UK Hazard formula based on UK FD2321 Technical Report[11] using a conservative debris factor (0.5 or 1, depending on the depth).

5.3.3 The depth difference maps were created by subtracting the peak modelled flood depths for the 'with scheme' scenario from the baseline scenario. The green colours on the difference maps refer to areas where the depth has reduced in the 'with scheme' scenario compared to the baseline. Yellow and orange colours show where depths are predicted to be increased as a result of the scheme.

5.3.4 As well as assessing change in water level, any potential change in pass forward flow downstream of the scheme has also been checked. The disused railway adjacent to Sully Moors Road (see Figure 2-2) creates a barrier to over land flows and provides a good location to check flows discharging downstream into the industrial estate area. The flow passing through all the structures under the disused railway has been summed in order to determine any change in the total past forward flow between the baseline and design scenarios.

5.3.5 For reporting purposes, separate plots have been produced for the northern and southern sections of the scheme. The northern section covers the Dinas Powys area and the southern section covers the Cog Moors to Biglis roundabout area.

Fluvial Flood Results – 1 in 100 (1%) plus climate change event

5.3.6 Flooding is predicted within the northern section of the scheme, along St Cadoc's Avenue, in the 1 in 100 (1%) plus climate change event (Figure 5-5), with peak flood depths and velocities estimated to up to 0.4m and 1.2m/s, respectively. The resulting flood hazard is classified as 'significant' (Figure 5-7). At Parc Bryn-Y-Don, where the route passes through the flood extent, the model predicts flood depths and velocities of approximately 0.1 m and 0.5 m/s, respectively. The resulting flood hazard is classified as 'low hazard'.

5.3.7 The southern section of the route incudes a raised embankment through the Cog Moors area and the majority of this section is flood free in the 1 in 100 (1%) plus climate change flood event (Figure 5-6). However, the section of embankment to the west of the new River Cadoxton crossing, while raised above the surrounding land, is predicted to be flooded in the 1% plus climate change event. The embankment has been set at the 1 in 50 (2%) peak flood level as this is considered to provide a reasonable level of flood resilience without causing third-party impacts on the A4055. The predicted maximum flood depth and velocity along this section of the route are approximately 0.25 m and 0.3 m/s, respectively. The resulting flood hazard (Figure 5-8) is predominantly classified as 'low hazard' with some localised sections of 'moderate hazard' (note, the very localised areas of 'high' hazard along the

[11] Defra / EA – Flood Risk to People FD2321TR2 - https://assets.publishing.service.gov.uk/media/602bbc3de90e07055f646148/Flood_risks_to_people_-_Phase_2_Guidance_Document_Technical_report.pdf

route are within the side slopes of the embankment rather than the surface of the active travel route itself).

5.3.8 The results of the depth difference analysis show that the northern part of the scheme would result in no change from the existing baseline flooding. This is to be expected as the route follows existing paths and roads, with no changes proposed to the existing ground levels.

5.3.9 With regards to the southern section of the scheme, as discussed in Section 5.2, the scheme includes mitigation which has been designed to offset the potential impacts of the raised embankment in the floodplain. The model predicts only minor changes to the flood depths along the southern part of the scheme (Figure 5-9). Changes to flood depths are less than 0.05 m and limited to areas immediately adjacent to the scheme (between the existing road and the scheme), in an area that is already inundated.

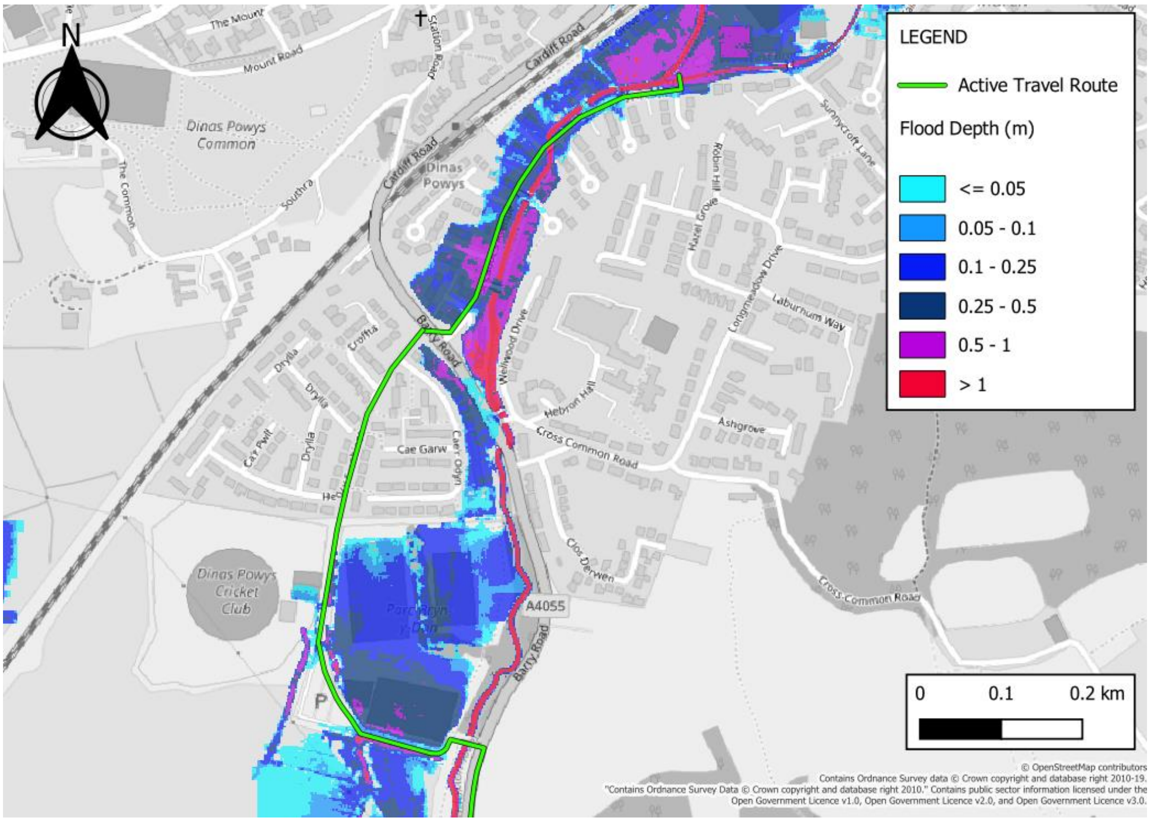


Figure 5-5 1 in 100 (1%) plus Climate Change Fluvial Event – 'With scheme' Flood Depth and Extent (Northern Section)

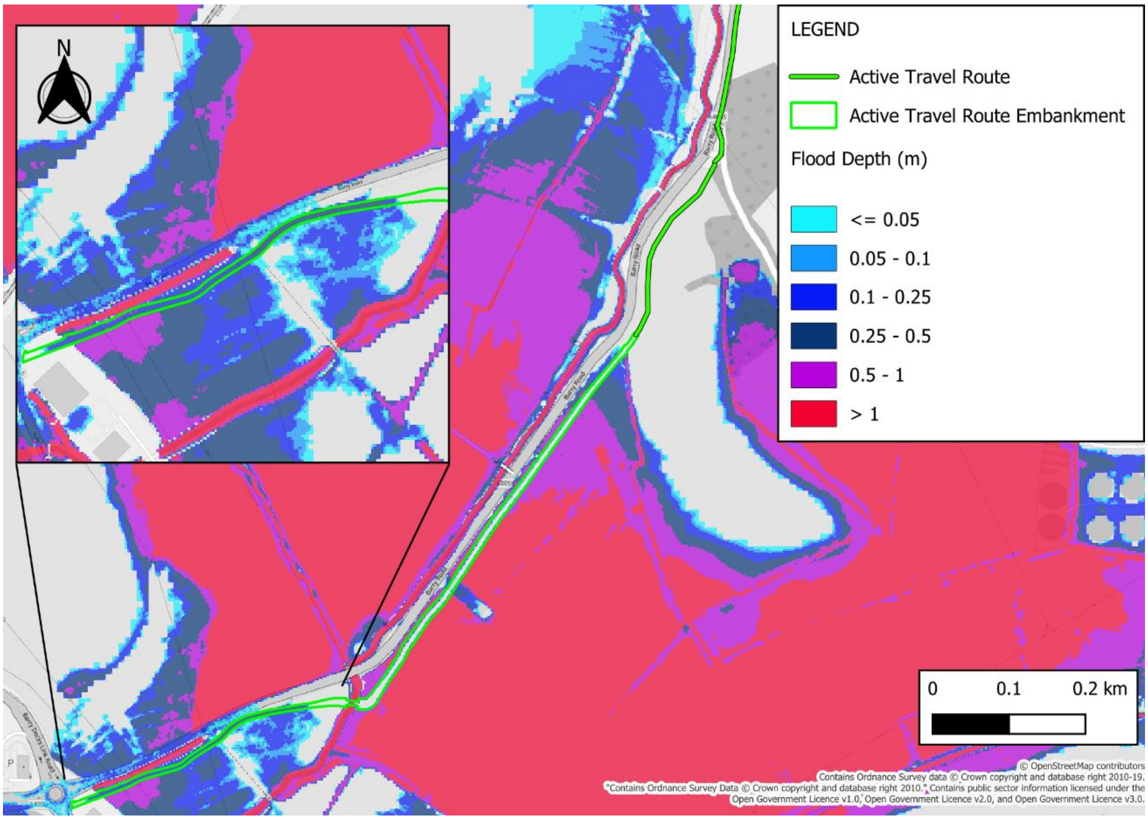


Figure 5-6 1 in 100 (1%) plus Climate Change Fluvial Event - 'With scheme' Flood Depth and Extent (Southern Section)

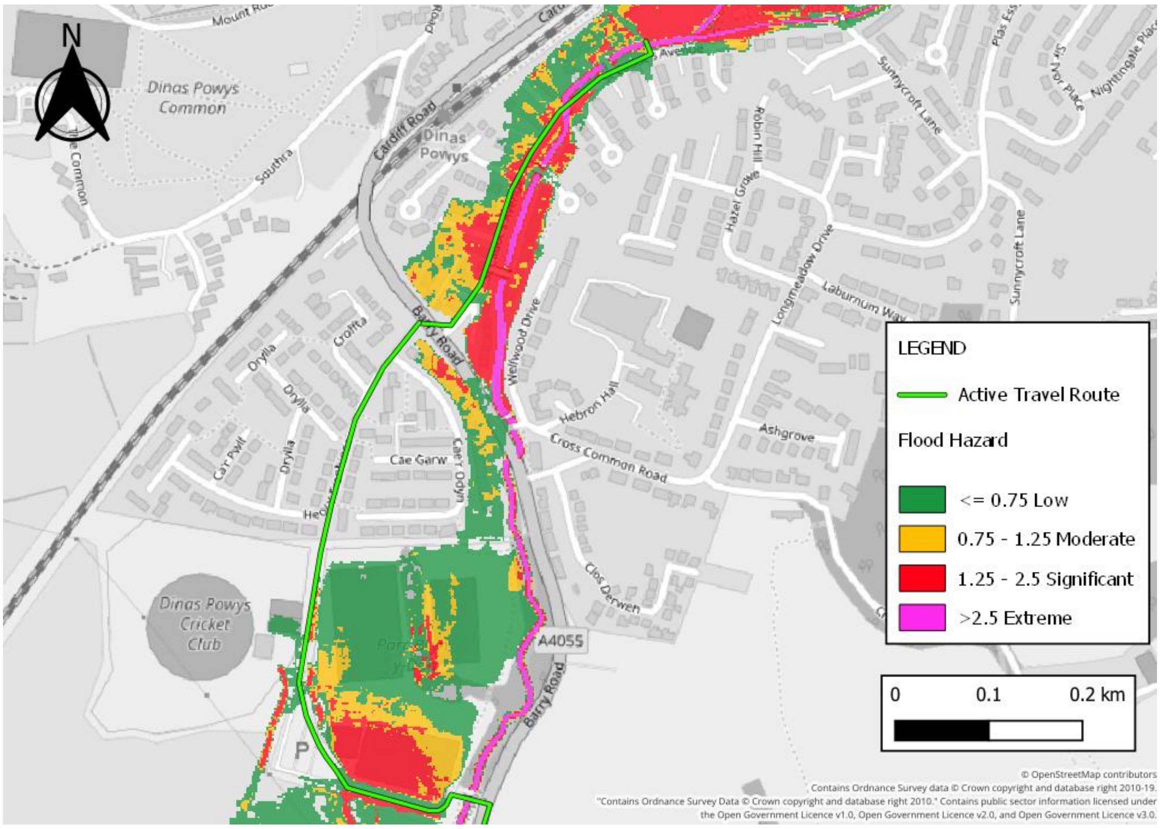


Figure 5-7 1 in 100 (1%) Plus Climate Change Fluvial Event - 'With scheme' Flood Hazard (Northern Section)

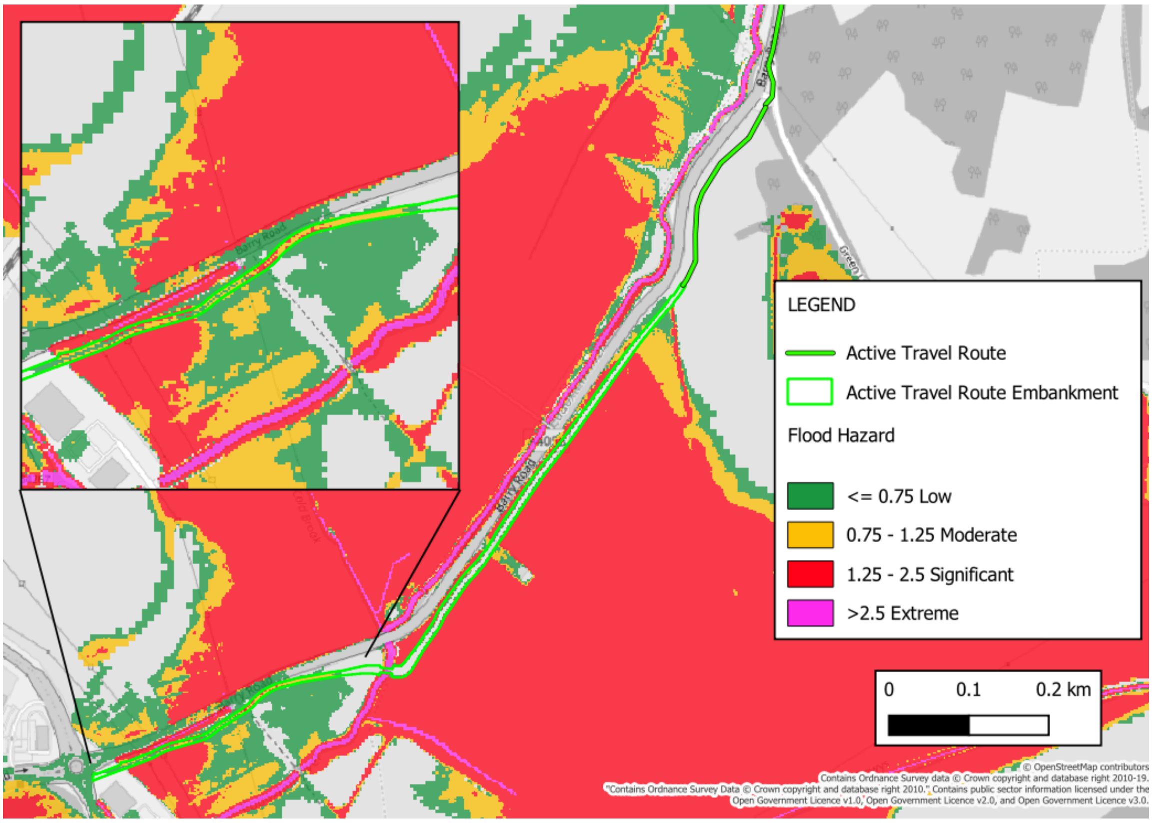


Figure 5-8 1 in 100 (1%) Plus Climate Change Fluvial Event - 'With scheme' Flood Hazard (Southern Section)

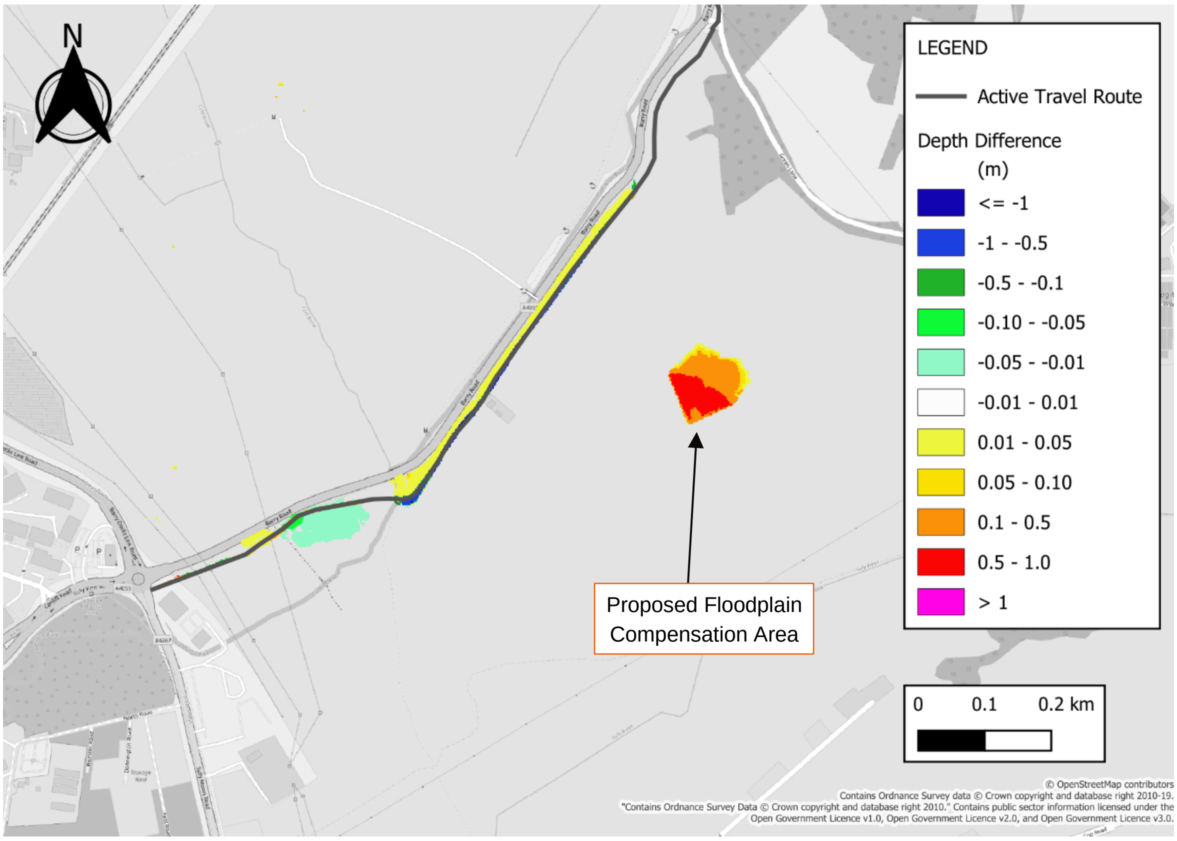


Figure 5-9 1 in 100 (1%) Plus Climate Change Fluvial Event - Depth Difference (Southern Section)

5.3.10 Figure 5-10 shows the flow through the railway embankment in the baseline and 'with scheme' scenarios. The results show a reduction of 0.5% in peak flow in the with scheme model and a 0.05% increase in total volume of pass forward flow. These results indicate there would be negligible change in pass forward flow as a result of the scheme. The pass forward flow has been checked for events between the 1 in 10 (10%) and 1 in 1000 (0.1%) and the results are very similar to the 1 in 100 (1%) that is presented below, showing no significant change in flows downstream.

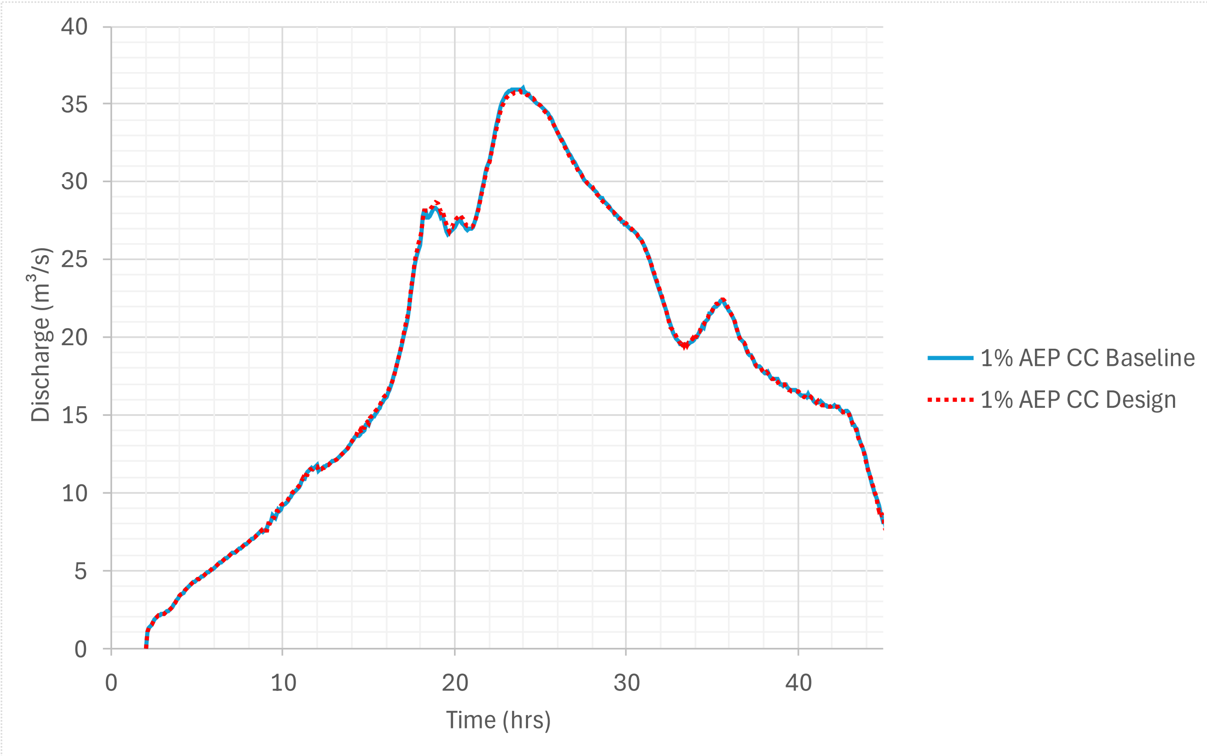


Figure 5-10 1 in 100 (1%) plus climate change fluvial event – Discharge through the disused railway

Fluvial Flood Results – 1 in 1000 (0.1%) event

5.3.11 The fluvial risk has been assessed using the extreme 1 in 1000 (0.1%) event and the predicted peak flood depths and extents across the northern and southern sections are shown in Figure 5-11 and Figure 5-12, respectively.

5.3.12 The model results show the scheme is inundated along St Cadoc's Avenue and Parc Bryn-Y-Don, within the northern section of the scheme, with peak flood depths along St Cadoc's Avenue of approximately 0.8 m. Within the southern section of the scheme, flooding is predicted along sections of the raised embankment with a peak flood depth of 0.4 m along the western section.

5.3.13 Peak velocities along the eastern section of embankment are in excess of 0.3 m/s in localised areas whilst the on the western embankment they are 0.2 m/s.

5.3.14 The flood hazard is categorised as 'significant' along St Cadoc's Avenue, 'low' through Parc Bryn-Y-Don (Figure 5-13) and 'low' along the majority raised embankment (Figure 5-14), with the eastern end of the embankment classified as 'moderate' to 'significant'. Egress remains possible from the embankment to the north; therefore, the risk is considered acceptable for such an extreme event.

5.3.15 For the storm duration modelled, the rate of rise of the flooding is 20 cm / hour and the active travel route remains flood free for 5 hours after floodwater first reaches the toe of the embankment.

5.3.16 The results of the depth difference analysis show that the northern part of the scheme would result in no change from the existing baseline flooding. This is to be expected as the route follows existing paths and roads, with no changes proposed to the existing ground levels.

5.3.17 With regards to the southern section of the scheme, as discussed in Section 5.2, the scheme includes mitigation which has been designed to offset the potential impacts of the raised embankment in the floodplain. The model predicts only minor changes to the flood depths along the southern part of the scheme (Figure 5-15). Changes to flood depths are limited to areas immediately adjacent to the scheme (between the existing road and the scheme) in an area that is already inundated.

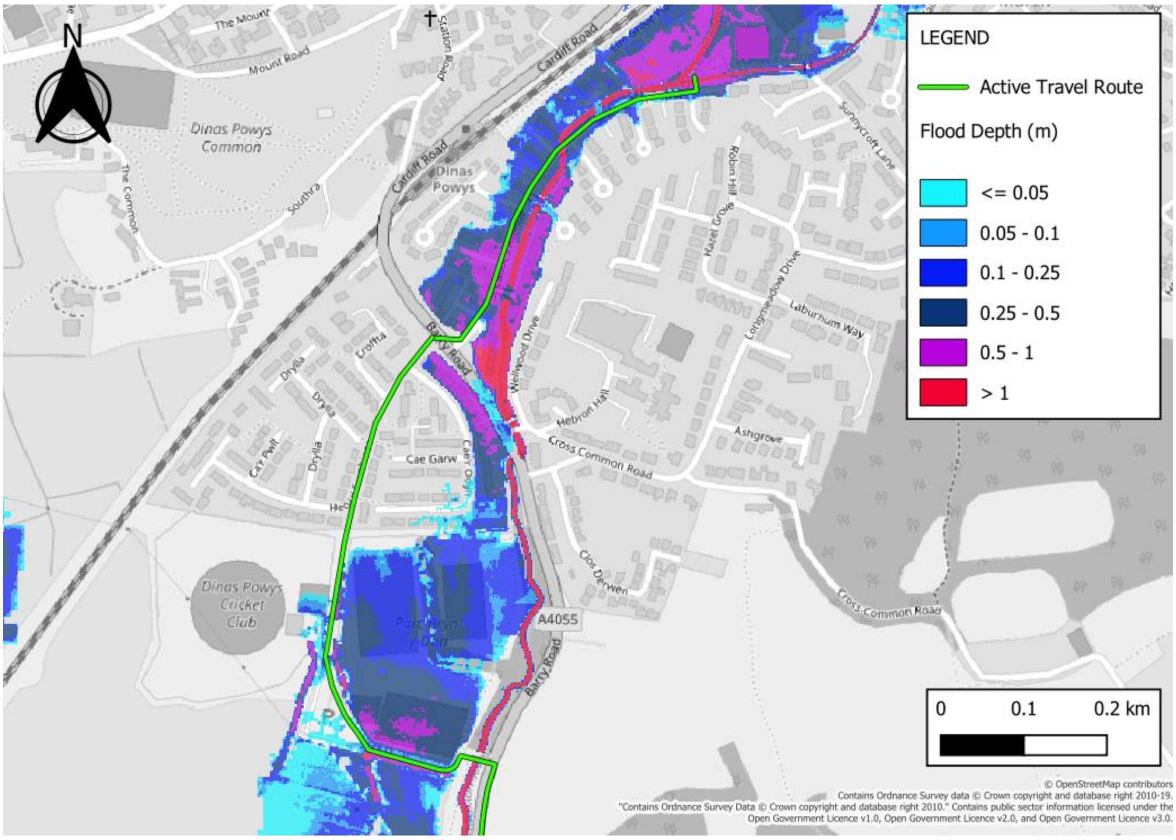


Figure 5-11 1 in 1000 (0.1%) Fluvial Event - 'With scheme' Flood Depth and Extent (Northern Area)

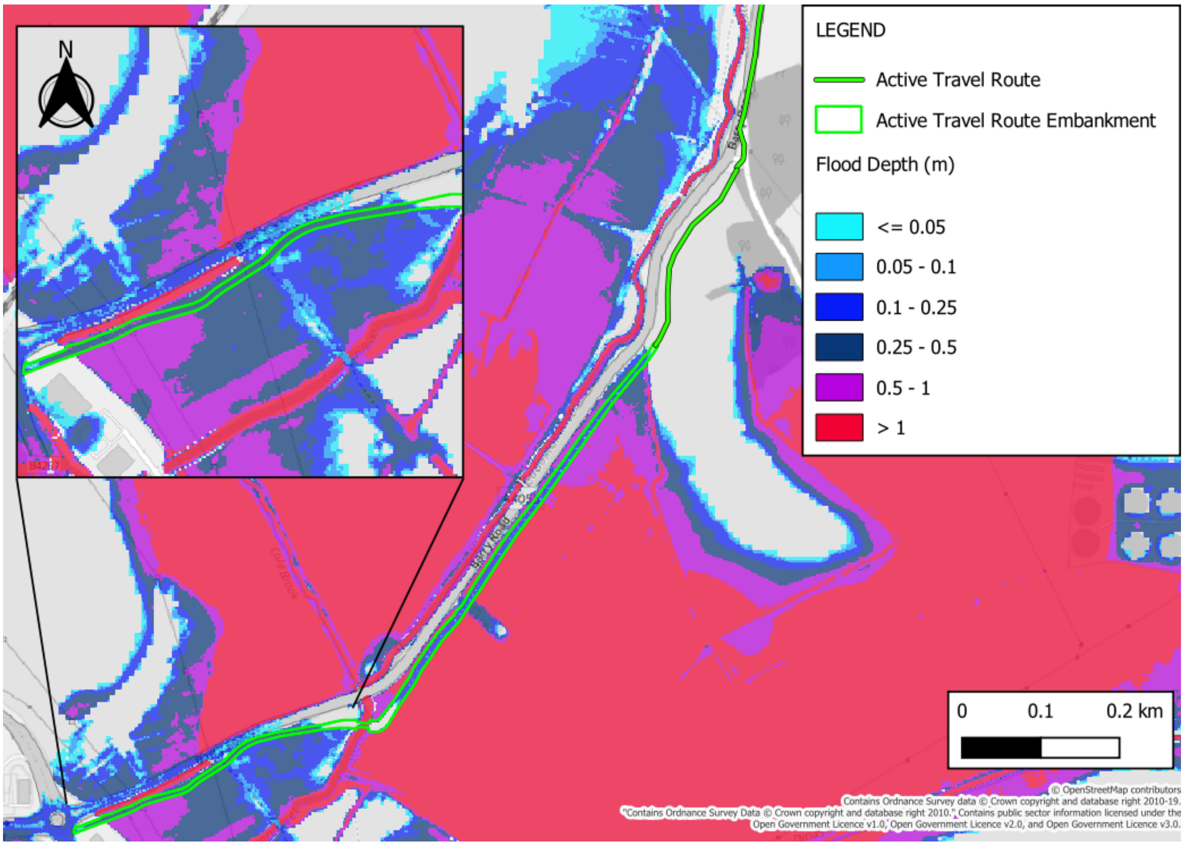


Figure 5-12 1 in 1000 (0.1%) Fluvial Event - 'With scheme' Flood Depth and Extent (Southern Area)

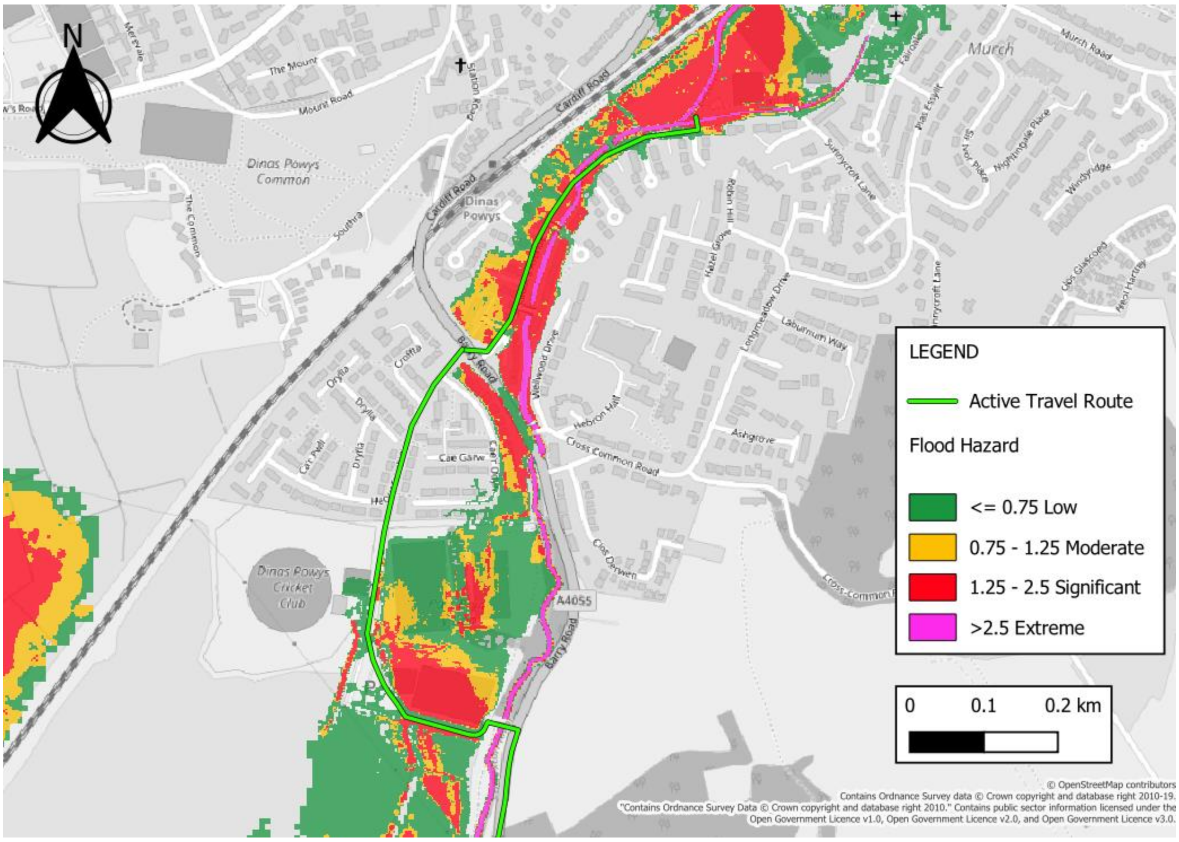


Figure 5-13 1 in 1000 (0.1%) Fluvial Event - 'With scheme' Flood Hazard (Northern Area)

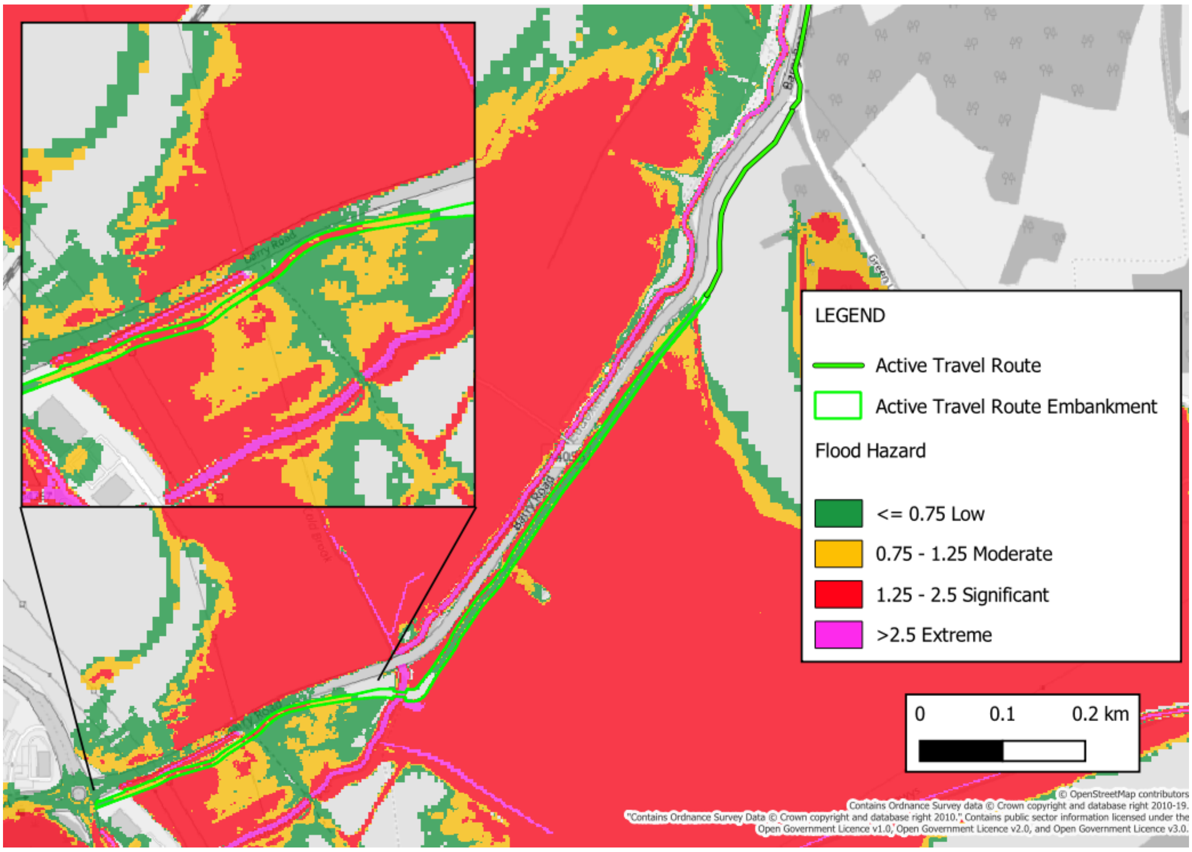


Figure 5-14 1 in 1000 (0.1%) Fluvial Event - 'With scheme' Flood Hazard (Southern Area)

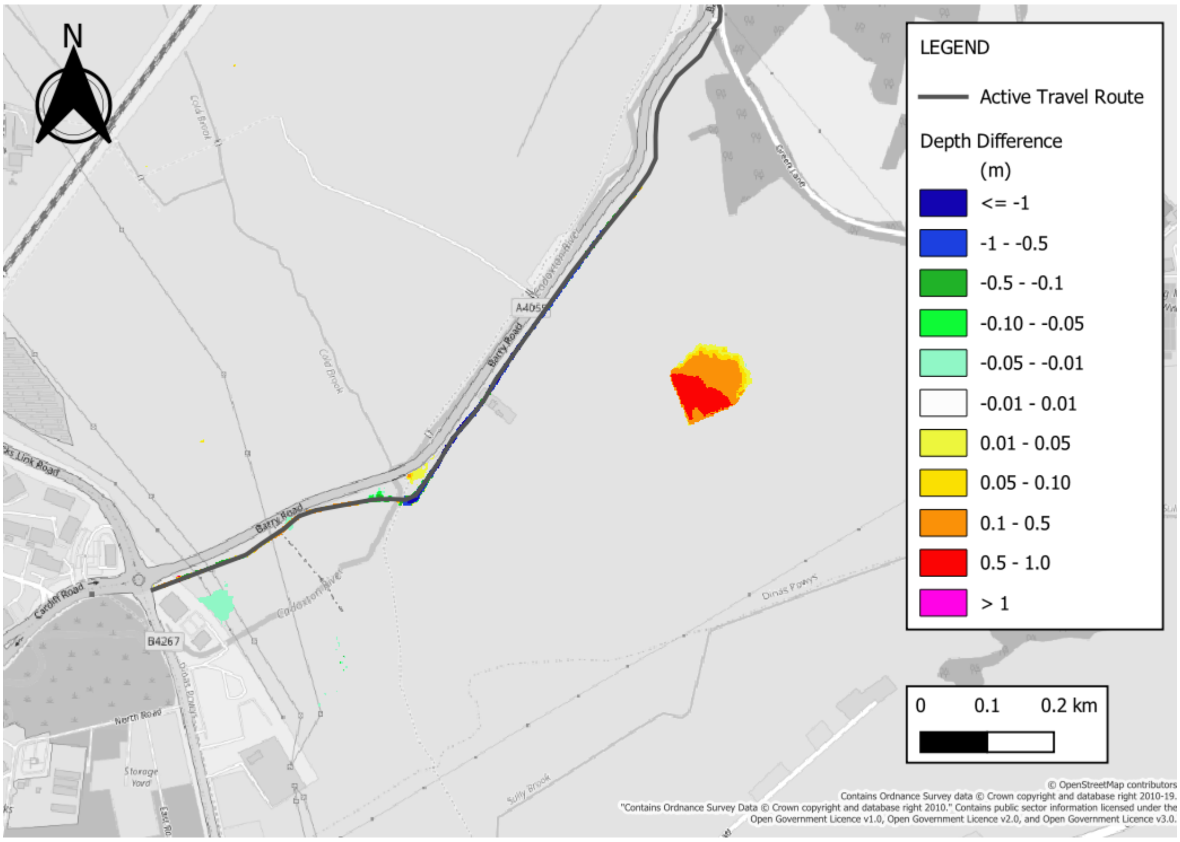


Figure 5-15 1 in 1000 (0.1%) Fluvial Event - Depth Difference (Southern Area)

Tidal Flood Modelling Results

5.3.18 The tidal flood model was run for the 1 in 200 (0.5%) and 1 in 1000 (0.1%) events, with both scenarios including predicted sea level change due to climate change up to the year 2099 (i.e. 75 year design lifetime). 'The tidal scenario was run with a coincident 1 in 2 (50%) fluvial inflow.

Tidal Flood Results 1 in 200 (0.5%) plus climate change event

5.3.19 The with scheme tidal flood extent and depth for the 1 in 200 (0.5%) plus climate change (2099) event is presented in Figure 5-16 for the southern section of the scheme. There is no tidal flooding predicted in the northern part of the scheme and, therefore, this area is not reported.

5.3.20 The model results predict the scheme to be flood free in the 1 in 200 (0.5%) plus climate change (2099) event. As the scheme is flood free the hazard is not mapped. The majority of the flooding shown in 5-16 is due to fluvial flooding as a result of tide locking rather than tidal inundation.

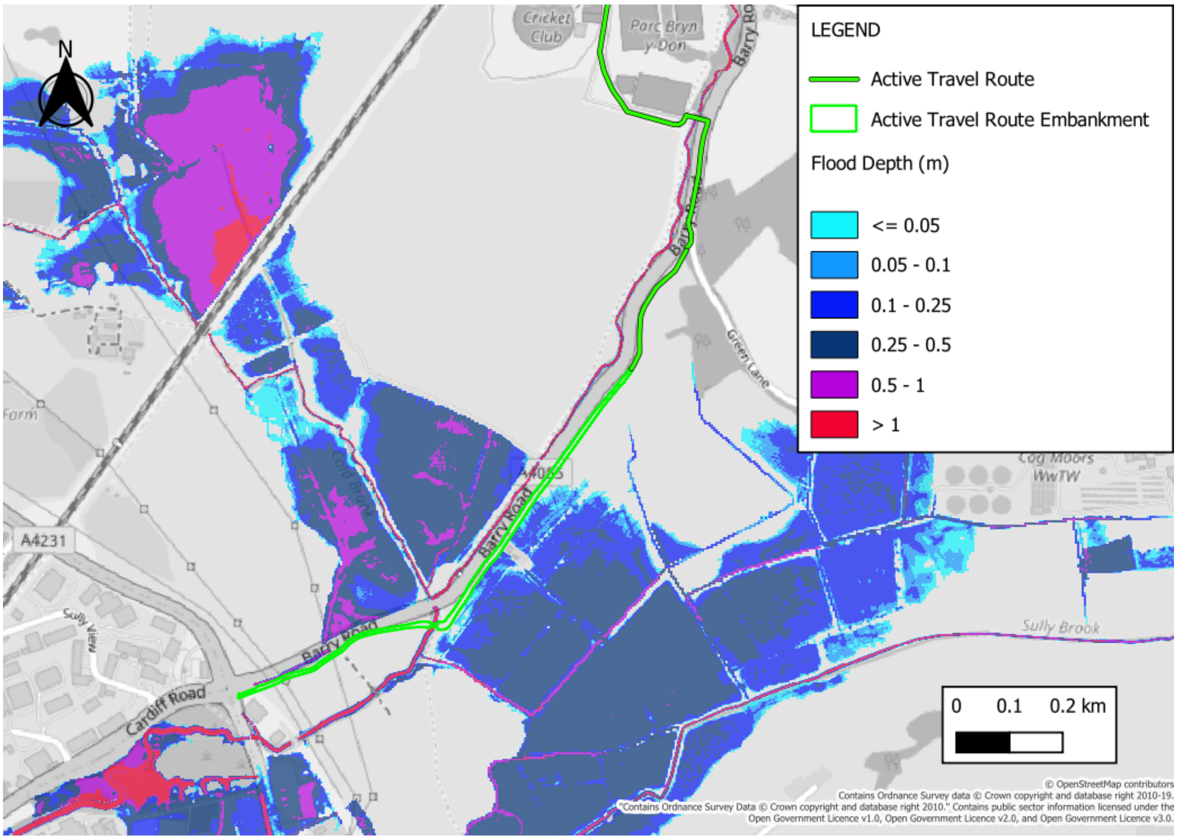


Figure 5-16 1 in 200 (160.5%) plus Climate Change (2099) Tidal Event - 'With scheme' Flood Depth and Extent

Tidal Flood Results 1 in 1000 (0.1%) plus climate change event

5.3.21 The with scheme tidal flood extent and depth for the 1 in 1000 (0.1%) plus climate change (2099) event is presented in Figure 5-17 for the southern section of the scheme. There is no tidal flooding predicted in the northern part of the scheme and, therefore, this area is not reported.

5.3.22 The model results predict the scheme to be flood free in the 1 in 1000 (0.1%) event plus climate change (2099) event. The majority of the flooding shown in 5-17 is due to fluvial flooding as a result of tide locking rather than tidal inundation.

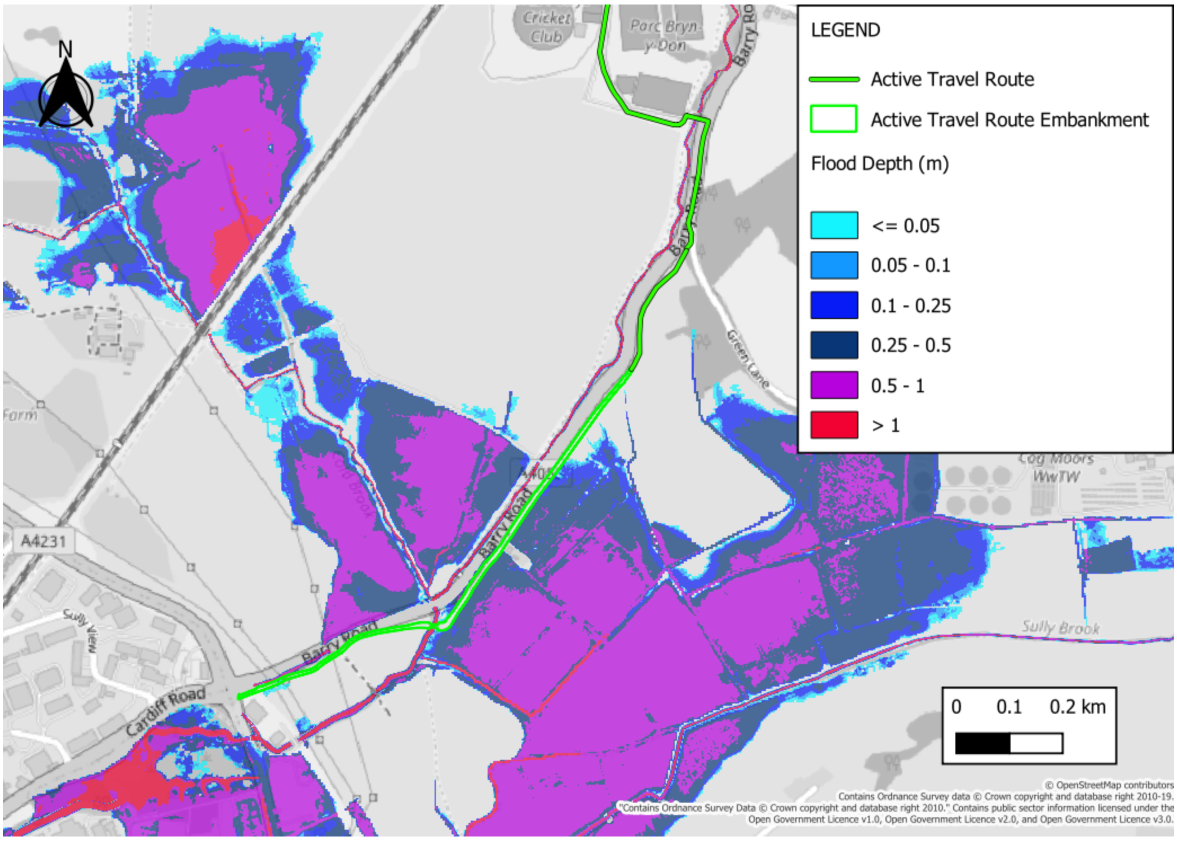


Figure 5-17 1 in 1000 (0.1%) plus Climate Change Tidal Event - 'With scheme' Flood Depth and Extent

5.4 Residual Risk

Bridge Blockage

5.4.1 The residual risk both to and resulting from the scheme and surrounding area has been assessed by undertaking a 50% blockage scenario on the proposed new Cadoxton Brook bridge crossing for the 1 in 30 (3.33%) and 1 in 100 (1%) fluvial flood events.

5.4.2 The results of the blockage scenario in the 1 in 30 (3.33%) event show an increase in flood levels upstream of the new crossing of approximately 0.1 m (Figure 5-18). The results of the blockage scenario in the 1 in 100 (1%) event show an increase in flood levels upstream of the new crossing of approximately 0.05 m (Figure 5-19). The flood impacts are limited to areas of moderate vulnerability agricultural land.

5.4.3 The results of the blockage assessment suggest that the change in flood risk associated with a blockage is relatively small in relation to the overall flood depths predicted in this area for these events. Furthermore, the actual risk of a blockage to the proposed structure is considered low as the bridge will be a free span structure, with abutments set back from the bank tops. The bridge soffit is 0.55 m higher than the peak 1 in 100 (1%) plus climate change water level, thus reducing the likelihood of a blockage occurring.

Un-defenced Flood Scenario

5.4.4 The results of the fluvial undefended scenarios show no significant change in peak water level for the 1 in 100 (1%) plus climate change scenario, therefore, the fluvial flood risk remains the same in the ‘with scheme’ scenario for the defended and undefended scenarios.

5.4.5 The results of the tidal undefended scenario show a greater flood extent and depth than the defended scenario, however, the increase in the depth is relatively small (approximately 0.1 m) in the scheme location and the embankment remains flood free. Therefore, the residual risk associated with a tidal defence breach scenario is acceptable.

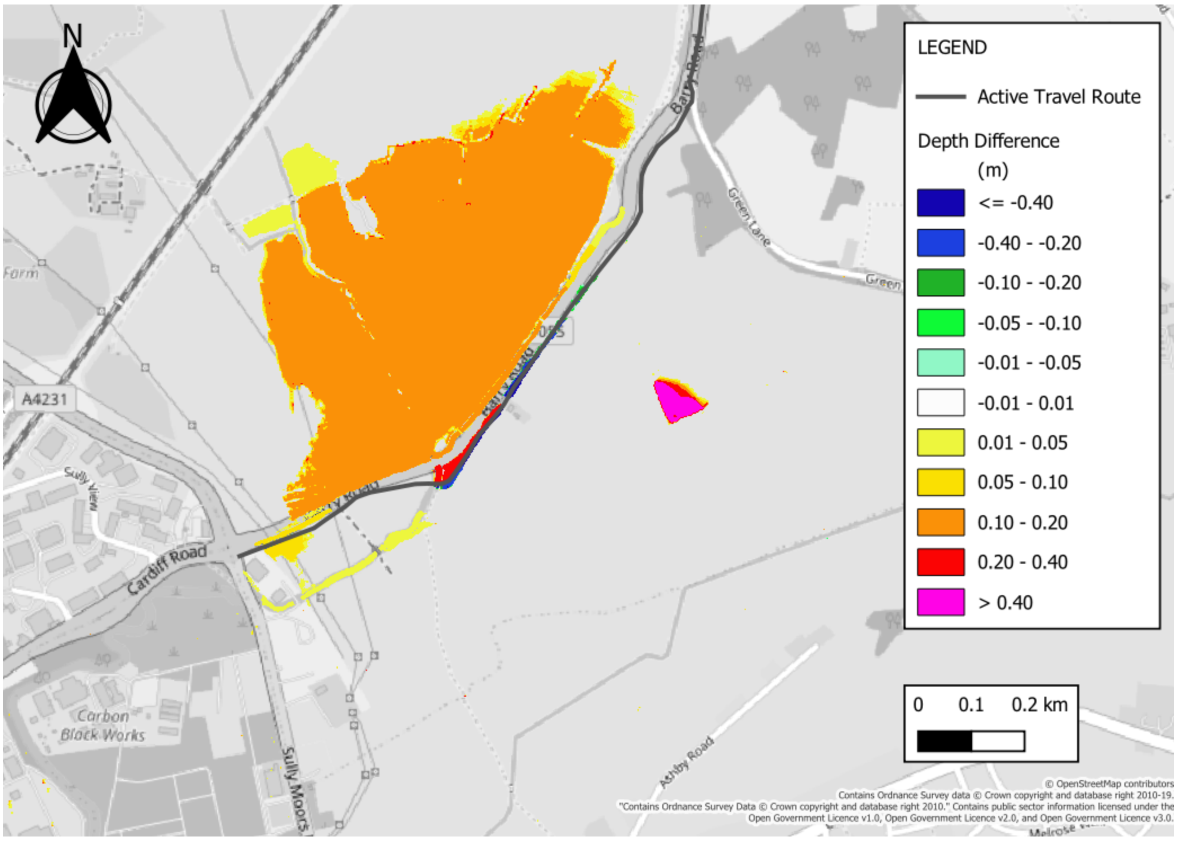


Figure 5-18 1 in 30 (3.33%) plus 50% Blockage scenario - Depth Difference relative to Baseline

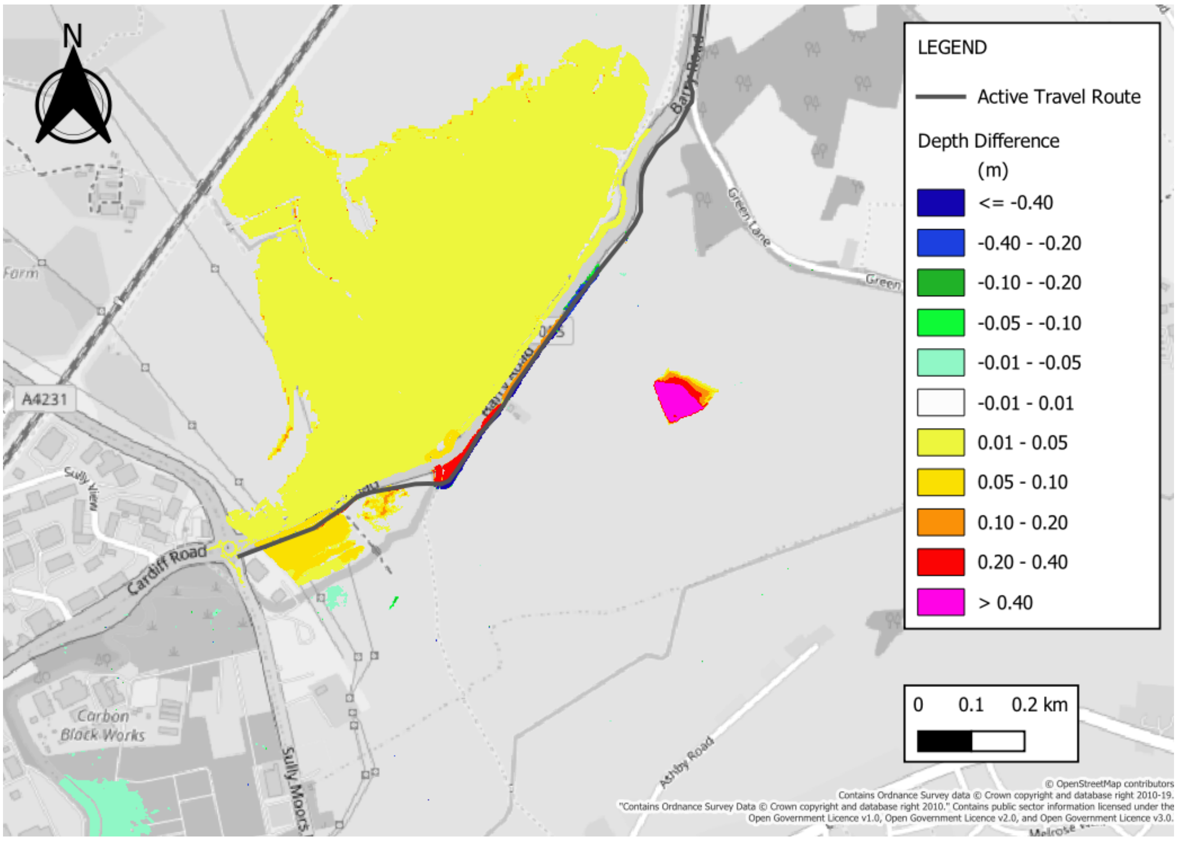


Figure 5-19 1 in 100 (1%) plus 50% Blockage scenario - Depth Difference relative to Baseline

5.5 Floodplain Compensation

5.5.1 The scheme includes a raised embankment that would result in some loss of flood storage volume from the floodplain. This lost flood volume has been calculated and an equivalent level-for-level flood volume has been created by lowering an area of land adjacent to the scheme that is outside of the predicted flood extent, thus creating a flood compensation area.

5.5.2 The location plus existing and proposed ground levels of the flood compensation area are presented in Figure 5-20 and a long section illustrating the ground elevations is shown in Figure 5-21.

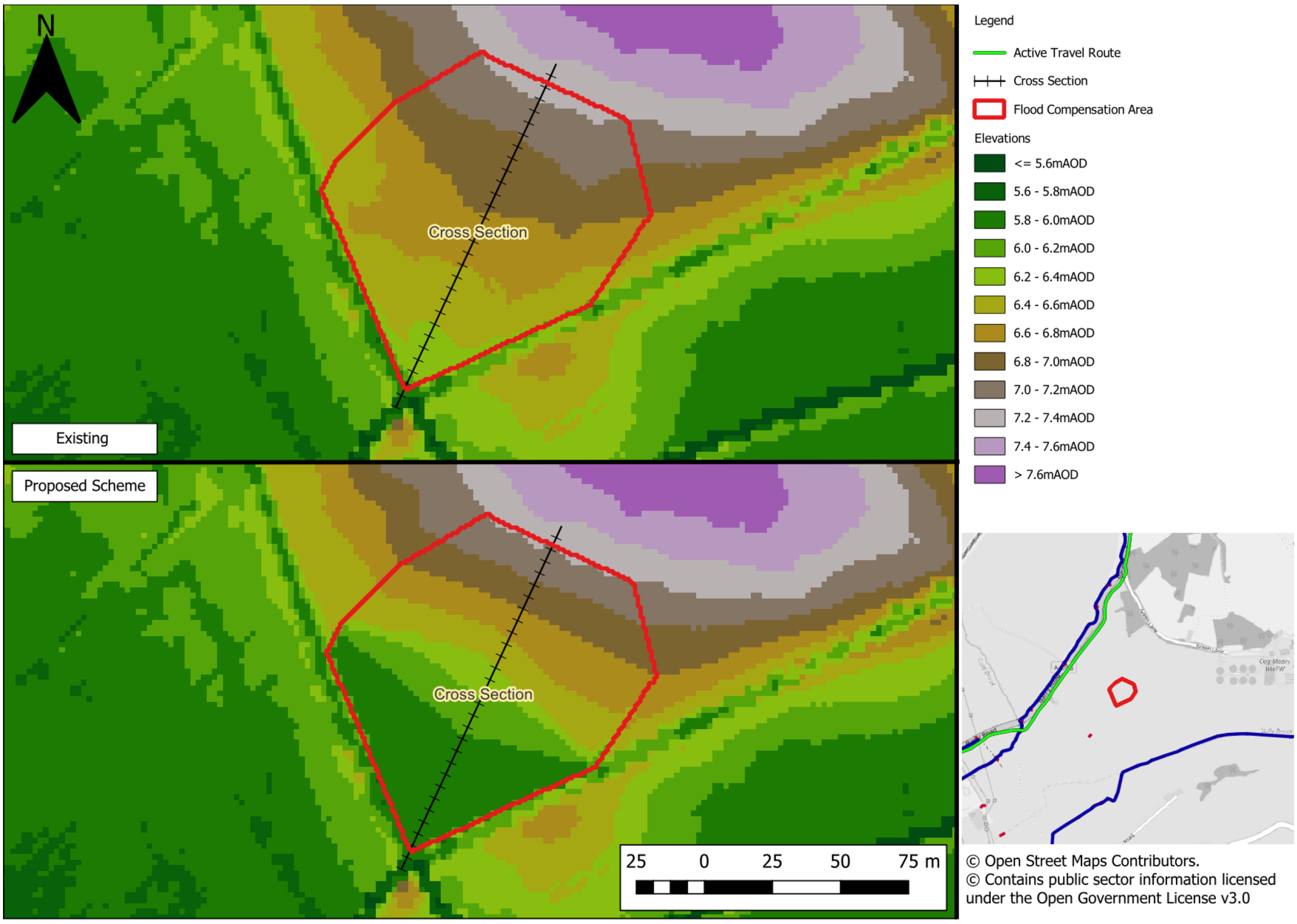


Figure 5-17 20 Flood Compensation Area

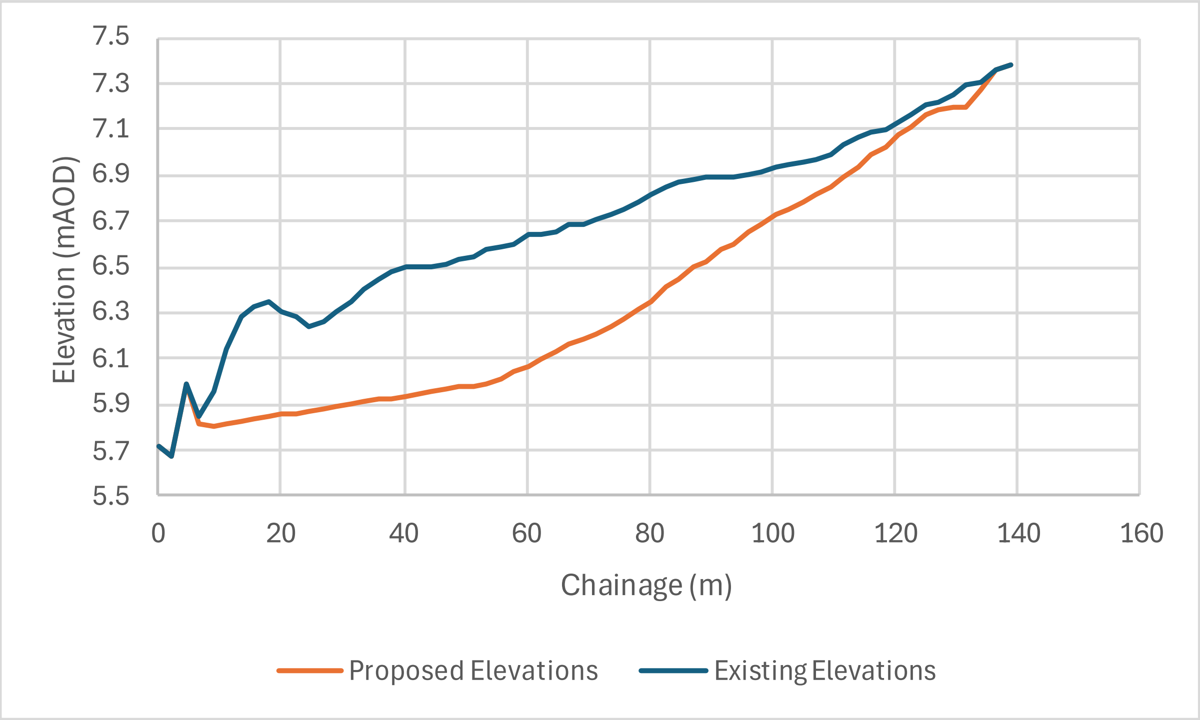


Figure 5-21 *Flood Compensation Area Ground Levels*

5.5.3 The calculated floodplain storage volume that is lost due to the embanked section of the scheme and the volumes that would be created by the compensation area are reported in Table 5-3.

5.5.4 The tabulated data shows a total flood volume, within the embankment footprint, in the baseline scenario to be 4,834 m³ up to the top water level for the 1 in 100 (1%) plus climate change event. The 'with scheme' total flood volume for the same area is 1,630 m³ meaning that the total volume loss is estimated to be 3,204 m³. The net gain in flood volume within the flood compensation area for each elevation slice has been calculated (Table 5-3). This estimates a total net gain in flood volume of 3,377 m³ and, therefore, confirms that an equivalent replacement volume has been created up to the peak 1 in 100 (1%) plus climate change flood level.

Table 5-3: Level for Level Flood Compensation Calculations

Flood Volumes		Pre-Development Embankment Area		Post Development Embankment Area		Embankment	Flood Compensation Area
Band	**Level (mAOD)**	**Total Area (m^2)**	**Total Volume (m^3)**	**Total Area (m^2)**	**Total Volume (m^3)**	**Incremental loss of floodplain volume (m^3)**	**Incremental gain in floodplain volume (m^3)**
1	7.1	7,071	4,834	5,108	1,630	208	200
2	7.0	6,490	4,159	4,337	1,162	230	255
3	6.9	5,930	3,538	3,661	771	320	324
4	6.8	5,496	2,967	1,942	521	378	386
5	6.7	5,266	2,432	1,559	363	391	384
6	6.6	5,002	1,918	1,225	241	392	368
7	6.5	4,428	1,446	911	160	353	357
8	6.4	3,802	1,035	668	103	303	339
9	6.3	3,088	688	486	58	252	301
10	6.2	2,422	414	325	36	197	227
11	6.1	1,994	196	179	16	139	148
12	6.0	892	45	63	4	40	73
13	5.9	95	3	13	2	1	15
14	5.8	8	1	8	1	0	0
					TOTALS	**3,204**	**3,377**

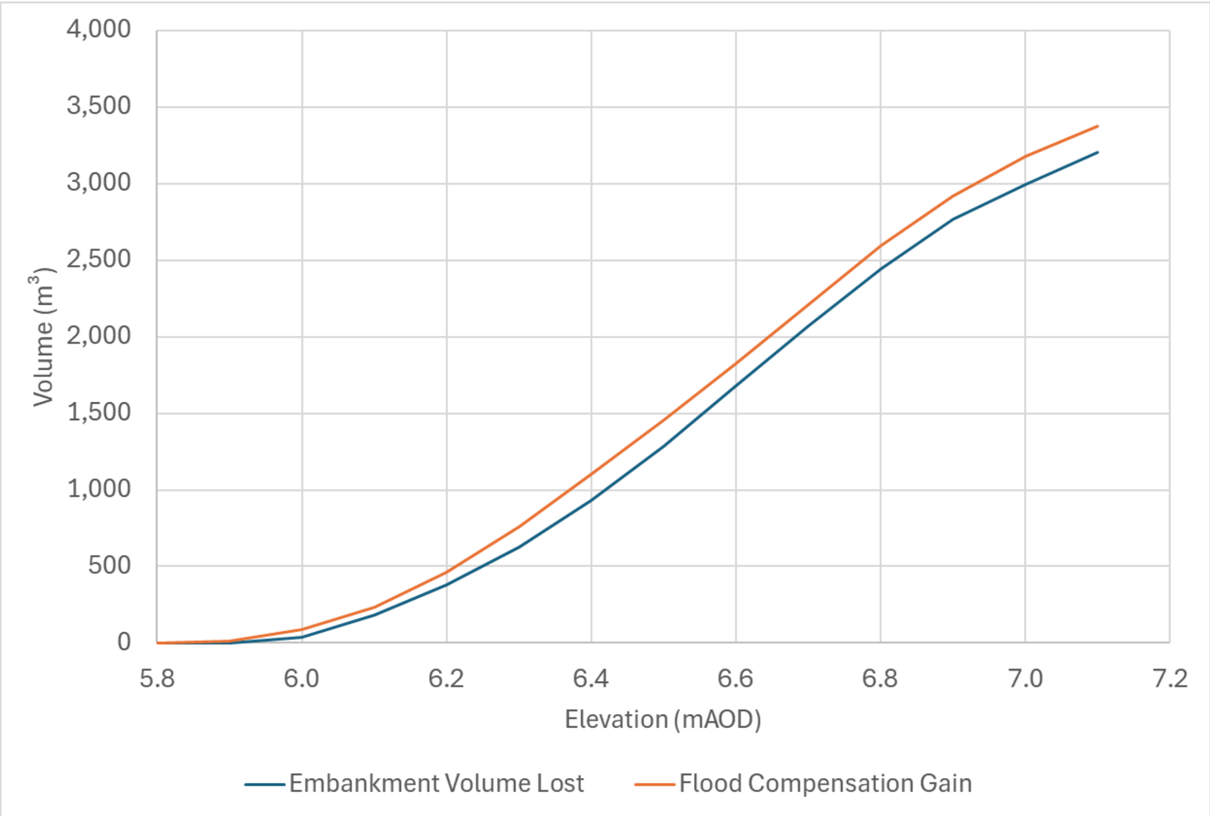


Figure 5-22 Cumulative Flood Volume Lost and Gained

6 CONCLUSION

6.1.1 An FCA for the proposed active travel route between Biglis Roundabout, Barry and Dinas Powys rail station, has been undertaken in accordance with the requirements of TAN15.

6.1.2 The Development Advice Map for the area shows that the southern part of the scheme lies within Flood Zone C2 (within the extreme flood extent (1 in 1000 (0.1%)) and without significant flood defence infrastructure). The northern extent of the scheme is located within Flood Zone C1 (within the extreme flood extent (1 in 1000 (0.1%)) and served by significant infrastructure, including flood defences).

6.1.3 The proposed scheme would come under the TAN15 'less vulnerable development' classification and, therefore, is an appropriate development type for this area. However, as the site is within Zone C2, justification of its location is required and an FCA is required to demonstrate that the development would be safe and would not impact third party flood risk.

6.1.4 The proposed scheme is considered to be justified under the Welsh Government Active Travel (Wales) Act 2013 which makes it a legal requirement for local authorities in Wales to map and plan for suitable routes for active travel within certain settlements. Therefore, it is considered that the scheme would pass the justification test given its significance both at a local and national level.

6.1.5 The FCA identifies that the only sources of flooding that pose a potential risk to the proposed development are tidal and fluvial. No other sources of flooding are considered to pose an onerous risk to the scheme. The scheme will result in a slight increase in impermeable land coverage which could result in an increase in surface water runoff. A surface water drainage strategy, detailed in a standalone report, has been developed to mitigate this.

6.1.6 Detailed fluvial modelling has shown that the predicted onset of flooding is more frequent than the TAN15 recommended 1 in 100 (1%) plus climate change threshold for some areas of the route. The use of existing highway and the low-lying nature of some parts of the scheme location make it impractical to construct a totally flood free scheme.

6.1.7 With the exception of a short section of the route that is located along St Cadoc's Avenue, the maximum predicted flood depths along the route in the extreme 1 in 1000 (0.1%) fluvial event are within the TAN15 maximum consequence thresholds. In addition, the rate of rise of floodwaters is predicted to be approximately 0.3 m / hour which, combined with the available egress to higher ground on the A4055, makes it possible to exit the scheme safely during an extreme event.

6.1.8 The modelling shows that the scheme would not be impacted by tidal flooding in events up to, and including, the 1 in 1000 (0.1%) scenario including sea level rise over the 75 year development lifetime.

6.1.9 The modelling has demonstrated that the proposed scheme would have no significant third-party impacts and flood consequences are judged to be acceptable. Therefore, the proposed development is considered appropriate.

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