A5 Western Transport Corridor

Flood Risk Assessment Report 3

Impact and Mitigation Assessment Report

A5 Western Transport Corridor

718736/0500/R/005

July 2016

Produced for

transportni

Department for Infrastructure
An Roinn Bonneagair
www.infrastructure-ni.gov.uk

Prepared by

mouchel
building great relationships

Project Office:
Shorefield House
30 Kinnegar Drive
Holywood
County Down
Northern Ireland
BT18 9JQ

T 028 9042 4117
F 028 9042 7039

Document Control Sheet

Project Title	A5 Western Transport Corridor
Report Title	Flood Risk Assessment Report 3
Revision	3
Status	Draft
Control Date	July 2016

Record of Issue

Issue	Status	Author	Date	Check	Date	Authorised	Date
V3	Draft	CMI/LG	Jul 16	OC	Jul 16	AH	Jul 16
V2	For Approval	LG	Nov 12	OC	Nov 12	AMcC	Nov 12
V1	Draft	LS	Apr 11	SMcG	Apr 11	AJH	Apr 11

Distribution

Organisation	Contact	Copies
Transport NI		1 Electronic
Rivers Agency		1 Electronic 1 Hard Copy

Contents

Table of Figures

Table of Tables

Appendices

Appendix A: Drawings

Drawing No.	Description
718736-S1-0500-0108	FLOOD MITIGATION DRAWING, MODEL A – GORTIN HALL DRAIN (SECTION 1), SHEET 1 OF 1
718736-S1-0500-0109	FLOOD MITIGATION DRAWING, MODEL B – BLACKSTONE BURN (SECTION 1), SHEET 1 OF 1
718736-S1-0500-0107	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), OVERVIEW
718736-S1-0500-0111	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 1 OF 10
718736-S1-0500-0101	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 2 OF 10
718736-S1-0500-0102	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 3 OF 10
718736-S1-0500-0112	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 4 OF 10
718736-S1-0500-0113	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 5 OF 10
718736-S1-0500-0103	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 6 OF 10
718736-S1-0500-0104	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 7 OF 10
718736-S1-0500-0105	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 8 OF 10
718736-S1-0500-0106	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 9 OF 10
718736-S1-0500-0110	FLOOD MITIGATION DRAWING, MODEL 1 – FOYLE RIVER (SECTION 1), SHEET 10 OF 10

Drawing No.	Description
718736-S2-0500-0101	FLOOD MITIGATION DRAWING, MODEL D – UNDESIGNATED (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0102	FLOOD MITIGATION DRAWING, MODEL 5 – DERG (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0103	FLOOD MITIGATION DRAWING, MODEL E – COOLAGHY BURN (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0112	FLOOD MITIGATION DRAWING, MODEL F – BACK BURN (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0104	FLOOD MITIGATION DRAWING, MODEL G – UNDESIGNATED (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0105	FLOOD MITIGATION DRAWING, MODEL H – TULLY DRAIN (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0106	FLOOD MITIGATION DRAWING, MODEL 4 – OMAGH (SECTION 2), OVERVIEW
718736-S2-0500-0107	FLOOD MITIGATION DRAWING, MODEL 4 – OMAGH (SECTION 2), SHEET 1 OF 4
718736-S2-0500-0108	FLOOD MITIGATION DRAWING, MODEL 4 – OMAGH (SECTION 2), SHEET 2 OF 4
718736-S2-0500-0109	FLOOD MITIGATION DRAWING, MODEL 4 – OMAGH (SECTION 2), SHEET 3 OF 4
718736-S2-0500-0110	FLOOD MITIGATION DRAWING, MODEL 4 – OMAGH (SECTION 2), SHEET 4 OF 4
718736-S2-0500-0113	FLOOD MITIGATION DRAWING, MODEL I – FIREAGH DRAIN (SECTION 2), SHEET 1 OF 1
718736-S2-0500-0111	FLOOD MITIGATION DRAWING, MODEL 6 –DRUMRAGH RIVER (SECTION 2), SHEET 1 OF 1
718736-S3-0500-0112	FLOOD MITIGATION DRAWING, MODEL L – RANELLY (SECTION 3), OVERVIEW
718736-S3-0500-0113	FLOOD MITIGATION DRAWING, MODEL L – RANELLY (SECTION 3), SHEET 1 OF 3

Drawing No.	Description
718736-S3-0500-0101	FLOOD MITIGATION DRAWING, MODEL L – RANELLY (SECTION 3), SHEET 2 OF 3
718736-S3-0500-0102	FLOOD MITIGATION DRAWING, MODEL L – RANELLY (SECTION 3), SHEET 3 OF 3
718736-S3-0500-0103	FLOOD MITIGATION DRAWING, MODEL M – UNDESIGNATED (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0118	FLOOD MITIGATION DRAWING, MODEL N – UNDESIGNATED (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0119	FLOOD MITIGATION DRAWING, MODEL O – UNDESIGNATED (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0124	FLOOD MITIGATION DRAWING, MODEL PQ – ROUTING BURN AND EXT (SECTION 3), OVERVIEW
718736-S3-0500-0104	FLOOD MITIGATION DRAWING, MODEL PQ – ROUTING BURN AND EXT (SECTION 3), SHEET 1 OF 2
718736-S3-0500-0120	FLOOD MITIGATION DRAWING, MODEL PQ – ROUTING BURN AND EXT (SECTION 3), SHEET 2 OF 2
718736-S3-0500-0115	FLOOD MITIGATION DRAWING, MODEL R – UNDESIGNATED (SECTION 3), OVERVIEW
718736-S3-0500-0116	FLOOD MITIGATION DRAWING, MODEL R – UNDESIGNATED (SECTION 3), SHEET 1 OF 3
718736-S3-0500-0117	FLOOD MITIGATION DRAWING, MODEL R – UNDESIGNATED (SECTION 3), SHEET 2 OF 3
718736-S3-0500-0105	FLOOD MITIGATION DRAWING, MODEL R – UNDESIGNATED (SECTION 3), SHEET 3 OF 3
718736-S3-0500-0127	FLOOD MITIGATION DRAWING, MODEL S – UNDESIGNATED (SECTION 3), OVERVIEW
718736-S3-0500-0121	FLOOD MITIGATION DRAWING, MODEL S – UNDESIGNATED (SECTION 3), SHEET 1 OF 2
718736-S3-0500-0122	FLOOD MITIGATION DRAWING, MODEL S – UNDESIGNATED (SECTION 3), SHEET 2 OF 2

Drawing No.	Description
718736-S3-0500-0106	FLOOD MITIGATION DRAWING, MODEL T – ROUGHAN (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0114	FLOOD MITIGATION DRAWING, MODEL U – BALLYGAWLEY RIVER (SECTION 3), OVERVIEW
718736-S3-0500-0107	FLOOD MITIGATION DRAWING, MODEL U – BALLYGAWLEY RIVER (SECTION 3), SHEET 1 OF 2
718736-S3-0500-0108	FLOOD MITIGATION DRAWING, MODEL U – BALLYGAWLEY RIVER (SECTION 3), SHEET 2 OF 2
718736-S3-0500-0109	FLOOD MITIGATION DRAWING, MODEL V – TULLYVAR (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0110	FLOOD MITIGATION DRAWING, MODEL W – RAVELLA (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0123	FLOOD MITIGATION DRAWING, MODEL X – UNDESIGNATED (SECTION 3), SHEET 1 OF 1
718736-S3-0500-0125	FLOOD MITIGATION DRAWING, MODEL Y – LISADAVIL (SECTION 3), OVERVIEW
718736-S3-0500-0111	FLOOD MITIGATION DRAWING, MODEL Y – LISADAVIL (SECTION 3), SHEET 2 OF 2
718736-S3-0500-0126	FLOOD MITIGATION DRAWING, MODEL Y – LISADAVIL (SECTION 3), SHEET 1 OF 2
718736-0500-D-00228	SECTION 2 STORAGE COMPENSATION S2-CS-01 UD_15
718736-0500-D-00229	SECTION 2 STORAGE COMPENSATION S2-CS-02 DERG
718736-0500-D-00230	SECTION 2 STORAGE COMPENSATION S2-CS-03 COLLAGHY
718736-0500-D-00231	SECTION 2 STORAGE COMPENSATION S2-CS-04 UD_39
718736-0500-D-00232	SECTION 2 STORAGE COMPENSATION S2-CS-05 UD_42 TULLY
718736-0500-D-00233	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH OVERVIEW

Drawing No.	Description
718736-0500-D-00234	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 1 OF 11
718736-0500-D-00235	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 2 OF 11
718736-0500-D-00236	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 4 OF 11
718736-0500-D-00237	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 5 OF 11
718736-0500-D-00238	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 6 OF 11
718736-0500-D-00239	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 7 OF 11
718736-0500-D-00240	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 8 OF 11
718736-0500-D-00241	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 9 OF 11
718736-0500-D-00242	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 10 OF 11
718736-0500-D-00243	SECTION 2 STORAGE COMPENSATION MODEL M.6 DRUMRAGH
718736-0500-D-00244	SECTION 3 STORAGE COMPENSATION MODEL M.L RANELLY DRAIN OVERVIEW
718736-0500-D-00245	SECTION 3 STORAGE COMPENSATION S3-CS-01 MODEL M.L RANELLY DRAIN SHEET 2 OF 4
718736-0500-D-00246	SECTION 3 STORAGE COMPENSATION S3-CS-02 MODEL M.L RANELLY DRAIN SHEET 3 OF 4
718736-0500-D-00247	SECTION 3 STORAGE COMPENSATION S3-CS-03 MODEL M.L RANELLY DRAIN SHEET 4 OF 4
718736-0500-D-00248	SECTION 3 STORAGE COMPENSATION S3-CS-05 MODEL M.M LETFERN

Drawing No.	Description
718736-0500-D-00250	SECTION 3 STORAGE COMPENSATION S3-CS-08 MODEL M.R UNDESIGNATED
718736-0500-D-00251	SECTION 3 STORAGE COMPENSATION S3-CS-09 MODEL M.T ROUGHAN
718736-0500-D-00253	SECTION 3 STORAGE COMPENSATION S3-CS-10 MODEL M.U BALLYGAWLEY
718736-0500-D-00255	SECTION 3 STORAGE COMPENSATION S3-CS-11.1 S3-CS-12 MODEL M.V TULLYVAR SHEET 1 OF 2
718736-0500-D-00256	SECTION 3 STORAGE COMPENSATION S3-CS-11.2 MODEL M.V TULLYVAR SHEET 2 OF 2
718736-0500-D-00257	SECTION 3 STORAGE COMPENSATION S3-CS-13 MODEL M.W UNDESIGNATED
718736-0500-D-00258	SECTION 3 STORAGE COMPENSATION S3-CS-14 MODEL M.YUNDESIGNATED
718736-0500-D-00259	SECTION 3 STORAGE COMPENSATION S3-CS-15.1 MODEL M.Y LISDAVIL SHEET 1 OF 2
718736-0500-D-00260	SECTION 3 STORAGE COMPENSATION S3-CS-15.2 MODEL M.Y LISDAVIL SHEET 2 OF 2
718736-0500-D-00420	SECTION 3 STORAGE COMPENSATION S3-CS-20 MODEL M.L RANELLY DRAIN SHEET 1 OF 4
718736-0500-D-00421	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 3 OF 11
718736-0500-D-00422	SECTION 2 STORAGE COMPENSATION MODEL M.4 OMAGH SHEET 11 OF 11
718736-1700-D-0507	RIVER BURN DENNET (REF S1/B06) PRELIMINARY GENERAL ARRANGEMENT
718736-1700-D-0508	RIVER GLENMORNAN (REF S1/B08) PRELIMINARY GENERAL ARRANGEMENT

Drawing No.	Description
718736-1700-D-0509	RIVER MOURNE (REF S1/B14) PRELIMINARY GENERAL ARRANGEMENT 4 SPAN STEEL
718736-1700-D-0510	RIVER DERG (REF S2/B07) PRELIMINARY GENERAL ARRANGEMENT
718736-1700-D-0511	RIVER FAIRYWATER (REFS2-B19) PRELIMINARY GENERAL ARRANGEMENT
718736-1700-D-0512	RIVER DRUMRAGH (REF S2/B28) PRELIMINARY GENERAL ARRANGEMENT
718736-1700-D-0513	RIVER COOLAGHY (REFS2-B9.1) BURN PRELIMINARY GENERAL ARRANGEMENT
718736-1700-D-0514	RIVER BALLYGAWLEY PRELIMINARY GENERAL ARRANGEMENT (REF S3/B17.3)
718736-1700-D-0515	ROUTING BURN U/B (REF S3/B08.1) PRELIMINARY GENERAL ARRANGMENT
718736-1700-D-0516	BALLYMAGORRY FLOOD RELIEF STRUCTURES GENERAL ARRANGEMENT REF S1-B10
718736-1700-D-0517	BALLYMAGORRY FLOOD RELIEF STRUCTURES GENERAL ARRANGEMENT B10.1
718736-1700-D-0518	BALLYMAGORRY FLOOD RELIEF STRUCTURES GENERAL ARRANGEMENT REF B10.2A & B10.2B
718736-1700-D-0519	PARK ROAD FLOOD RELIEF STRUCTURES GENERAL ARRANGEMENT REF B09
718736-1700-D-0520	RIVER BALLYGAWLEY (REF S3/B17.4) PRELIMINARY GENERAL ARRANGEMENT UNDER PASS

This report is presented to DRD Transport NI (TNI) in respect of the A5 Western Transport Corridor Flood Risk Assessment and may not be used or relied on by any other person or by the client in relation to any other matters not covered specifically by the scope of this report.

Notwithstanding anything to the contrary contained in the report, Mouchel Consulting Limited is obliged to exercise reasonable skill, care and diligence in the performance of the services required by DRD TNI and Mouchel Limited shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This report has been prepared by Mouchel Consulting Limited. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

Executive Summary

Introduction

This report is number three of the A5 Western Transport Corridor (A5 WTC) Flood Risk Assessment (FRA) Reports and provides a summary of the impact of the A5 WTC in relation to flooding and the mitigation options for the Proposed Scheme. This report follows FRA 1 - *Assessment Parameters and Preliminary Flood Risk Assessment* and FRA 2 – *Hydraulic Model Build Report* and contains information in relation to impact identification, assessment of mitigation options, integration of mitigation into hydraulic models and discussion of the modelling results.

Additional information pertaining to the development and route selection of the A5 WTC is available on the A5 WTC website, www.a5wtc.com, in the form of the Preliminary Options Report, Preferred Options Report and the Stage 3 Scheme Assessment Report

FRA Report 2 – *Hydraulic Model Build Report* detailed that the route has been developed to the current alignment design: the Proposed Scheme. Information and assessments outlined in this report are based on the Proposed Scheme designs.

Proposed Scheme Summary

The Preferred Route has undergone continuing design development and as a result of this, the alignment has changed both horizontally and vertically at a number of locations. Drawings 718736-0500-D-00184 to 718736-0500-D-00193 in Appendix A of FRA 2 – *Hydraulic Build Report* provide an overview of the Proposed Scheme.

A5WTC Drainage and Flooding Design Development

The design process for the Proposed Scheme involved an iterative approach between various disciplines. Input from drainage and flooding engineers, formed part of this multidisciplinary iterative design process. The purpose of this current document is not to report on every design iteration, but rather to present the engineering features for the Proposed Scheme, assess potential impacts should the scheme be constructed and review mitigation proposals.

The drainage design philosophy for the Proposed Scheme ensures a solution that satisfies the design criteria. Measures are incorporated to mitigate against potential increased risks of future flooding as a result of the Proposed Scheme. These include the provision of pre-earthworks drainage that prevent the flows from embankment slopes flooding adjacent lands, provision of attenuation where required to manage discharge to watercourses and provision of appropriately sized culverts to enable watercourses to cross the Proposed Scheme alignment.

All proposed drainage aspects have been discussed in detail with Rivers Agency alongside the development of flooding and mitigation assessment, with 'Consent in Principal' being granted for all notable river engineering works. Where minor changes are required these follow the same principles. Design proposals for all culverts, outfalls and watercourse diversions based on the detailed discussions to date with Rivers Agency will be submitted for approval in accordance with Schedule 6 of the Drainage Order (Northern Ireland) 1973, at an appropriate stage in the project. A Drainage Impact Assessment Report has also been completed as an addendum to this report.

A5WTC Floodplain Interaction, Impacts and Mitigation Assessment

Water levels and associated existing floodplain extents were evaluated and mapped for a range of return periods, focusing on the 'design' event; 100year [1% Annual Exceedance Probability (AEP)] for fluvial floodplains and 200 year plus climate change [0.5+cc% AEP] for tidal floodplains. FRA Reports 1 and 2 provide full details in relation to the identification of floodplains and the development of hydraulic models to identify water levels. These models and extents have been used to identify any impacts arising from the A5 WTC proposals and where appropriate to assess flood mitigation proposals.

Summary of Flood Risk Strategy and Mitigation

The various hydraulic models were utilised to inform the route development and to assist in the avoidance and/or reduction of impacts arising from the road alignment as far as reasonably practicable. The models facilitated the testing of various crossing structure sizes and floodplain impacts. Generally, flood impacts have been mitigated using measures which include some, or all, of the following:

- Avoidance of floodplains as far as reasonably practicable whilst incorporating multi-discipline engineering and non-engineering factors,
- Minimisation of road footprint as far as reasonably practicable whilst incorporating multi-discipline engineering and non-engineering factors,
- Appropriately sized culverts,
- Large span structures where feasible,
- Provision of floodplain connectivity structures to maintain floodplain conveyance where floodplains are bisected by the road alignment, and
- Provision of compensatory storage where material volumetric floodplain encroachment remains.

Design Manual for Roads and Bridges (DMRB) and Rivers Agency guidance state that where fluvial floodplain loss due to development is unavoidable it should be mitigated by the provision of volumetric compensation on a 'level for level' equivalent. Compensatory flood storage must become effective at the same point in a flood event as the lost storage would have done. It should therefore provide the same volume, and be at the same relative hydraulic level as the lost storage.

The requirement for flood volume mitigation addresses the issue of cumulative floodplain loss due to numerous small developments within catchments. Cumulatively, numerous small pieces of floodplain removal within a wider catchment can have notable impacts lower down the catchment. Compensatory storage seeks to avoid and/or mitigate piecemeal floodplain degradation.

An important point to note in the allocation of volume compensation storage is that the eventual engineering works (plan area and volume) required to achieve the necessary compensation storage may be significantly more than the actual volumes displaced by flooding.

Although volumetric compensation storage for displaced floodplains is generally accounted for within DMRB and Rivers Agency guidance, alternative measures were agreed with Rivers Agency for displaced flood volumes on the Foyle / Finn:

- The Foyle system (including the Finn, Mourne, Burndennet, Glenmornan, Deele and Swilly tributaries) comprising fluvial, tidal and inter fluvial / tidal zones. The Foyle hydraulic model extends into Lough Foyle and consequently the potential for undetermined / unassessed cumulative downstream impacts has been reduced.

- The most effective and practical mitigation options tested to maintain floodplain extents, levels and temporal nature were to reduce floodplain encroachment, reduce road footprint, provide floodplain connectivity and large structures (on main channels and some key floodplain conveyance locations). These more practical options have been explored in detail and form the major impact mitigation strategy that has been proposed for the scheme following discussions with TNI and Rivers Agency.

Where development is required within a floodplain, additional works may be required to mitigate flood risk changes caused by the scheme. The purpose of mitigation measures within a floodplain is to manage floodwater levels in a way that reduces the potential impact of flooding on the scheme itself and also elsewhere in the catchment.

Various iterations with regards to the mitigation measures have been undertaken to find the optimum mitigation solution, within practical / feasible bounds. These iterations have run alongside the multidisciplinary evolution of the scheme and have been discussed with Rivers Agency throughout. The proposed mitigation

options are presented along with the potential impacts arising from the Proposed Scheme.

Flood Risk Assessment

Flood risk is generally assessed using the specified 100 year [1% AEP] 'design' flood event for fluvial systems and the 200 year [0.5% AEP] 'design' flood event for tidal systems. In relation to the floodplain extents, the hydraulic modelling shows that the plan outline for the flooding would not significantly change except as a consequence of storage compensation should the scheme be constructed and appropriate measures incorporated.

For each of the hydraulic models, features such as culvert sizing, diversion alignments, structure arrangements, connectivity structure location and sizing and compensatory storage are discussed. A comparison of the water elevations, pre and post scheme, for specific points along the watercourses are provided for each of the modelled reaches. The analyses address local impacts of the Proposed Scheme and as such compensatory storage provision is not the focus. The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed along with the qualifying conditions for the overall assessment score for flood risk in accordance with the DMRB guidance.

To determine the residual, post scheme flood risk associated with the identified locations, the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10 HD45/09 *Road Drainage and the Water Environment* was utilised to review the impacts.

This report outlines the Proposed Scheme Flood Risk Assessment with reference to guidance provided within the DMRB for each of the modelled locations.

Summary

It is outlined that the Proposed Scheme Flood Risk Assessment is completed with reference to guidance provided within the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10, HD 45/09 Road Drainage and the Water Environment for each of the modelled locations.

In reference to the DMRB methodology; the overall impact of the Proposed Scheme on floodplains and flood risk (scheme wide) is Slight Adverse.

It should be noted that ongoing value engineering exercises will be conducted in relation to the Proposed Scheme; any refinements will be provided through the appropriate approval process.

1 Introduction

This report is number three of the A5 Western Transport Corridor (A5 WTC) Flood Risk Assessment (FRA) Reports and provides a summary of the impact of the A5 WTC in relation to flooding, and outlines the mitigation options for the Proposed Scheme. This report covers impact identification, assessment of mitigation options, integration of mitigation into hydraulic models and discussion of the mitigation results.

Information relating to flood risk assessment parameters, the study area, the development of the A5 WTC flood risk assessment and preliminary flood risk assessment studies is contained with *A5 WTC FRA Report 1 - Assessment Parameters and Preliminary Flood Risk Assessment.*

Hydraulic model development locations were identified in FRA Report 1. Information in relation to the development of these models is contained within *A5 WTC FRA Report 2- Hydraulic Model Build*. FRA Report 2 provides a summary of software utilised, key parameters, hydrology, model results and model validation.

Additional information pertaining to the development and route selection of the A5 WTC is available on the A5 WTC website, www.a5wtc.com, in the form of the *Preliminary Options Report*, *Preferred Options Report* and *Stage 3 Scheme Assessment Report.*

1.1 A5 WTC Route Development

A5 WTC FRA Report 2 – *Hydraulic Model Build Report* detailed the route that had been developed for the Proposed Scheme. For this report, the information is based on that Proposed Scheme.

2 Proposed Scheme Summary

The Preferred Route has undergone continuing design development, and as a result of this, the alignment has changed both horizontally and vertically at a number of locations to form the Proposed Scheme. The following sections provide a description of the Proposed Scheme alignment and the interaction with hydraulically modelled watercourses. Drawings 718736-0500-D-00184 to 718736-0500-D-00193 in Appendix A of FRA 2 – *Hydraulic Build Report* provide a detailed overview of the Proposed Scheme.

2.1 Section 1 Route Description

The northern terminal point of the Proposed Scheme is located to the northwest of Newbuildings, close to Woodside road. The Dual Carriageway continues southwest between the River Foyle and the existing A5, passing over Gortin Hall Drain, then travels south west and to the northwest of the village of Magheramason and crosses Blackstone Burn.

The Proposed Scheme travels south bypassing the village of Bready and it is proposed that the Dual Carriageway is bridged over the Burndennet. The Proposed Scheme travels to the west of the existing A5 before crossing another major watercourse; the Glenmornan River.

The Dual Carriageway maintains its course between the River Foyle and A5 passing to the west of Ballymagorry and then onwards past the west of Strabane. It is proposed that the A5 WTC will bridge the Mourne River.

The Dual Carriageway continues to the southwest travelling between the Glen Finn and Urney Road. The Proposed Scheme then travels south into Section 2.

2.2 Section 2 Route Description

At the beginning of Section 2 the Proposed Scheme bypasses Sion Mills to the west of the existing A5. The route continues south to the west of the existing A5. The proposed Dual Carriageway then crosses an undesignated watercourse near Concess Road and traverses southeast. It is proposed that the route would bridge the River Derg and Coolaghy Burn. It is then proposed that the Proposed Scheme proceeds to the south of Newtownstewart towards the existing A5. The Proposed Scheme crosses Back Burn and then travels south, traversing a number of watercourses including an undesignated watercourse, close to Cashty Road, and Tully Drain.

Approaching Omagh, the Proposed Scheme would bridge the Fairy Water and cross the Aghnamoyle Drain. It would then bypass Omagh to the west of the town and cross Fireagh Lough Drain.

As the Proposed Scheme reaches the end of Section 2, it is proposed that the Dual Carriageway bridges over the Drumragh River.

2.3 Section 3 Route Description

At the beginning of Section 3, the Proposed Scheme continues southeast; west of the existing A5. It then crosses Ranelly Drain at a number of locations and the Letfern River. South of this point the Dual Carriageway continues southeast, crossing a series of undesignated watercourses.

The Proposed Scheme would bridge Routing Burn south of Greenmount Road before crossing several undesignated watercourses. Further south, the route would cross an undesignated watercourse at the Springhill road.

The proposed Dual Carriageway traverses southeast and crosses an undesignated watercourse at the Tullanafoile Road. It continues southeast crossing additional undesignated watercourses near Tycanny Road.

The Proposed Scheme then traverses in a more easterly direction and crosses the Roughan River. From this location the Dual Carriageway travels southeast and it is proposed that the route bridges the Ballygawley Water. It then crosses the Tullyvar River.

The Proposed Scheme would continue southeast crossing undesignated watercourses, then south and cross the Lisadavil River. Following this crossing the route travels southwest then south, terminating close to the River Blackwater.

3 A5 WTC Drainage and Flooding Design Development

The design process for the Proposed Scheme involved an iterative approach between various highways, environment, structural and geotechnical disciplines. Input from drainage and flooding engineers, including flood modelling output formed part of this multidisciplinary iterative design process. The purpose of this current document is not to report on every design iteration, but rather to present the engineering features for the Proposed Scheme, assess potential impacts and review mitigation proposals.

The drainage design philosophy for the Proposed Scheme ensures a solution that satisfies the design criteria. Measures are incorporated to mitigate against potential increased risks of future flooding as a result of the Proposed Scheme. These include the provision of pre-earthworks drainage that prevent the flows from embankment slopes flooding adjacent lands, provision of attenuation where required to manage discharge to watercourses and provision of appropriately sized culverts to enable watercourses to cross the Proposed Scheme alignment.

Design proposals for all culverts, outfalls and watercourse diversions are based on the detailed discussions to date with Rivers Agency and will be submitted for approval in accordance with Schedule 6 of the Drainage Order (Northern Ireland) 1973 at an appropriate stage in the project.

Agreement in Principle (AIP) has been granted for the majority of locations during the design evolution. At locations where minor amendments have arisen due to landowner discussions and previous PI recommendations, engineering proposals such as outfall location discharge to the same watercourses as previous and the same principles are applied in assessing the impacts.

4 A5 WTC Floodplain Interaction, Impacts and Mitigation Assessment

4.1 Introduction

Water levels and associated existing floodplain extents were evaluated and mapped for a range of return periods with the identified 'design' event being; 100 year [1% Annual Exceedance Probability (AEP)] for fluvial floodplains and 200 year plus climate change [0.5+cc% AEP] for tidal floodplains. FRA Reports 1 and 2 provide full details in relation to the identification of floodplains and the development of hydraulic models to identify existing water levels. These models and extents have been used to assess any impacts arising from the A5 WTC proposals and where appropriate to determine flood mitigation proposals.

Table 4.1-1 provides a summary of the floodplains that are impacted by the A5 WTC Proposed Scheme for Sections 1, 2 and 3:

Table 4.1-1 - Summary of Watercourses Required for A5 WTC Flood Risk Assessment

Section	Watercourse	Hydraulic Model ID
1	Gortin Hall Drain	M.A
	Blackstone Burn	M.B
	River Foyle, River Finn, Mourne River, Deele River, Swilly Burn, Glenmornan & Burndennet Rivers	M.1, M.2 and M.3
2	Undesignated Watercourse	M.D
	Derg River	M.5
	Coolaghy Burn	M.E
	Back Burn	M.F
	Undesignated Watercourse	M.G
	Tully Drain	M.H
	Omagh (including Fairy Water, Aghamoyle Drain, Coneywarren Drain, Tully Drain and Strule River	M.4
	Fireagh Lough Drain	M.I
	Drumragh River	M.6
3	Ranelly Drain	M.L
	Letfern Watercourse	M.M
	Undesignated Watercourse	M.N
	Routing Burn	M.P, M.Q
	Undesignated Watercourse	M.O
	Undesignated Watercourse (Newtownsaville)	M.R

	Undesignated Watercourse (Kilgreen)	M.S
	Roughan River	M.T
	Ballygawley River	M.U
	Tullyvar Drain	M.V
	Ravella Drain	M.W
	Undesignated Watercourse	M.X
	Lisadavil River	M.Y

4.2 Summary of Flood Risk Strategy and Mitigation

The various hydraulic models were utilised to inform the route development and to assist in the avoidance and/or reduction of impacts arising from the road alignment as far as reasonably practicable. The models facilitated the testing of various crossing structure sizes and floodplain impacts. Generally, flood impacts have been mitigated using measures which include some, or all, of the following:

- Avoidance of floodplains as far as reasonably practicable whilst incorporating multi-discipline engineering and non-engineering factors,
- Minimisation of road footprint as far as reasonably practicable whilst incorporating multi-discipline engineering and non-engineering factors,
- Appropriately sized culverts,
- Large span structures where feasible,
- Provision of floodplain connectivity structures to maintain floodplain conveyance where floodplains are bisected by the road alignment, and
- Provision of compensatory storage where material volumetric floodplain encroachment remains.

Where development is required within a floodplain, additional works as outlined above may be required to mitigate flood risk changes caused by the scheme. The purpose of mitigation measures within a floodplain is to manage floodwater levels in a way that reduces the potential impact of flooding on the scheme itself and also elsewhere in the catchment.

Various iterations with regards to the mitigation measures have been undertaken to find the optimum mitigation solution, within practical / feasible bounds.

4.2.1 Storage Compensation

If scheme proposals include alterations to the topography within floodplains, those changes have the potential to impact upon water levels upstream and/or downstream of the site. This is a potential consequence of the removal of volumes that were once floodable (floodplain removal).

The Design Manual for Roads and Bridges (DMRB) and Rivers Agency guidance state that where fluvial floodplain loss due to development is unavoidable it could be mitigated by the provision of volumetric compensation on a 'level for level' equivalent. Compensatory flood storage must become effective at the same point in a flood event as the lost storage would have done. It should therefore provide the same volume, and be at the same relative hydraulic level as the lost storage. Volumetric compensation requirements are outlined in Construction Industry Research and Information Association (CIRIA) C624 – *Development and Flood Risk – Guidance for the Construction Industry* and Rivers Agency guidance.

The DMRB identifies that *'Providing compensatory flood storage can significantly mitigate the effect of the project on the maximum flood level….storage is required for all developments regardless of their anticipated effect, so as to result in no net change in catchment hydrology, and to the capacity of the floodplain.*' (Para. 3.29 HD 45/09). However, it is noted that although volumetric compensation storage for displaced floodplains is generally accounted for within DMRB and Rivers Agency guidance, alternative measures were agreed with Rivers Agency for displaced flood volumes on the Foyle / Finn; this being outlined further in Section 4.5.

An important point to note in the allocation of volume compensation storage is that the eventual engineering works (plan area and volume) required to achieve the necessary compensation storage may be significantly more than the actual volumes displaced by flooding. The actual engineering works depend on the prevailing topography and how much ground needs to be removed before the hydraulically relevant layers of earth are removed. The back faces of the volume compensation areas must also be sloped back into existing ground levels, this may affect the overall engineering works and associated footprint of the volume compensation works.

4.2.2 Determination of Residual Flood Risk

Flood risk is assessed using the specified 'design' flood event. To assist in the determination of residual, post scheme flood risk, assessment methodologies identified within appendices of the DMRB where used, whereby the importance of the floodplain, the magnitude of the impact and the significance of the potential effects have been defined as per the guidance tables A4.3 HD 45/09, A4.4 HD 45/09 and A4.5 HD 45/09. Finally, the qualifying conditions for the

overall assessment score for residual, post mitigation flood risk from Table A4.6 HD 45/09 have been applied.

4.3 Model M.A - Gortin Hall Drain – Impact and Mitigation Assessment

4.3.1 Floodplain Interaction

The existing floodplain identified for the Gortin Hall Drain is attributable to the downstream tidal boundary at the River Foyle, this influencing water levels within the channel.

As identified within *A5 WTC FRA Report 2 - Hydraulic Model Build*, the determination of the 'design' fluvial floodplain is based on the estimated 100 year fluvial flows with the defined downstream boundary being an annual tidal level. The determination of the 'design' tidal floodplain is based on the estimated 200 year plus climate change tide level (as outlined within the *Model Build and Hydrology Report – Foyle River System (718736/0500/R/004))* and annual fluvial inputs. Joint probability analysis, as detailed within the *Model Build and Hydrology Report – Foyle River System (718736/0500/R/004),* concluded that the probability of these events occurring simultaneously was reasonable. The probability of an extreme flood (100 year) coinciding with an extreme tide (200 year) was extremely low and would result in overly conservative water level predictions.

It is identified that within the extents of the Gortin Hall Drain Model the Proposed Scheme crosses the designated watercourse at one location; refer to Figure 4.3.1-1. However, given that the floodplain is primarily restricted to the downstream side of the Proposed Scheme, the alignment does not interfere with the floodplain flowpaths / connectivity.

Based on the existing 100 year fluvial and annual tidal levels (within the River Foyle) the proposals result in the displacement of approximately 55m^3 of floodwater. These areas are outlined in Figure 4.3.1-1.

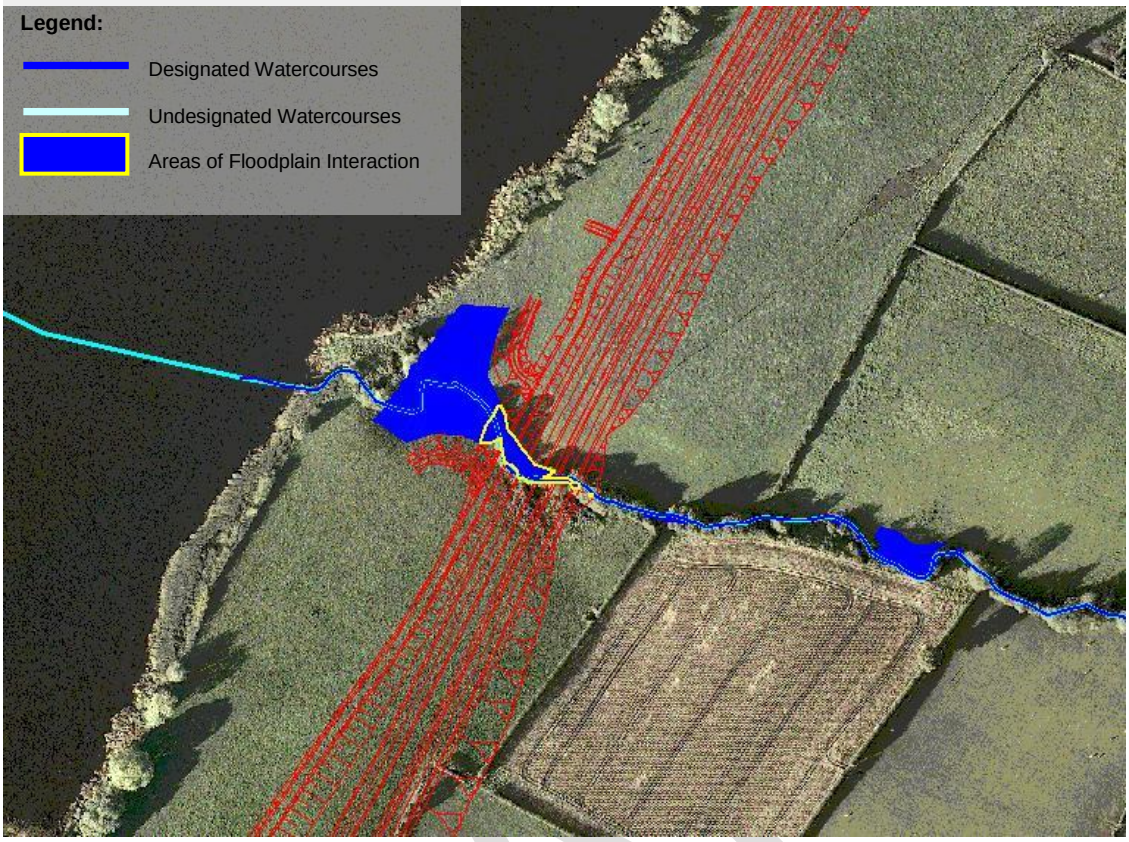

Figure 4.3.1-1 – Gortin Hall Drain Floodplain Interaction (Existing Scenario 100 Year Fluvial / Annual Tidal)

4.3.2 Mitigation Assessment - Culverts and Diversions

Scheme proposals include culverting and river diversion works for the one river crossing within the extents of the model. The proposed arrangement aims to minimise the length of culvert required through perpendicular crossing of the road. This arrangement can be seen in Figure 4.3.2-1.

There is no bridge structure proposed for the Gortin Hall Drain.

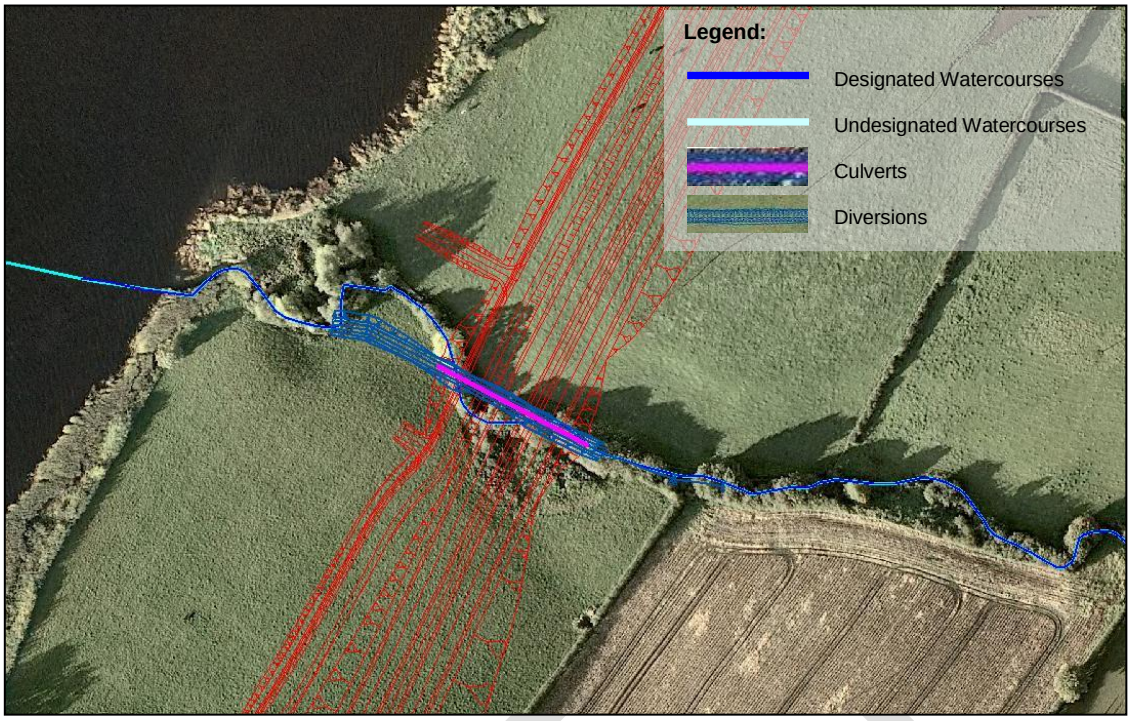

Figure 4.3.2-1 - Plan of Gortin Hall Drain Diversion (S1-WD-16) and Culvert Arrangement (S1-PC-03)

The proposed culvert has been modelled hydraulically for the 100 year fluvial event with a minimum 600mm freeboard allowance. Table 4.3.2-1 provides a summary of the modelled culvert size.

Table 4.3.2-1 - Model M.A, Gortin Hall Drain Modelled Culvert Size

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
239819 411378	S1-PC-03	Box	4.5	1.8

The proposed diversion has also been hydraulically modelled. Table 4.3.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.3.2-2 - Model M.A, Gortin Hall Drain Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
239785 411390	S1-WD-16	Channel Length	123m	93m
		Channel Gradient	1:43	1:32, 1:40

The culvert and diversion arrangements can be seen in Drawing 718736-S1-0500-D-0108, in Appendix A.

A comparison of the water elevations, for specific points along the watercourse, pre and post scheme are shown in Tables 4.3.2-3 and 4.3.2-4. These points can be seen in Figure 4.3.2-2.

Figure 4.3.2-2 – Model M.A, Points along Channel for Water Elevation Comparison

Table 4.3.2-3 - Predicted Impact for Model M.A Gortin Hall Drain for Proposed Scheme (100 Yr Fluvial Flows with Annual Tide level)

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	8.83	8.83	0
2	6.62	6.62	0
3	5.9	5.9	0
4	4.32	4.36	+0.04
5	2.42	2.42	0
6	2.42	2.42	0

Table 4.3.2-4 - Predicted Impact for Model M.A Gortin Hall Drain for Proposed Scheme (200 Yr Tidal Flows with Annual Fluvial Input)

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**200 Year**	**200 Year**	**200 Year**
1	8.53	8.53	0
2	6.52	6.52	0
3	5.72	5.72	0
4	3.66	4.32	+0.66
5	2.84	2.84	0
6	2.84	2.84	0

It is observed that, in the vicinity of Point ID 4, peak post scheme water levels for both the fluvial and tidal design scenarios are retained within the existing watercourse channel.

4.3.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.3.1, approximately 55m^3 of floodwater is displaced as a consequence of the A5 WTC Proposed Scheme. It is observed that the floodplain at this location is within an inter-tidal zone and consequently the potential impacts arising from displacement are minimal and where a change in water level is denoted this is retained within the existing channel, therefore, storage compensation as a mitigation option is not considered appropriate. Accordingly, no provision has been made for flood volume compensation at this location.

4.3.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.3.4-1.

Table 4.3.4-1 – Model M.A Gortin Hall Drain Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Adverse	Slight / Moderate

There are no residential or commercial properties within the extent of the modelled floodplain and consequently the importance of the feature is characterised as Low. The model results show that there is a maximum of 660mm change in water levels for the design flood water levels post scheme,

consequently the magnitude is Major Adverse, therefore the significance of impact on the floodplain is considered to be Slight / Moderate.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Gortin Hall Drain is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties'.*

A comparison of the 100 year existing fluvial flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-0108, in Appendix A.

4.4 Model M.B - Blackstone Burn – Impact and Mitigation Assessment

4.4.1 Floodplain Interaction

The 100 year existing floodplain for the Blackstone Burn is primarily linear in its shape, extending slightly from the river channel and is attributable to the downstream inter-tidal boundary at the River Foyle, this influencing water levels within the channel.

It is identified that the Proposed Scheme encroaches slightly into the floodplain of the Blackstone Burn and that the Proposed Scheme crosses the designated watercourse at one location, refer to Figure 4.4.1-1. Given that the floodplain is linear, the alignment does not significantly interfere with floodplain flowpaths or connectivity.

Based on the existing 100 year fluvial and annual tidal levels (within the River Foyle) the proposals result in the displacement of approximately 135m^3 of floodwater. These areas are outlined in Figure 4.4.1-1.

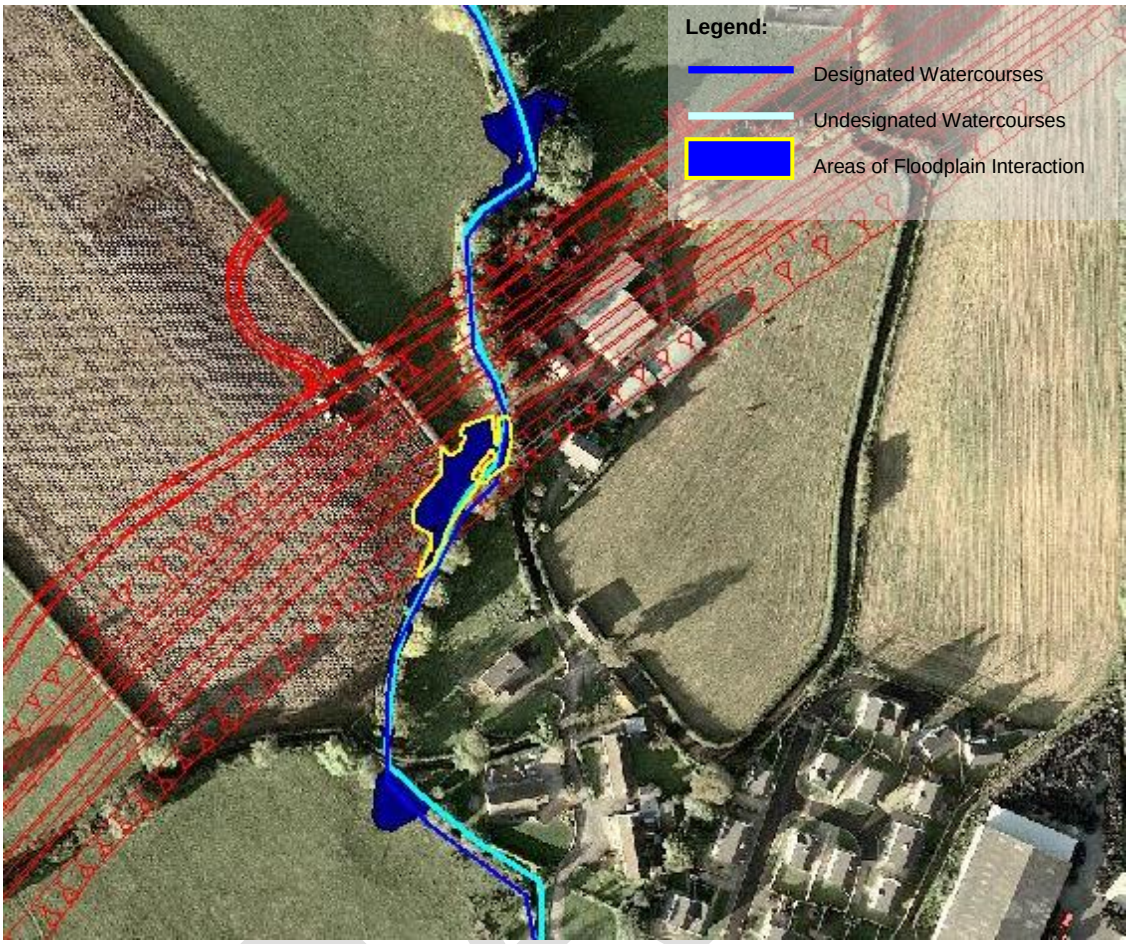

Figure 4.4.1-1 – Blackstone Burn Floodplain Interaction (Existing Scenario - 100 Year Fluvial / Annual Tidal)

4.4.2 Mitigation Assessment - Culverts and Diversions

Scheme proposals include culverting and river diversion works for the watercourse crossings which will rationalise the watercourse form and facilitate construction. This arrangement can be seen in Figure 4.4.2-1.

There is no bridge structure proposed within the Blackstone Burn watercourse model.

Figure 4.4.2-1 - Plan of Blackstone Burn Diversion (S1-WD-03) and Culvert Arrangement (S1-PC-05)

The proposed culverts have been modelled hydraulically for the 100 year fluvial event with 600mm freeboard allowance. Table 4.4.2-1 below provides a summary of the modelled culvert size for the watercourse.

Table 4.4.2-1 - Model M.B, Blackstone Burn Modelled Culvert Size

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
239228 410734	S1-PC-05	Box	3.9	2.1

The proposed diversion has also been hydraulically modelled. Table 4.4.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.4.2-2 - Model M.B, Blackstone Burn Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
239226 410735	S1-WD-03	Channel Length	212m	182m
		Channel Gradient	1:31	1:21, 1:59

The culvert and diversion arrangements can be seen in Drawings 718736-S2-0500-0109, in Appendix A.

4.4.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.4.1, approximately 135m^3 of floodwater is displaced as a consequence of the A5 WTC Proposed Scheme. It is identified that, at this specific location, river engineering proposals together with the inter-tidal downstream extent result in design event fluvial flows being retained within channel. Consequently, the potential impacts arising from flood water displacement are minimal and no provision has been made for flood volume compensation at this location.

4.4.4 Residual Post Scheme Flood Risk

Comparisons of the water elevations, for specific points along the watercourse, pre and post scheme, are shown in Table 4.4.4-1. These points can be seen in Figure 4.4.4-1.

Figure 4.4.4-1 – Model M.B, Points along Channel for Water Elevation Comparison

Table 4.4.4-1 - Predicted Impact for Model M.B Blackstone Burn for Proposed Scheme (100 Yr Fluvial Flows with Annual Tide level)

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	8.82	8.86	+0.04
2	8.79	8.84	+0.05
3	2.42	2.42	0

Table 4.4.4-2 - Predicted Impact for Model M.B Blackstone Burn for Proposed Scheme (200 Yr Tidal Flows with Annual Fluvial Input)

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**200 Year**	**200 Year**	**200 Year**
1	8.11	8.19	+0.08
2	7.84	8.10	+0.27
3	2.84	2.84	0

It is observed that the effect of the proposed river engineering works is an increase in upstream predicted water levels for the identified locations and that water levels for the design fluvial event are higher than those associated with the design tidal event. It is further noted that predicted increases in water levels are retained within the watercourse channel, and that adjacent properties are elevated (>10m AOD) such that a reasonable level of freeboard persists.

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.4.4-3.

Table 4.4.4-3 – Model M.B Blackstone Burn Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Adverse	Slight/Moderate

There are no residential or commercial properties within the extent of the floodplain and consequently the importance of the feature is characterised as Low. The model results show that there is a maximum change in water levels of 270mm for the 200 year tidal flood water levels post scheme consequently the magnitude is considered Major Adverse, therefore the significance of the potential effects on the floodplain is considered to be Slight/Moderate.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Blackstone Burn is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S2-0500-0109 in Appendix A.

4.5 Model M.1, 2 and 3 - The River Foyle System – Impact and Mitigation Assessment

4.5.1 Floodplain Interaction

The design event existing floodplain for the River Foyle system is a significant attribute, inundating extensively from the river over the left and right banks into County Londonderry/Derry and County Donegal. The modelled floodplain system incorporates the Mourne River, the River Finn, the Foyle River and the incoming tributaries; River Deele, River Swilly, Glenmornan River and the Burn Dennet River; the downstream boundary of the model extends beyond the City of Londonderry/Derry into Lough Foyle.

It is observed that flooding within the Foyle model arises as a consequence of both tidal inundation, fluvial inundation and inundation at an inter-tidal zone which is mainly around Ballymagorry / Burndennet River. Flood extents for the two design event scenarios: 100 year fluvial flows with an annual (plus climate change) tidal boundary and the 200 year (plus climate change) tide with annual fluvial inflows, are illustrated in Figure 4.5.1-1, whereby floodplain indicated in red is principally associated with tidal inundation and floodplain indicated in blue is principally associated with fluvial inundation.

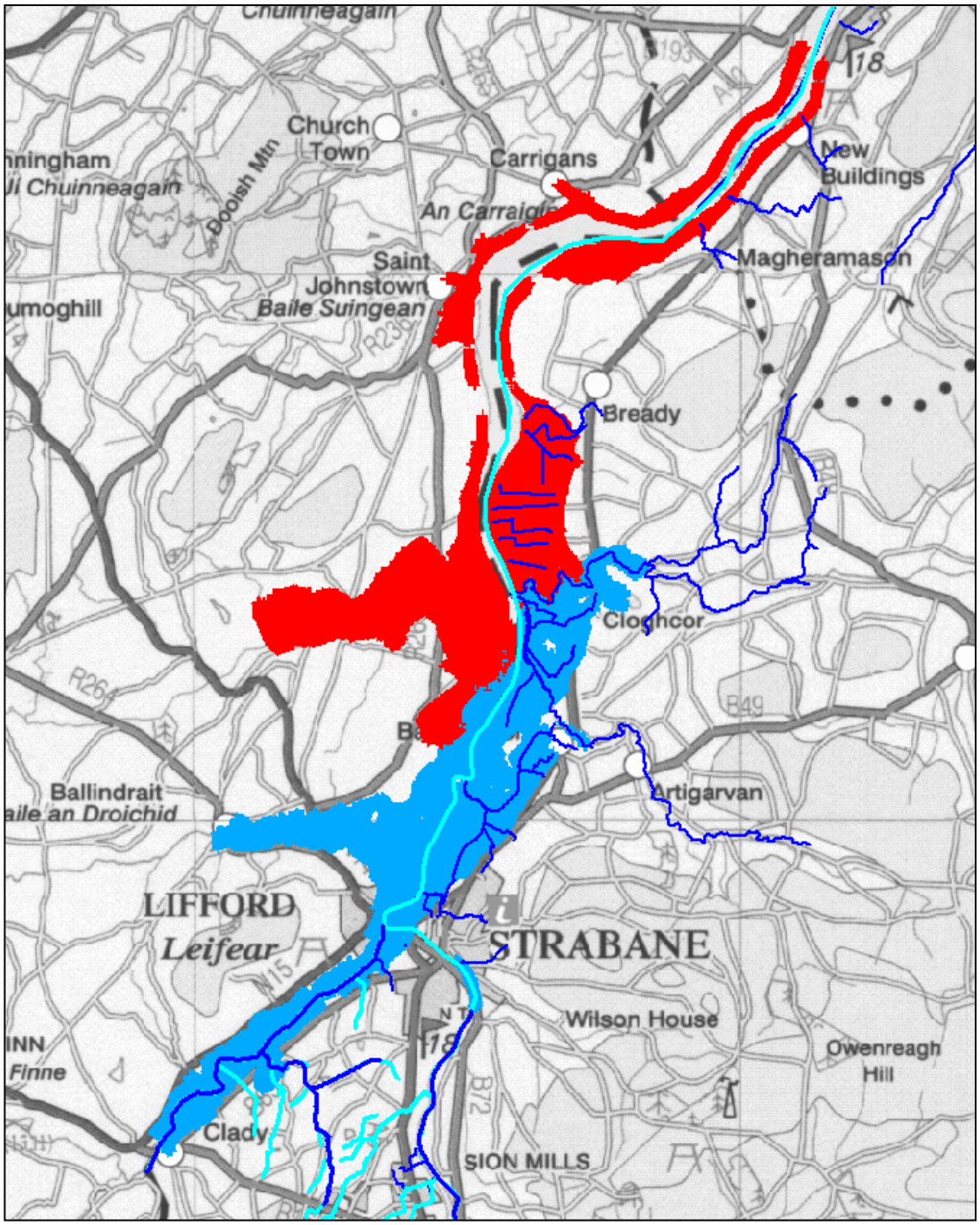

Figure 4.5.1-1 – Model M.1, M.2 and M.3 - River Foyle Joint Q_{100} (fluvial) / Q_{200} (tidal) Floodplains

Further information on the Foyle River system model can be seen in the Draft *Model Build and Hydrology Report – Foyle River System (718736/0500/R/004).*

It is identified that for the design flood scenarios there are a number of locations where there would be a displacement of floodplain as a consequence of the Proposed Scheme. The following figures depict the potential extent of the Proposed Scheme's interaction with the Foyle System floodplain.

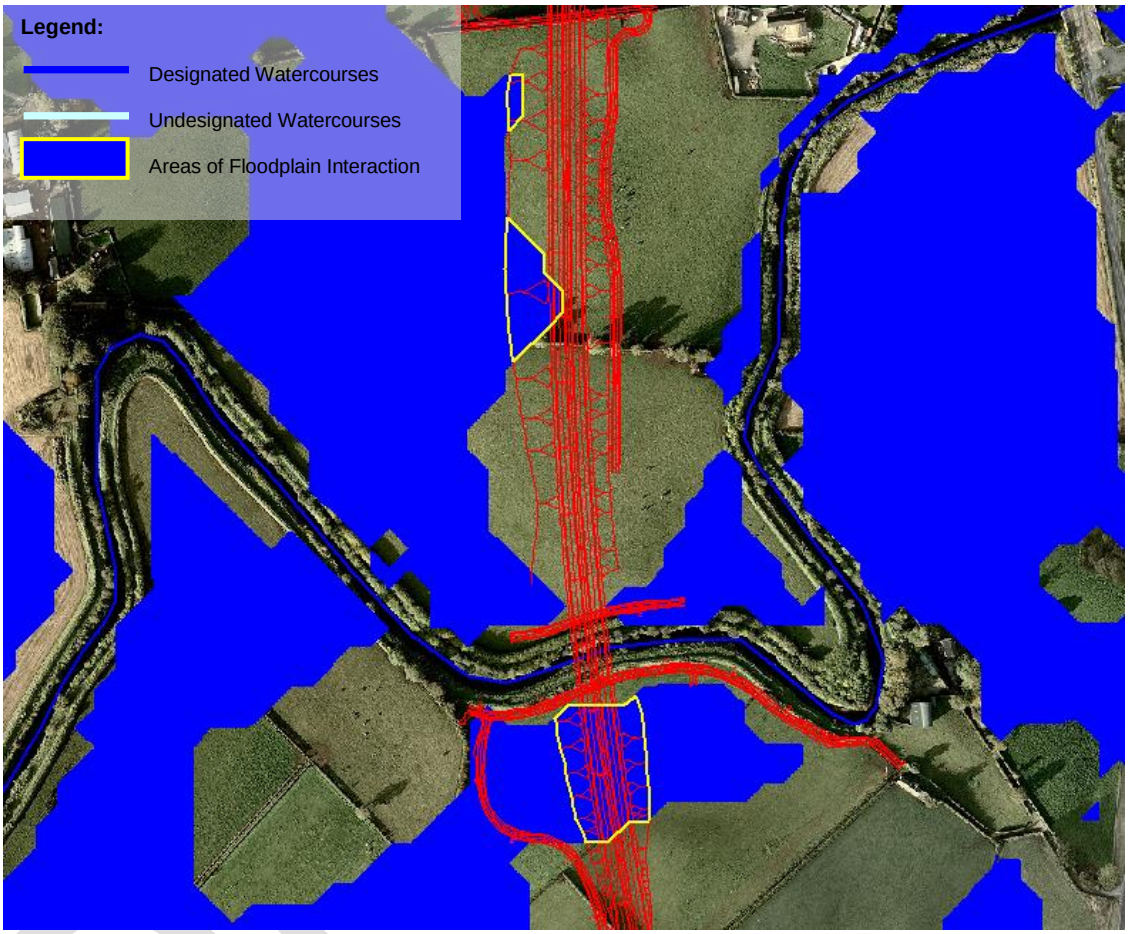

Figure 4.5.1-2 – Foyle System Floodplain Interaction – Burn Dennet River (Image 1 of 8)

As the proposed A5 WTC approaches and crosses the Burn Dennet River there is displacement of floodplain, approximately 7,740m^3. There may also be the potential to affect conveyance of flow along the Burn Dennet River if crossing structures are not sufficiently sized. It is further observed that the alignment of the A5WTC may disrupt flood plain flows to the north and south of the Burn Dennet River if not appropriately mitigated resulting in further losses in floodplain storage.

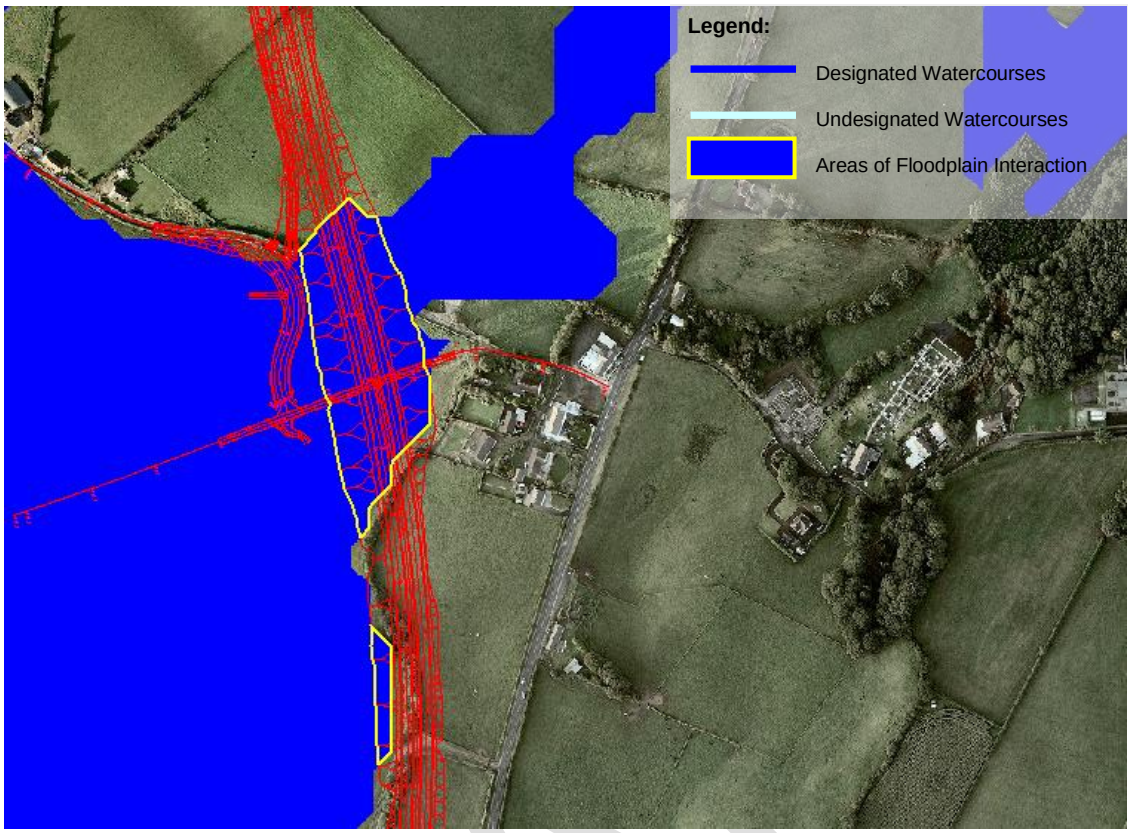

Figure 4.5.1-3 - Foyle System Floodplain Interaction – Ballydonaghy Drain (Image 2 of 8)

In the areas depicted in the figure above the A5WTC is primarily located along the periphery of the floodplain area and outwith of the floodplain. The proposals do cross the floodplain were it extends along the Ballydonaghy Drain watercourse. It is identified that at this crossing there is approximately 15,900m^3 of floodwater displaced as a result of the Proposed Scheme, furthermore, there is the potential to disrupt floodplain flows along this watercourse if mitigation were not provided.

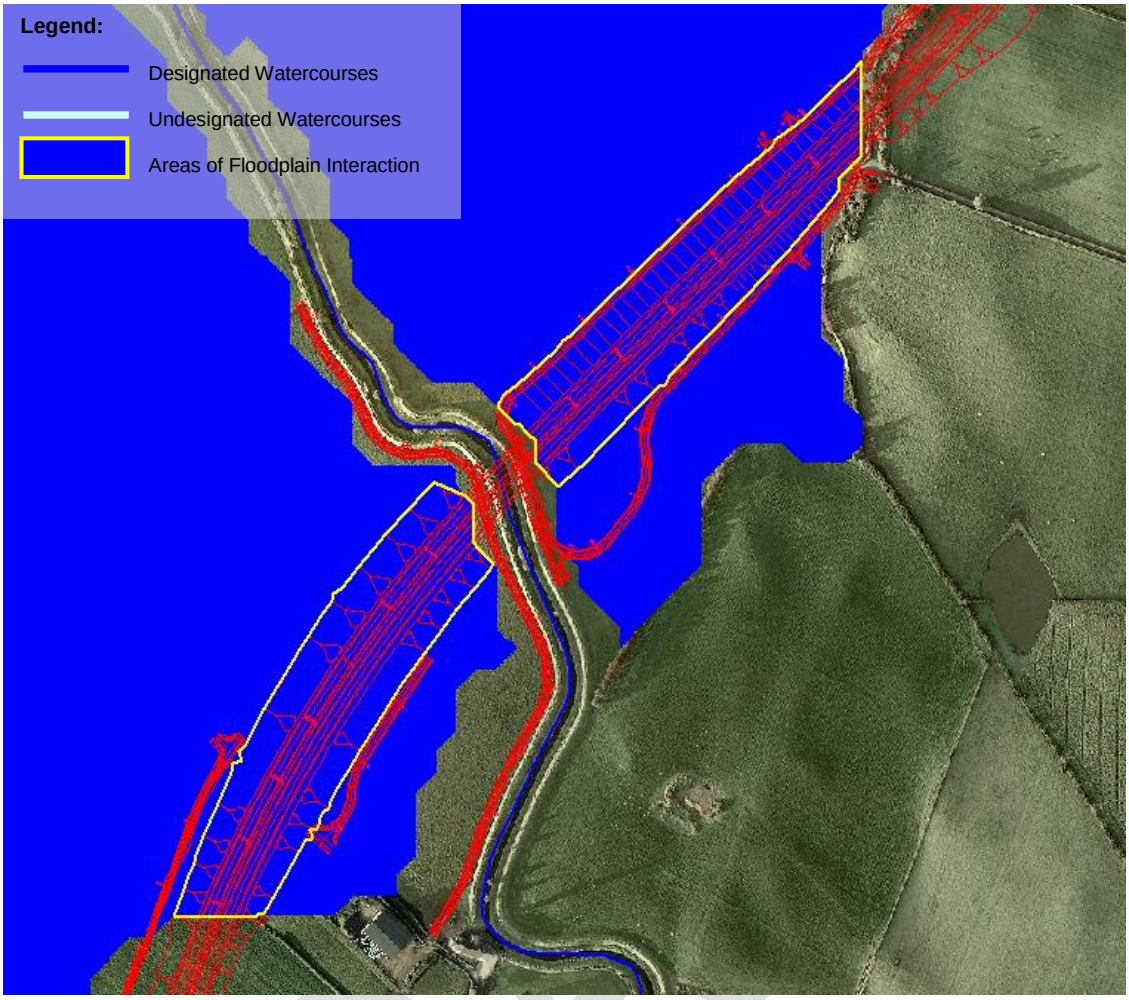

Figure 4.5.1-4 - Foyle System Floodplain Interaction - Glenmornan River (Image 3 of 8)

In the area depicted in the figure above the Proposed Scheme encroaches into the Foyle floodplain as it approaches and crosses the Glenmornan River. It is evidenced that the alignment results in the displacement of approximately 36,810m^3 of floodwater. There may also be the potential to affect conveyance of flow along the Glenmornan River if crossing structures are not sufficiently sized. It is further observed that the alignment of the A5WTC may disrupt flood plain flows to the north and south of the Glenmornan River if not appropriately mitigated resulting in further losses in floodplain storage.

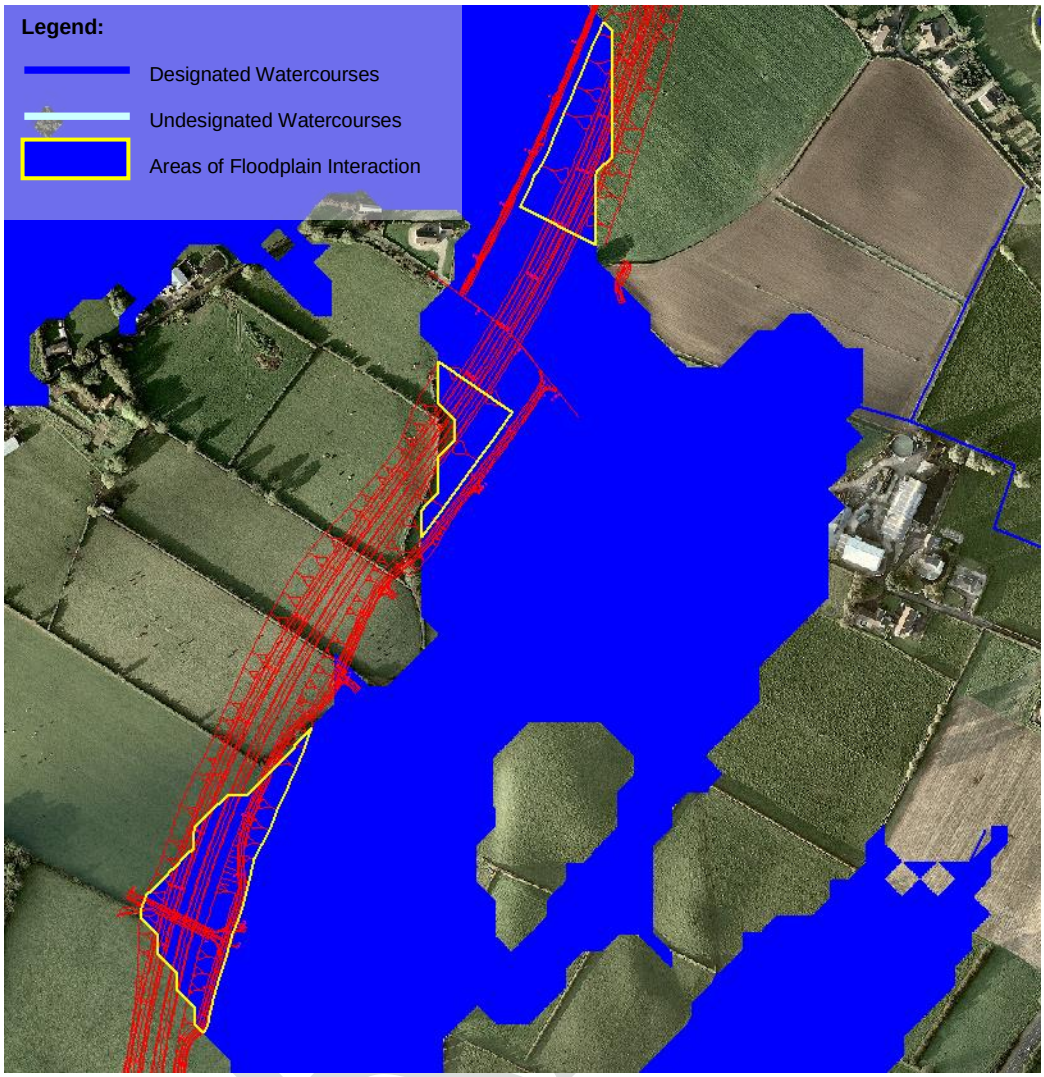

Figure 4.5.1-5 - Foyle System Floodplain Interaction – Park Road (Image 4 of 8)

As illustrated in Figure 4.5.1-5 the Proposed Scheme has potential to disrupt floodplain flows at the Park Road convergence area and inundation paths between the existing A5 and the Proposed Scheme. The estimated total volume of floodwater displacement for the area depicted, as a consequence of embankments, is 34,390m^3.

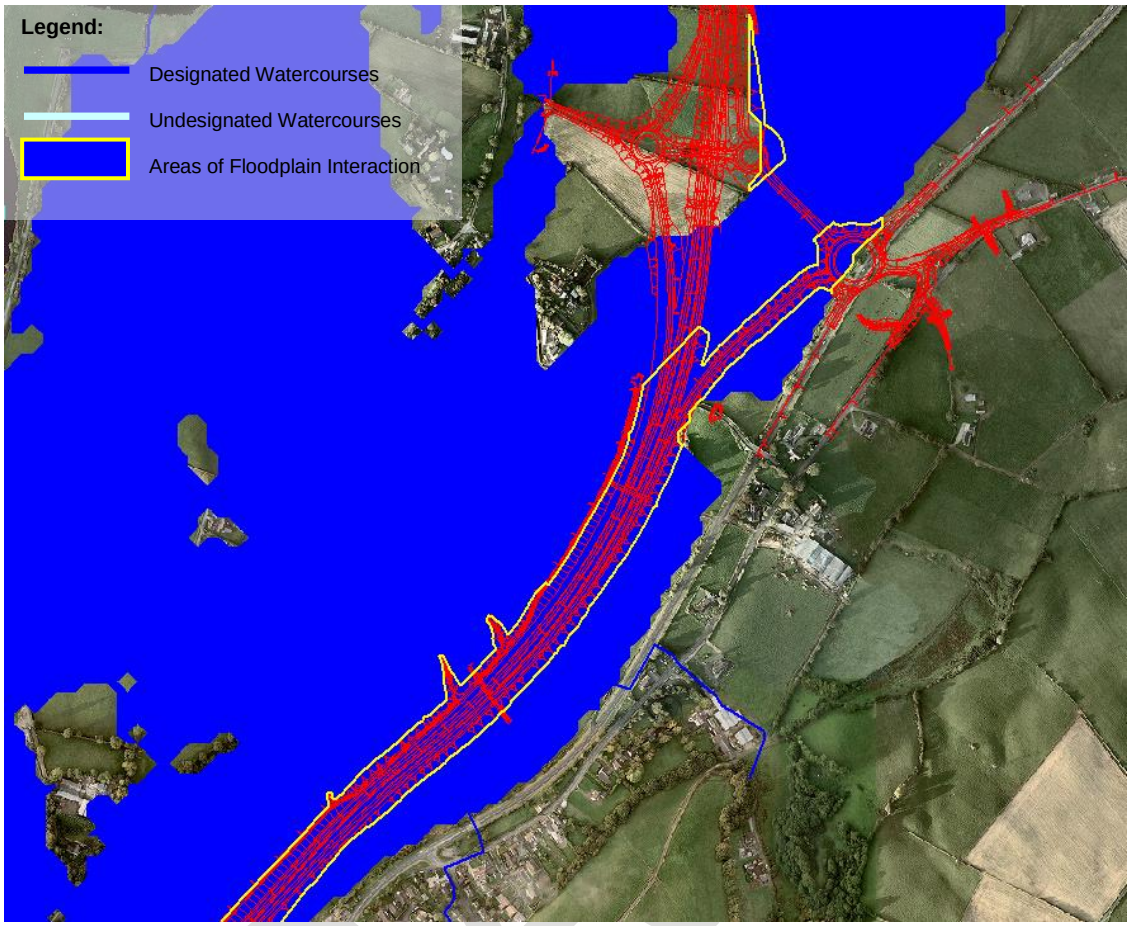

Figure 4.5.1-6 - Foyle System Floodplain Interaction - Ballymagorry (Image 5 of 8)

Figure 4.5.1-6 demonstrates another area where the Proposed Scheme has potential to disrupt floodplain flows at the Park Road convergence area and inundation paths between the existing A5 and the Proposed Scheme. The estimated total volume of floodwater displacement for the area depicted in Figure 4.5.1-6, as a consequence of embankments, is 173,215m^3.

It is observed that the locating of the Ballymagorry junction out of the floodplain reduces some of the road interactions with the floodplain, however, maintenance of flow paths from the proposed Ballymagorry junction to the existing Park Road area is critical to limit further potential water level impacts.

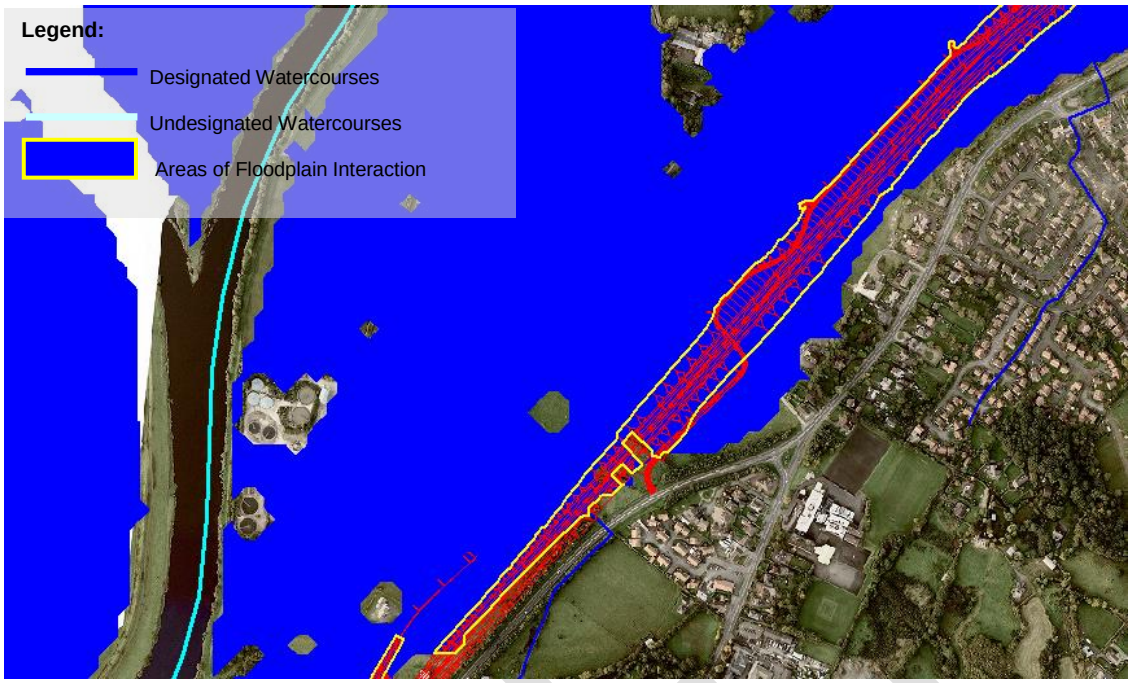

Figure 4.5.1-7 - Foyle System Floodplain Interaction - Strabane (Image 6 of 8)

South of the Ballymagorry junction the A5 WTC enters into the Foyle floodplain. It highlighted that the alignment attempts to maximise peripheral floodplain locations, however, it is constrained by the River Foyle (and associated floodplain), the town of Strabane and existing A5 Road. Approximately 102,270m^3 of floodwater is displaced within the boundaries of Figure 4.5.1-7 above.

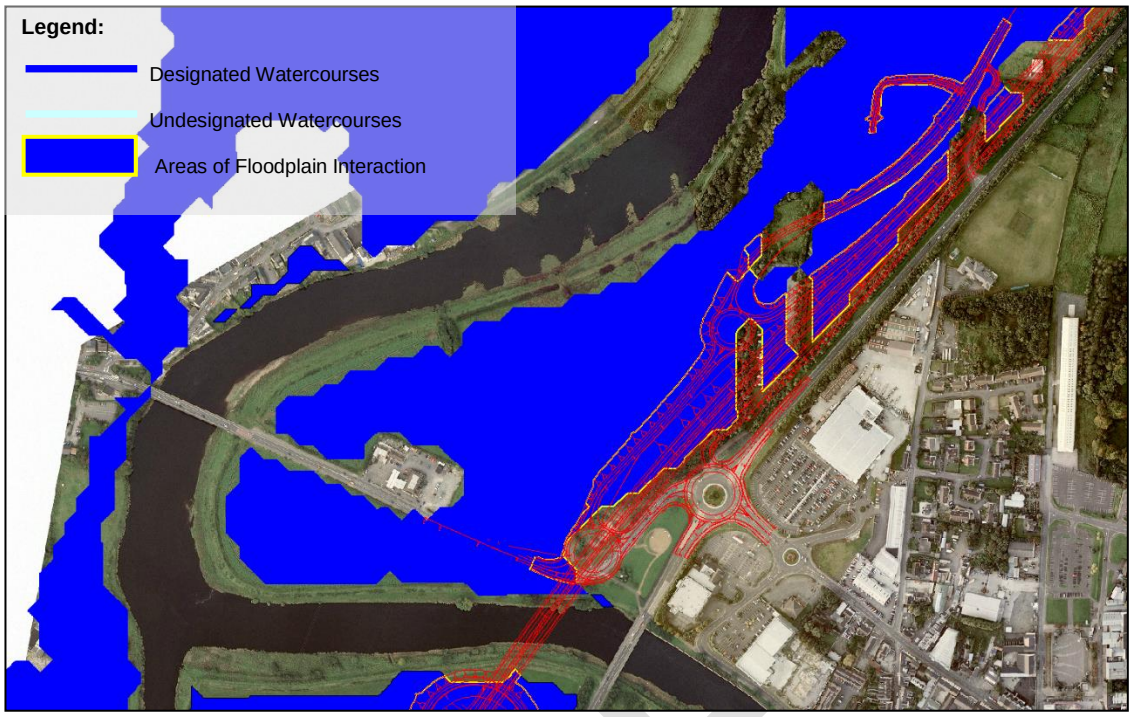

Figure 4.5.1-8 - Foyle System Floodplain Interaction – Mourne / Finn Confluence (Image 7 of 8)

In the vicinity of the Mourne and Finn Rivers confluence the A5 WTC is constrained by the River Foyle (and associated floodplain), the town of Strabane, the existing A5 Road and the proposed Three Rivers Development. Approximately 47,010m^3 of floodwater is displaced within the boundaries of Figure 4.5.1-8 above.

The proposed Three Rivers Development is located to the west of the Proposed Scheme and is bounded by the Rivers Mourne and Foyle. The Three Rivers Development proposals include extensive river and floodplain engineering works, which it is understood would be progressed on a phased basis.

At the time of writing this report, it is understood the requirements for the proposed Three Rivers development include provisions whereby no detrimental flood risk impacts arise in connection with A5 WTC. Subject to the timing of both schemes progressing on the basis of funding and delivery programmes; further environmental and engineering assessment (including Three Rivers Development if constructed in the intervening period) would be undertaken.

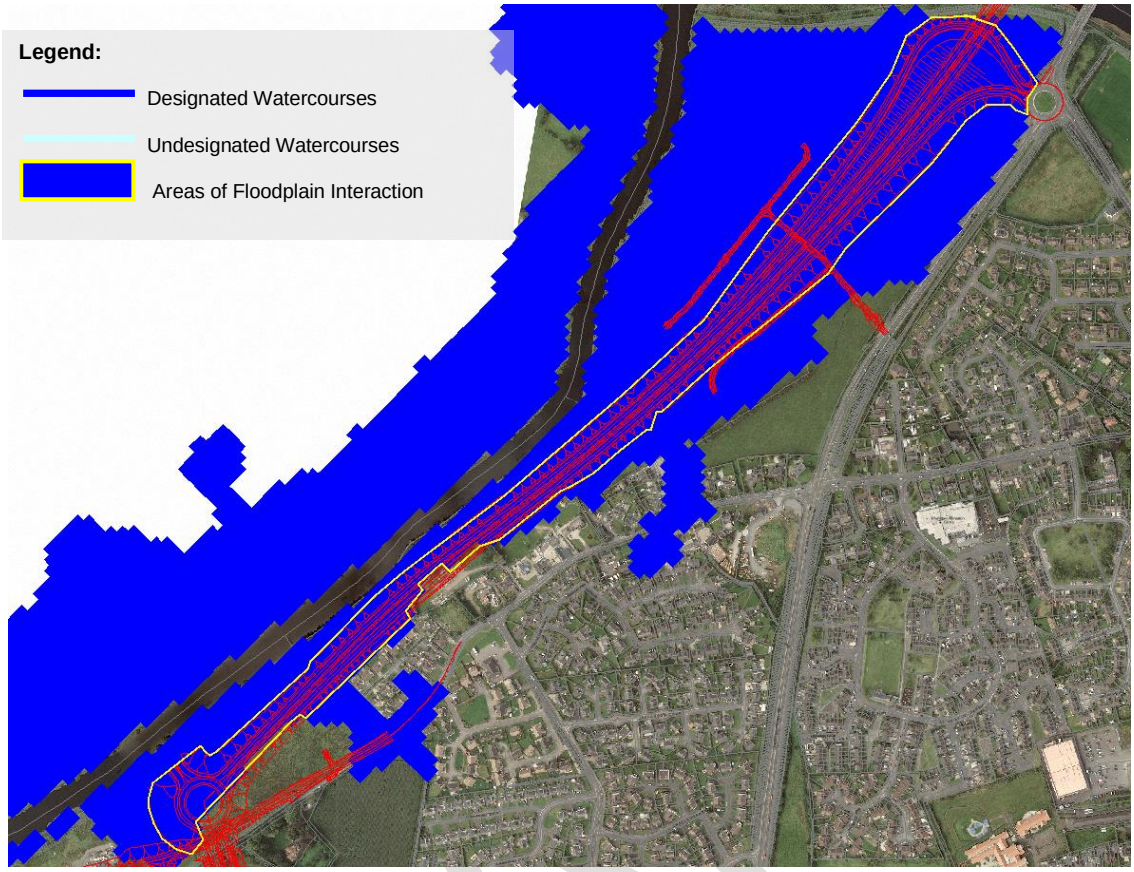

Figure 4.5.1-9 - Foyle System Floodplain Interaction – Finn River (Image 8 of 8)

In the vicinity of the Finn River the A5 WTC is constrained by the associated floodplain, the town of Strabane and the existing A5 Road. Approximately 268,610m^3 of floodwater is displaced within the boundaries of Figure 4.5.1-9 above.

It is identified that the displacement of flood water arising from Figures 4.5.1-1 to 4.5.1-09 is approximately 685,945m^3. The proposed road also crosses the Mourne River, where there is the potential to affect the conveyance of flow along the river if crossing structures are not sufficiently sized. It is also identified that there are a number of locations between Ballymagorry junction and Strabane where the alignment may disrupt floodplain flows if not appropriately mitigated resulting in further losses in floodplain storage and water level impacts.

4.5.2 Mitigation Assessment – Structures, Culverts and Diversions

To maintain the hydraulic operation of watercourses and rivers within the Foyle floodplain area, scheme proposals include bridge crossings of the principal rivers; the Burn Dennet, the Glenmornan and the Mourne Rivers, a number of culverts and river diversions and connectivity structures. The proposed arrangements aim to minimise the number and the length of culverts required through perpendicular crossings. These arrangements can be seen in Figures 4.5.2-1 - 4.5.2-10.

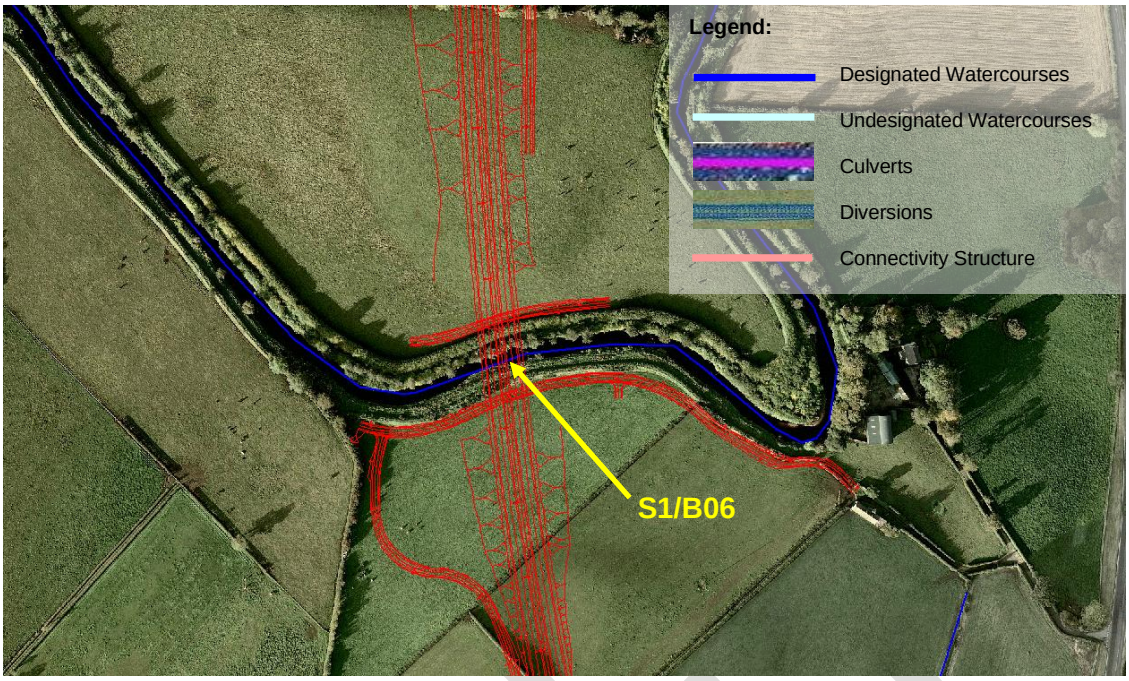

Figure 4.5.2-1 - Plan of Burndennet Bridge Structure (S1/B06)

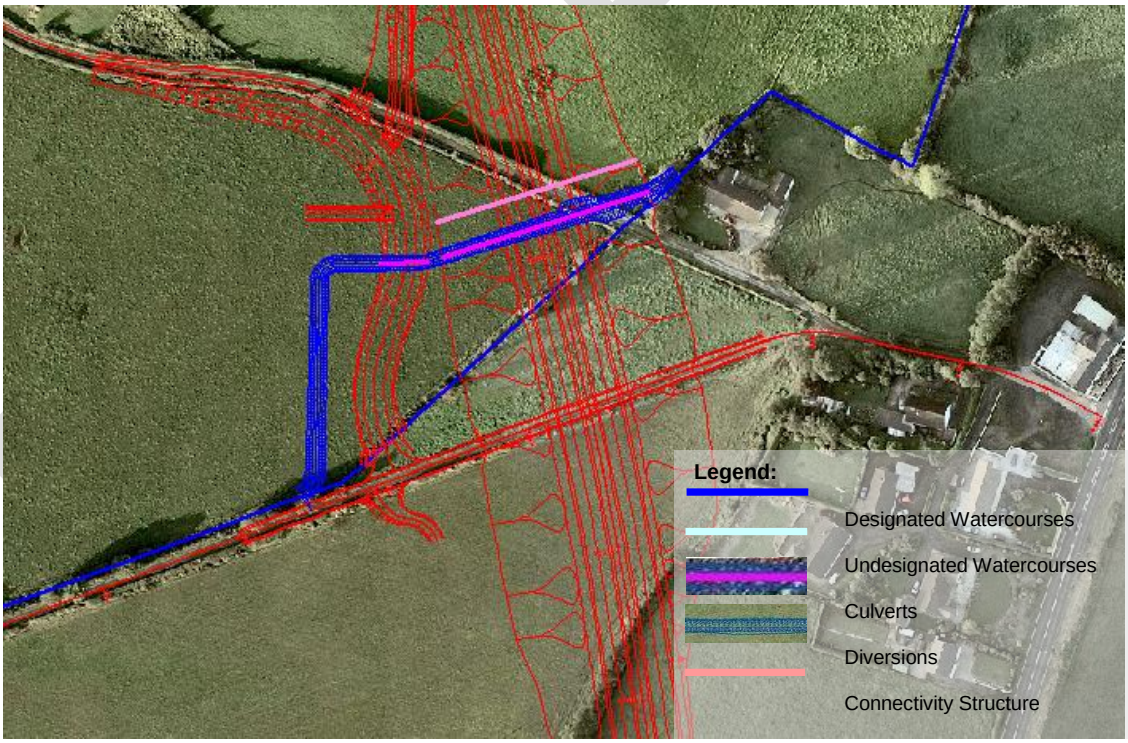

Figure 4.5.2-2 - Plan of Ballydonaghy Drain Diversion (S1-WD-08) and Culverts (S1-PC-09 and S1-PC-40) Arrangement and Connectivity Culvert (S1-CC-01)

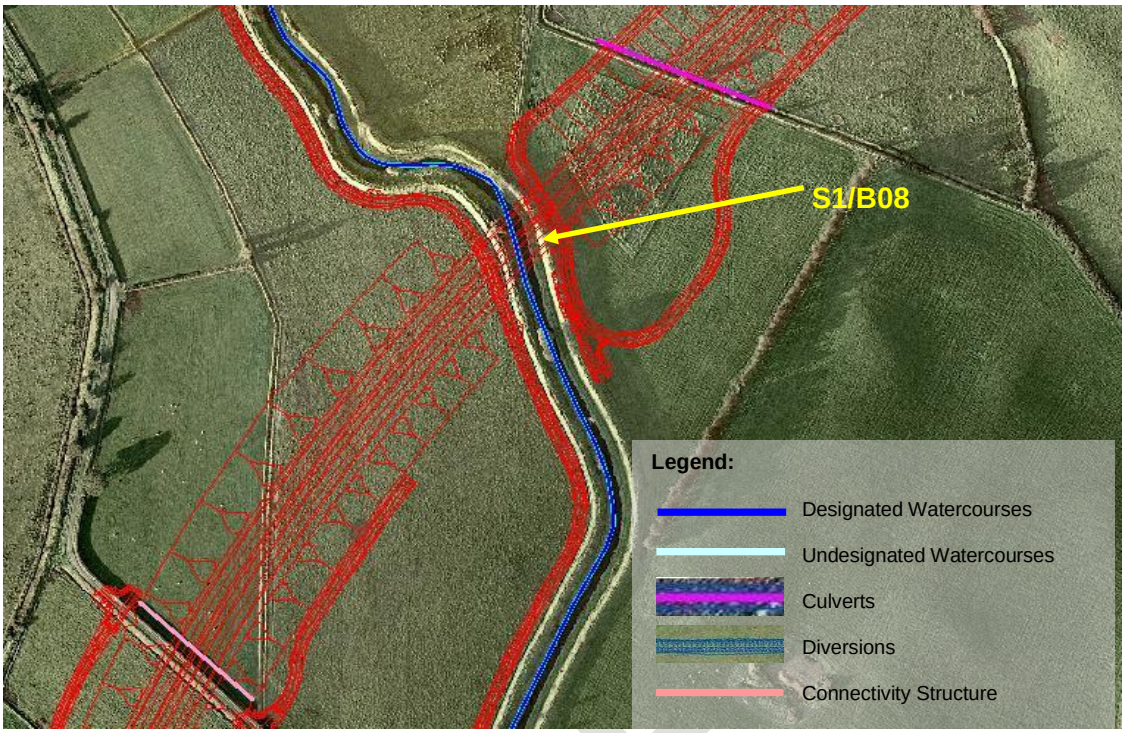

Figure 4.5.2-3 - Plan of Glenmornan River Bridge Crossing (S1/B08) including Ancillary Structures, Culvert (S1-PC-10) and Connectivity Culvert (S1-CC-02)

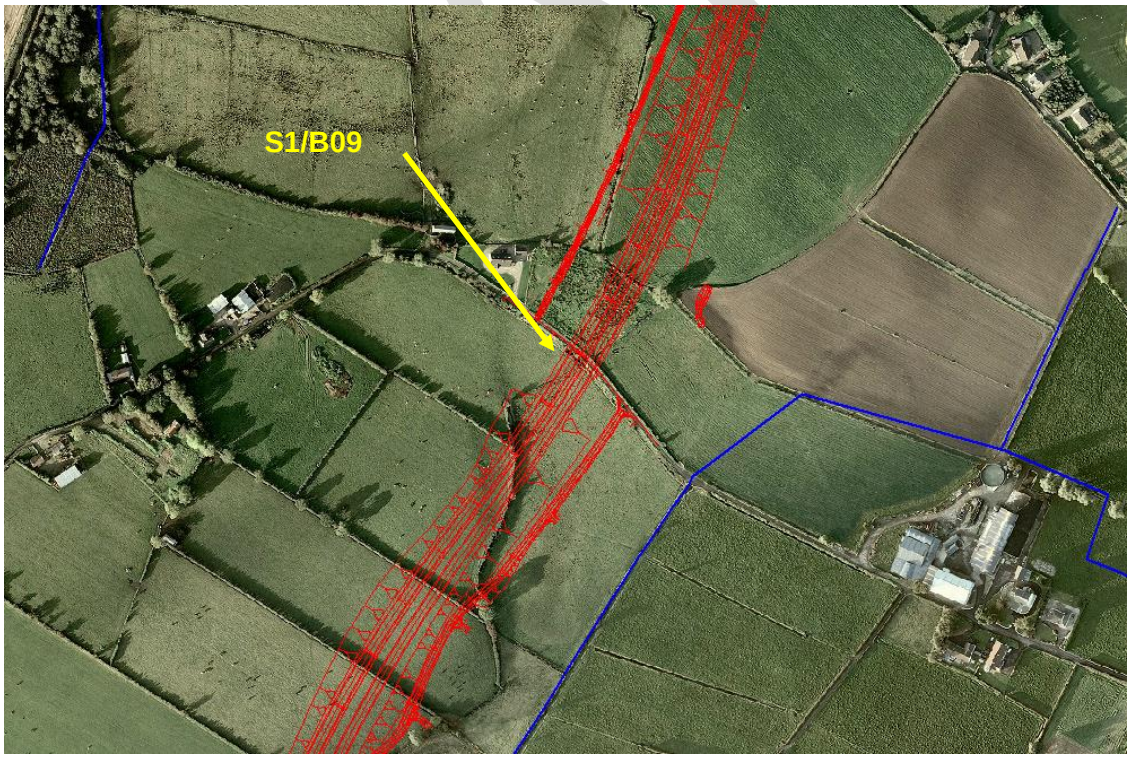

Figure 4.5.2-4 - Plan of Park Road Flood Relief Structure (S1/B09)

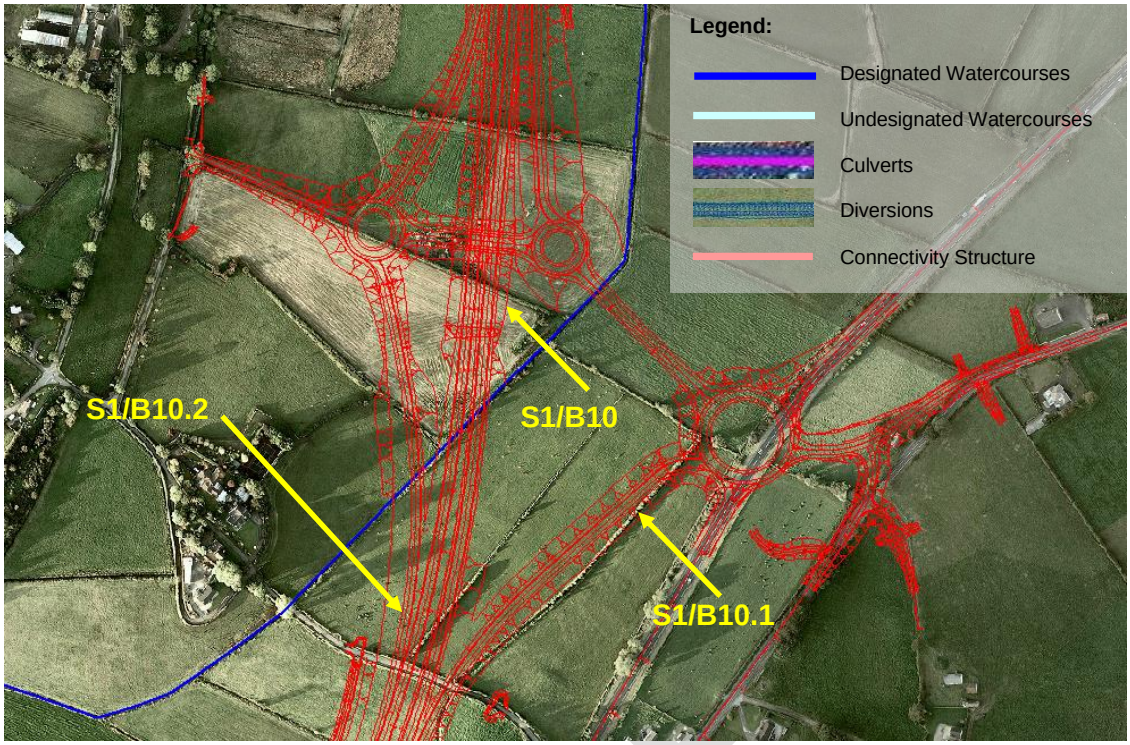

Figure 4.5.2-5 - Plan of Ballymagorry Flood Relief Structures (S1/B10, S1/B10.1 and S1/B10.2).

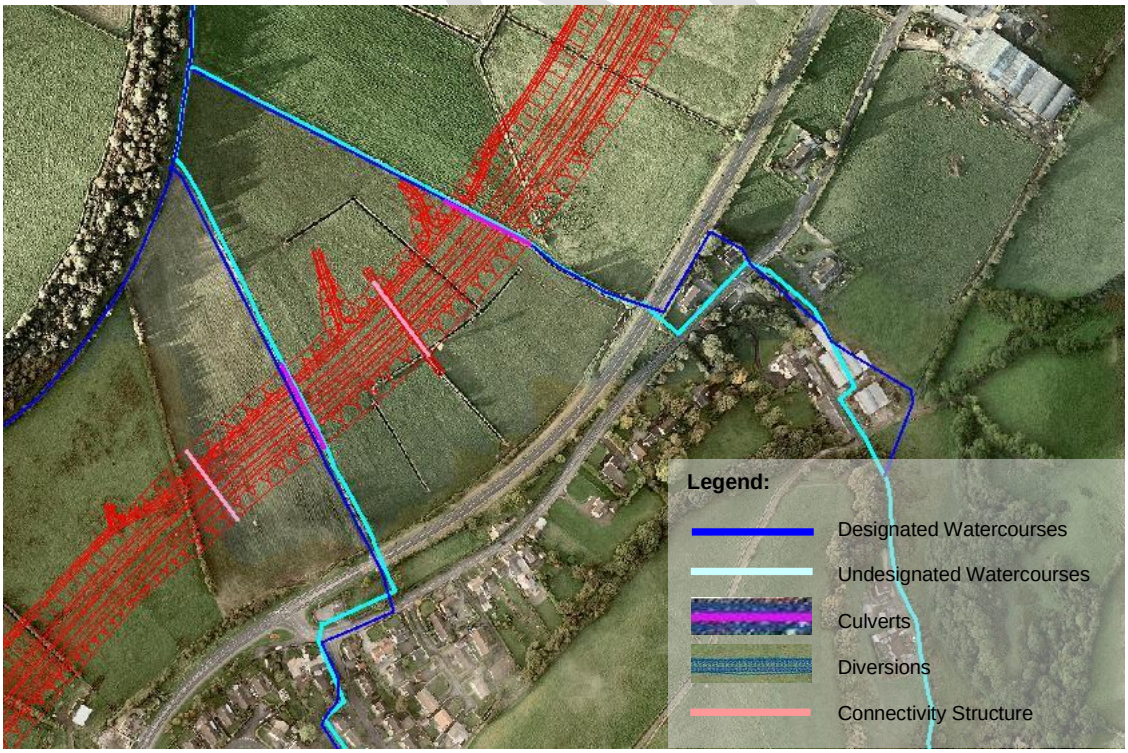

Figure 4.5.2-6 - Plan of Strabane Glen Stream and Roundhill River Culvert Arrangement; Culverts (S1-PC-16 and S1-PC-17) and Connectivity Culverts (S1-CC-04 and S1-CC-03)

Figure 4.5.2-7 - Plan of Backfence Drain and Field Drain Culvert Arrangement; Culvert (S1-PC-18 and S1-PC-19) and Connectivity Culvert (S1-CC-05)

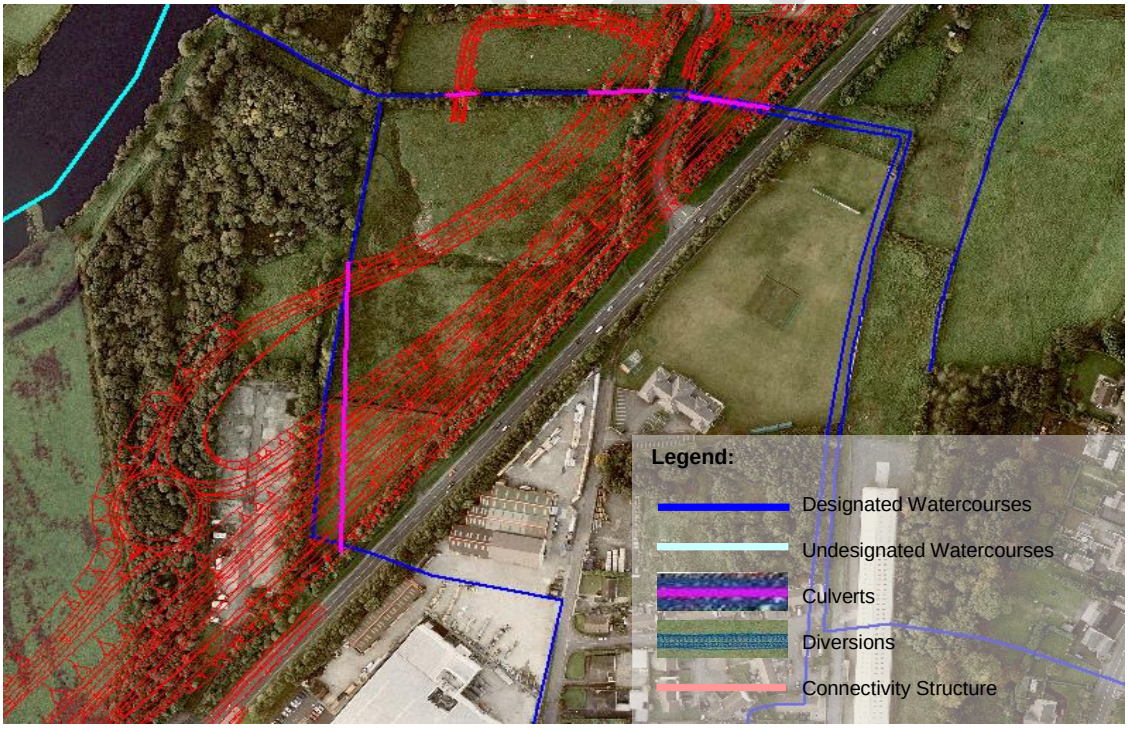

Figure 4.5.2-8 - Plan of Park Road Drain and Nancy Burn Diversion and Culvert Arrangement; Culverts (S1-PC-42, S1-PC-33, S1-PC-20 and S1-PC-22)

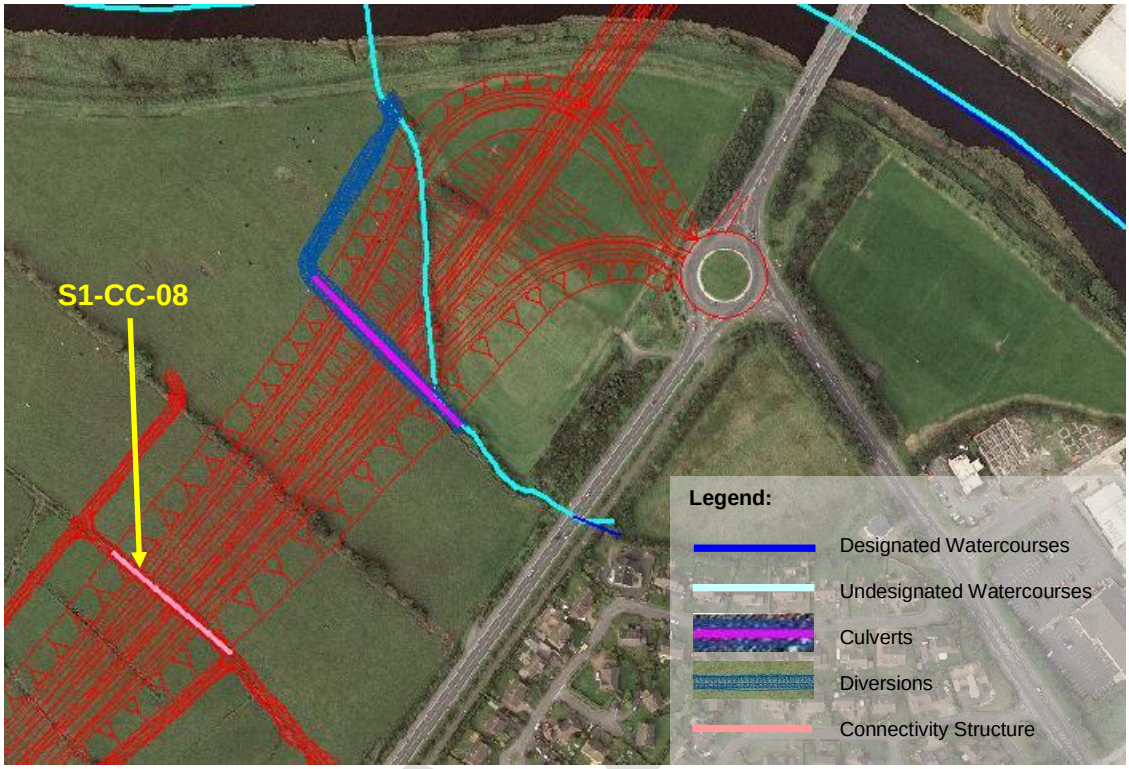

Figure 4.5.2-9 - Plan of UD_08 Diversion and Culvert Arrangement, Culvert (S1-PC-23), Watercourse Diversion (S1-WD-18) and Connectivity Culvert (S1-CC-08)

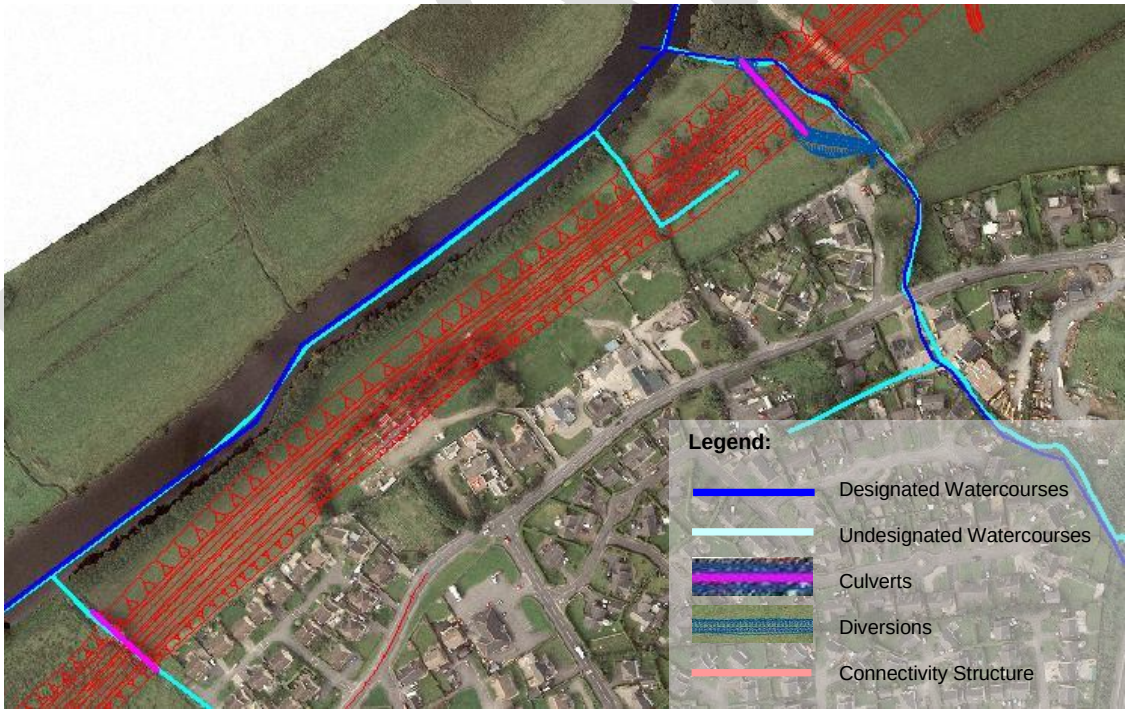

Figure 4.5.2-10 - Plan of Urney Road Drain and Undesignated Watercourse Diversion and Culvert Arrangement; Culverts (S1-PC-24 and S1-PC-25) and Watercourse Diversion (S1-WD-14)

The scheme proposals for the bridge structures at the Burn Dennet, Glenmornan Rivers and Mourne River are provided in Table 4.5.2-1. Minimum soffit levels of the structures are determined by the 100 year flood water level (incorporating 100 year flows within the Burn Dennet and Glenmornan Rivers) plus a minimum 600mm freeboard. It is confirmed that there are no piers within the watercourse channels. Figures 4.5.2-3 and 4.5.2-4 depict the location of the structures.

Table 4.5.2-1 - Model M.1, M.2 and M.3 – Foyle River System Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
236990 404319	Burn Dennet	S1/B06	21+33+21	5.47
236446 402334	Glenmornan	S1/B08	20+25+20	4.49
233841 398037	Mourne	S1/B14	50+64+85+72	7.06

The general arrangement of the bridge structures can be seen in Drawings 718736-1700-D-0507 to 718736-1700-D-0509.

The culverts have been designed hydraulically for the 100 year event with 600mm freeboard allowance.

It is noted that individual minor watercourses within the Foyle floodplain have not been hydraulically modelled. Culverts designs are based on guidance provided by Rivers Agency, the DMRB and in CIRIA C689 Culvert Design and Operation Guide. These culverts have been included as structures through the proposed alignment to facilitate assessment in relation to the conveyance of floodplain flows arising from the principal catchment watercourses. Table 4.5.2-2 below provides a summary of the modelled culvert sizes for the watercourses within the Foyle model.

Table 4.5.2-2 - Model M.1, M.2 and M.3 – Foyle River System Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
237088 403822	S1-PC-09	Pipe	-	1.8 Ø
237037 403828	S1-PC-40	Pipe	-	1.8 Ø
236532 402430	S1-PC-10	Pipe	-	1.5 Ø
235470 399844	S1-PC-16	Box	3.0	2.7
235334 399689	S1-PC-17	Box	2.4	1.8
234967 399309	S1-PC-18	Pipe	-	1.8 Ø
234655 398955	S1-PC-19	Pipe	-	2.4 Ø
234322 398649	S1-PC-33	Box	3.9	2.4
234232 398646	S1-PC-42	Box	3.9	2.4
234385 398641	S1-PC-20 (a)	Pipe	-	0.6 Ø

Table 4.5.2-2 - Model M.1, M.2 and M.3 – Foyle River System Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
234382 398643	S1-PC-20 (b)	Pipe	-	1.2 Ø
134382 398643	S1-PC-20 (c)	Pipe	-	0.6 Ø
234140 398411	S1-PC-22	Pipe	-	1.5 Ø
233674 397822	S1-PC-23	Pipe	-	1.8 Ø
233304 397436	S1-PC-24	Box	2.4	2.4
232905 397103	S1-PC-25	Pipe	-	1.8 Ø

The proposed diversions have also been hydraulically designed based on existing channel geometry. As with culverts these minor watercourses have not been individually modelled. Table 4.5.2-3 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.5.2-3 - Model M.1, M.2 and M.3 – Foyle River System Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
237045 403806	S1-WD-08	Channel Length	133m	200m
		Channel Gradient	1:270	1:173
233629 397875	S1-WD-18	Channel Length	182m	243
		Channel Gradient	1:916	1:1000
233322 397416	S1-WD-14	Channel Length	110m	107m
		Channel Gradient	1:250	1:303, 1:210

The culvert and diversion arrangements can be seen in Drawings 718736-S1-0500-0101 to 718736-S1-0500-0106 and 718736-S1-0500-0110 to 718736-S1-0500-0113.

As identified in Section 4.5.1 the Proposed Scheme has the potential to disrupt the conveyance of floodplain flows and floodplain connectivity unless suitable mitigation is provided. It is proposed that additional floodplain conveyance structures are provided as detailed in Table 3.5.2-4.

Table 4.5.2-4 - Model M.1, M.2 and M.3 – Foyle River System Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
237099 403779	S1-CC-01	Pipe	-	1.8 Ø
236320 402179	S1-CC-02	Pipe	-	1.8 Ø
235410 399759	S1-CC-03	Box	4.0	3.3

Table 4.5.2-4 - Model M.1, M.2 and M.3 – Foyle River System Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
235261 399627	S1-CC-04	Box	4.0	3.0
234862 399191	S1-CC-05	Box	4.0	2.1
234197 398525	S1-CC-08	Box	4.0	5.1

It is noted that structures provided north and south of the Burn Dennet and Glenmornan Rivers are dual purpose, providing connectivity to the floodplain and access for local landowners.

In addition to the structures providing connectivity noted above, larger span structures have also been included through the Ballymagorry junction and Park Road conveyance area to maintain critical flow paths and to minimise loss of existing floodplain storage. The proposed structures comprise multiple span structures, with each spanning approximately 27m, 17m and 28.5m, with a total overall span of 135m, 120m and 142.5m for the Park Road area and Ballymagorry junctions respectively. It is identified that the proposed span height is not less than the 100 year flood water level. Table 4.5.2-5 below provides details of the proposed structures; the general arrangement of these flood relief structures can be seen in Drawings 718736-1700-D-0517 to 718736-1700-D-0519.

Table 4.5.2-5 - Model M.1, M.2 and M.3 – Foyle River System Structures Arrangements

Location Grid Reference	Name	Structure Reference	Structural Arrangement	Min. Spring Level (mAOD)
236111 401710	Park Road Connectivity Structure	S1/B09	5 no. 27m wide spans	4.0
235850 400487	Ballymagorry Structure	S1/B10.1	7 no. 17.15m wide spans	4.0
235692, 400268	Ballymagorry Structure	S1/B10.2	5 no. 28.5m wide spans	4.0

A comparison of the water elevations, along the principal watercourses, pre and post scheme has been completed for specific points along the watercourse. These points can be seen in Figures 4.5.2-4 and 4.5.2-5.

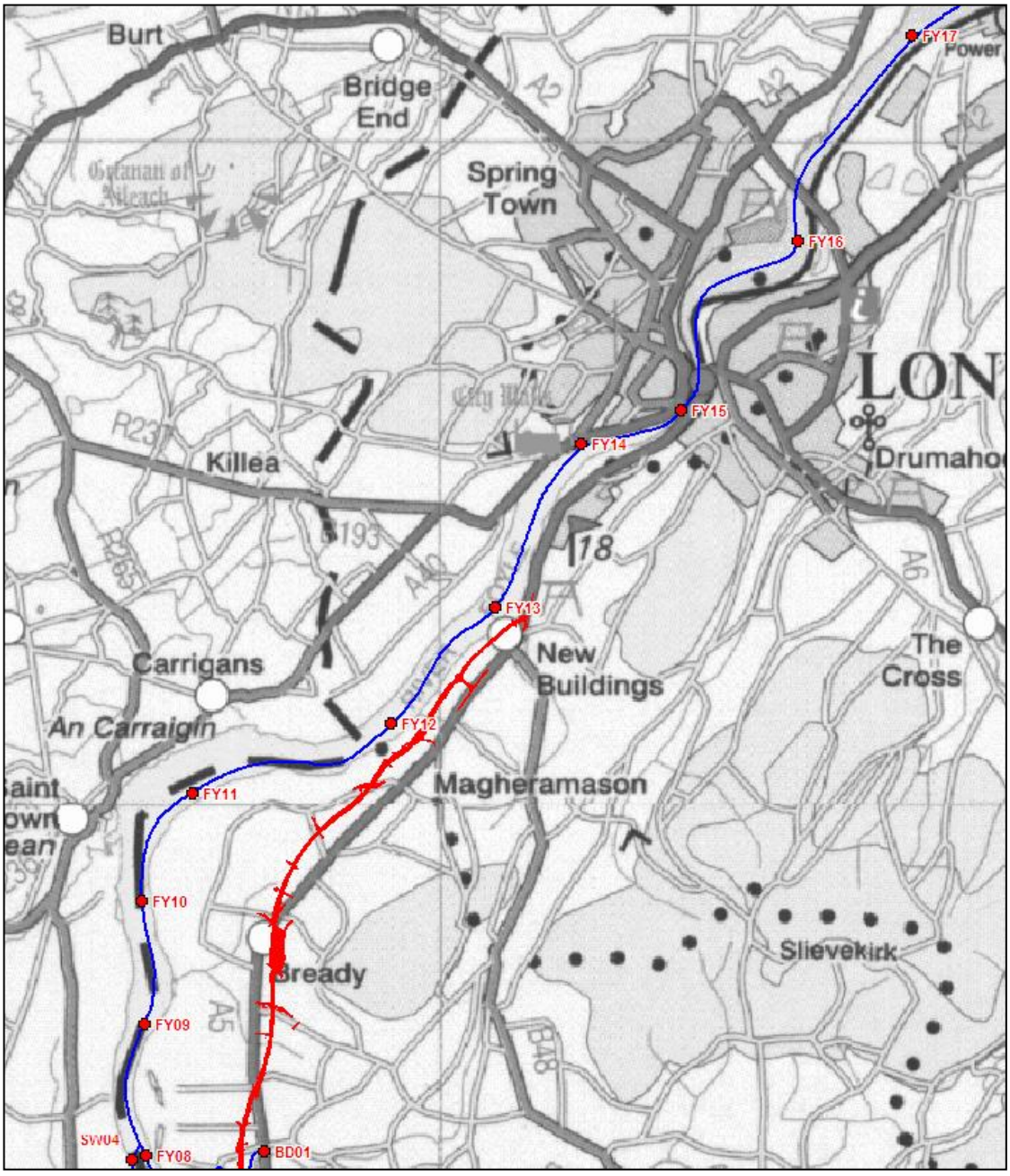

Figure 4.5.2-11 – Model M.1, M.2, M.3, Points along Channel for Water Elevation Comparison

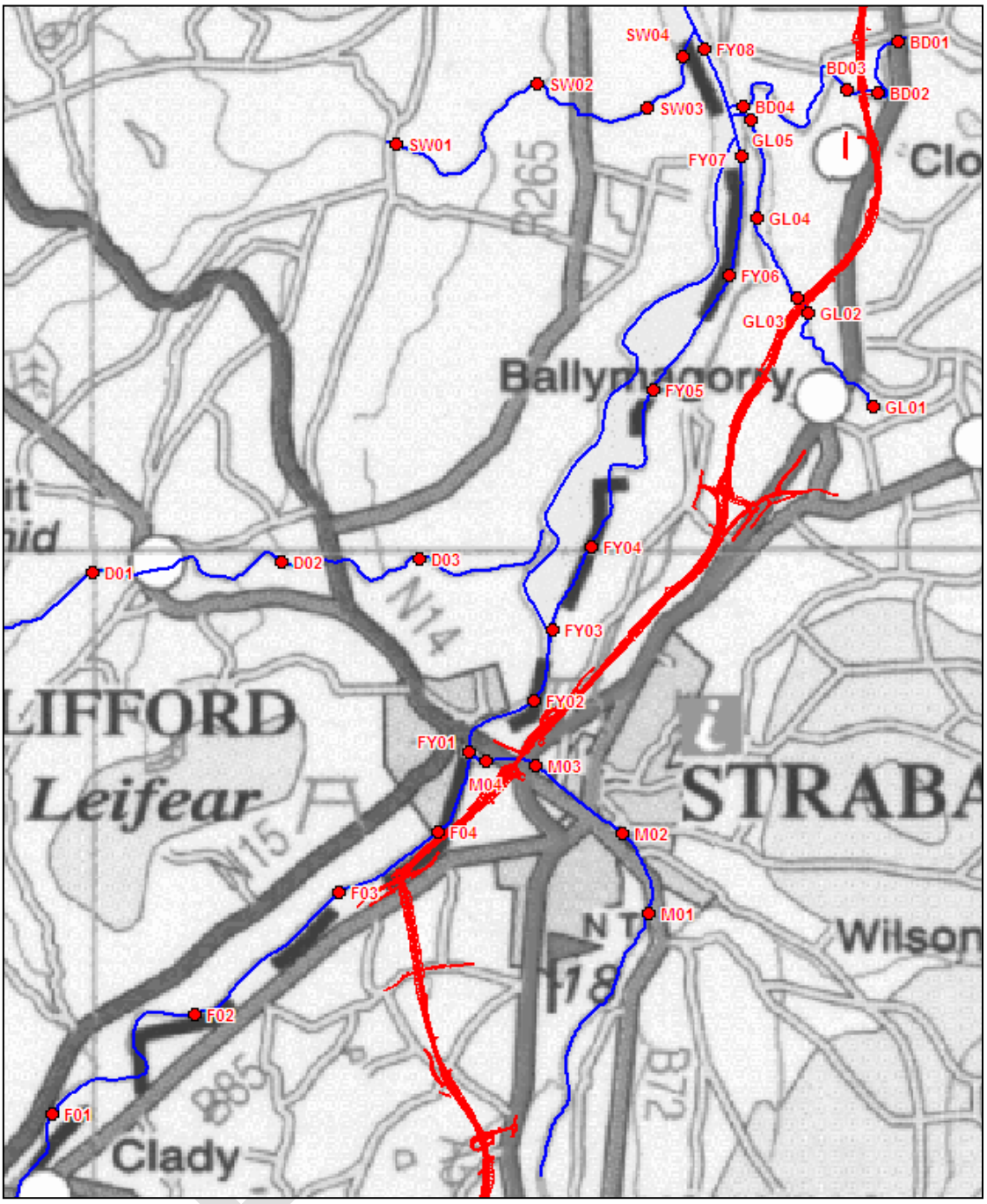

Figure 4.5.2-12 – Model M.1, M.2, M.3, Points along Channels for Water Elevation Comparison

As the River Foyle has both fluvial and tidal influences, the river has been assessed for both the fluvial design event (100 year flows with annual plus climate change tidal boundary) and the tidal design event (200 year plus climate change tidal level with annual fluvial flows). The results can be seen for each of these scenarios in Tables 4.5.2-6 and 4.5.2-7.

Table 4.5.2-6- Fluvially Dominant Predicted Impact for Model M.1, M.2, M.3 River Foyle for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
M01	8.064	8.065	0.001
M02	7.32	7.322	0.002
M03	6.541	6.541	0
M04	6.251	6.249	-0.002
F01	6.813	6.816	0.003
F02	6.573	6.579	0.006
F03	6.358	6.363	0.005
F04	6.241	6.241	0
FY01	6.09	6.09	0
FY02	5.498	5.499	0.001
FY03	4.615	4.619	0.004
FY04	4.269	4.275	0.006
FY05	3.801	3.811	0.01
FY06	3.479	3.483	0.004
FY07	3.428	3.431	0.003
FY08	3.338	3.341	0.003
FY09	3.273	3.275	0.002
FY10	3.252	3.253	0.001
FY11	3.237	3.239	0.002
FY12	3.202	3.204	0.002
FY13	3.176	3.178	0.002
FY14	3.14	3.141	0.001
FY15	3.113	3.114	0.001
FY16	3.063	3.064	0.001
FY17	3.012	3.012	0
BD01	6.352	6.352	0
BD02	5.065	5.065	0
BD03	4.658	4.658	0
BD04	3.386	3.389	0.003
SW01	3.213	3.213	0
SW02	3.204	3.205	0.001
SW03	3.285	3.285	0
SW04	3.33	3.332	0.002
D01	5.444	5.444	0
D02	4.796	4.8	0.004

Table 4.5.2-6- Fluvially Dominant Predicted Impact for Model M.1, M.2, M.3 River Foyle for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
D03	4.694	4.698	0.004
GL01	9.123	9.123	0
GL02	4.614	4.615	0.001
GL03	4.134	4.134	0
GL04	3.582	3.59	0.008
GL05	3.411	3.417	0.006

Table 4.5.2-7- Tidally Dominant Predicted Impact for Model M.1, M.2, M.3 River Foyle for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**200 Year**	**200 Year**	**200 Year**
M01	6.867	6.867	0
M02	6.14	6.14	0
M03	5.536	5.536	0
M04	5.328	5.328	0
F01	5.795	5.796	0.001
F02	5.586	5.586	0
F03	5.415	5.415	0
F04	5.333	5.332	-0.001
FY01	5.23	5.23	0
FY02	4.827	4.827	0
FY03	4.222	4.222	0
FY04	3.982	3.982	0
FY05	3.716	3.716	0
FY06	3.596	3.596	0
FY07	3.579	3.579	0
FY08	3.563	3.563	0
FY09	3.543	3.543	0
FY10	3.521	3.521	0
FY11	3.5	3.5	0
FY12	3.482	3.482	0
FY13	3.473	3.473	0
FY14	3.459	3.459	0
FY15	3.448	3.448	0
FY16	3.43	3.43	0

Table 4.5.2-7- Tidally Dominant Predicted Impact for Model M.1, M.2, M.3 River Foyle for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**200 Year**	**200 Year**	**200 Year**
FY17	3.399	3.4	0.001
BD01	5.688	5.688	0
BD02	4.549	4.549	0
BD03	4.238	4.238	0
BD04	3.573	3.573	0
SW01	3.443	3.444	0.001
SW02	3.423	3.424	0.001
SW03	3.513	3.514	0.001
SW04	3.555	3.556	0.001
D01	4.907	4.907	0
D02	4.215	4.215	0
D03	4.106	4.107	0.001
GL01	8.683	8.683	0
GL02	4.149	4.149	0
GL03	3.693	3.693	0
GL04	3.469	3.471	0.002
GL05	3.555	3.555	0

**Note: all tidally dominant scenarios include an allowance for climate change*

It can be seen in Tables 4.5.2-6 and 4.5.2-7 that the impacts vary at each Point ID along the main river channels. In consideration of the scale and complexity of the associated floodplain areas and the overall variability in water depths across these floodplains, it was considered that the residual, post mitigation flood impacts should be presented for these extensive floodplain areas (taken from 2D model output). Consequentially, the fluvial 100 year design event impacts are presented in Figure 4.5.2-10.

Generally, impacts vary across the floodplain, however, to simplify the presentation of this information, impact values are shown within key locations which are indicative of the impacts across discrete floodplain areas, and in some cases the impacts vary within these discrete areas.

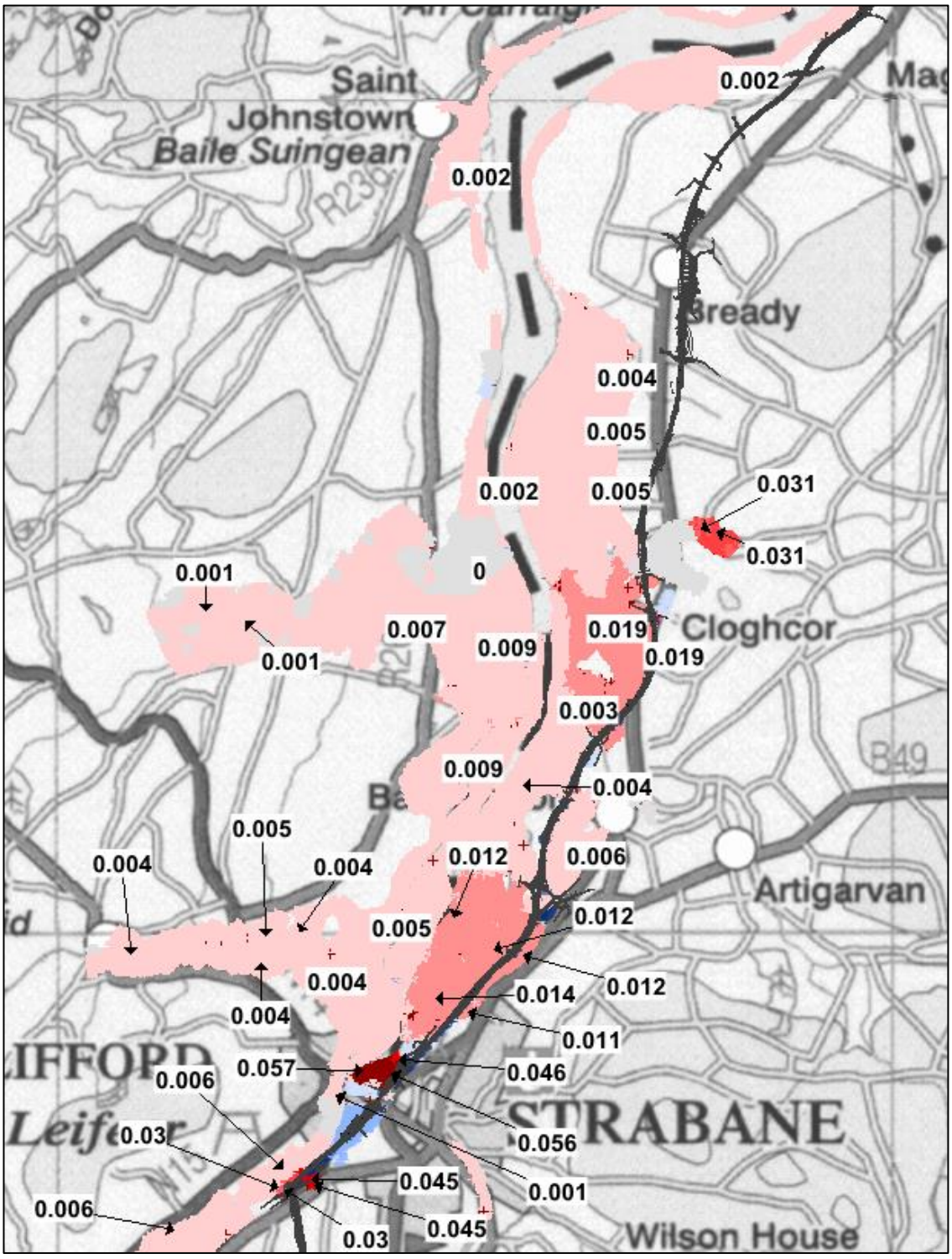

Figure 4.5.2-13 – Model M.1, M.2, M.3, Flood Impact Assessment Areas (m)

4.5.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

Within the fluvially dominated and inter tidal zone of the Foyle System floodplain it is identified that approximately 685,945m^3 of floodwater is displaced as a consequence of the Proposed Scheme. The water level impacts associated with the Proposed Scheme (including connectivity mitigation) are displayed in Figure 4.5.2-13.

Although volumetric compensation storage for displaced floodplains is generally accounted for within DMRB and Rivers Agency guidance, alternative measures were agreed with Rivers Agency for displaced flood volumes on the Foyle / Finn:

- The Foyle system (including the Finn, Mourne, Burndennet, Glenmornan, Deele and Swilly tributaries) has been replicated using a dynamic unsteady model with the lower boundary limits extending beyond Londonderry / Derry City to Lough Foyle and consequentially the likelihood of unquantified downstream impacts arising from floodplain degradation has been reduced.

- The most effective and practical mitigation options tested to maintain floodplain extents, levels and temporal nature were to reduce floodplain encroachment, reduce road footprint, provide floodplain connectivity and large structures (on main channels and some key floodplain conveyance locations). These more practical options have been explored in detail and form the major impact mitigation strategy that has been proposed for the scheme following discussions with TNI and Rivers Agency.

These measures have been discussed at length, and the principles agreed, with Rivers Agency during the course of a series of meetings to discuss the Proposed Scheme.

4.5.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.5.4-4.

Table 4.5.4-1 – Model M.1, M.2, M.3 River Foyle Flood Risk Assessment

Flood Water Level Impact (mm)	No. of Properties within Floodplain	Importance	Magnitude	Significance	Overall Assessment Score for Flood Risk
59	0	Low	Moderate Adverse	Slight	Slight Adverse
45	5 (residential)	High	Minor Adverse	Sight/Moderate	Slight Adverse
35	0	Low	Minor Adverse	Neutral	Slight Adverse

Table 4.5.4-1 – Model M.1, M.2, M.3 River Foyle Flood Risk Assessment

Flood Water Level Impact (mm)	No. of Properties within Floodplain	Importance	Magnitude	Significance	Overall Assessment Score for Flood Risk
31	0	Low	Minor Adverse	Neutral	Slight Adverse
30	1 (residential)	High	Minor Adverse	Sight/Moderate	Slight Adverse
19	3 (2 residential, 1 farm building)	High	Minor Adverse	Sight/Moderate	Slight Adverse
17	1 (residential)	High	Minor Adverse	Sight/Moderate	Slight Adverse
14	1 (industrial)	Medium	Minor Adverse	Sight	Slight Adverse
13	1 (commercial)	Medium	Minor Adverse	Sight	Slight Adverse
12	6 (residential)	High	Minor Adverse	Sight/Moderate	Slight Adverse
11	0	Low	Minor Adverse	Neutral	Slight Adverse
9	3 (2 residential, 1 farm building)	High	Negligible	Neutral	Neutral
6	3 (1 residential, 2 farm buildings)	High	Negligible	Neutral	Neutral
5	3 (residential)	High	Negligible	Neutral	Neutral
4	0	Low	Negligible	Neutral	Neutral
3	19 (8 residential, 1 abandoned residential, 7 commercial, 2 farm buildings, 1 unknown)	High	Negligible	Neutral	Neutral
2	1 (residential)	High	Negligible	Neutral	Neutral
2	>100 (flood defence feature)	Very High	Negligible	Neutral	Neutral
1	1 (residential)	High	Negligible	Neutral	Neutral
0	3 (residential)	High	Negligible	Neutral	Neutral
-2	6 (1 residential, 5 commercial)	High	Negligible	Neutral	Neutral
-6	1 (residential)	High	Negligible	Neutral	Neutral
-17	3 (residential)	High	Minor Beneficial	Slight / Moderate	Slight Beneficial
-20	1 (commercial)	Medium	Minor Beneficial	Slight	Neutral

Due to the extensive nature of the Foyle floodplain area and the variety of areas covered it was not considered appropriate to apply a generic attribute

(importance) value for the whole floodplain. Assessment has been completed for individual areas within the floodplain as evidenced in Table 4.5.4-4.

It is noted that the number of properties to the west of the River Foyle were not quantified given the low water level impact results at all return periods. It can be seen in Figure 4.5.2 13 that the flood impact to the west of the River Foyle is in the region of 0-10mm and therefore considered to be of negligible magnitude and neutral significance, giving the overall assessment score for flood risk in this area as Neutral.

Water levels across the Foyle floodplain increase marginally for the 100 year design event, with increases (and some decreases) variable across the extents of local floodplain topography.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Foyle floodplain area is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties '.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S1-0500-0101 to 718736-S1-0500-0106 and 718736-S1-0500-0110 to 718736-S1-0500-0113 in Appendix A.

4.6 Model M.D – Undesignated Watercourse (Upstream Seein Bridge) – Impact and Mitigation Assessment

4.6.1 Floodplain Interaction

The 100 year existing floodplain for Model M.D is mostly linear, with small areas of flooding associated with tributaries joining the main watercourse in low lying areas extending from the river.

It is identified that the Proposed Scheme is primarily located outside the 100 year floodplain. The Proposed Scheme crosses the undesignated watercourse at one location; refer to Figure 4.6.1-1. Given that the majority of the proposed alignment does not interfere with the floodplain, there is no significant disruption of floodplain flowpaths/connectivity.

For the 100 year flood event, modelling indicates that approximately 185m^3 of floodwater is displaced as the result of the Proposed Scheme (design event). These areas are outlined in Figure 4.6.1-1:

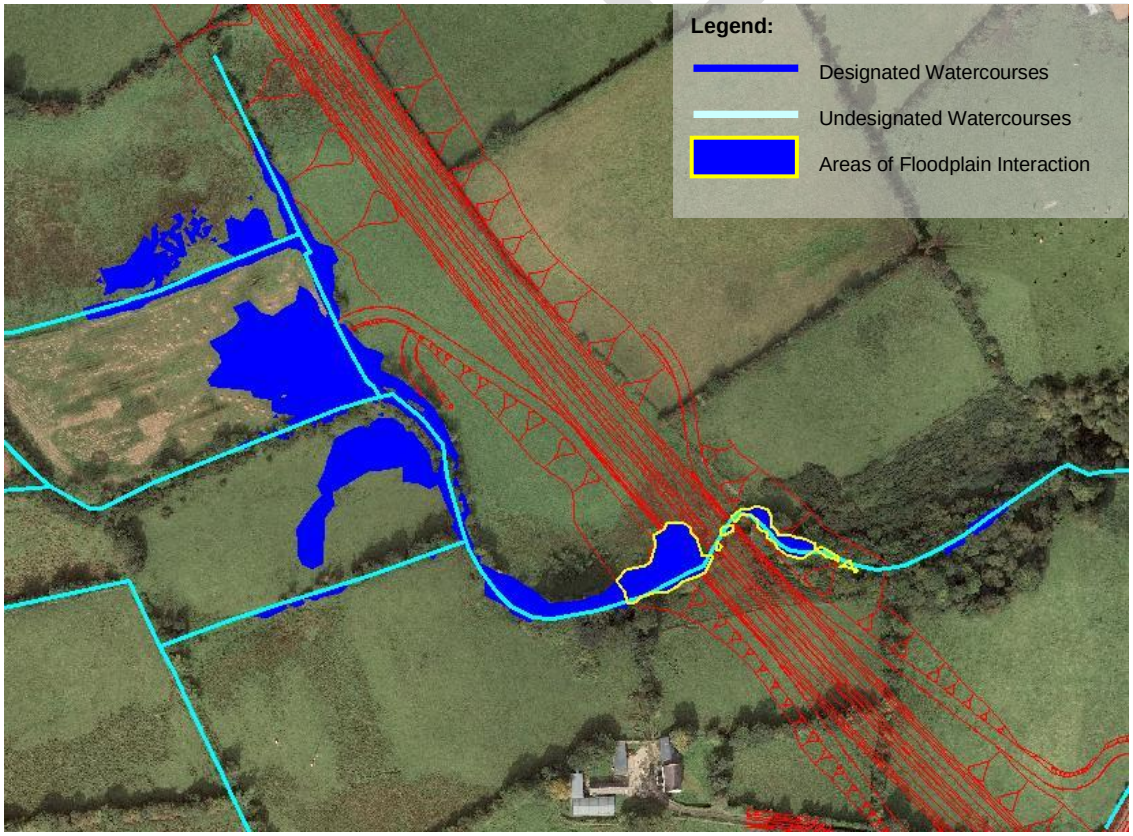

Figure 4.6.1-1 - Undesignated Watercourse Floodplain Interaction

4.6.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting and river diversion works for the watercourse crossing. The proposed arrangement aims to minimise the length of culvert required through a perpendicular crossing. This arrangement can be seen in Figure 4.6.2-1.

There are no bridge structures proposed within the extents of the undesignated watercourse model.

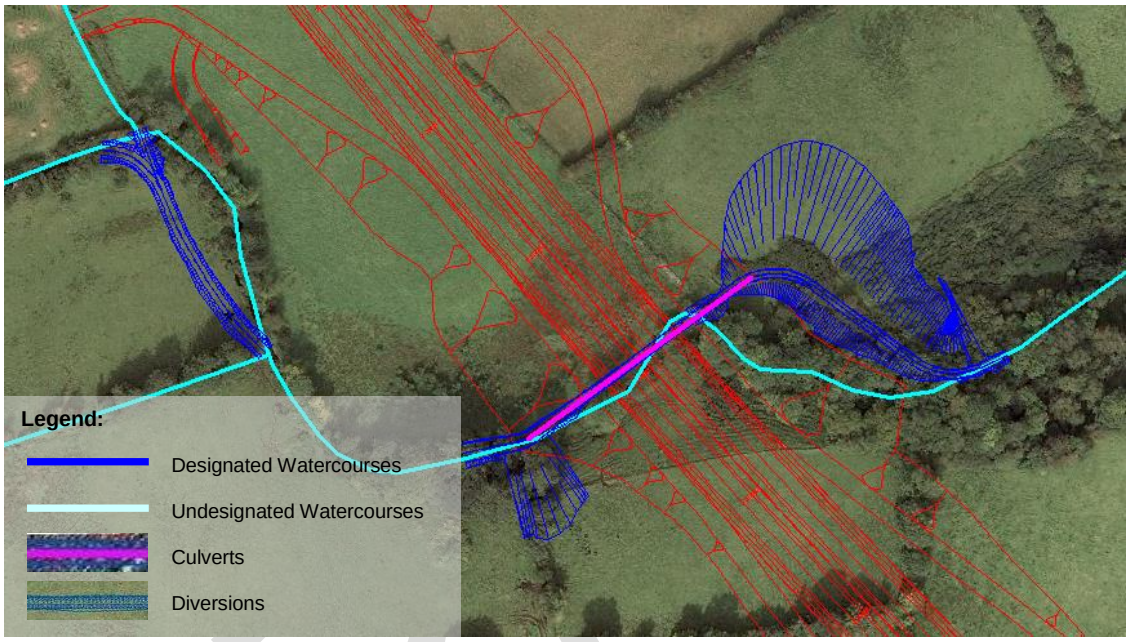

Figure 4.6.2-1 - Plan of Undesignated Watercourse Diversions (S2-WD-01 and S2-WD-43) and Culvert Arrangement (S2-PC-01)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.6.2-1 below provides a summary of the modelled culvert size for this undesignated watercourse.

Table 4.6.2-1 - Model M.D, Undesignated Watercourse Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
233546 391079	S2-PC-01	Box	5.4	2.4

The proposed diversion has also been hydraulically modelled. Table 4.6.2-2 below provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.6.2-2 - Model M.D, Undesignated Watercourse Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
233586 39110	S2-WD-01	Channel Length	203m	198m
		Channel Gradient	1:40	1:27
233408 391110	S2-WD-43	Channel Length	96m	85m
		Channel Gradient	1:149	1:138.5

The culvert and diversion arrangement can be seen in Drawing 718736-S2-0500-0101.

A comparison of the water elevations pre and post scheme is shown in Table 4.6.2-2 for specific points along the watercourse. These points can be seen in Figure 4.6.2-2:

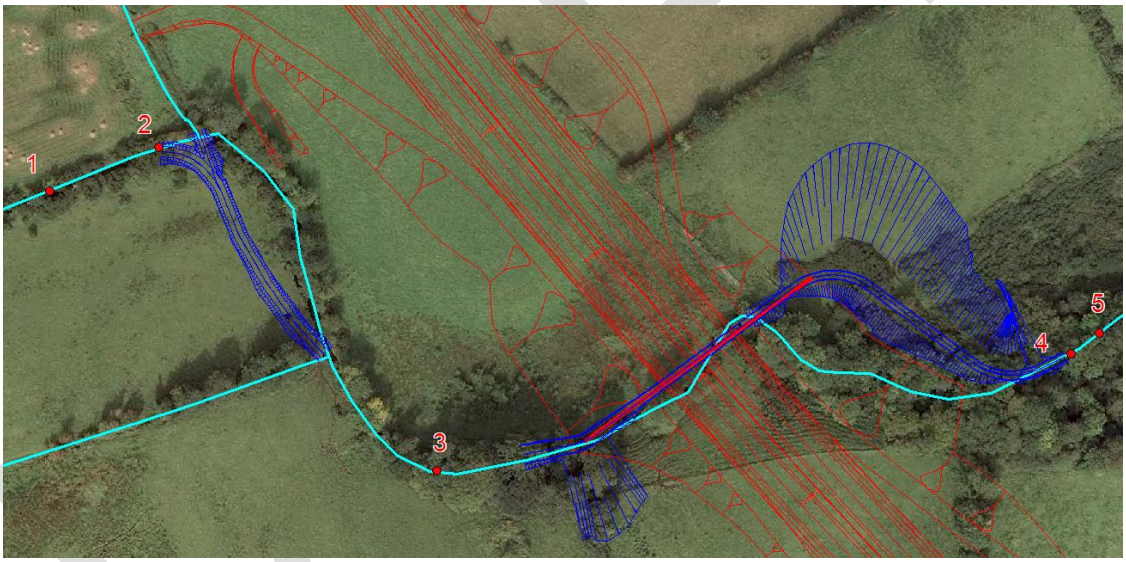

Figure 4.6.2-2 – Model M.D, Points along Channel for Water Elevation Comparison

Table 4.6.2-3 - Predicted Impact for Model M.D Undesignated for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	100 Year	100 Year	100 Year
1	50.29	50.43	+0.14
2	50.25	50.41	+0.16
3	48.97	48.83	-0.14
4	40.44	40.44	0
5	40.11	40.11	0

It is observed that there are some increases in water levels for Point IDs 1 and 2, these increases are considered localised and attributable to the slight changes in the local geometry post scheme (gradient, alignment and channel cross section) but result in an increase in the overall floodplain area upstream of the road within fields.

4.6.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.6.1, approximately 185m^3 of floodwater is displaced as consequence of the A5 WTC Proposed Scheme. The compensatory storage location (reference S2-CS-01) for this model can be seen in Drawing 718736-S2- 0500-0101 and in Figure 4.6.3-1 below.

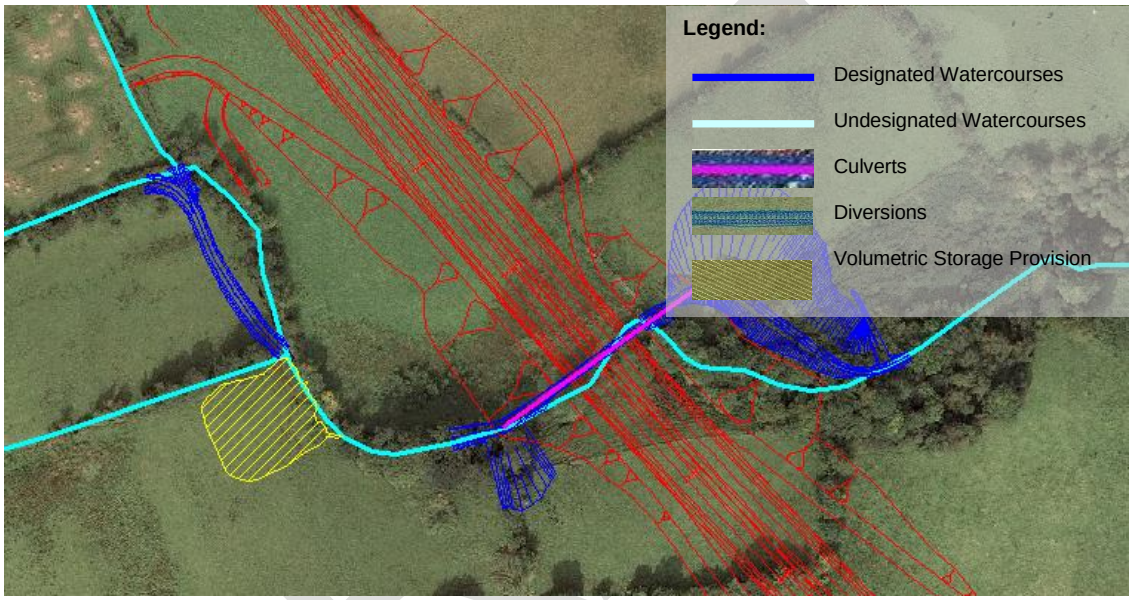

Figure 4.6.3-1 – Model M.D, Plan of Undesignated Watercourse Volumetric Floodplain Storage Provision (S2-CS-01)

Table 4.6.3-1 identifies the volumetric storage requirements, Drawing 718736-0500-D-00228 illustrates the application of this in detail.

Table 4.6.3-1 – Model M.D, Undesignated Watercourse Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-01	233422	391055	~185	~185	~1660	UD_15

4.6.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.6.4-1:

Table 4.6.4-1 – Model M.D Undesignated Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Adverse	Slight/Moderate

There are no residential or commercial properties within the extent of the floodplain and the importance of the feature is characterised as Low. The model results show that there is maximum change of 160mm in the 100 year flood water levels post Proposed Scheme, as such the magnitude of impact is considered Major Adverse. The significance of impact on the floodplain is considered to be Slight/Moderate.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the undesignated watercourse is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2- 0500-0101 in Appendix A.

4.7 Model M.5 – 101 River Derg – Impact and Mitigation Assessment

4.7.1 Floodplain Interaction

The 100 year existing floodplain for River Derg is linear in its shape, extending from the river banks of the watercourse in the vicinity of the Proposed Scheme. Due to the extents of the floodplain, the proposed alignment has the potential to disrupt floodplain flow path / connectivity unless mitigation is proposed.

Furthermore, for the 100 year flood event, modelling indicates that approximately 375m^3 of floodwater is displaced as a result of the Proposed Scheme. These areas are outlined in Figure 4.7.1-1:

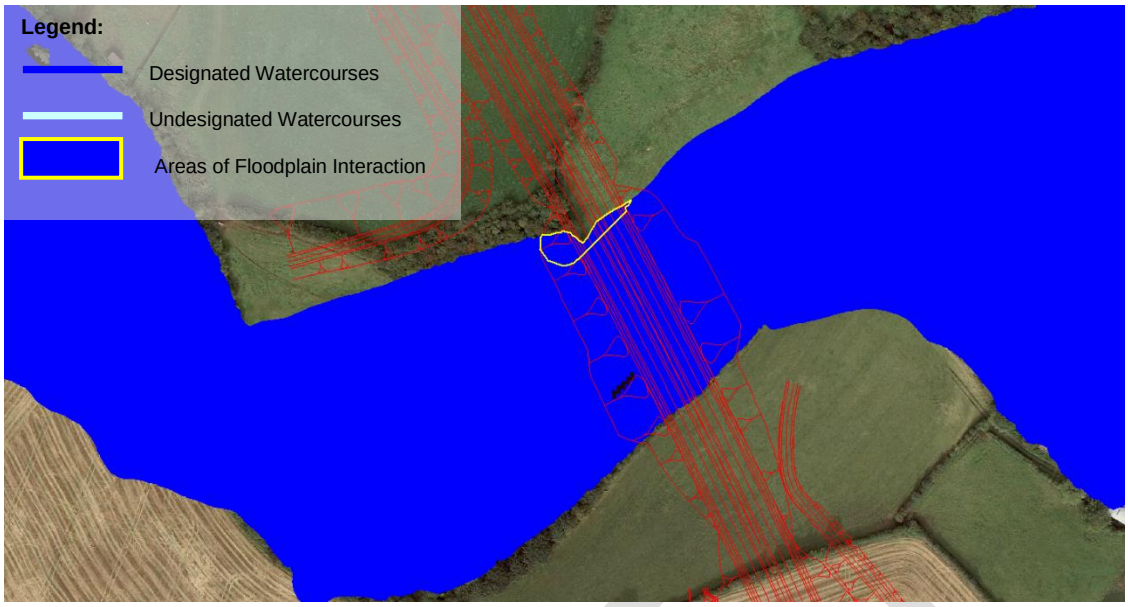

Figure 4.7.1-1 - River Derg Floodplain Interaction

A number of mitigation scenarios were analysed to facilitate an assessment of the most effective options for mitigation. The main variables tested were in relation to bridge structure arrangements.

4.7.2 Mitigation Assessment – Structures, Culverts and Diversions

To maintain the existing hydraulic operation of the River Derg, there is a proposed bridge structure associated with the watercourse crossing for the River Derg and the location is identified in the following figure.

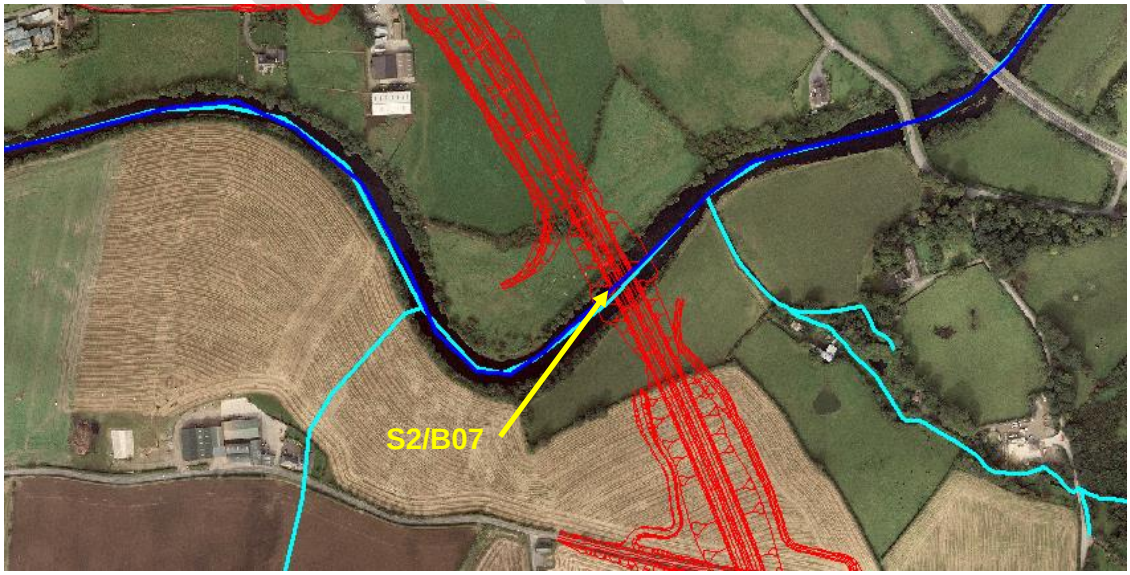

Figure 4.7.2-1 - Plan of River Derg Bridge Crossing Location (S2/B07)

Modelling was undertaken to evaluate the effectiveness of various bridge structure options. Following this analysis, the proposed bridge structure arrangement can be seen in Table 4.7.2-1.

Table 4.7.2-1 – Model M.5, River Derg Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
237353 385884	River Derg	S2/B07	31 + 61	30.42

The general arrangement of the bridge structure can be seen in Drawing 718736-1700-D-0510. An overview of the bridge arrangement in association with the other mitigation elements can be seen in Drawing 718736-S2-0500-0102.

A comparison of the water elevations pre and post scheme is shown in Table 4.7.2-2 for specific points along the watercourse. These points can be seen in Figure 4.7.2-2:

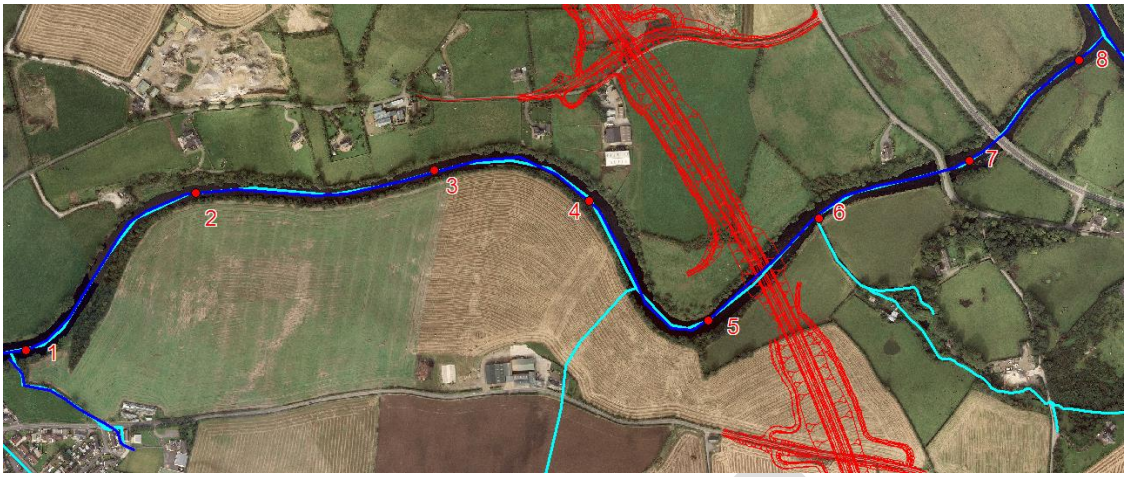

Figure 4.7.2-2 – Model M.5, Points along Channel for Water Elevation Comparison

Table 4.7.2-2 - Predicted Impact for Model M.5 River Derg for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	31.46	31.46	0
2	30.90	30.91	+0.01
3	30.35	30.35	0
4	30.04	30.05	+0.01
5	29.81	29.82	+0.01
6	29.74	29.74	0
7	29.64	29.64	0
8	29.54	29.54	0

It is observed that for the 100 year event for the River Derg, the river engineering proposals results in a 0 – 10mm increase in water levels along the length of the model.

4.7.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.7.1, approximately 375m^3 of floodwater is displaced as consequence of the A5 WTC Proposed Scheme. The compensatory storage location (reference S2-CS-02) for this model can be seen in Drawing 718736-S2-0500-0102 and in Figure 4.7.3-1.

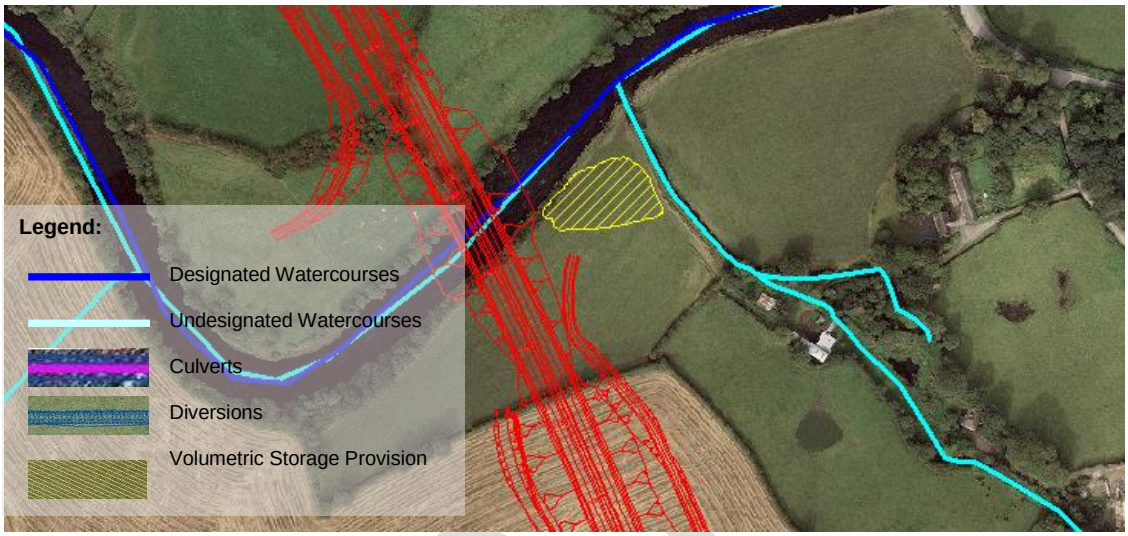

Figure 4.7.3-1 – Model M.5, Plan of River Derg Volumetric Floodplain Storage Provision (S2-CS-02)

Table 4.7.3-1 identifies the volumetric storage requirements, Drawing 718736-0500-D-00229 illustrates the application of this in detail.

Table 4.7.3-1 – Model M.5, River Derg Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-02	236292	387570	~375	~375	~1355	River Derg

4.7.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.7.4-1:

Table 4.7.4-1 – River Derg Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Negligible	Neutral

There are no residential or commercial properties within the extent of the floodplain. Consequentially, importance of the feature is characterised as Low. The model results show that along the length of the River Derg there is a predicted maximum increase of 10mm in water levels, as such the magnitude of impact is considered Negligible. The significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the River Derg is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-0102 in Appendix A.

4.8 Model M.E – Coolaghy Burn (Undesignated) – Impact and Mitigation Assessment

4.8.1 Floodplain Interaction

The 100 year existing floodplain for Coolaghy Burn is linear in its shape, extending approximately 95m from the left bank of the watercourse in the vicinity of the Proposed Scheme. Due to the extents of the floodplain on the left bank, the proposed alignment would interfere with floodplain flowpaths/connectivity unless mitigation is proposed.

Furthermore, for the 100 year flood event, modelling indicates that approximately 1,735m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.8.1-1:

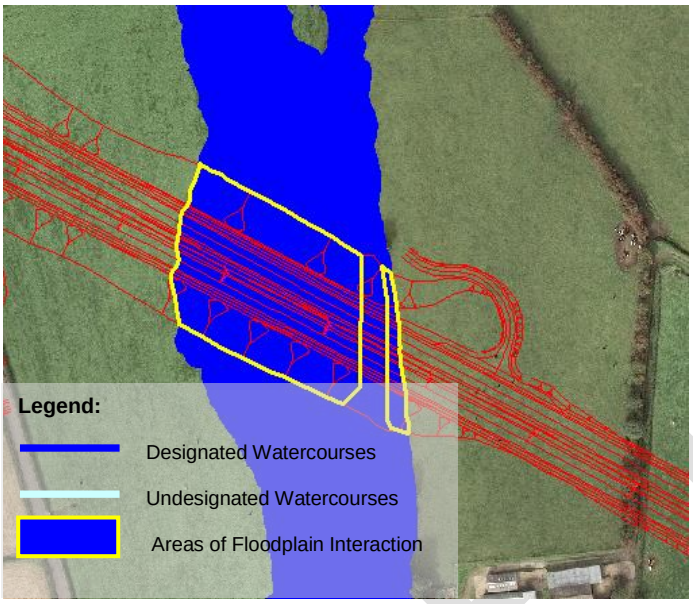

Figure 4.8.1-1 - Coolaghy Burn Floodplain Interaction

4.8.2 Mitigation Assessment – Structures, Culverts and Diversions

To maintain the existing hydraulic operation of Coolaghy Burn there is a proposed bridge structure associated with the watercourse crossing for Coolaghy Burn and the location is identified in Figure 4.8.2-1.below.

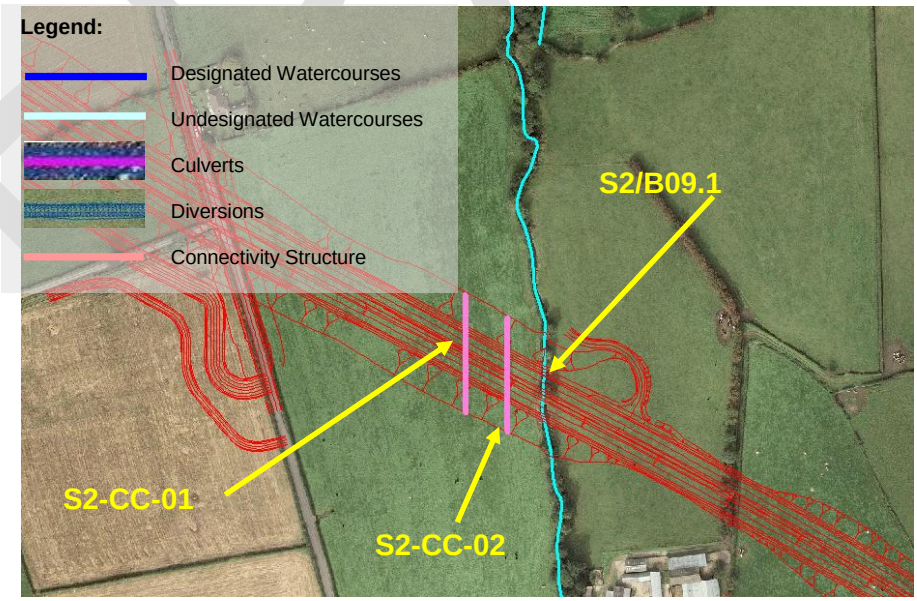

Figure 4.8.2-1 - Plan of Coolaghy Burn Bridge Crossing Location and Connectivity Culverts (S2-CC-01 and S2-CC-02)

Modelling was undertaken to evaluate the effectiveness of various bridge structure options. Following this analysis, the proposed bridge structure arrangement can be seen in Table 4.8.2-1.

Table 4.8.2-1 - Model M.E, Coolaghy Burn Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
237353 385884	Coolaghy Burn	S2/B09.1	12	53.03

The general arrangement of the bridge structure can be seen in Drawing 718736-1700-D-0513. An overview of the bridge arrangement in association with the other mitigation elements can be seen in Drawing 718736-S2-0500-D-0103.

It is also proposed that floodplain conveyance structures are provided for this watercourse to mitigate the reduction in floodplain connectivity due to the location of the A5 WTC Proposed Scheme. The location of these structures are shown Figure 4.8.2-1 and details are provided in Table 4.8.2-2 below.

Table 4.8.2-2 - Model M.E, Coolaghy Burn Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
237306 385910	S2-CC-01	Box	6.0	1.5
237332 385898	S2-CC-02	Box	6.0	1.5

A comparison of the water elevations pre and post scheme is shown in Table 4.8.2-3 for specific points along the watercourse. These points can be seen in Figure 4.8.2-2:

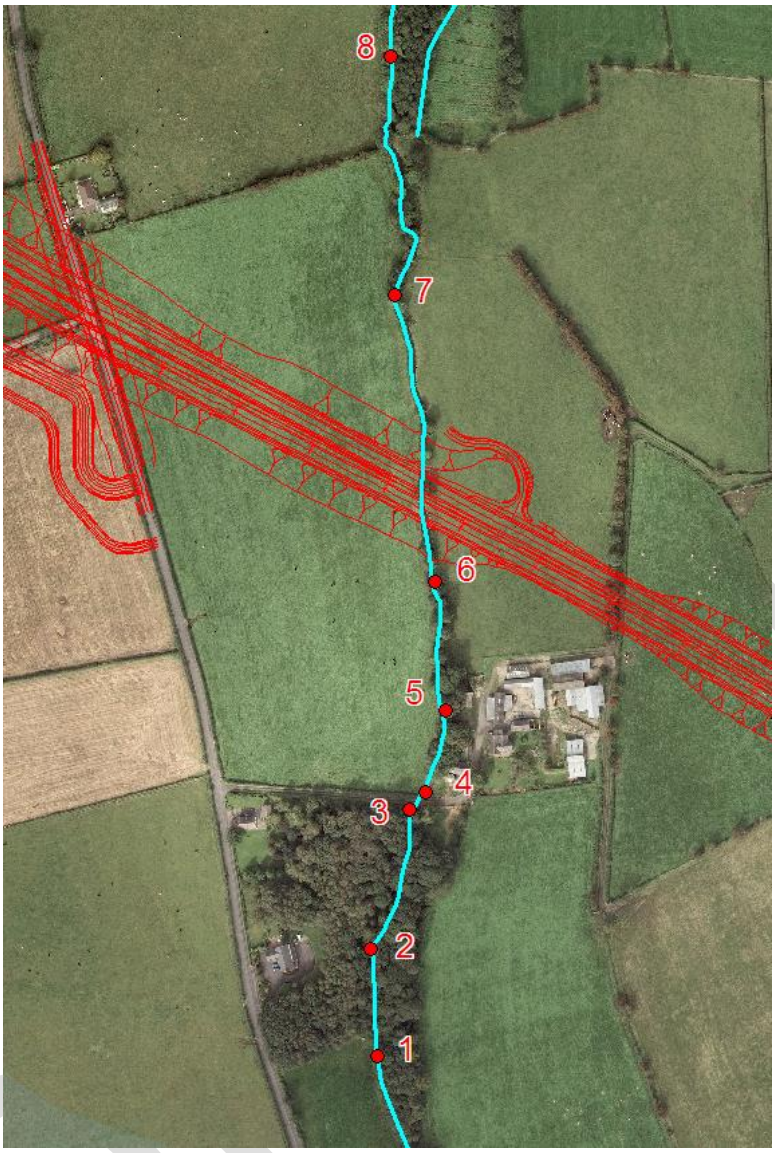

Figure 4.8.2-2 – Model M.E, Points along Channel for Water Elevation Comparison

Table 4.8.2-3 - Predicted Impact for Model M.E Coolaghy Burn for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	53.86	53.86	0
2	53.55	53.55	0
3	53.49	53.49	0
4	52.61	52.65	+0.04
5	52.43	52.53	+0.1
6	52.05	52.43	+0.38
7	51.45	51.45	0
8	50.49	50.49	0

It is identified that the combined effect of the proposed culverts and diversions result in an increase in water levels at various locations throughout the length of the model. The minor impacts associated with the 100 year design are attributed to changes in the local geometry of the floodplain predicted post scheme.

4.8.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As mentioned in Section 4.8.1, approximately 1,735m^3 of floodwater is displaced as consequence of the A5 WTC Proposed Scheme. The compensatory storage location (reference S2-CS-03) for this model can be seen in Drawing 718736-S2-0500-D-0103 and in Figure 4.8.3-1 below.

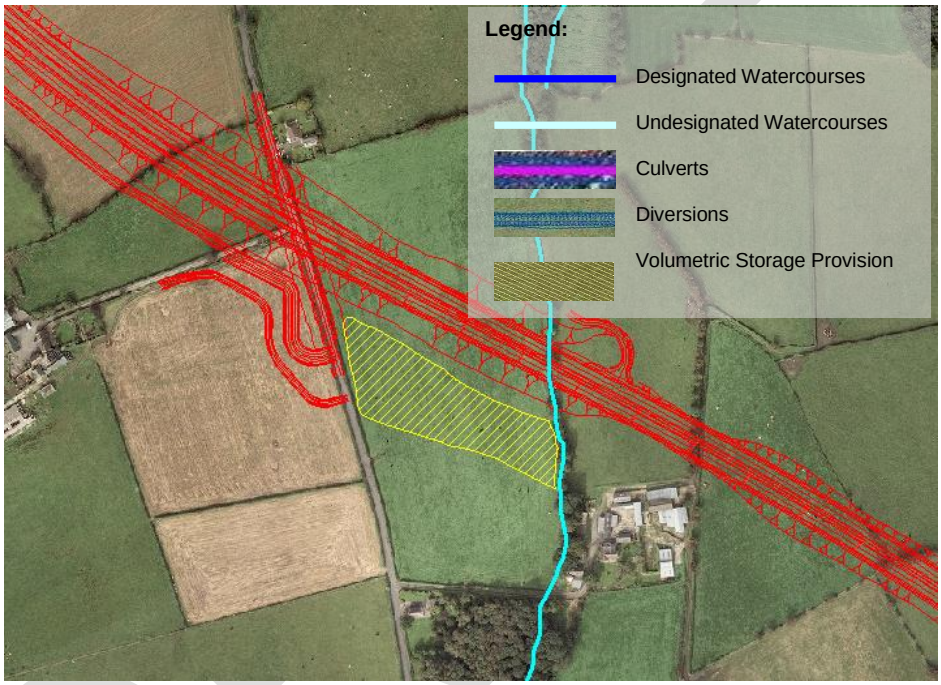

Figure 4.8.3-1 – Model M.E, Plan of Coolaghy Burn Volumetric Floodplain Storage Provision (S2-CS-03)

Table 4.8.3-1 identifies the volumetric storage requirements, Drawing 718736-0500-D-00230 illustrates the application of this in detail.

Table 4.8.3-1 – Model M.E, Coolaghy Burn Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-03	237258	385864	~1,735	~1,735	~9,660	Coolaghy Burn

4.8.4 Residual Post Scheme Flood Risk

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed. This information can be seen in Table 4.8.4-1:

Table 4.8.4-1 – Model M.E Coolaghy Burn Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Adverse	Slight / Moderate

There are no residential or commercial properties within the extent of the modelled floodplain. It is also observed that the existing property adjacent to the watercourse is elevated (~55.9mAOD) such that a reasonable freeboard persists for the 100 year predicted water levels. Consequentially the importance of the feature is characterised as low. The model results show that for the worst case point location there is a predicted 380mm change in predicted 100 year flood water levels post Proposed Scheme; the magnitude of this impact is considered to be Major Adverse and the significance of impact on the floodplain is considered to be Slight/Moderate.

On review of the overall qualifying conditions for assessment score of flood risk, the score for Coolaghy Burn is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-D-0103 in Appendix A.

4.9 Model M.F – U1704 Ext Back Burn Extension, Newtownstewart Loss of Floodplain – Impact and Mitigation Assessment

4.9.1 Floodplain Interaction

For the 100 year flood event, as illustrated in Figure 4.9.1-1, modelling indicates that there will be no floodwater displacement as a consequence of the Proposed Scheme, however, appropriately sized culverting will be required to facilitate the conveyance of flow.

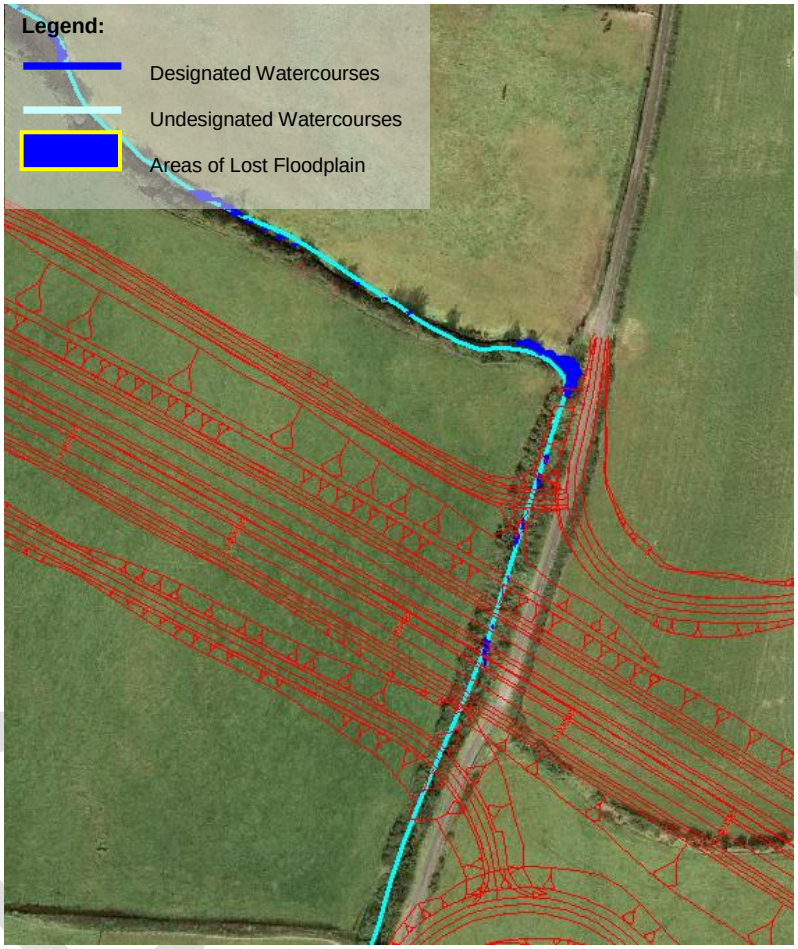

Figure 4.9.1-1 – Back Burn Floodplain Interaction

4.9.2 Mitigation Assessment – Structures, Culverts and Diversions

There are no proposed diversions associated with Back Burn and the watercourse will be culverted perpendicularly to the Proposed Scheme. This arrangement can be seen in Figure 4.9.2-1. The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.9.2-1 below provides a summary of the modelled culvert size for Back Burn.

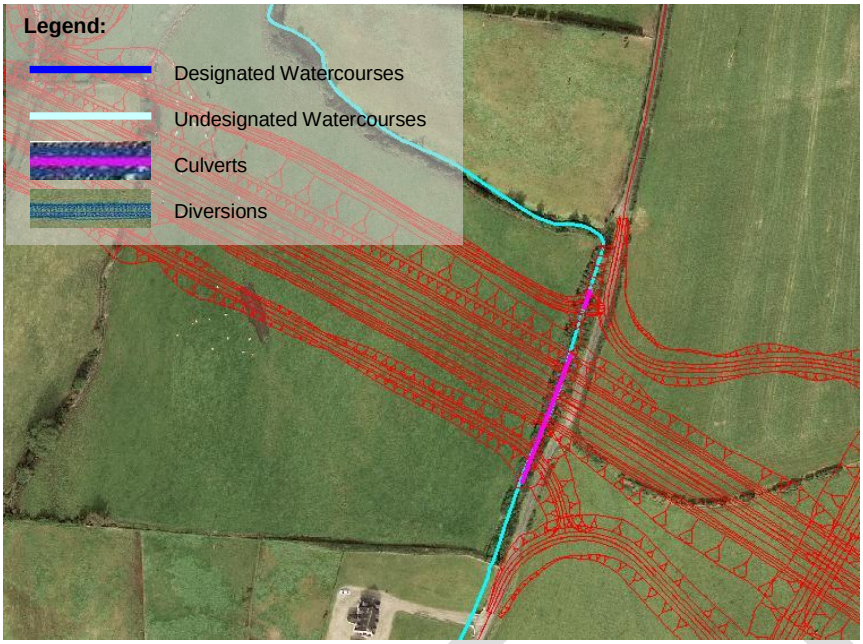

Figure 4.9.2-1 – Plan of Back Burn Culvert Arrangement (S2-PC-09)

Table 4.9.2-1 - Model M.F, Back Burn Modelled Culvert Sizes

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
239874 384685	S2-PC-09	Box	1.8	1.8

The culvert arrangement can be seen in Drawing 718736-S2-0500-D-0112.

A comparison of the water elevations pre and post scheme is shown in Table 4.9.2-2 for specific points along the watercourse. These points can be seen in Figure 4.9.2-2:

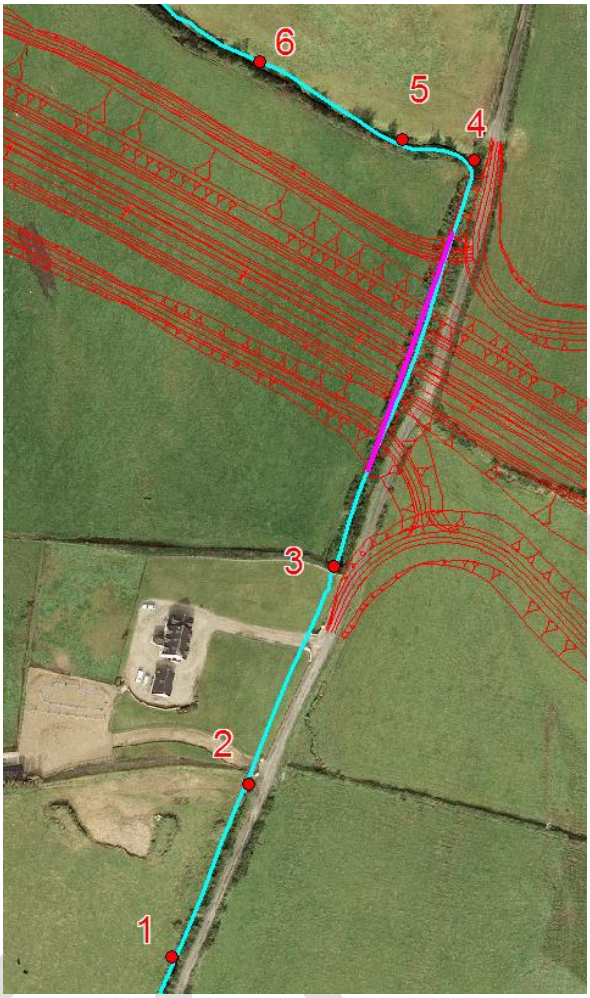

Figure 4.9.2-2 – Model M.F, Points along Channel for Water Elevation Comparison

Table 4.9.2-2 - Predicted Impact for M.F Back Burn for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	124.06	124.06	0
2	118.43	118.43	0
3	110.83	110.83	0
4	103.26	103.26	0
5	100.22	100.22	0
6	96.88	96.88	0

It is observed that for the 100 year event for the Back Burn watercourse, the river engineering proposals results in no change in water levels at all locations throughout the length of the model.

4.9.3 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.9.3-1:

Table 4.9.3-1 – Model M.F Back Burn Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Negligible	Neutral

There are no residential or commercial properties within the extent of the floodplain and the importance of the feature is characterised as Low. The model results show that there is no change in the predicted water levels, as such the magnitude of impact is considered Negligible. The significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Back Burn is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-D-0112 in Appendix A.

4.10 Model M.G – Undesignated Watercourse – Impact and Mitigation Assessment

4.10.1 Floodplain Interaction

The predicted 100 year existing water levels and associated floodplain at this location are attributable to an existing undersized pipe located within the vicinity of the Proposed Scheme, where proposed culvert S2-PC-22 is to be situated; the restriction in conveyance results in flooding to surrounding low lying areas extending from the river.

For the 100 year flood event, modelling indicates that approximately 2,070m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.10.1-1.

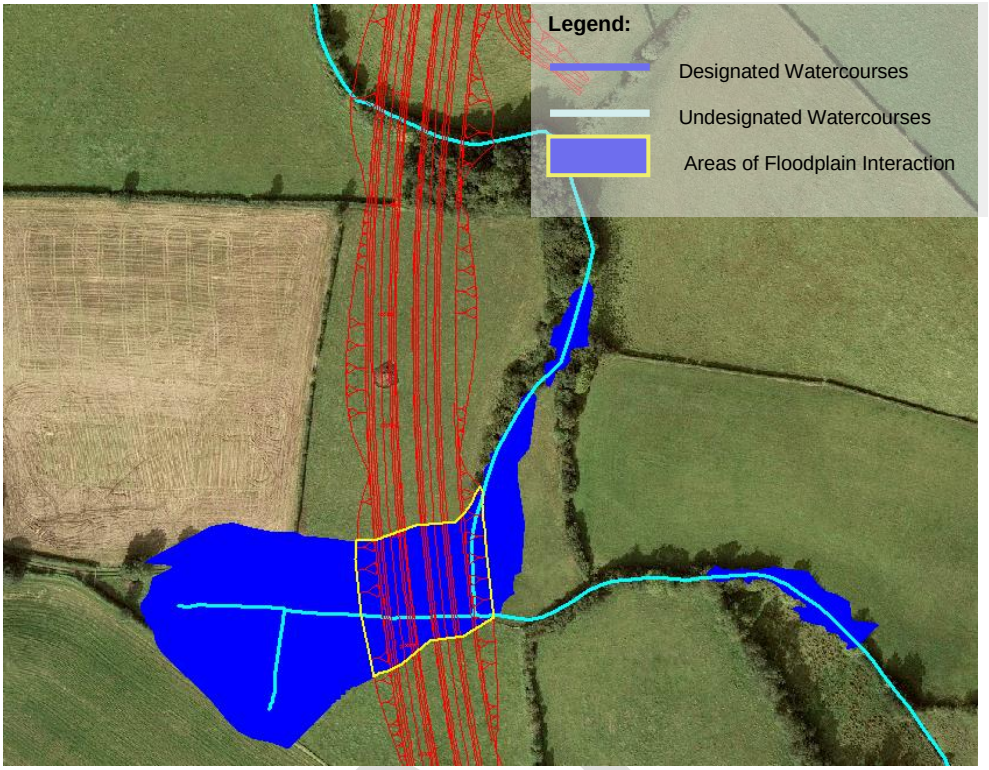

Figure 4.10.1-1 - Undesignated Watercourse Floodplain Interaction

4.10.2 Mitigation Assessment – Structures, Culverts and Diversions

A number of mitigation scenarios were analysed to facilitate an assessment of the most effective options for mitigation. The main variables tested were in relation to culvert sizing, watercourse diversion and volumetric floodplain compensation.

There is a proposed diversion associated with the undesignated watercourse which aims to minimise the length of culvert required and remove the watercourse from the Proposed Scheme footprint. The proposed river engineering works will also include the removal of the existing undersized pipe. These arrangements can be seen in Figure 4.10.2-1.

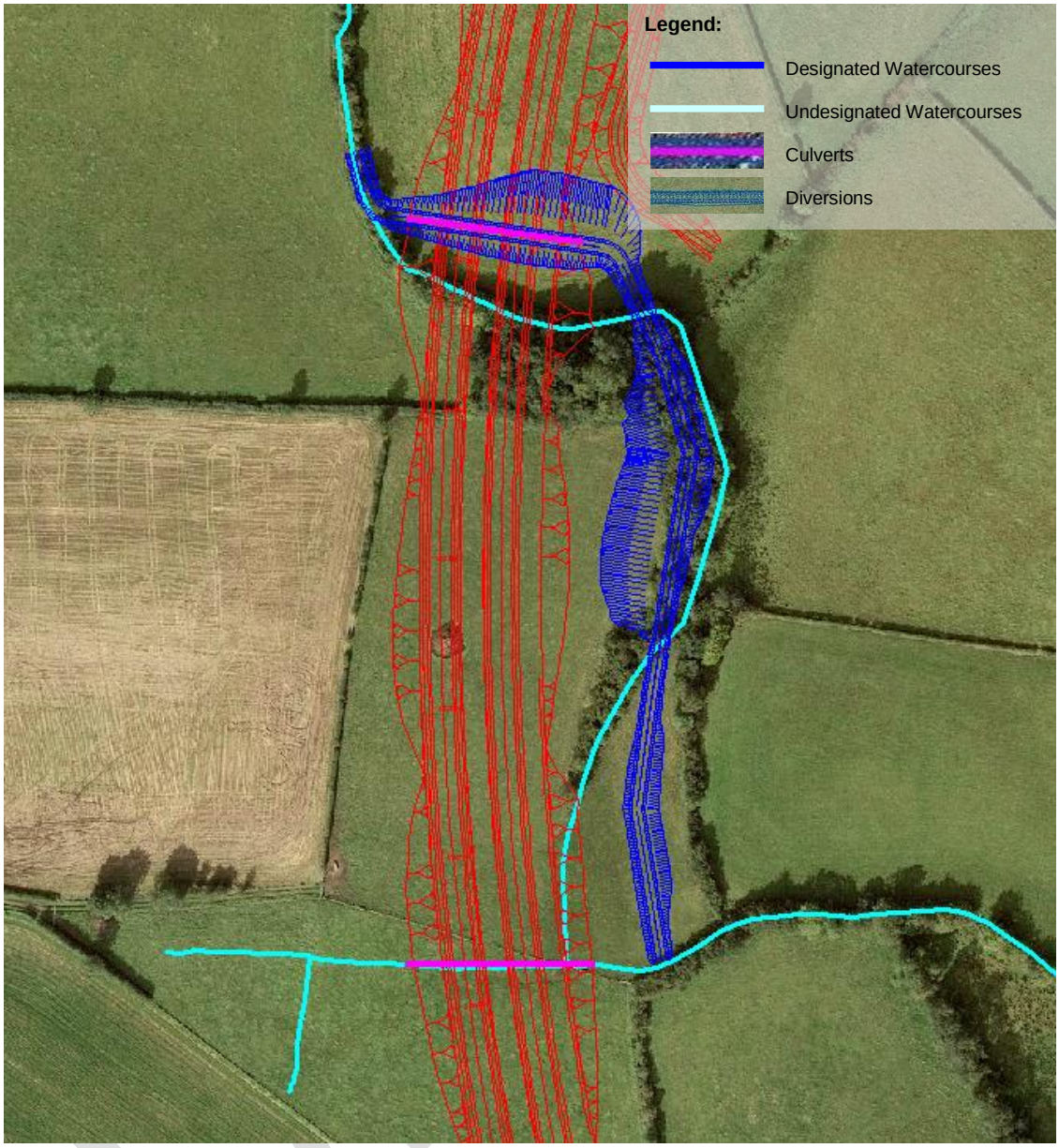

Figure 4.10.2-1 - Plan of Undesignated Watercourse Diversion (S2-WD-14 and S2-WD-15) and Culvert Arrangement (S2-PC-21 and S2-PC-22)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.10.2-1 below provides a summary of the modelled culvert sizes for the undesignated watercourses.

Table 4.10.2-1 - Model M.G, Undesignated Watercourse Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
241526 378540	S2-PC-21	Box	3.0	2.1
241534 378308	S2-PC-22	Box	3.0	1.8

The proposed diversion has also been hydraulically modelled. Table 4.10.2-2 below provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.10.2-2 - Model M.G, Undesignated Watercourse Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
241570 378551	S2-WD-14	Channel Length	260m	174m
		Channel Gradient	1:1250	1:113
241579 378380	S2-WD-15	Channel Length	114m	174m
		Channel Gradient	1:80	1:57

The culvert and diversion arrangements can be seen in Drawing 718736-S2-0500-0104.

A comparison of the water elevations pre and post scheme is shown in Table 4.10.2-3 for specific points along the watercourse. These points can be seen in Figure 4.10.2-2:

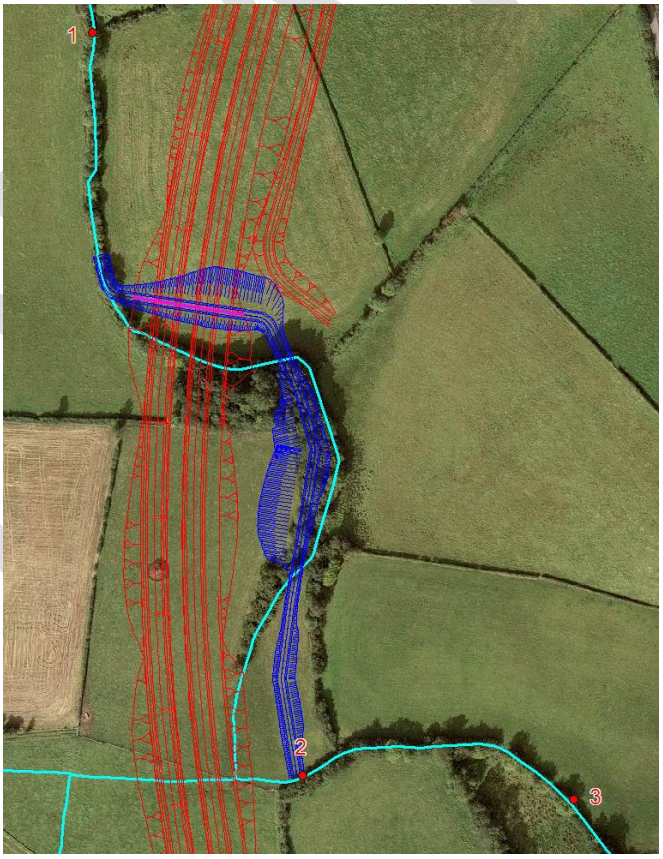

Figure 4.10.2-2 – Model M.G, Points along Channel for Water Elevation Comparison

Table 4.10.2-3 - Predicted Impact for M.G Undesignated for Proposed Scheme			
	Existing Water Elevation (m AOD)	**Post Road Water Elevation (m AOD)**	**Impact (m)**
Point ID	**100 Year**	**100 Year**	**100 Year**
1	84.013	83.853	-0.160
2	79.341	79.154	-0.187
3	78.91	78.692	-0.218

It is observed that for the 100 year event for the undesignated watercourse, the river engineering proposals results in a general reduction in water levels at all locations throughout the length of the model.

4.10.3 Mitigation Assessment - Volumetric Floodplain Storage Provision

As mentioned in Section 4.10.1, approximately 2,070m^3 of floodwater is displaced as consequence of the A5 WTC Proposed Scheme. The proposed compensatory storage location (reference S2-CS-04) for this model can be seen in Drawing 718736-S2-0500-0104 and in Figure 4.10.3-1 below.

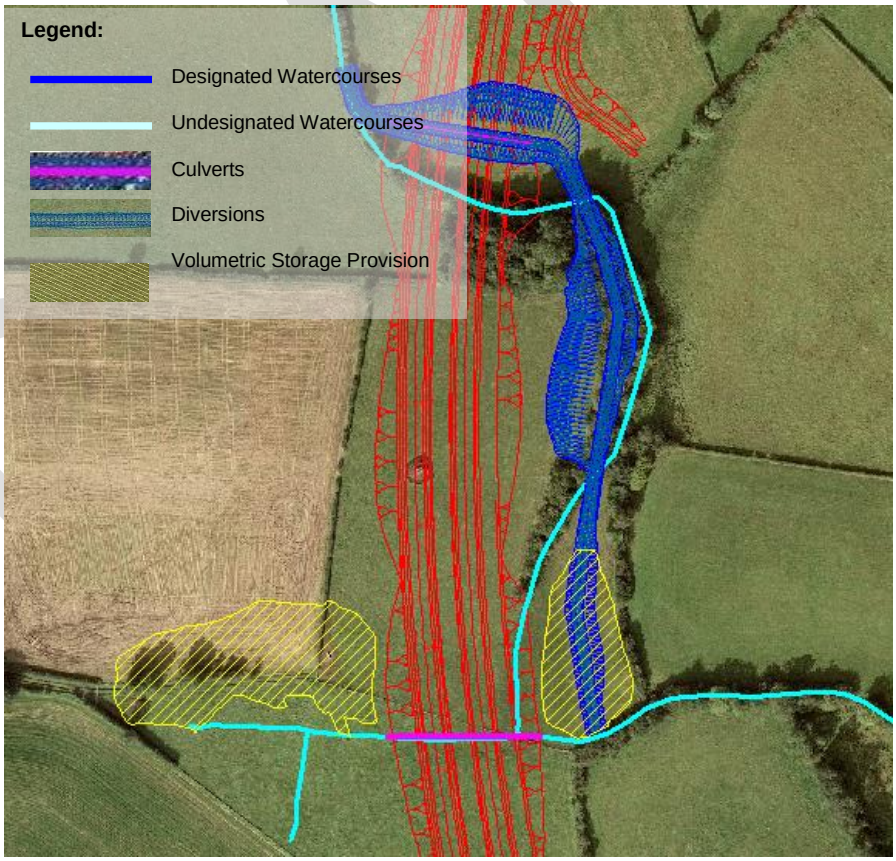

Figure 4.10.3-1 – Model M.G, Plan of Undesignated Watercourse Volumetric Floodplain Storage Provision (S2-CS-04)

Table 4.10.3-1 identifies the volumetric storage requirements and Drawing 718736-0500-D-00231 illustrates the application of this in detail. It is considered that the river engineering proposals fully mitigate the impacts arising from the Proposed Scheme; during value engineering stages the application of storage compensation will be reviewed at this location.

Table 4.10.3-1 – Model M.G, Undesignated Watercourse Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-04	241447	378338	~2,070	~2,070	~3,660	UD_39

4.10.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.10.4-1.

Table 4.10.4-1 – Model M.G Undesignated Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Beneficial	Slight / Moderate

There are no residential or commercial properties within the extent of the floodplain and the importance of the feature is characterised as Low. The model results show that along the length of the undesignated watercourse there is minimum of 160mm decrease in predicted water levels, as such the magnitude of impact is considered Major Beneficial. The significance of impact on the floodplain is considered to be Slight / Moderate.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the undesignated watercourse is Slight Beneficial (Table A4.6, Annex IV, HD 45/09) – *'a reduction in peak flood level (1% annual probability) > 10mm resulting in a reduced risk of flooding to 1-100 residential properties'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-0104 in Appendix A.

4.11 Model M.H – Tully Drain (Undesignated Reach – Mountjoy) – Impact and Mitigation Assessment

4.11.1 Floodplain Interaction

The 100 year existing floodplain for this watercourse is in low lying areas of land adjacent to the river banks of the watercourse.

For the 100 year flood event, modelling indicates that approximately 200m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.11.1-1.

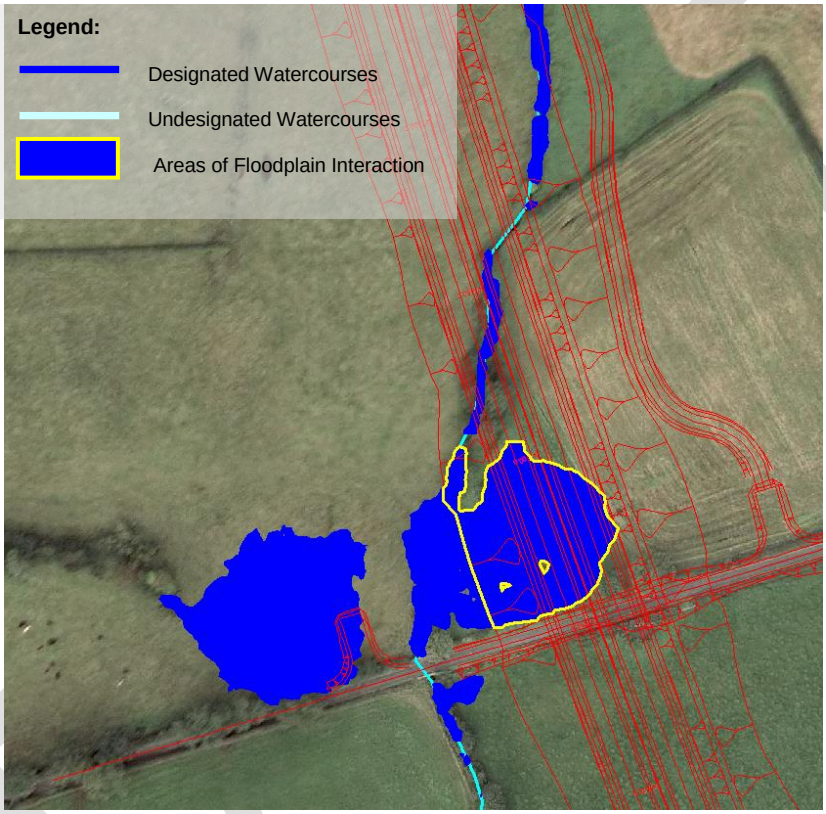

Figure 4.11.1-1 - Tully Drain Floodplain Impact

4.11.2 Mitigation Assessment – Structures, Culverts and Diversions

A number of mitigation scenarios were analysed to facilitate an assessment of the most effective options for mitigation. The main variables tested were in relation to culvert sizing.

There is also a proposed diversion associated with Tully Drain which aims to minimise the length of culvert required as the watercourse will be culverted perpendicularly to the Proposed Scheme.

The proposed culvert and diversion arrangement can be seen in Figure 4.11.2-1.

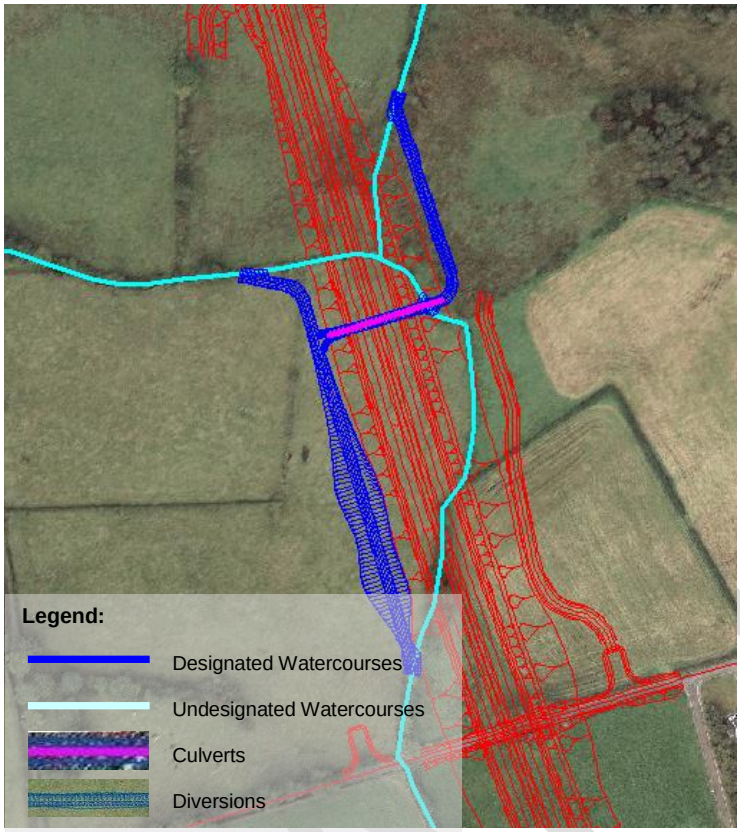

Figure 4.11.2-1 - Plan of Tully Drain watercourse Diversions (S2-WD-16 and S2-WD-18) and Culvert Arrangement (S2-PC-47)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.11.2-1 below provides a summary of the modelled culvert size for the watercourses within this model.

Table 4.11.2-1 - Model M.H – Tully Drain Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
241794 377377	S2-PC-47	Box	2.1	2.1

The proposed diversion has also been hydraulically modelled. Table 4.11.2-2 below provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.11.2-2 - Model M.H – Tully Drain Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
241827 377404	S2-WD-16	Channel Length	76m	165m
		Channel Gradient	1:70	1:204

Table 4.11.2-2 - Model M.H – Tully Drain Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
241780 377320	S2-WD-18	Channel Length	282m	210m
		Channel Gradient	1:250	1:139

The culvert and diversion arrangements can be seen in Drawing 718736-S2-0500-0105.

A comparison of the water elevations pre and post scheme is shown in Table 4.11.2-3 for specific points along the watercourse. These points can be seen in Figure 4.11.2-2.

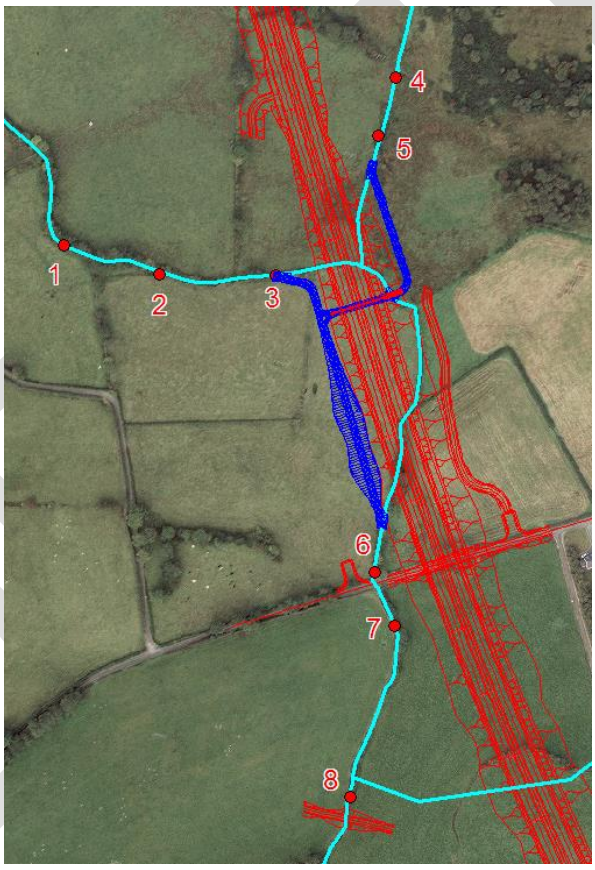

Figure 4.11.2-2 – Model M.H, Points along Channels for Water Elevation Comparison

Table 4.11.2-3 - Predicted Impact for Model M.H Tully Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	100 Year	100 Year	100 Year
1	73.76	73.75	-0.01

Table 4.11.2-3 - Predicted Impact for Model M.H Tully Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
2	72.96	72.98	+0.02
3	72.30	72.07	-0.23
4	73.21	73.22	+0.01
5	72.52	72.49	-0.03
6	70.83	70.83	0
7	69.59	69.52	-0.07
8	68.24	68.22	-0.02

It is observed that for the 100 year event for the Tully Drain watercourse, the river engineering proposals results in a general reduction in water levels at most locations throughout the length of the model.

4.11.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As outlined in Section 4.11.1, approximately 200m^3 of floodwater is displaced as consequence of the A5 WTC Proposed Scheme. The compensatory storage location (reference S2-CS-05) for this watercourse can be seen in Drawing 718736-S2-0500-0105 and in Figure 4.11.3-1 below.

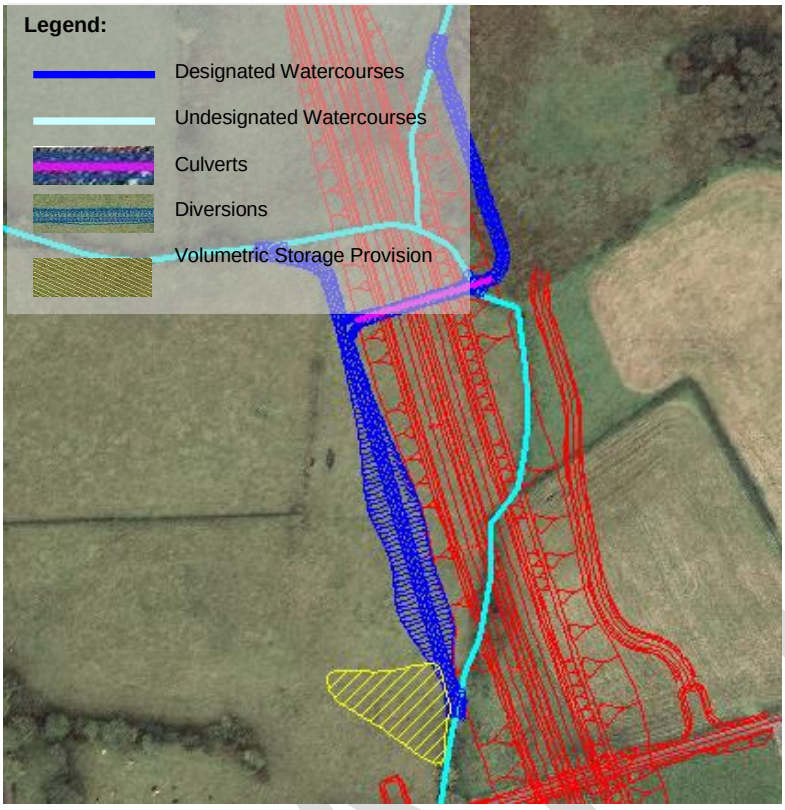

Figure 4.11.3-1 – Model MH, Plan of Tully Drain Volumetric Floodplain Storage Provision (S2-CS-05)

Table 4.11.3-1 identifies the volumetric storage requirements, Drawing 718736-0500-D-00232 illustrates the application of this in detail.

Table 4.11.3-1 – Model M.H, Tully Drain Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-05	242211	375888	~200	~200	~414	Tully Drain

4.11.4 Residual Post Scheme Flood Risk

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed. This information can be seen in Table 4.11.4.1:

Table 4.11.4-1 – Model M.H Tully Drain Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Minor Adverse	Neutral

There are no residential or commercial properties within the extent of the floodplain and consequentially the importance of the feature is characterised as Low. The model results show that for the worst case point there is a 20mm increase in predicted water levels, as such the magnitude of impact is considered Minor Adverse. The significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for Tully Drain is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-0105 in Appendix A.

4.12 Model M.4 – Omagh (including Fairy Water, Aghnamoyle Drain, Coneywarren Drain, Tully Drain and Strule River) – Impact and Mitigation Assessment

4.12.1 Floodplain Interaction

The 100 year existing floodplain for the Omagh modelled area is an expansive system, with inundation occurring at numerous locations across the Proposed Scheme. The modelled floodplain system incorporates the Fairy Water, Aghnamoyle Drain, Coneywarren Drain, Tully Drain and Strule River.

For the 100 year flood event there are three locations where displacement of floodwater is observed as a consequence of the Proposed Scheme.

The first area is associated with the Tully Drain; at this location modelling indicates that approximately 34,765m^3 of floodwater is displaced. This area is outlined in Figure 4.12.1-1:

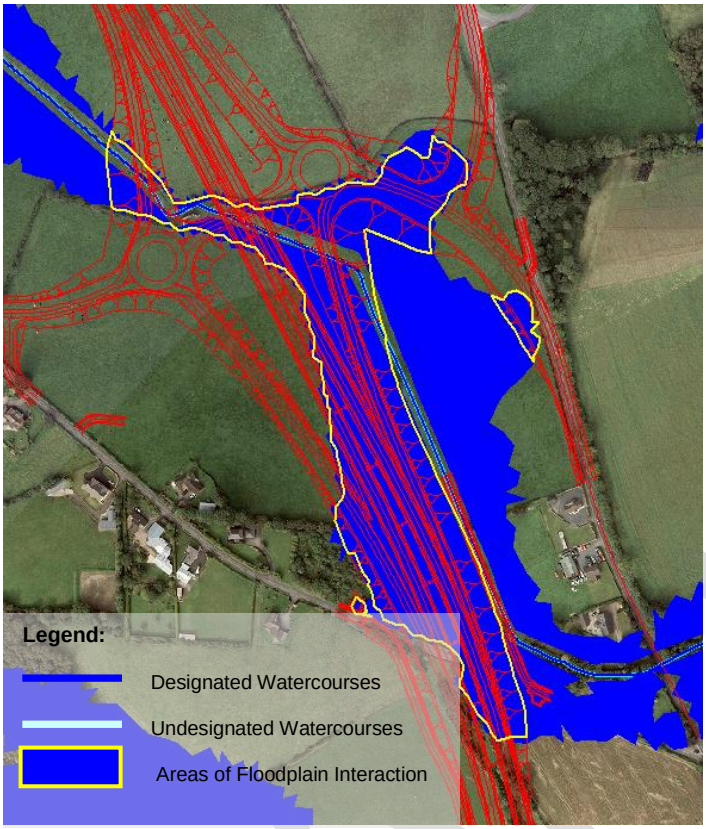

Figure 4.12.1-1 - Tully Drain Floodplain Interaction

It is further identified that, given the arrangement of the floodplain at the Tully Drain tributary and the orientation of the Proposed Scheme, there is the potential for floodplain connectivity to be affected unless mitigation is proposed.

The second location is in relation to the Fairywater, Mourne-Strule Extension and Coneywarren Drain; modelling indicates that approximately 102,615m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.12.1-2.

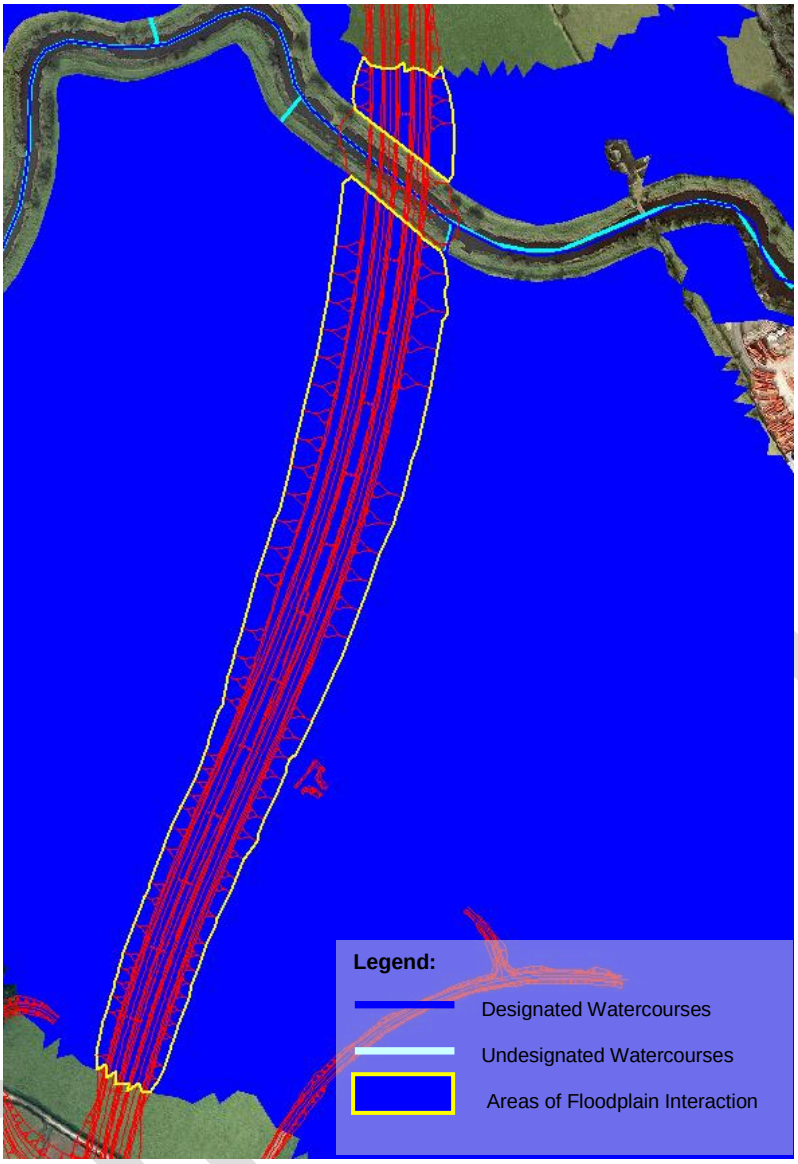

Figure 4.12.1-2 - Fairywater and Coneywarren Floodplain Interaction

Again, as a consequence of the extents of the floodplain and the orientation of the Proposed Scheme there exists the potential that proposals could significantly interact with floodplain flow paths / connectivity unless mitigation is proposed.

The third location is in relation to the Aghnamoyle Drain, Coneywarren Drain and the Mourne-Strule Extension; modelling indicates that approximately 12,345m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.12.1-3.

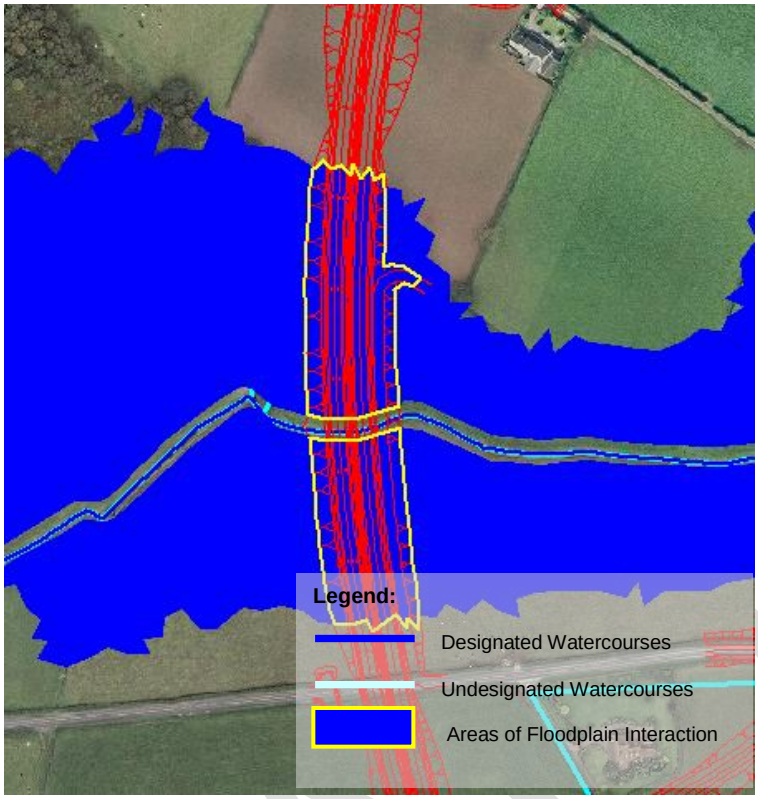

Figure 4.12.1-3 - Aghnamoyle Drain Floodplain Interaction

Similarly to the other two locations, due to the extents of the floodplain the proposed alignment could significantly interact with floodplain flow paths / connectivity unless mitigation is proposed.

4.12.2 Mitigation Assessment – Structures, Culverts and Diversions

In relation to the watercourses within the extents of the Omagh modelled area, there are three areas requiring river engineering; the first of these being at the Tully Drain. River engineering works incorporating three culverts and associated diversionary works are proposed for the Tully Drain tributary to rationalise the watercourse form and facilitate construction, the proposed arrangements are shown in Figure 4.12.2-1.

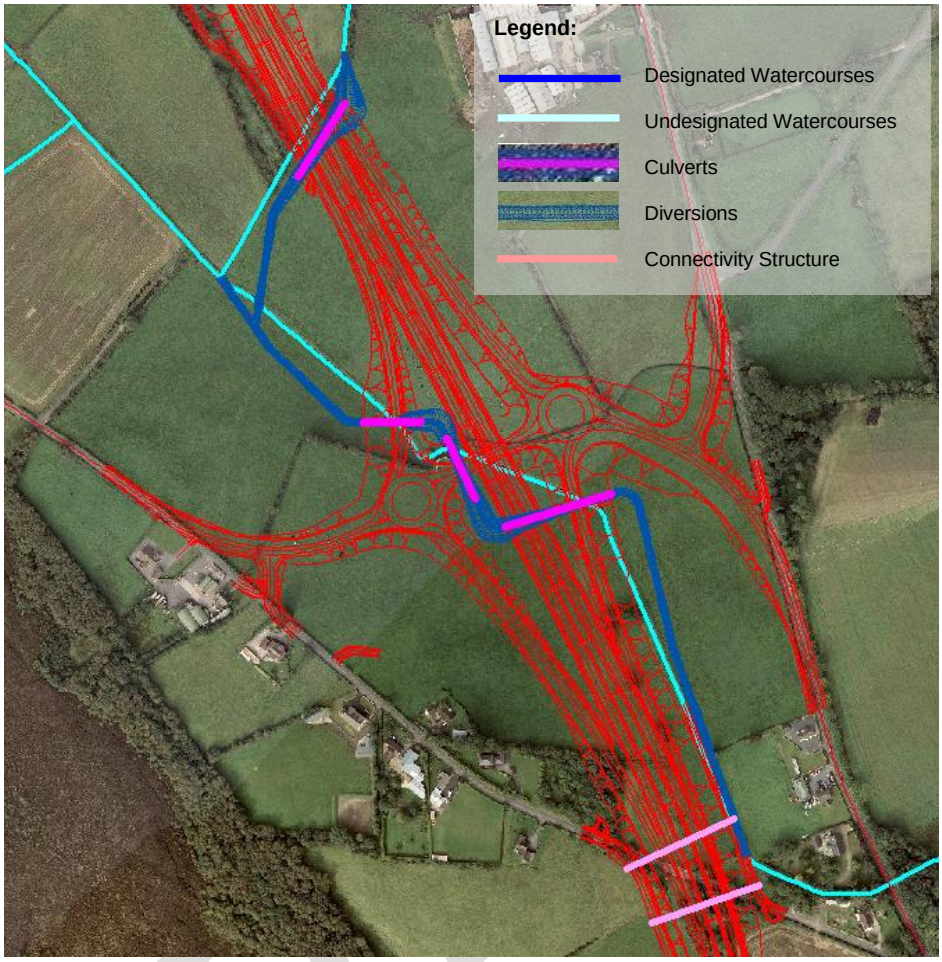

Figure 4.12.2-1 - Plan of Tully Drain Diversion (S2-WD-19, S2-WD-39 and S2-WD-20), Culvert Arrangement (S2-PC-26, S2-PC-27, S2-PC-28, S2-PC-53) and Connectivity Culverts (S2-CC-03 and S2-CC-16)

The second location is at the Fairy Water. To maintain the operation of the Fairy Water River, proposals include a bridge crossing, a diversion and a number of connectivity structures. These arrangements can be seen in Figure 4.12.2-2.

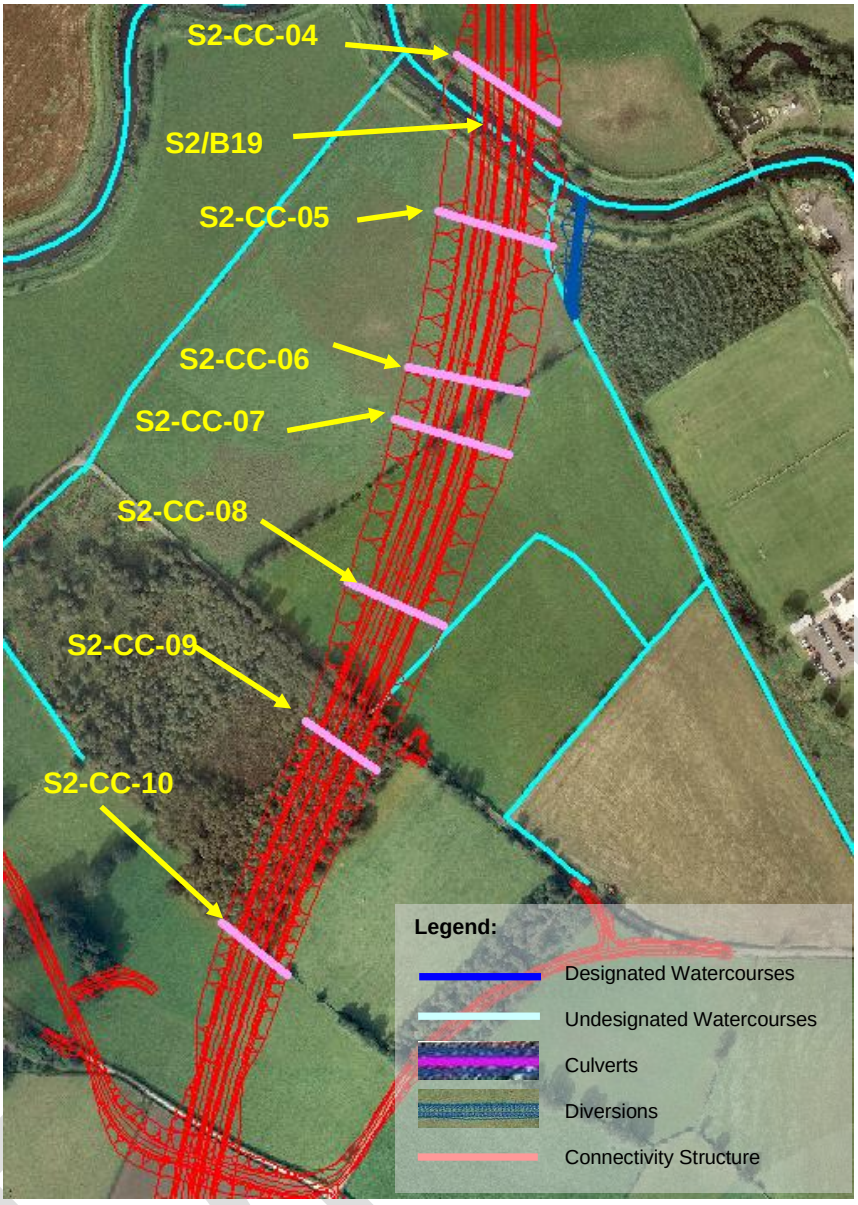

Figure 4.12.2-2 - Plan of Fairy Water Bridge Structure (S2/B19), Diversion (S2-WD-21) and Connectivity Culverts (S2-CC-04 to S2-CC-10)

The other location is at the Aghnamoyle Drain. There are no proposed diversions associated with Aghnamoyle; however, the watercourse will be culverted perpendicularly to the Proposed Scheme. This arrangement can be seen in Figure 4.12.2-3.

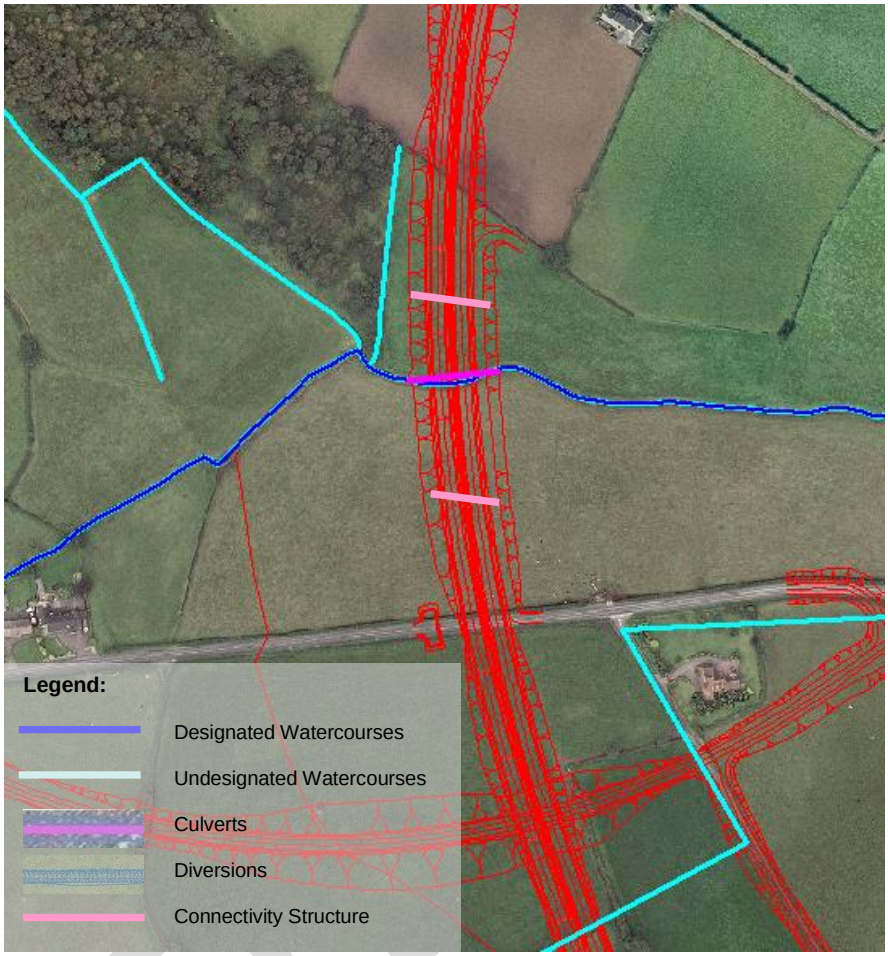

Figure 4.12.2-3 - Plan of Aghnamoyle Drain Culvert Arrangement (S2-PC-29) and Connectivity Culvert Arrangement (S2-CC-11 and S2-CC-12)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.12.2-1 provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.12.2-1 - Model M.4, Omagh Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
242473 375742	S2-PC-27	Box	5.1	3.9
242416, 375977	S2-PC-26	Box	1.5	1.5
242531 375710	S2-PC-53	Box	5.1	3.9
242606 375680	S2-PC-28	Box	5.1	3.9
242557 374013	S2-PC-29	Box	5.1	4.5

The proposed diversions have also been hydraulically modelled. Table 4.12.2-2 below provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.12.2-2 - Model M.4, Omagh Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
242446 375750	S2-WD-39	Channel Length	373m	453m
		Channel Gradient	1:333	1:639
242742 375544	S2-WD-20	Channel Length	305m	301m
		Channel Gradient	1:166	1:639
242818 374897	S2-WD-21	Channel Length	77m	83m
		Channel Gradient	1:252	1:242
242818 374897	S2-WD-19	Channel Length	239	241
		Channel Gradient	1.37	1:93

The culvert and diversion arrangements can be seen in Drawings 718736-S2-0500-0106 to 718736-S2-0500-0110.

There is a proposed bridge structure associated with the Fairywater and the crossing location is identified in Figure 4.12.2-2. Extensive modelling was undertaken to evaluate the effectiveness of various bridge structure mitigation options. Following this analysis, the proposed bridge structure arrangement can be seen in Table 4.12.2-3 below.

Table 4.12.2-3 - Model M.4, Omagh Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
242773 374961	Fairy Water	S2/B19	46	64.141

The general arrangement of the bridge structure can be seen in Drawing 718736-1700-D-0511. An overview of the bridge arrangement in association with the other mitigation elements can be seen in Drawings 718736-S2-0500-0106 to 718736-S2-0500-0110.

It is proposed that floodplain conveyance structures are provided for this area to mitigate the reduction in floodplain connectivity due to the location of the Proposed Scheme. Details of these structures are shown in Table 4.12.2-4 below:

Table 4.12.2-4 - Model M.4, Omagh Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
242725 375359	S2-CC-03	Box	5.0	2.1
242779 374991	S2-CC-04	Box	5.0	3.6
242773 374897	S2-CC-05	Box	5.0	4.2
242756 374796	S2-CC-06	Box	5.0	3.9
242746 374756	S2-CC-07	Box	5.0	3.6
242708 374644	S2-CC-08	Box	5.0	3.0
242668 374551	S2-CC-09	Box	5.0	2.7
242612 374414	S2-CC-10	Box	5.0	2.7
242555 374060	S2-CC-11	Box	5.0	2.1
242564 373944	S2-CC-12	Box	5.0	1.5
242696, 375405	S2-CC-16	Box	5.0	2.1

4.12.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.12.1, floodwater will be displaced due to the Proposed Scheme; approximately 34,765m^3 of floodwater is displaced around Tully Drain, approximately 102,615m^3 of floodwater is displaced around the Fairywater and approximately 13,245m^3 of floodwater is displaced around the Aghnamoyle Drain. The compensatory storage locations (references S2-CS-06, S2-CS-07, S2-CS-08, S2-CS-09, S2-CS-10, S2-CS-11, S2-CS-14 and S2-CS-15) for this model can be seen in Drawings 718736-S2-0500-0106 to 718736-S2-0500-0110 and Figures 4.12.3-1 to 4.12.3-3.

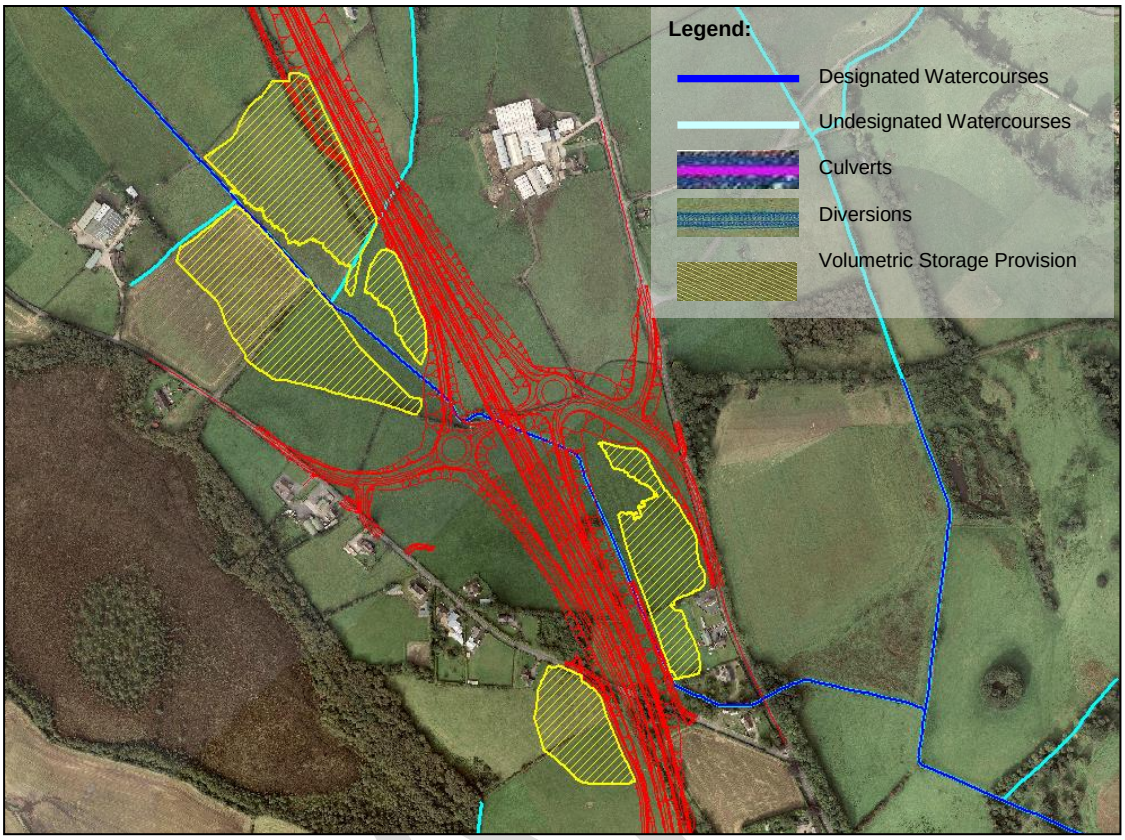

Figure 4.12.3-1 – Model M.4, Plan of Omagh Volumetric Floodplain Storage Provision – Tully Drain (S2-CS-06, S2-CS-07,S2-CS-08, S2-CS-14 and S2-CS-15)

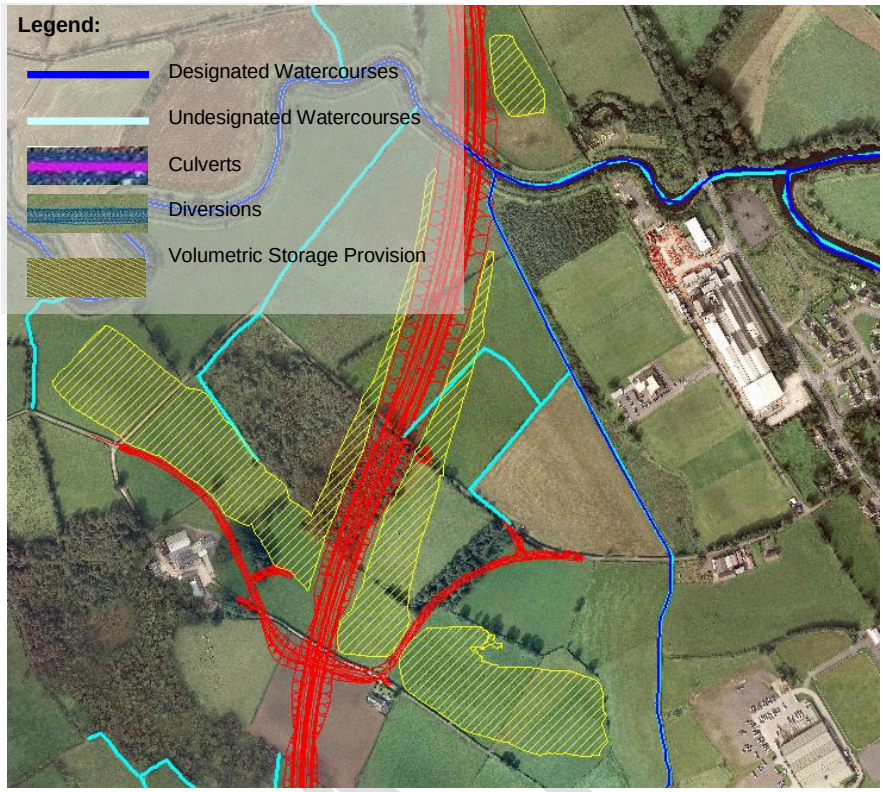

Figure 4.12.3-2 – Model M.4, Plan of Omagh Volumetric Floodplain Storage Provision (S2-CS-09 and S2-CS-10)

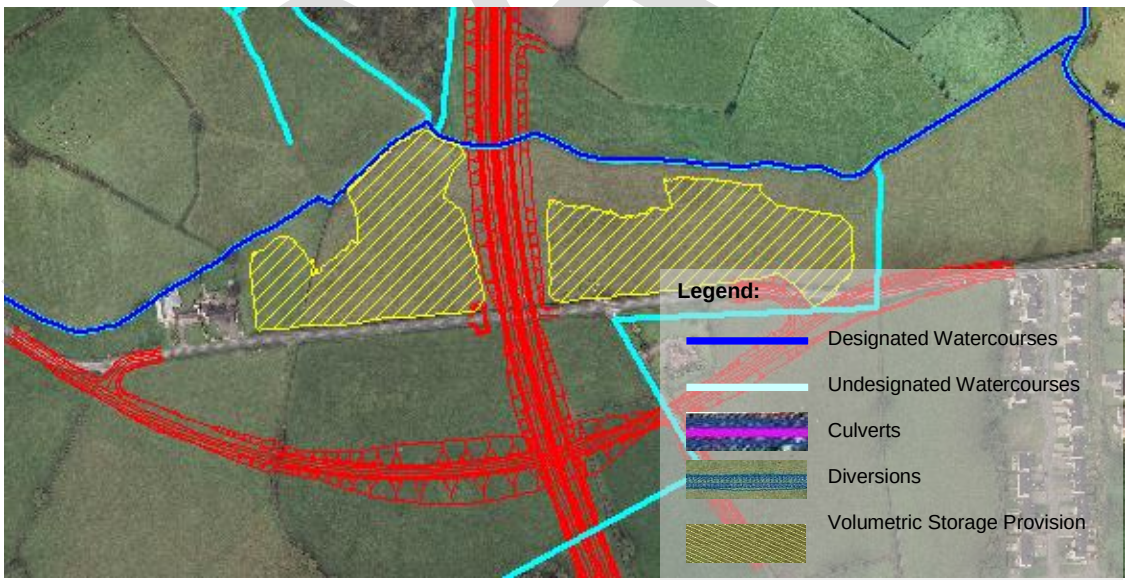

Figure 4.12.3-3 – Model M.4, Plan of Omagh Volumetric Floodplain Storage Provision (S2-CS-11 and S2-CS-12)

Table 4.12.3-1 identifies the volumetric storage requirements, Drawings 718736-0500-D-00233 to 718736-0500-D-00242 and Drawings 718736-0500-D-00421 and 718736-0500-D-00422 illustrate the application of this in detail.

Table 4.12.3-1 – Model M.4, Omagh Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^6)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-06	242206	375903	~34,765	~34,765	~127,995	Tully Drain
S2-CS-14	242288	376032				
S2-CS-07	242415	375869			~5,710	Tully Drain
S2-CS-08	242753	375569			~21,780	Tully Drain
S2-CS-15	242634	375318				
S2-CS-09	242849	375038	~7,135	~7,135	~11,390	Fairywater
S2-CS-10	242484	374533	~95,480	~95,480	~125,305	UD_46
S2-CS-11	242485	373941	~12,345	~12,345	~10,720	Aghnamoyle Drain
S2-CS-12	242743	373928			~20,845	Aghnamoyle Drain

4.12.4 Residual Post Scheme Flood Risk

A comparison of the water elevations pre and post scheme is shown in Table 4.12.4-1 for specific points along the watercourse. These points can be seen in Figure 4.12.4-1:

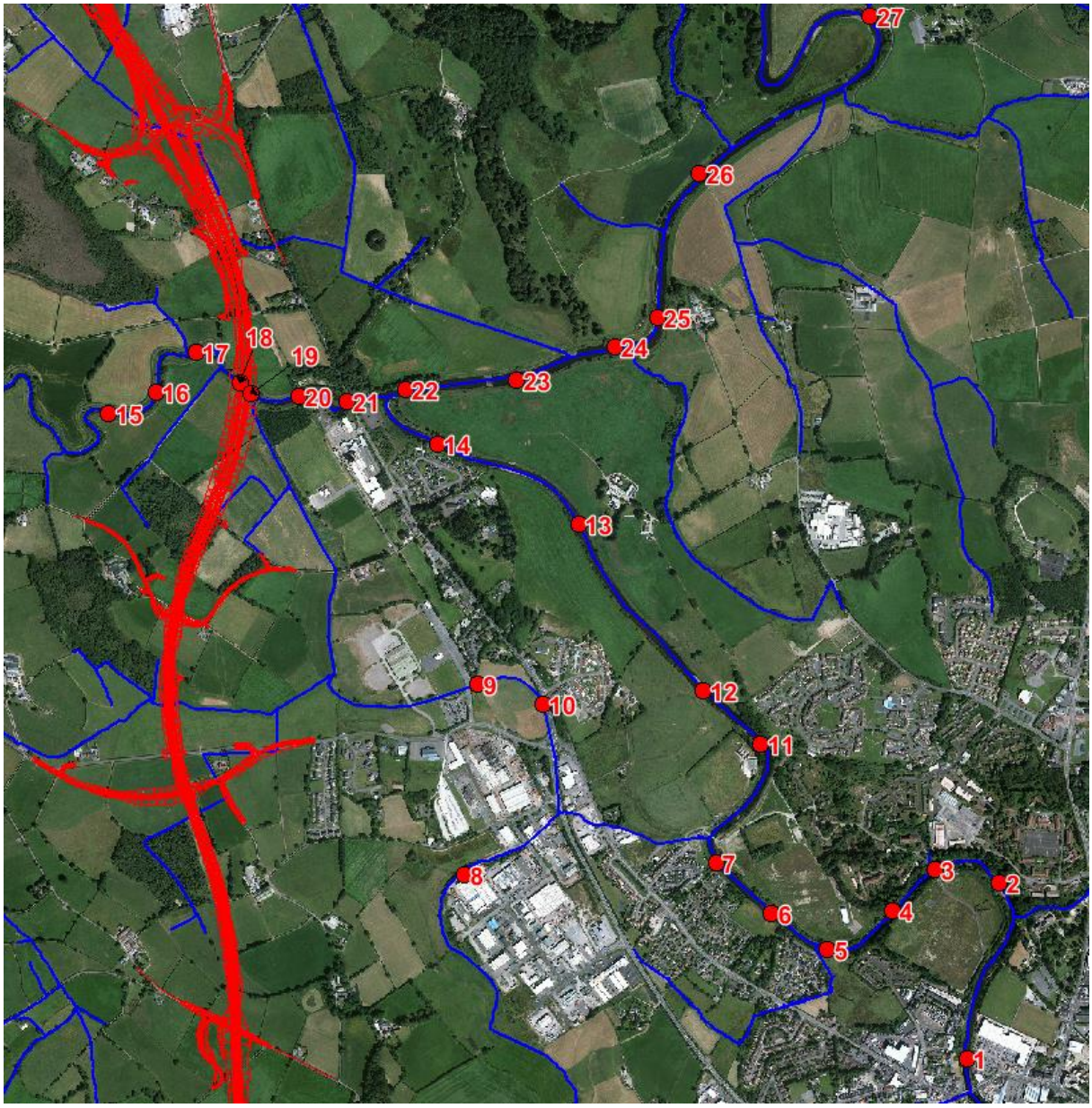

Figure 4.12.4-1 – Model M.4, Points along Channels for Water Elevation Comparison

Table 4.12.4-1- Predicted Impact for Model M.4 Omagh for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	65.579	65.579	0
2	65.254	65.256	0.002
3	65.092	65.095	0.003
4	64.939	64.94	0.001
5	64.503	64.49	-0.013
6	64.426	64.42	-0.006
7	64.347	64.339	-0.008
8	63.893	63.897	0.004
9	63.619	63.539	-0.08
10	63.631	63.552	-0.079
11	63.817	63.766	-0.051
12	63.488	63.544	0.056
13	63.175	63.166	-0.009
1415	63.112	63.111	-0.001
15	63.603	63.622	0.019
16	63.605	63.619	0.014
17	63.6	63.614	0.014
18	63.582	63.541	-0.041
19	63.579	63.533	-0.046
20	63.535	63.525	-0.01
21	63.385	63.382	-0.003
22	63.11	63.124	0.014
23	63.09	63.089	-0.001
24	63.005	63.002	-0.003
25	62.899	62.892	-0.007
26	62.84	62.831	-0.009
27	62.651	62.637	-0.014

It can be seen in Table 4.12.4-1 that the impacts vary at each point ID along the main river channels. In consideration of the nature and complexity of the associated floodplain areas and the overall variability in water depths across these floodplains, it was considered that the residual, post mitigation flood impacts should be presented for these extensive floodplain areas (taken from

2D model output). The 100 year 'design' event impacts are presented here. These areas can be seen in Figure 4.12.4-2. Generally, impacts vary upon floodplain location however to simplify the presentation of this information, impact values are shown in key locations which are indicative of the impacts across these floodplain areas.

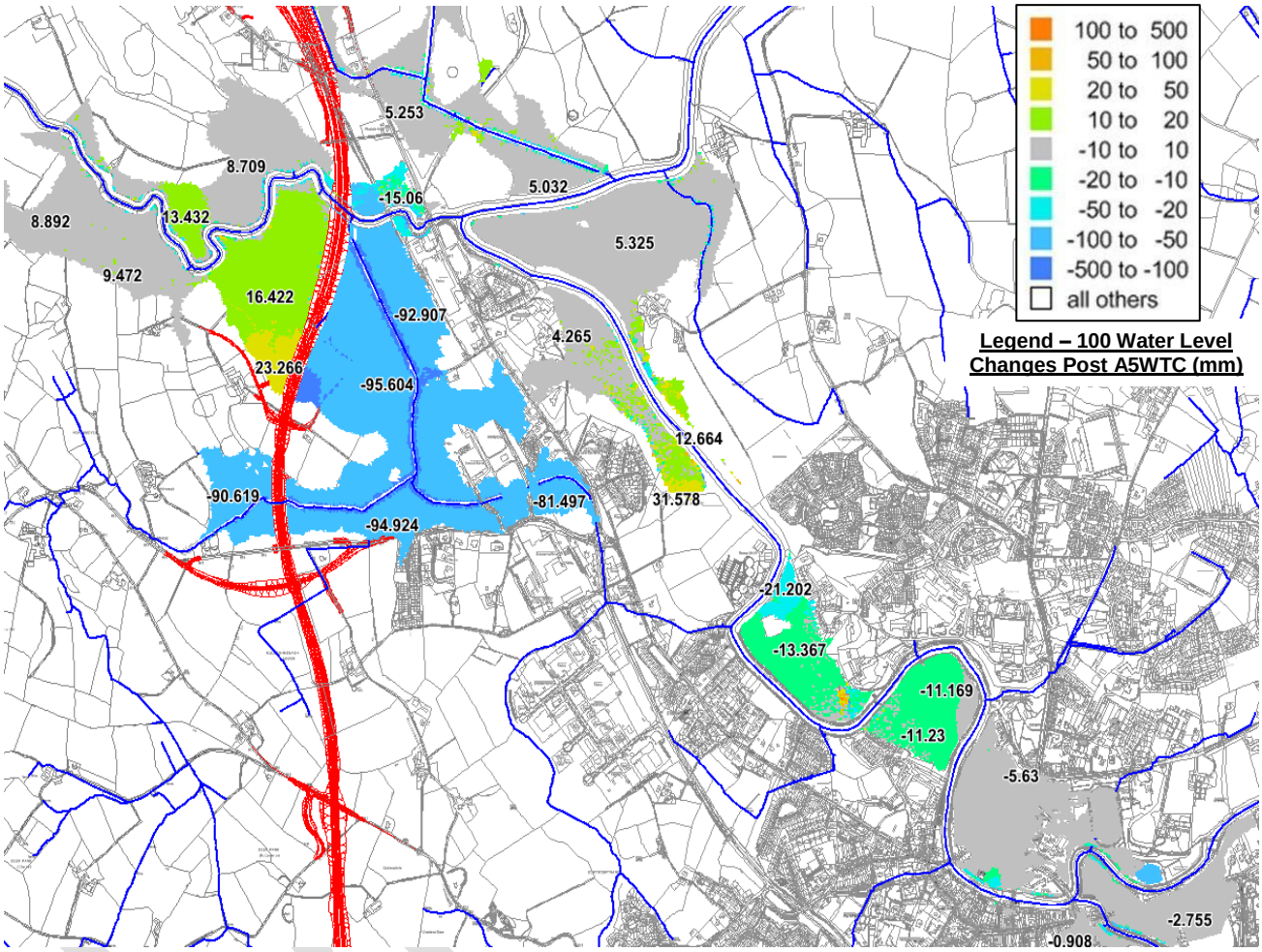

Figure 4.12.4-2 – Model M.4, Flood Impact Assessment Areas

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed for each of the floodplain sections identified in Figure 4.12.4-2. The qualifying conditions for the overall assessment score for flood risk has also been included. This information can be seen in Table 4.12.4-4.

Table 4.12.4-4 – Model M.4 Omagh Flood Risk Assessment

Flood Water Level Impact (mm)	No. of Properties within Floodplain	Importance	Magnitude	Significance	Overall Assessment Score for Flood Risk
+31	0	Low	Minor Adverse	Neutral	Slight Adverse
+20 - 30	0	Low	Minor Adverse	Neutral	Slight Adverse
+5	0	Low	Negligible	Neutral	Negligible
+4	1 (residential)	High	Negligible	Neutral	Negligible
-1 to -6	>100 Flood defence feature Omagh	Very High	Negligible	Neutral	Negligible
-11	0	Low	Minor Beneficial	Neutral	Negligible
-13	0	Low	Minor Beneficial	Neutral	Slight Beneficial
-91	1 (other)	Medium	Moderate Beneficial	Moderate	Slight Beneficial
-92	7 (5 residential, 1 commercial, 1 other)	High	Moderate Beneficial	Moderate / Large	Moderate Beneficial
-93	2 (1 residential, 1 other)	High	Moderate Beneficial	Moderate / Large	Moderate Beneficial
-95	4 (3 residential, 1 other)	High	Moderate Beneficial	Moderate / Large	Moderate Beneficial
-96	4 (residential)	High	Moderate Beneficial	Moderate / Large	Moderate Beneficial

Within the extents of the Omagh floodplain area there are numerous residential and commercial properties as well as extensive areas of agricultural land, consequentially the overall importance of the feature is characterised as High / Very High, although areas of agricultural land have been classed as Low. The model results show that, in relation to overall assessment scores generally there is a Slight / Moderately Beneficial or Negligible Score for the Omagh floodplain area arising from the A5WTC proposals.

It is identified that the worst case points are generally in the vicinity of Strathroy and west of the proposed A5WTC in the area of Mellon Park Drive where there is an approximate 20 - 30mm increase in predicted 100 year water levels; as such the magnitude of impact at these locations is Minor Adverse, with the overall assessment score being Slight Adverse.

On review of the overall qualifying conditions for assessment score of flood risk based on the worst case, the score for the Omagh area would be considered Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties',* however, benefits in relation to water levels are also realised across large areas of the flood plain.

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S2-0500-0106 to 718736-S2-0500-0110 in Appendix A.

4.13 Model M.I – MW1545 Fireagh Lough Drain – Impact and Mitigation Assessment

4.13.1 Floodplain Interaction

For the 100 year flood event, as illustrated in Figure 4.13.1-1, modelling indicates that there will be no floodwater displacement as a consequence of the Proposed Scheme, however, culverting is required to facilitate the conveyance of flow.

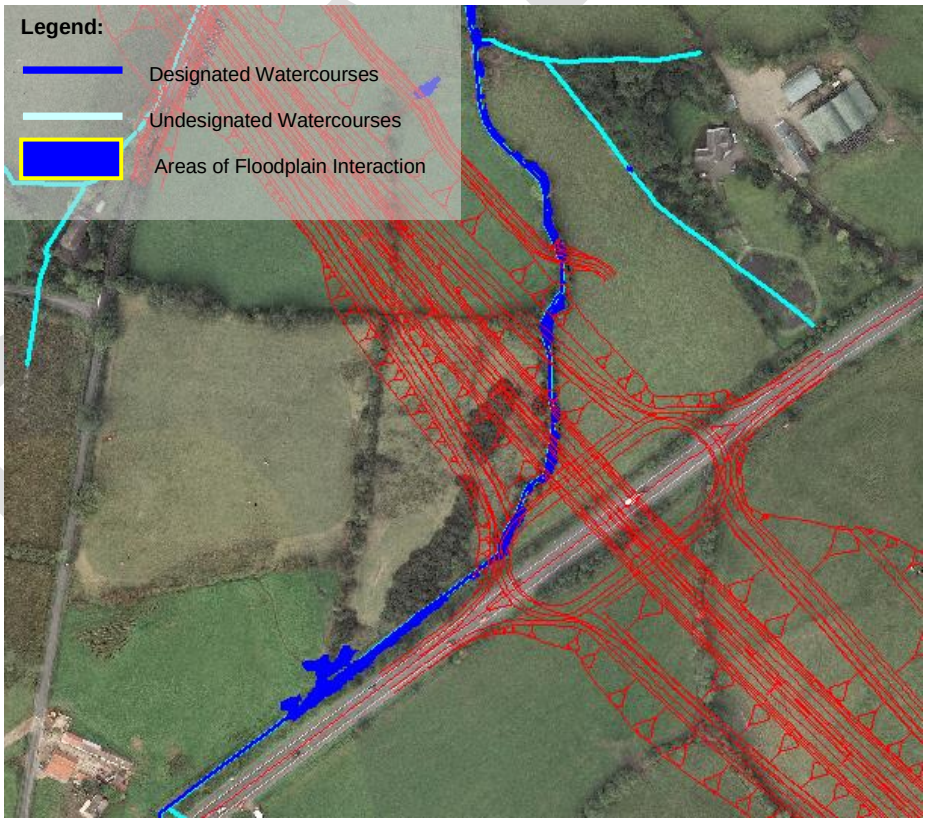

Figure 4.13.1-1 - Fireagh Lough Drain Floodplain Interaction

4.13.2 Mitigation Assessment – Structures, Culverts and Diversions

There is a proposed diversion associated with Fireagh Lough Drain which aims to minimise the length of culvert required as the watercourse will be culverted

perpendicularly to the Proposed Scheme. The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.13.2-1 below provides a summary of the modelled culvert sizes for Fireagh Lough Drain.

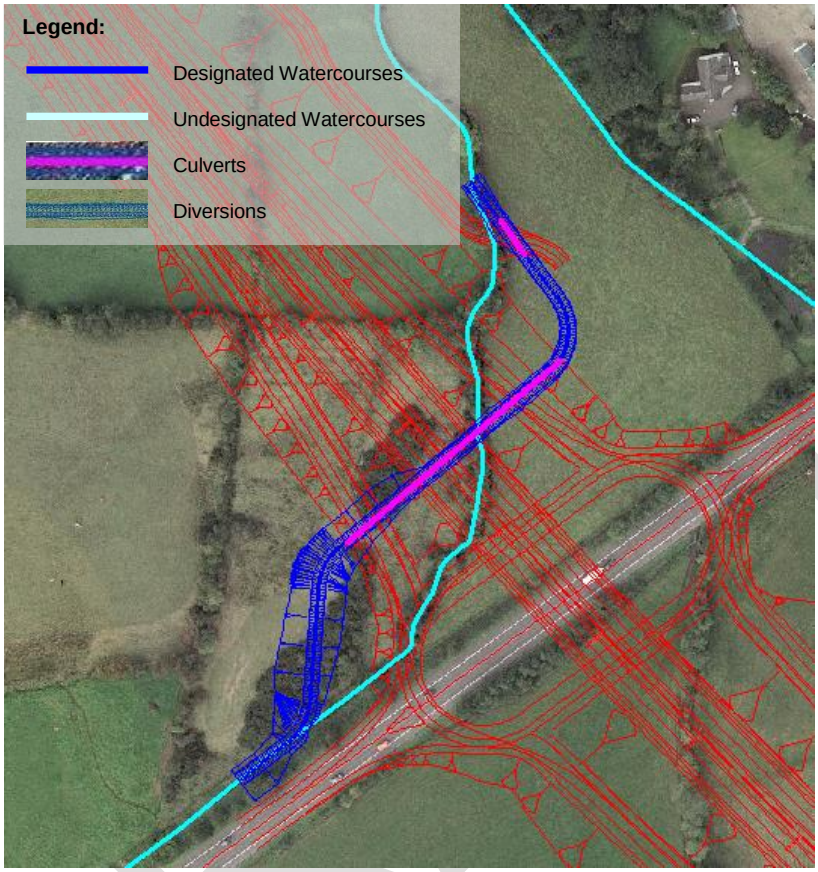

Figure 4.13.2-1 - Plan of Fireagh Lough Drain Diversion (S2-WD-57) and Culvert Arrangement (S2-PC 57 and S2-PC-36)

Table 4.13.2-1 - Model M.I, Fireagh Lough Drain Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
243531 371384	S2-PC-57	Box	3.0	2.1
243507 371306	S2-PC-36	Box	3.0	2.1

The proposed diversion has also been hydraulically modelled. Table 4.13.2-2 below provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.13.2-2 - Model M.I, Fireagh Lough Drain Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
243464 371263	S2-WD-27	Channel Length	250m	271m
		Channel Gradient	1:100	1:181

The culvert and diversion arrangements can be seen in Drawing 718736-S2-0500-0113.

A comparison of the water elevations pre and post scheme is shown in Table 4.13.2-3 for specific points along the watercourse. These points can be seen in Figure 4.13.2-2:

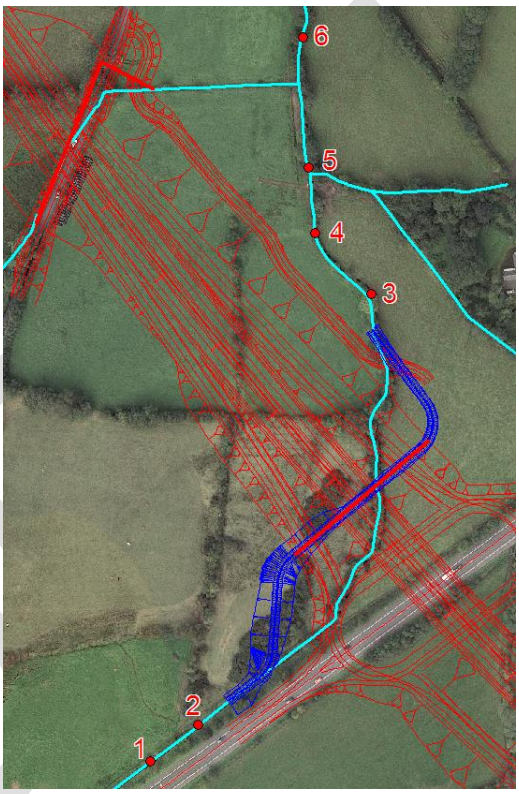

Figure 4.13.2-2 – Model M.I, Points along Channel for Water Elevation Comparison

Table 4.13.2-3 - Predicted Impact for Model M.I Fireagh Lough Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	78.50	78.53	+0.03
2	78.29	78.19	-0.10
3	74.86	74.86	0
4	74.39	74.39	0
5	74.08	74.08	0
6	73.73	73.73	0

It is observed that for the 100 year event for the Fireagh Lough Drain, the river engineering proposals generally result in no change to predicted water levels. There is a predicted 30mm increase in 100 year water levels adjacent to the Clanabogan Road, however, the Clanabogan Road is elevated at approximately 79.7m AOD such that a reasonable level of freeboard persists. The minor impacts associated with the 100 year design event are considered to be localised.

4.13.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.13.1, there is no loss of floodplain storage as a consequence of the Proposed Scheme.

4.13.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.13.4-1:

Table 4.13.4-1 – Model M.I Fireagh Lough Drain Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Minor Adverse	Neutral

There are no residential or commercial properties within the extent of the floodplain and the importance of the feature is characterised as Low. The model results show that for the worst case point there is a 30mm increase in predicted flood 100 year water levels, as such the magnitude of impact on the floodplain is Minor Adverse. The significance of impact is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Fireagh Lough Drain is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S2-0500-0113 in Appendix A.

4.14 Model M.6 – 121 Drumragh River (Extension) – Impact and Mitigation Assessment

4.14.1 Floodplain Interaction

The 100 year existing floodplain for Drumragh River is linear in its shape, extending from the river banks in the vicinity of the Proposed Scheme. Due to the extents of the floodplain, the proposed scheme would interact with floodplain flow path / connectivity unless mitigation is proposed.

For the 100 year flood event, modelling indicates that approximately 2,765m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.14.1-1.

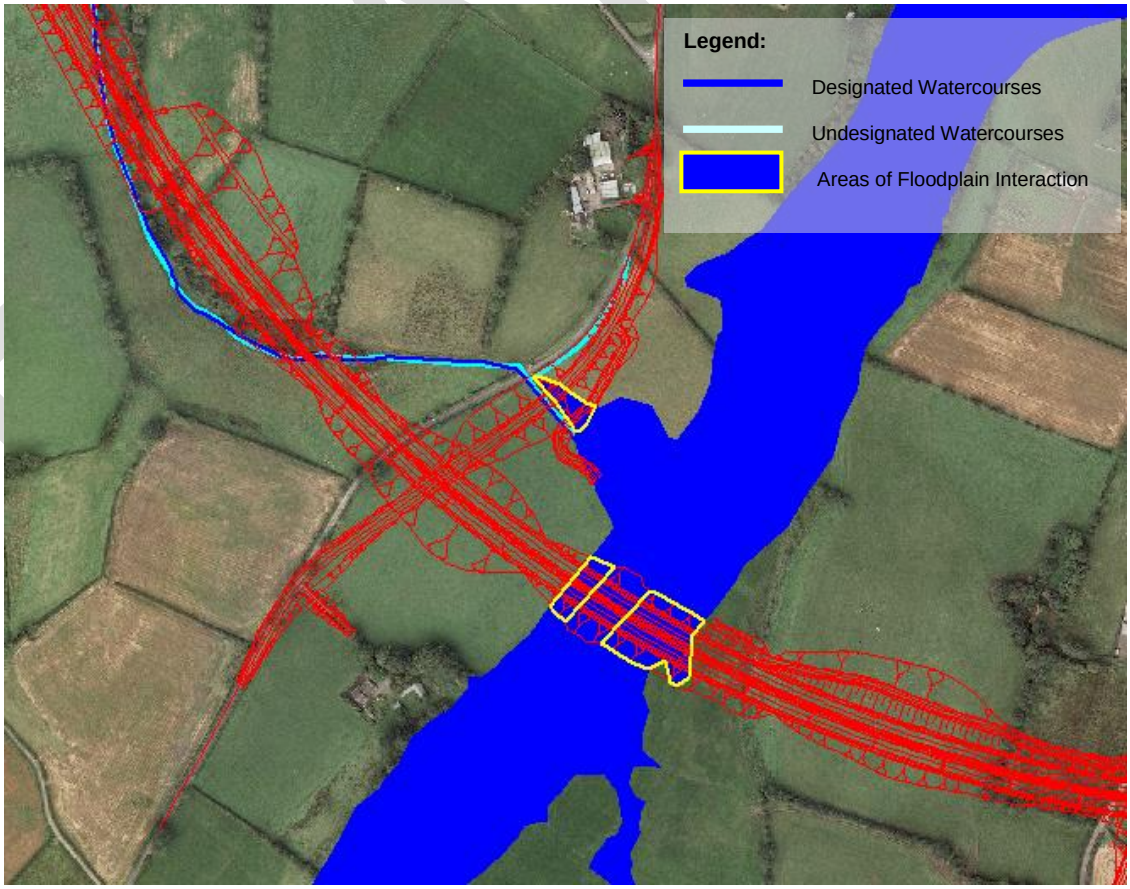

Figure 4.14.1-1 - Drumragh Floodplain Interaction

4.14.2 Mitigation Assessment – Structures, Culverts and Diversions

Modelling was undertaken to evaluate the effectiveness of various bridge structure mitigation options. Following this analysis, the proposed bridge structure arrangement can be seen in Table 4.14.2-1.

Table 4.14.2-1 - Model M.6, Drumragh River Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
245296 369433	Drumragh River	S2/B28	34	74.27

There is a proposed bridge structure associated with the Drumragh River and the crossing location can be seen in the following image.

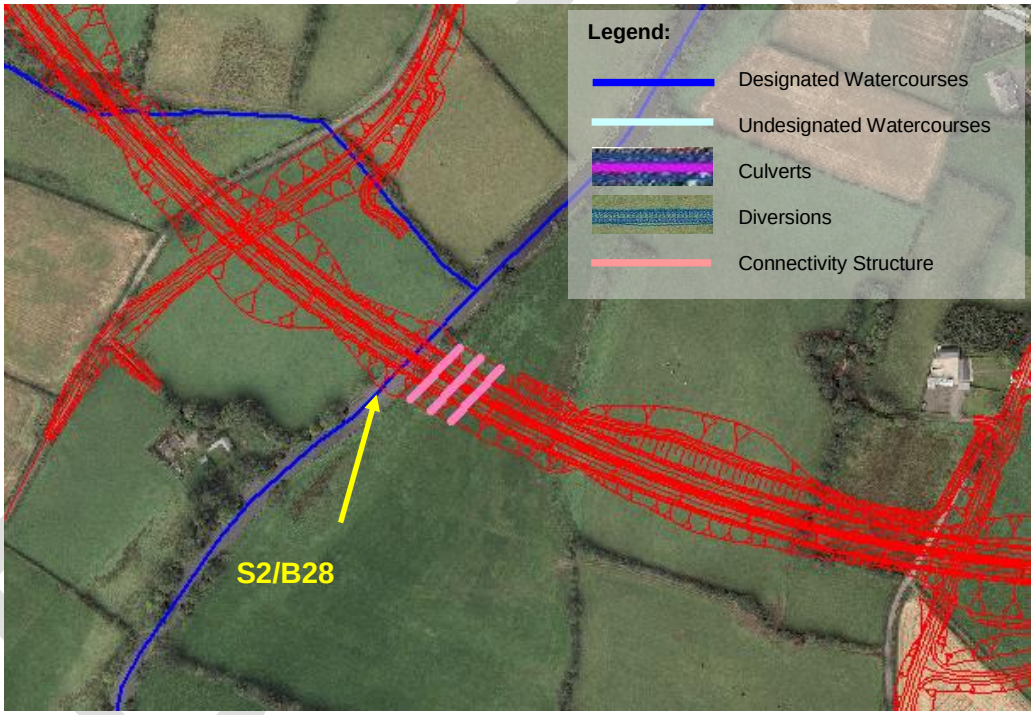

Figure 4.14.2-1 - Plan of Drumragh River Bridge Crossing Location (S2/B28) and Connectivity Culvert Arrangement (S2-CC-13 to S2-CC-15)

The general arrangement of the bridge structure can be seen in Drawing 718736-1700-D-0512. An overview of the bridge arrangement in association with the other mitigation elements can be seen in Drawing 718736-S2-0500-D-0111.

It is also proposed that floodplain conveyance structures are provided for this location to mitigate the reduction in floodplain connectivity due to the location of the Proposed Scheme. Details of these structures are shown in Table 4.14.2-2 below:

Table 4.14.2-2 - Model M.6, Drumragh River Modelled Connectivity Structures

Location	Connectivity Structures Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
245316 369424	S2-CC-13	Box	6.0	1.8
245329 369415	S2-CC-14	Box	6.0	1.8
245344 369408	S2-CC-15	Box	6.0	1.8

A comparison of the water elevations pre and post scheme is shown in Table 4.14.2-3 for specific points along the watercourse. These points can be seen in Figure 4.14.2-2:

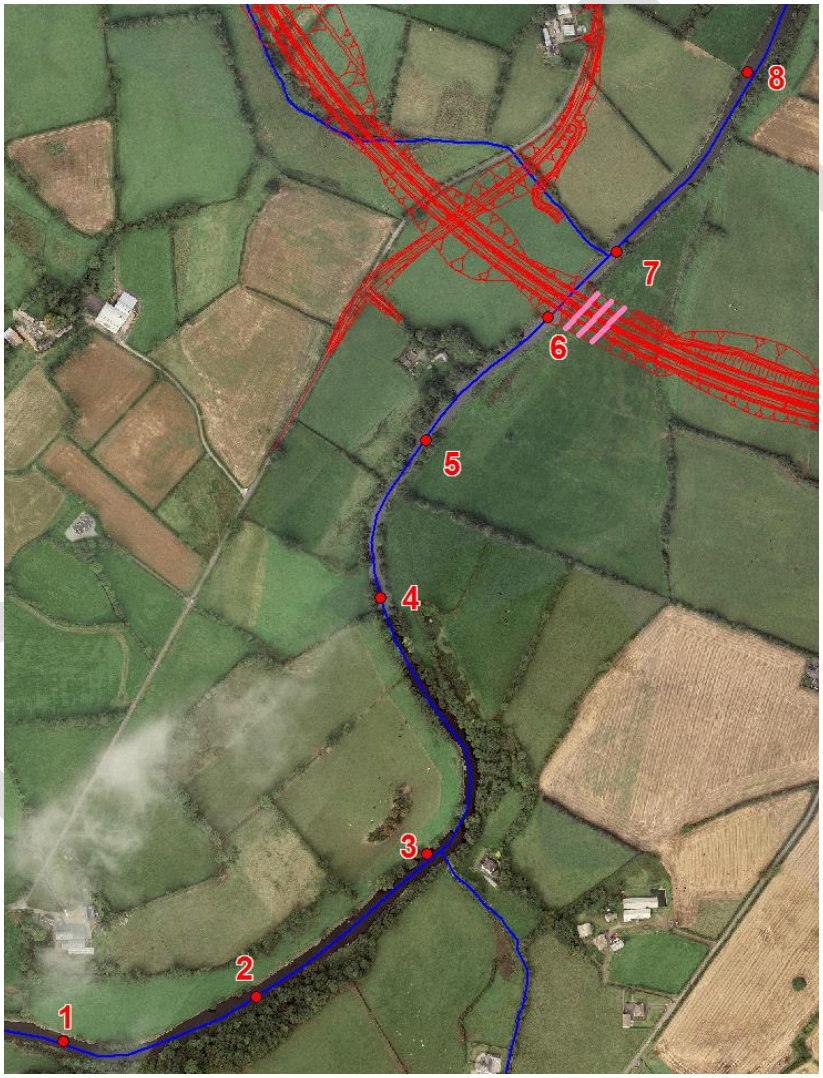

Figure 4.14.2-2 – Model M.6, Points along Channel for Water Elevation Comparison

Table 4.14.2-3 - Predicted Impact for Model M.6 Drumragh River for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	74.977	74.982	+0.005
2	74.462	74.474	+0.012
3	74.416	74.431	+0.015
4	74.071	74.101	+0.03
5	73.756	73.812	+0.056
6	73.601	73.672	+0.071
7	73.569	73.568	-0.001
8	73.113	73.113	0

It is identified that the combined effect of the proposed culverts and diversions result in an increase in water levels at most locations throughout the length of the model.

4.14.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As mentioned in Section 4.14.1, approximately 2,765m^3 of floodwater is displaced due to the Proposed Scheme. Therefore, an area of land is proposed for compensatory storage. The compensatory storage location (reference S2-CS-13) for this location can be seen in Drawing 718736-S2-0500-D-0111 with more detailed information in Drawing 718736-0500-D-00243.

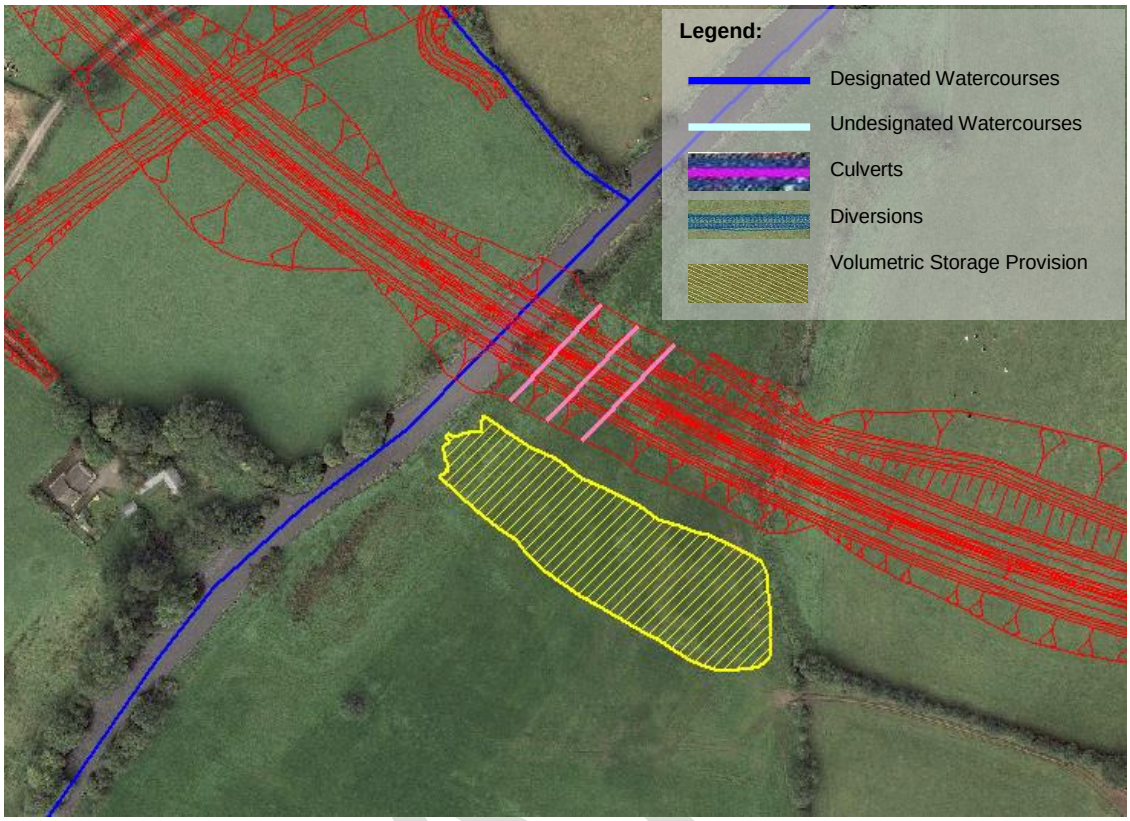

Figure 4.14.3-1 – Model M.6 Plan of Drumragh River Volumetric Floodplain Storage Provision (S2-CS-13)

Table 4.14.3-1 below details the storage compensation proposals for the Drumragh for the Proposed Scheme

Table 4.14.3-1 – Model M.6, Drumragh Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S2-CS-13	245330	369347	~2,765	~2,765	~7,015	Drumragh (Extension)

4.14.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.14.4-1.

Table 4.14.4-1 – Model M.6 Drumragh River Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Moderate Adverse	Slight

There are no residential or commercial properties within the extents of the floodplain, it is also observed that properties adjacent to the modelled watercourse are elevated (between ~81m and ~83m AOD) such that a reasonable level of freeboard persists for the 100 year predicted water levels. Consequentially, importance of the feature is characterised as Low. The model results indicate that along the Drumragh River, for the worst case location, there is an increase of 71mm in predicted 100 year water levels; the magnitude of this is considered to be Moderate Adverse. The significance of the potential effects is considered to be Slight.

On reviewing the qualifying conditions for assessment score of flood risk, the score for the Drumragh River is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties.'*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S2-0500-D-0111 in Appendix A.

4.15 Model M.L - Ranelly Drain – Impact and Mitigation Assessment

4.15.1 Floodplain Interaction

The predicted 100 year existing floodplain for the Ranelly Drain extends from the watercourse to low lying grounds in the vicinity of the drain.

It is identified that within the extents of the Ranelly Drain hydraulic model, the Proposed Scheme crosses the designated watercourse at four separate locations, refer to Figures 4.15.1-1 and 4.15.1-2. However, given the nature of the floodplain the proposals do not significantly interfere with the floodplain flow-paths/connectivity.

Furthermore, based on the existing 100 year predicted water levels, the proposals result in the displacement of approximately 2,390m^3 of floodwater. These areas are outlined in Figures 4.15.1-1 and 4.15.1-2.

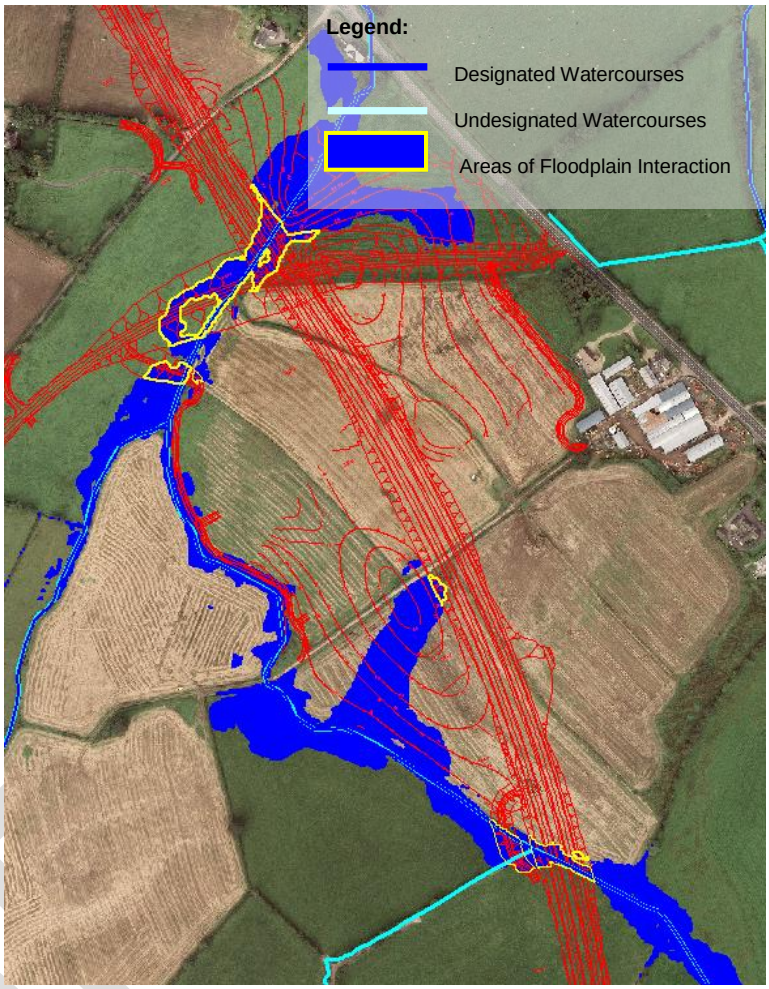

Figure 4.15.1-1 - Ranelly Drain Floodplain Interaction

Figure 4.15.1-2 - Ranelly Drain Floodplain Interaction

4.15.2 Mitigation Assessment – Structures, Culverts and Diversions

Detailed design proposals include culverting and river diversion works for all four river crossing within the extents of the model. The proposed arrangements aim to minimise the length of culvert required through perpendicular crossings. This arrangement can be seen in Figures 4.15.2-1 and 4.15.2-2.

There are no bridge structures proposed within the extents of the Ranelly Drain model.

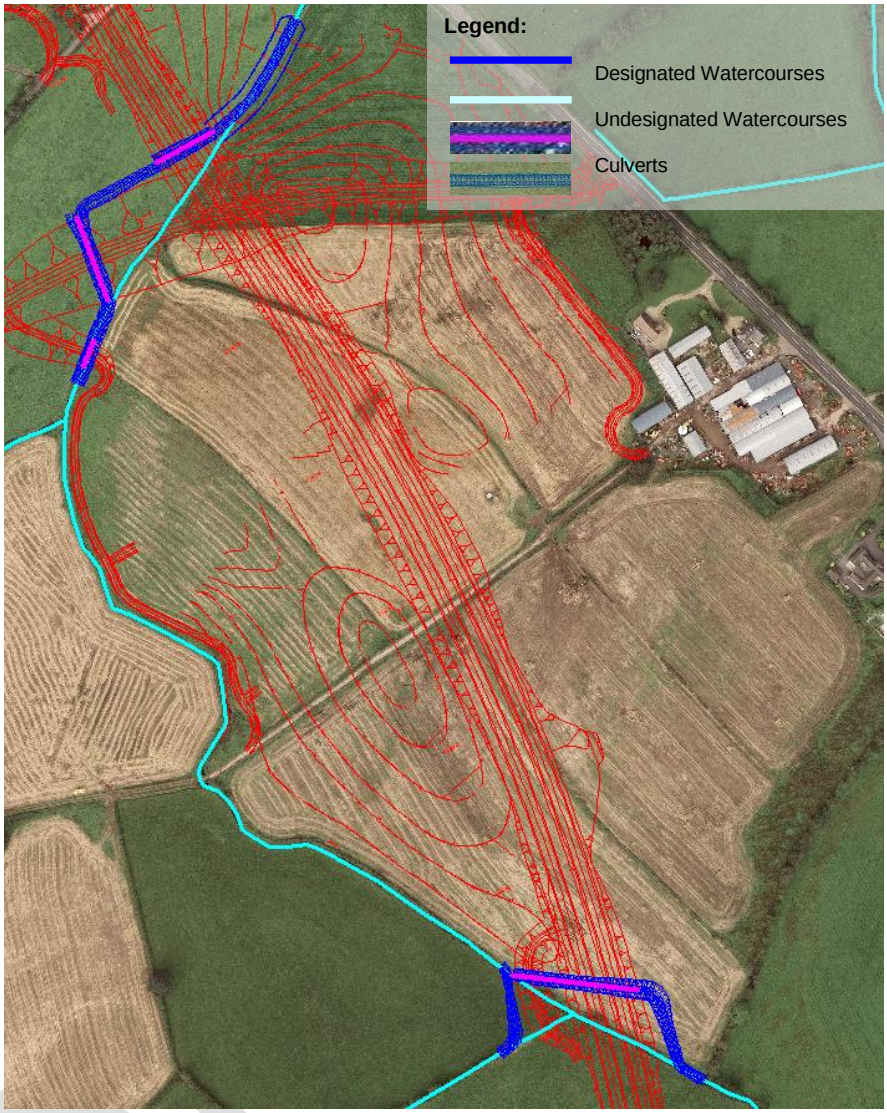

Figure 4.15.2-1 - Plan of Ranelly Drain Diversion (S3-WD-04, S3-WD-05 and S3-WD-46) and Culvert Arrangement (S3-PC-06, S3-PC-74, S3-PC-82 and S3-PC-53)

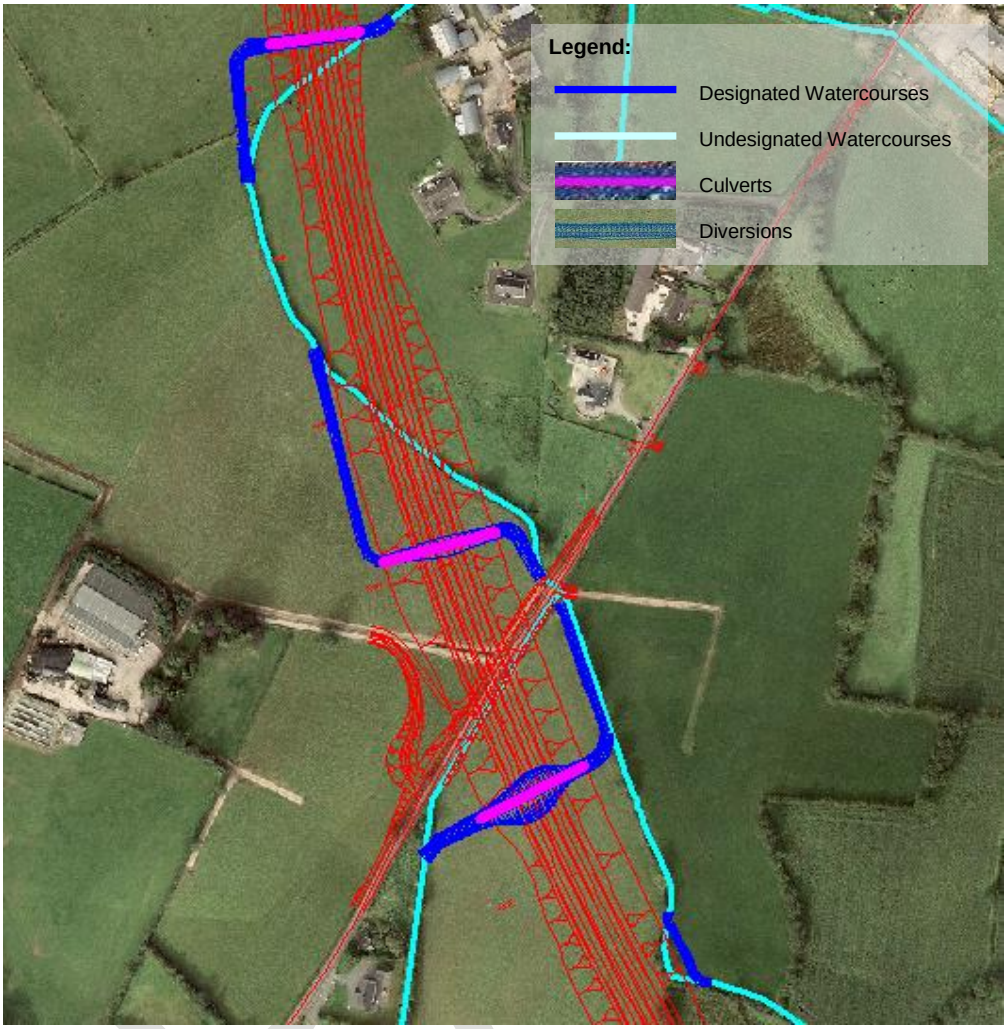

Figure 4.15.2-2 - Plan of Ranelly Drain Diversion (S3-WD-06, S3-WD-07, S3-WD-08, S3-WD-09) and Culvert Arrangement (S3-PC-07, S3-PC-08 and S3-PC-10)

The proposed culverts have been modelled hydraulically for the 100 year event with a minimum 600mm freeboard allowance. Table 4.15.2-1 provides a summary of the modelled culvert sizes.

Table 4.15.2-1 - Model M.L, Ranelly Drain Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
248321 367706	S3-PC-74	Box	3.3	2.7
248262 367636	S3-PC-53	Box	3.3	2.7
248762 367573	S3-PC-82	Box	4.2	2.7
248605 367138	S3-PC-06	Box	3.0	2.7
248677 366571	S3-PC-07	Box	2.7	2.4
278755 366278	S3-PC-08	Box	5.1	2.1
248809 366128	S3-PC-10	Box	2.7	2.1

The proposed diversions have also been hydraulically modelled. Table 4.15.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.15.2-2 - Model M.L, Ranelly Drain Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
248267 367593	S3-WD-46	Channel Length	184m	310m
		Channel Gradient	1:74	1:396, 1:390
248625 367161	S3-WD-05	Channel Length	145m	158m
		Channel Gradient	1:419	1:417
248541 367146	S3-WD-04	Channel Length	54m	61m
		Channel Gradient	1:74	1:64
248687 366351	S3-WD-07	Channel Length	154m	125m
		Channel Gradient	1:1476	1:1111
248800 366281	S3-WD-08	Channel Length	45m	125m
		Channel Gradient	1:1476	1:1092
248759 366104	S3-WD-09	Channel Length	182m	220m
		Channel Gradient	1:194	1:636
248900 366032	S3-WD-10	Channel Length	182m	52m
		Channel Gradient	1:194	1:100

The culvert, diversion and other river engineering arrangements can be seen in Drawings 718736-S3-0500-0112, 718736-S3-0500-0113, 718736-S3-0500-0101 and 718736-S3-0500-0102 in Appendix A.

Floodable berms and watercourse widening to the downstream undesignated watercourse (Extension of S3-WD-09) have been included within this model to rationalise the orientation of the existing floodplain and facilitate construction of the proposed scheme whilst not materially increasing flood risk. Table 4.15.2-3 identifies the floodable berm requirements.

Table 4.15.2-3 - Model M.L, Ranelly Drain Floodable Berm Characteristics

Location Grid Reference	Berm Reference	Dimensions	Proposed Gradient
248372 367751	S3-FB-01	See schematic (Figure 3.6.3-3)	1:703

Table 4.15.2-3 - Model M.L, Ranelly Drain Floodable Berm Characteristics

Location Grid Reference	Berm Reference	Dimensions	Proposed Gradient
248410 367260	S3-FB-02	See schematic (Figure 3.6.3-4)	1:573

Schematics of the floodable berms can be seen in the Figures below:

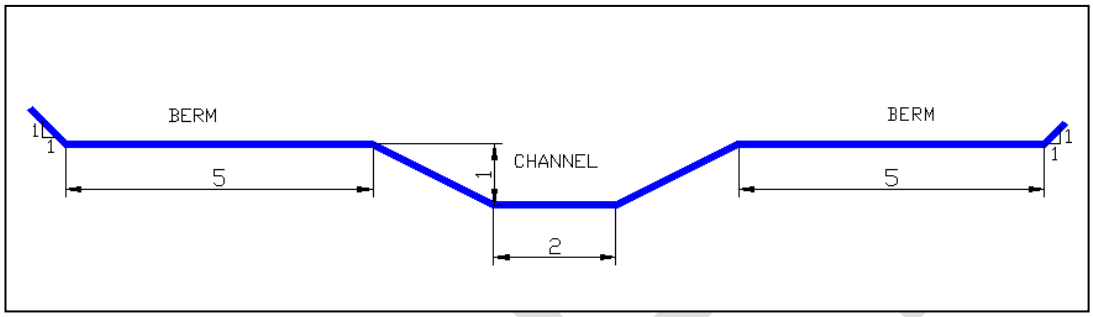

Figure 4.15.2-3 – Floodable Berm S3-FB-01 Cross Section Schematic

(Note: not to scale)

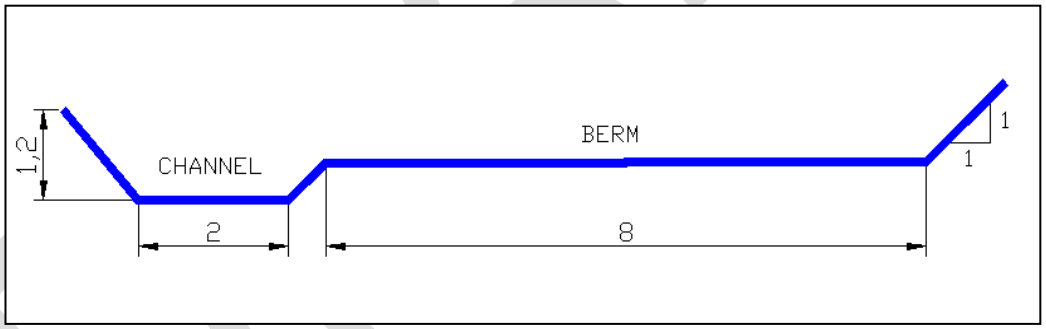

Figure 4.15.2-4 – Floodable Berm S3-FB-02 Cross Section Schematic

(Note: not to scale)

It is predicted that the river engineering proposals will not materially change flood risk along their length and have been tested within the flood model to assess their performance. The results can be seen in Table 4.15.2-4.

A comparison of the water elevations, for specific points along the watercourse, pre and post scheme are shown in Table 4.15.2-4. These points can be seen in Figures 4.15.2-5 and 4.15.2-6.

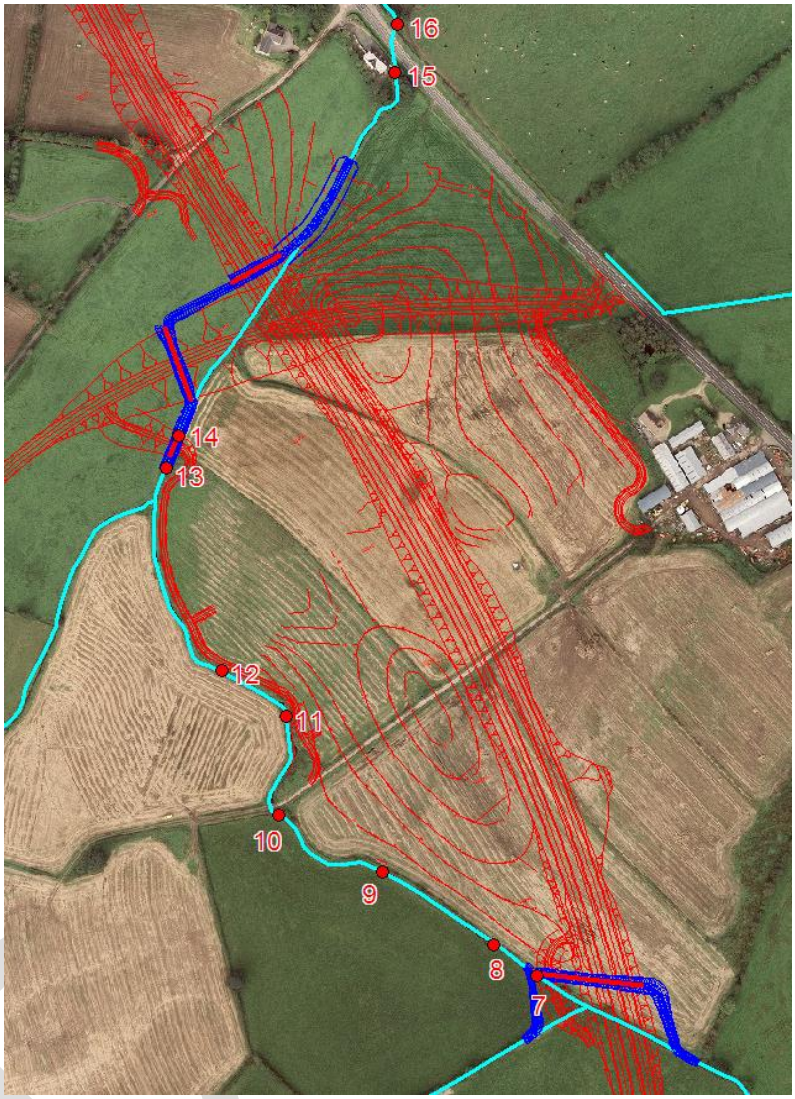

Figure 4.15.2-5 – Model M.L, Points along Channel for Water Elevation Comparison

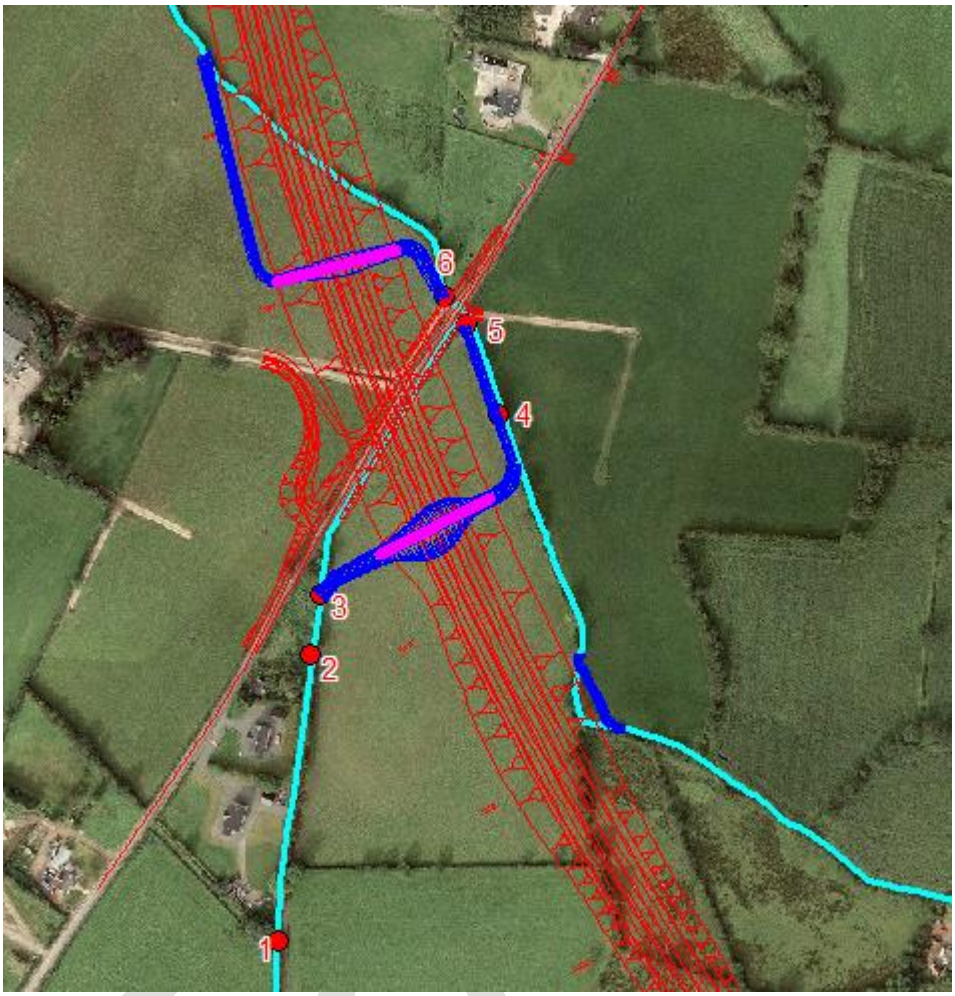

Figure 4.15.2-6 – Model M.L, Points along Channel for Water Elevation Comparison

Table 4.15.2-4 – Predicted 100 Year Impact for Model M.L Ranelly Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	92.313	92..289	-0.024
2	92.025	91.826	-0.199
3	91.843	91.75	-0.093
4	91.112	91.072	-0.04
5	91.017	90.738	-0.279
6	90.54	90.529	-0.011
7	88.606	88.513	-0.093
8	88.563	88.544	-0.019
9	88.513	88.523	+0.010
10	88.477	88.512	+0.035
11	87.92	87.877	-0.043
12	87.762	87.739	-0.023

Table 4.15.2-4 – Predicted 100 Year Impact for Model M.L Ranelly Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
13	87.19	87.221	+0.031
14	87.126	87.127	+0.001
15	86.517	86.521	+0.004
16	85.798	85.802	+0.004

It is identified that the combined effect of the proposed culverts and river engineering proposals result in a general reduction in water levels at most locations throughout the length of the model. The minor impacts associated with the 100 year design event are considered localised and attributed to the slight changes in the local geometry predicted post scheme. The model results show that for the worst case point location (point 10) there is a 35mm change in the 100year flood water levels post Proposed Scheme.

4.15.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.15.1, approximately 2,395m^3 of floodwater is displaced as consequence of the A5 WTC Proposed Scheme. The compensatory storage locations (reference S3-CS-01, S3-CS-02, S3-CS-03 and S3-CS-20) for this model can be seen in Drawings 718736-S3-0500-0112, 718736-S3-0500-0113, 718736-S3-0500-0101 and 718736-S3-0500-0102 and in Figures 4.15.3-1 to 4.15.3-3.

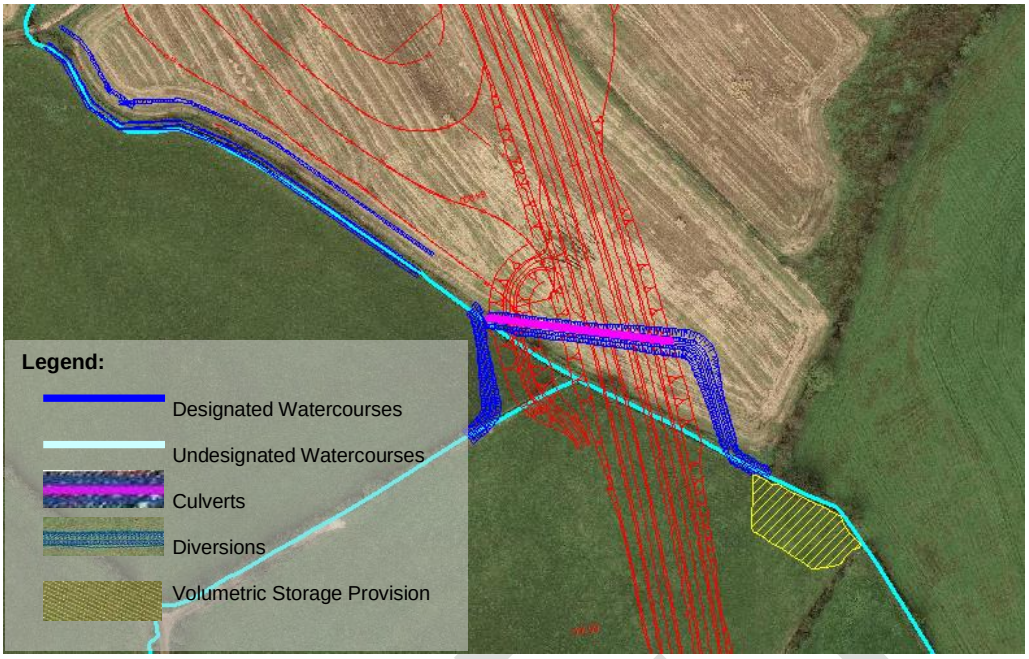

Figure 4.15.3-1 – Model M.L, Plan of Ranelly Drain Volumetric Floodplain Storage Provision (S3-CS-01)

Figure 4.15.3-2 – Model M.L, Volumetric Floodplain Storage Provision (S3-CS-02 and S3-CS-03)

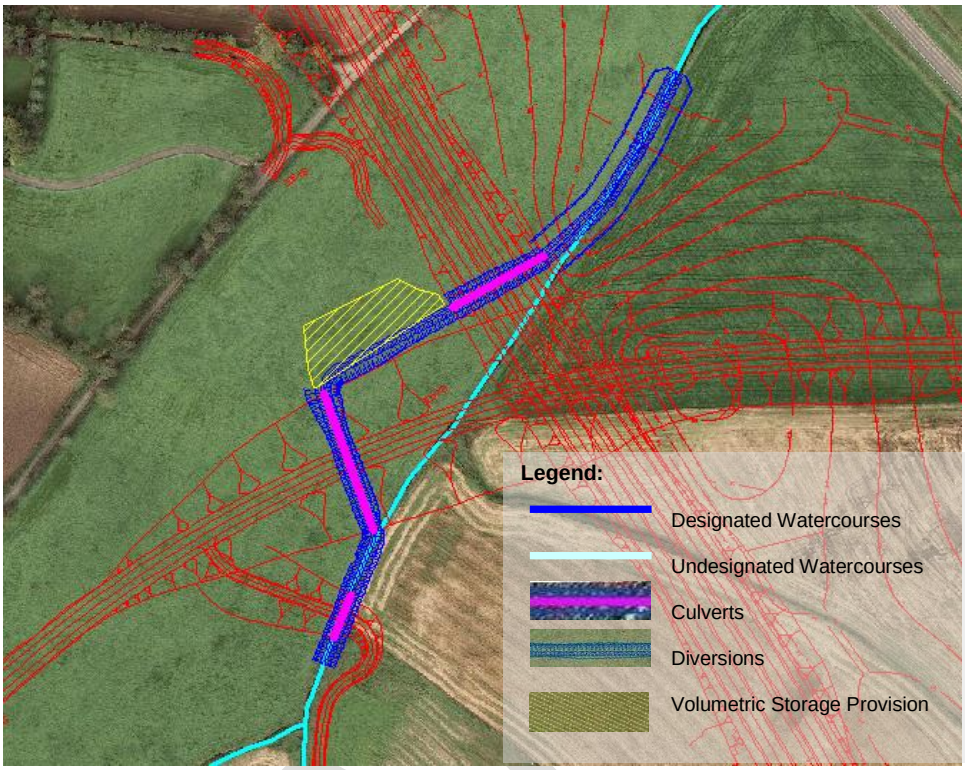

Figure 4.15.3-3 – Model M.L, Volumetric Floodplain Storage Provision (S3-CS-20)

Table 4.15.3-1 identifies the volumetric storage requirements, Drawings 718736-0500-D-00244 to 718736-0500-D-00247 and 718736-0500-D-00420 illustrate the application of this in detail.

Table 4.15.3-1 – Model M.L, Ranelly Drain Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^2)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-20	248256	367709	~2,395	~2,395	~440	Ranelly Drain
S3-CS-01	248662	367097			~405	Ranelly Drain
S3-CS-02	248606	366557			~1,645	Ranelly Drain
S3-CS-03	248631	366333			~5,495	Ranelly Drain
					Total =~7,885	

4.15.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise the significance of residual impact. This information can be seen in Table 4.15.4-1.

Table 4.15.4-1 – Model M.L Ranelly Drain Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Minor Adverse	Neutral

There are no residential or commercial properties within the extents of the floodplain and consequently the importance of the feature is characterised as Low. The model results show that, in general, there is a reduction in water levels for the 100 year flood water levels post scheme; however at localised locations, the predicted water levels increase, with a worst case increase of 35mm for the design scenario. Therefore, the magnitude is considered to be Minor Adverse. This significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for Ranelly Drain is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to fewer than 10 industrial properties'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S3-0500-0112, 718736-S3-0500-0113, 718736-S3-0500-0101 and 718736-S3-0500-0102 in Appendix A.

4.16 Model M.M - Letfern Watercourse – Impact and Mitigation Assessment

4.16.1 Floodplain Interaction

The 100 year existing floodplain for the Letfern watercourse is diffuse in its shape, with out of bank flow extending / accumulating in low lying areas extending from the river banks.

It is identified that the Proposed Scheme is primarily located outside the identified 100 year floodplain. The Proposed Scheme crosses the designated watercourse at two locations and an undesignated tributary at two locations; refer to Figure 4.16.1-1. Given that the majority of the proposed alignment does not interact with the floodplain there is no disruption of floodplain flow-paths / connectivity.

Furthermore, based on the existing 100 year predicted water levels, there is only a small displacement of floodwaters predicted at this location, approximately 10m^3, which is shown below in Figure 4.16.1-1.

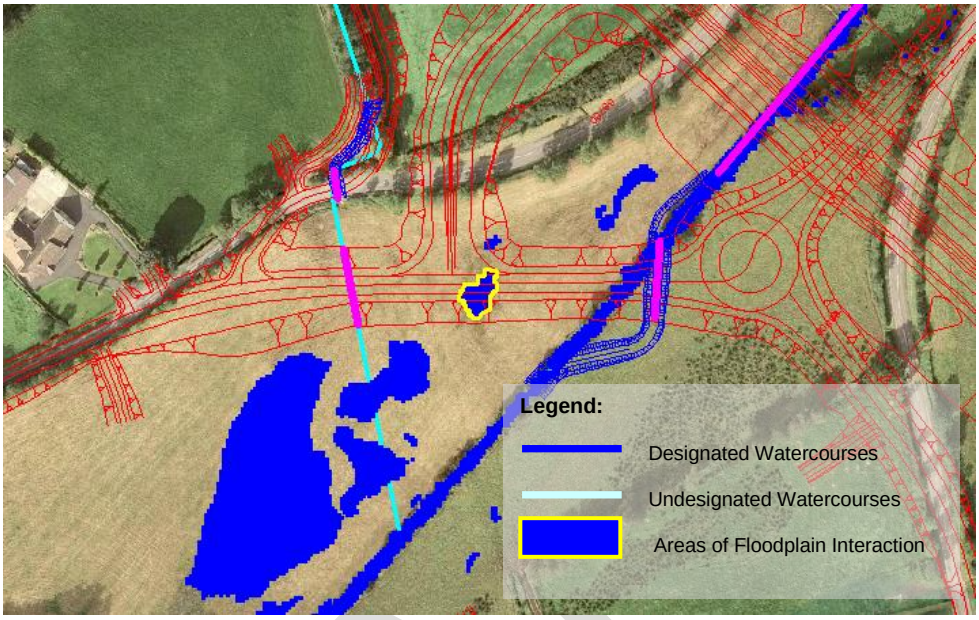

Figure 4.16.1-1 - Letfern Floodplain Interaction

4.16.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting of the watercourses and associated river diversionary works. The proposed arrangements aim to minimise the length of culvert required through perpendicular crossings. This arrangement can be seen in Figure 4.16.2-1.

There are no bridge structures proposed within the extents of the Letfern watercourse model.

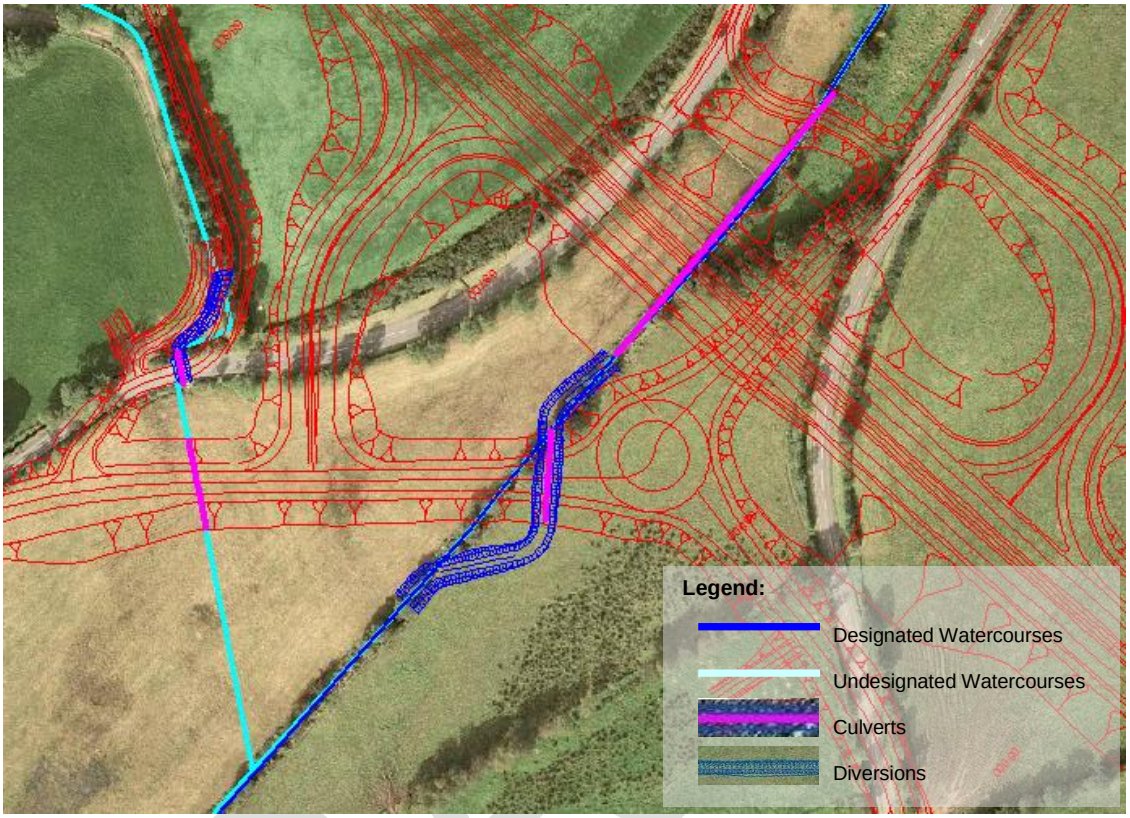

Figure 4.16.2-1 - Plan of Letfern Diversion (S3-WD-48) and Culvert Arrangement (S3-PC-14 and S3-PC-58)

(Note: the undesignated tributary in the above image has not been included within the flood model).

The proposed culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.16.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.16.2-1 - Model M.M, Letfern Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
250495 364057	S3-PC-14	Box	3.6	2.1
250572 363967	S3-PC-58	Box	3.6	2.1

The proposed Letfern diversion has also been hydraulically modelled. Table 4.16.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.16.2-2 - Model M.M, Letfern Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
250460 364021	S3-WD-48 / 12	Channel Length	193m	102m
		Channel Gradient	1:158	1:191

The culvert and diversion arrangements can be seen in Drawing 718736-S3-0500-0103 in Appendix A.

Comparisons of the water elevations, for specific points along the watercourse, pre and post scheme, are shown in Table 4.16.2-3. These points can be seen in Figure 4.16.2-2.

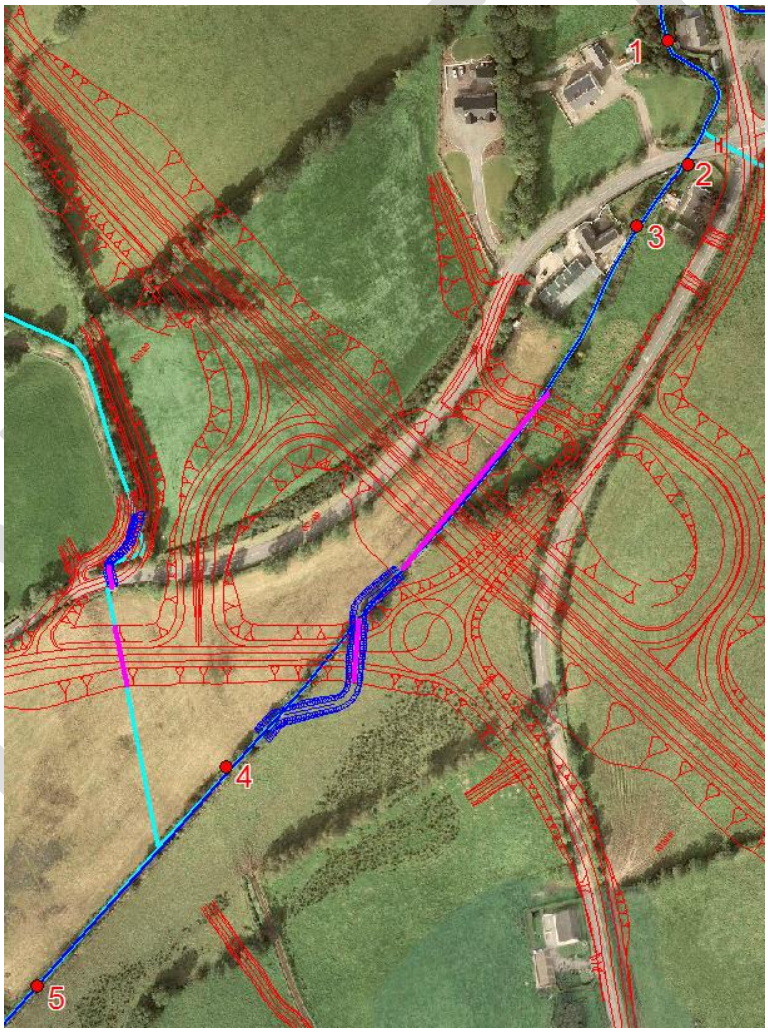

Figure 4.16.2-2 – Model M.M, Points along Channel for Water Elevation Comparison

Table 4.16.2-3 - Predicted Impact for Model M.M Letfern for Proposed Scheme			
	Existing Water Elevation (m AOD)	**Post Road Water Elevation (m AOD)**	**Impact (m)**
Point ID	**100 Year**	**100 Year**	**100 Year**
1	94.449	94.448	-0.001
2	93.778	93.774	-0.004
3	93.447	93.399	-0.048
4	90.989	90.989	0
5	90.989	90.989	0

It is identified that the combined effect of the proposed culverts and diversion result in a reduction in water levels at most locations throughout the length of the modelled watercourse. In summary, the model results show that there is no material difference in water levels pre and post scheme.

4.16.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.16.1, a small amount of floodwater is displaced as consequence of the Proposed Scheme. The compensatory storage location (reference S3-CS-05) for this area can be seen in Drawing 718736-S3-0500-0103 and in Figure 4.16.3-1 below.

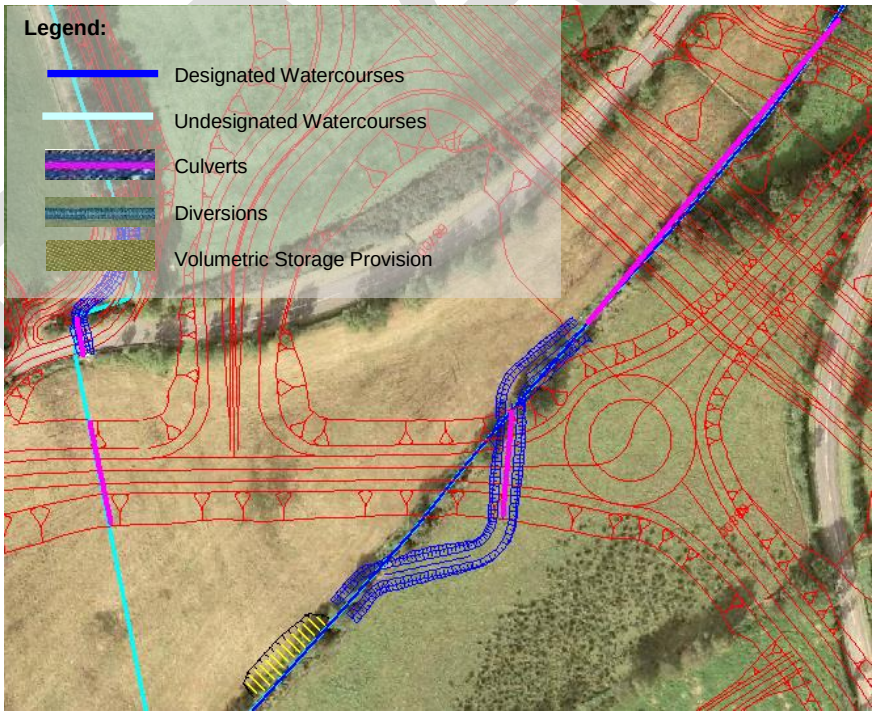

Figure 4.16.3-1 – Model M.M, Plan of Volumetric Floodplain Storage Provision (S3-CS-05)

Table 4.16.3-1 identifies the volumetric storage requirements and Drawing 718736-0500-D-00248 illustrates the application of this in detail.

Table 4.16.3-1 – Model M.M, Letfern Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-05	250393	363945	~10	~10	~35	Letfern

4.16.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.16.4-1.

Table 4.16.4-1 – Model M.M Letfern Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Minor Beneficial	Neutral

There are no residential or commercial properties within the extents of the floodplain and consequently the importance of the feature is characterised as Low. The model results show that there is a reduction in water levels with point 3 being - 48mm for the 100 year flood water levels post scheme, the magnitude of which is considered Minor Beneficial, therefore, the significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for Letfern watercourse is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0103 in Appendix A.

4.17 Model M.N - Undesignated Watercourse (Upstream MW1402 Letfern) – Impact and Mitigation Assessment

4.17.1 Floodplain Interaction

The 100 year existing floodplain for this undesignated watercourse consists of a small isolated pocket of floodplain where ground levels are slightly lower.

It is identified that the Proposed Scheme is entirely located outside of the identified 100 year floodplain. The Proposed Scheme crosses the undesignated watercourse at a number of locations; refer to Figure 4.17.1-1. As the road does not interact with the floodplain there is no disruption of floodplain flowpaths / connectivity. Furthermore, there is no displacement of floodwaters.

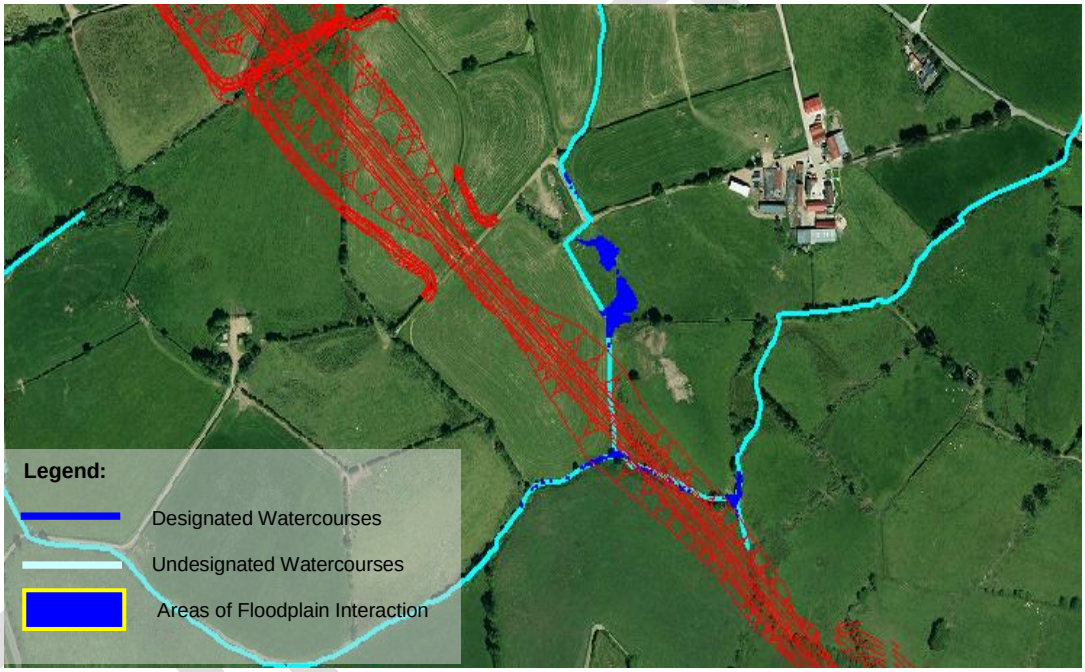

Figure 4.17.1-1 - Undesignated Watercourse Floodplain Interaction

4.17.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting and river diversion works for the two river crossings. The proposed arrangements aim to minimise the number and the length of culverts required, through perpendicular crossings. This arrangement can be seen in Figure 4.17.2-1.

There are no bridge structures proposed within the extents of the undesignated watercourse model.

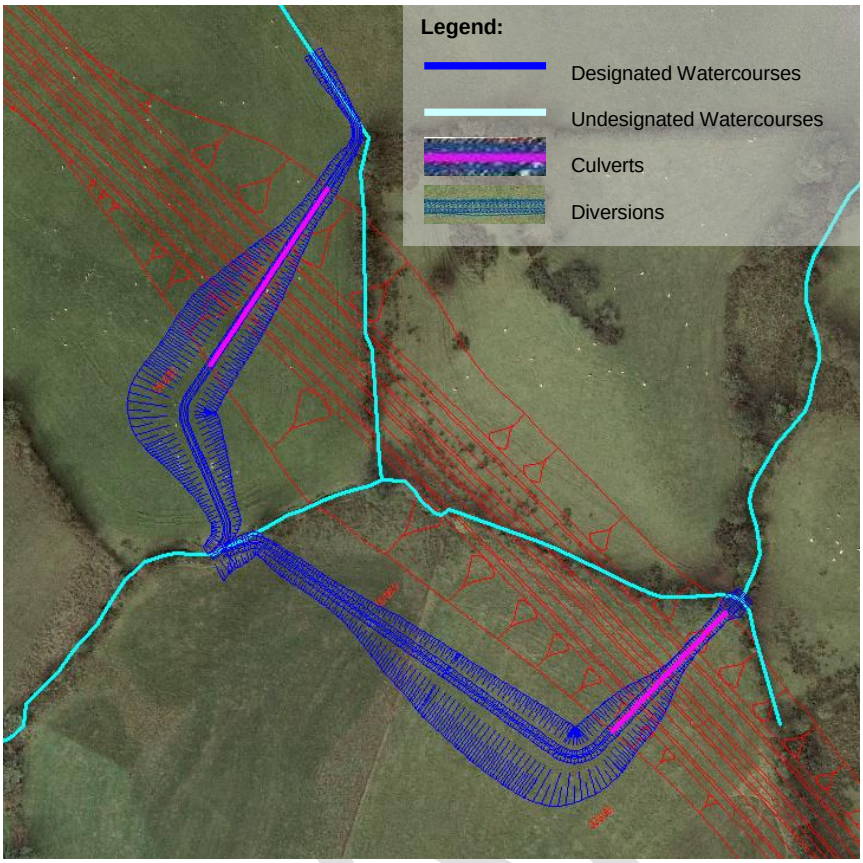

Figure 4.17.2-1 - Plan of Undesignated Watercourses Diversions (S3-WD-13 and S3-WD-14) and Culverts Arrangement (S3-PC-16 and S3-PC-17)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.17.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.17.2-1 - Model M.N, Undesignated Watercourse Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
251207 363372	S3-PC-16	Pipe	-	2.4 Ø
251308 363273	S3-PC-17	Box	1.8	1.8

The proposed diversions have also been hydraulically modelled. Table 4.17.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.17.2-2 - Model M.N, Undesignated Watercourse Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
251161 363359	S3-WD-13	Channel Length	173	186
		Channel Gradient	1:28	1:35,1:68, 1:30
251296 363236	S3-WD-14	Channel Length	187	218
		Channel Gradient	1:43	1:366, 1:21

The culvert and diversion arrangements can be seen in Drawing 718736-S3-0500-0118.

A comparison of the water elevations, pre and post scheme, are shown in Table 4.17.2-3 for specific points along the watercourse. These points can be seen in Figure 4.17.2-2:

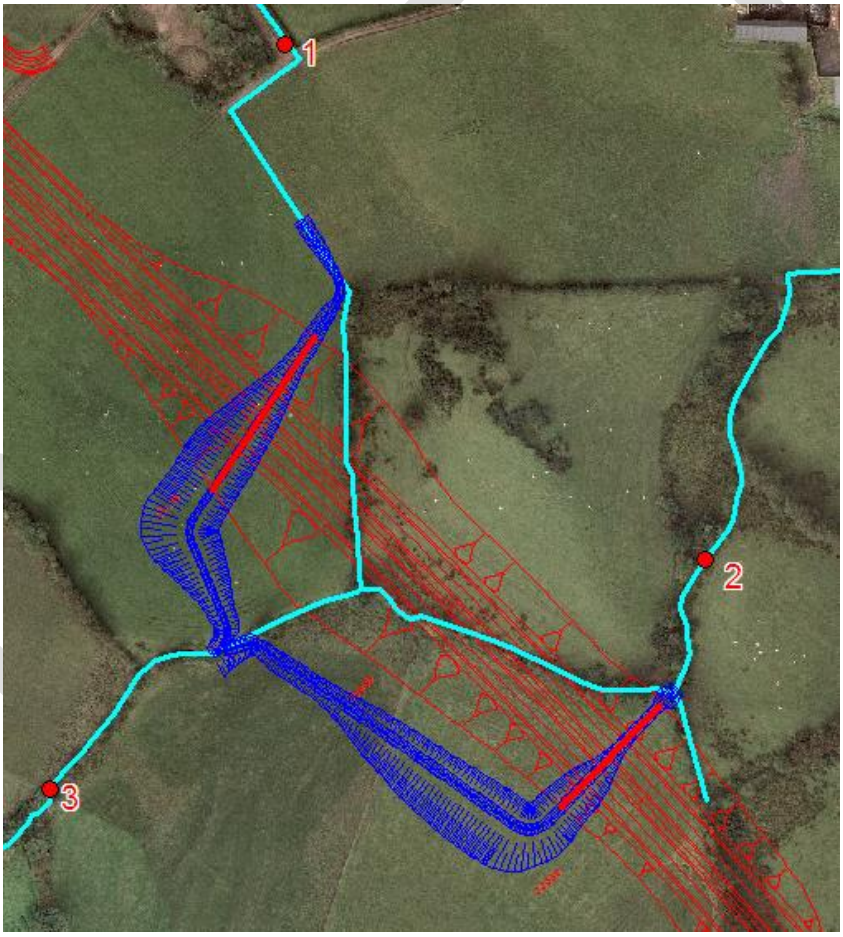

Figure 4.17.2-2 – Model M.N, Points along Channel for Water Elevation Comparison

Table 4.17.2-3 - Predicted Impact for Model M.N Undesignated Watercourse for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	107.760	107.766	+0.006
2	104.864	104.689	-0.175
3	98.134	98.119	-0.015

It is identified that the combined effect of the proposed culverts and diversions result in a reduction in water levels upstream of the proposed road for the southern tributary and no material change upstream of the proposed road for the northern tributary. Downstream of the proposed road there is a 15mm reduction in predicted 100 year water levels.

4.17.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.17.1 there is no loss of floodplain storage as a consequence of the Proposed Scheme.

4.17.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to collectively categorise significance of residual impact. This information can be seen in Table 4.17.4-1.

Table 4.17.4-1 – Model M.N Undesignated Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Negligible	Neutral

There are no residential or commercial properties within the extent of the floodplain and consequently the importance of the feature is characterised as Low. The model results show that in general there is a reduction in predicted water levels for the 100 year event post scheme, with the worst case point being a 6mm increase in water levels at point 1. Consequently, the magnitude of impact is considered Negligible. The significance of impact on the floodplain is considered Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the undesignated watercourse is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0118 in Appendix A.

4.18 Model M.O - Undesignated Watercourse – Impact and Mitigation Assessment

4.18.1 Floodplain Interaction

The 100 year existing floodplain for this undesignated watercourse consists of a small isolated pocket of floodplain and the Proposed Scheme does not interact with the floodplain.

For the 100 year flood event, modelling indicates that there will be no floodwater displaced as the result of the Proposed Scheme, as shown in Figure 4.18.1-1.

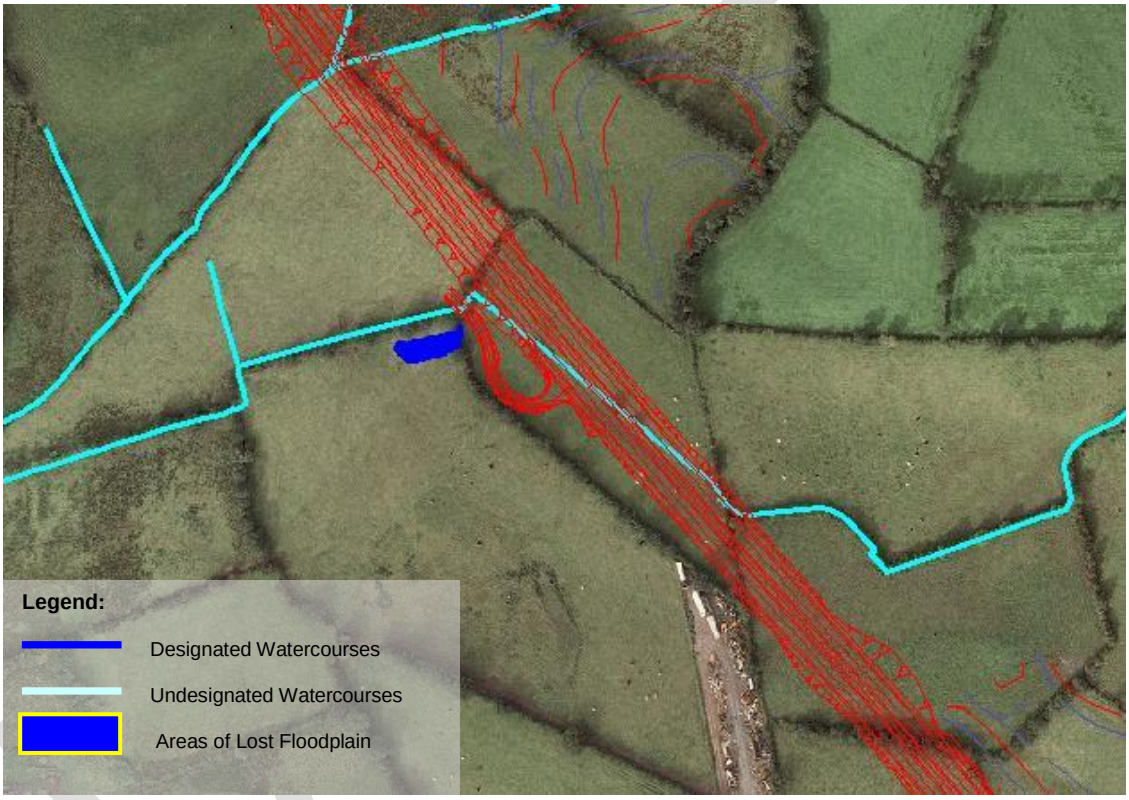

Figure 4.18.1-1 - Undesignated Watercourse Floodplain Interaction

4.18.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting and river diversion works within the extents of the model. There are two proposed diversions associated with the undesignated watercourses. One of the diversions aims to minimise the length of culvert required as the watercourse will be culverted perpendicularly to the Proposed Scheme and the other is to remove the watercourse from the road footprint.

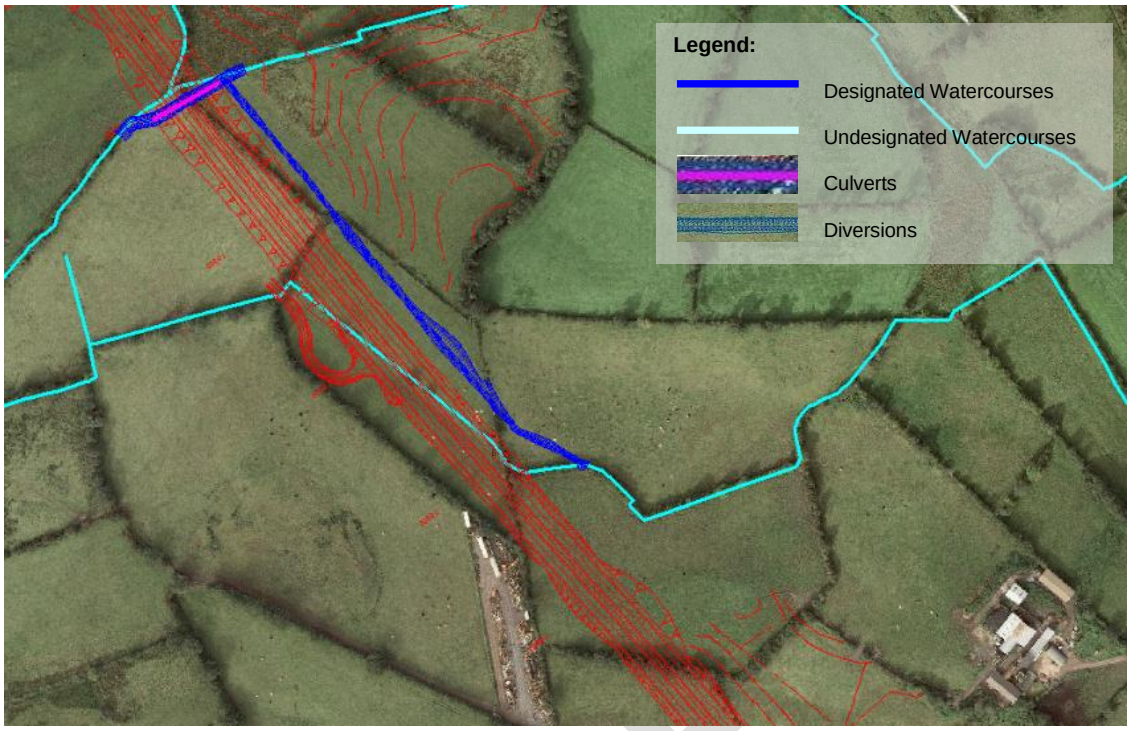

Figure 4.18.2-1 - Undesignated Watercourse Diversions (S3-WD-16 and S3-WD-17) and Culvert Arrangement (S3-PC-18)

The culvert has been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.18.2-1 below provides a summary of the modelled culvert size for the watercourses within this model.

Table 4.18.2-1 - Model M.O, Undesignated Watercourse Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
251522 363014	S3-PC-18	Box	2.7	1.5

The proposed diversions have also been hydraulically modelled. Table 4.18.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.18.2-2 - Model M.O, Undesignated Watercourse Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
251553 363025	S3-WD-16	Channel Length	52	87
		Channel Gradient	1:50	1:47
251650 362903	S3-WD-17	Channel Length	881	326
		Channel Gradient	1:37	1:40

The culvert and diversion arrangements can be seen in Drawing 718736-S3-0500-0119.

A comparison of the water elevations pre and post scheme is shown in Table 4.18.2-3 for specific points along the watercourse. These points can be seen in Figure 4.18.2-2:

Figure 4.18.2-2 – Model M.O, Points for Water Elevation comparison

Table 4.18.2-3 - Predicted Impact for Model M.O Undesignated watercourse for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	109.559	110.181	+0.622
2	102.945	102.942	-0.003
3	98.348	98.342	-0.006

It is observed that the combined effect of the proposed culvert and diversions result in an increase in predicted water levels at the upstream extent of the model. This increase being a consequence of the river engineering proposals which include a reduction in the overall river length at this area. However, it is highlighted that the predicted increases in water levels as identified in Table

4.18.2-3 (+622mm) are retained within the banks of the watercourse such that there is no predicted out of channel flooding.

4.18.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.18.1 there is no loss of floodplain storage as a consequence of the Proposed Scheme.

4.18.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to collectively categorise significance of residual impact. This information can be seen in Table 4.18.3-2:

Table 4.18.4-1 – Model M.O Undesignated Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Adverse	Slight/Moderate

There are no residential or commercial properties within the extent of the floodplain and the importance of the feature is characterised as Low. The model results show that there is a maximum change in the 100 year flood levels post Proposed Scheme of 622mm, with increases remaining in channel. Therefore the magnitude of impact on the floodplain is Major Adverse. The significance of impact on the floodplain is considered to be Slight/Moderate.

On reviewing the qualifying conditions for the overall assessment score for flood risk, the score for the Undesignated Watercourse is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – '*An increase in peak flood level (1% annual probability) >10mm resulting in an increased risk of flooding to fewer than 10 industrial properties'*.

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0119 in Appendix A.

4.19 Model M.P/M.Q - Routing Burn and Undesignated Tributary – Impact and Mitigation Assessment

4.19.1 Floodplain Interaction

The 100 year existing floodplain for the Model P/Q Routing Burn is linear along the Routing Burn (not extending significantly from channel), with more diffuse pockets of floodplain extending over low lying areas at the Routing Burn / Undesignated Tributary confluence and over mid reach areas of the undesignated tributary.

It is identified that the Proposed Scheme crosses watercourses at five locations and encroaches into the floodplain at the undesignated tributary. Review of the proposed alignment indicates that there is no disruption of floodplain flow-paths/connectivity, refer to Figure 4.19.1-1.

Furthermore, based on the existing 100 year predicted water levels, the proposals result in the displacement of approximately 595m^3 of floodwater at the this location. This area is outlined in Figure 4.19.1-1.

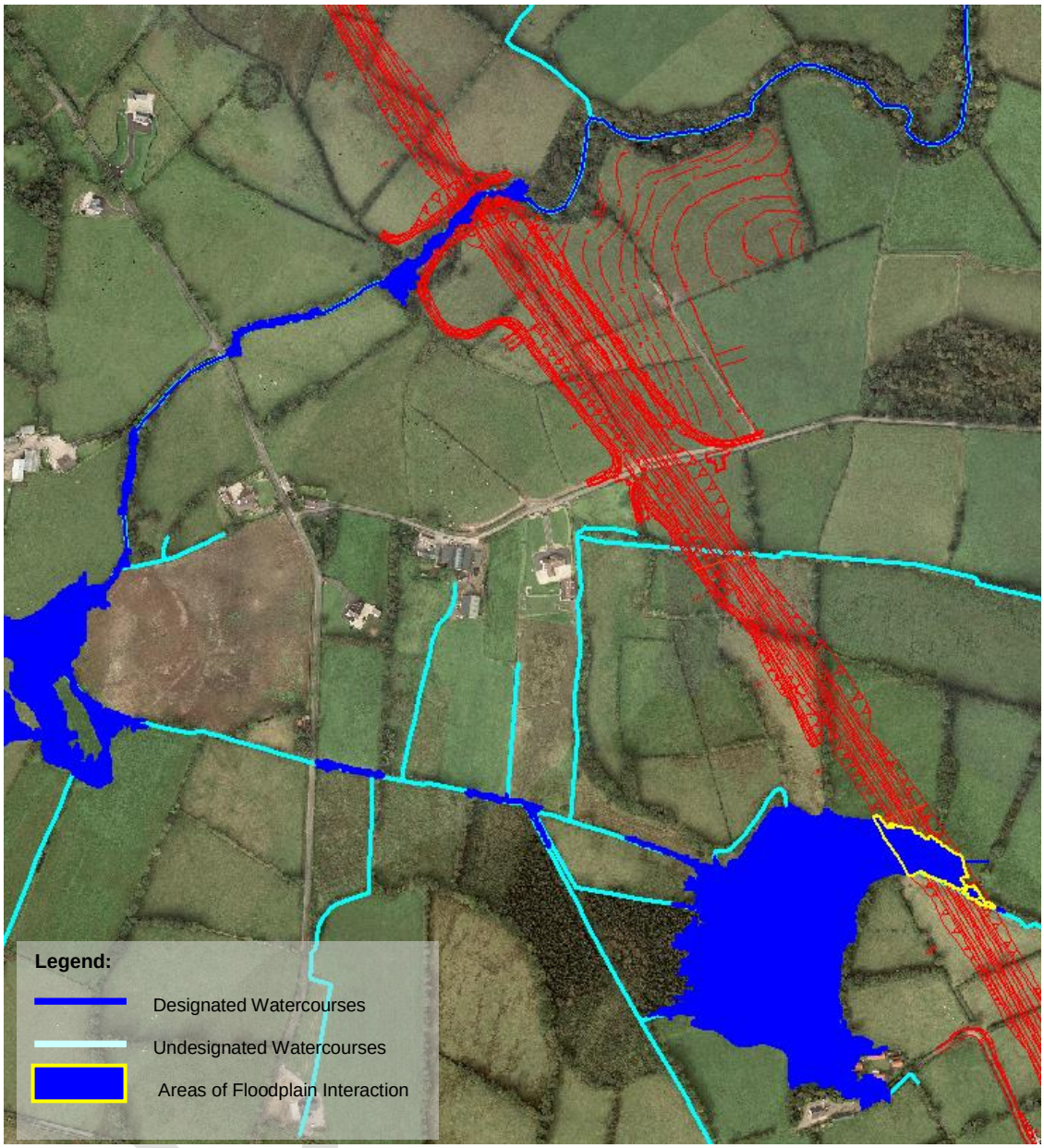

Figure 4.19.1-1 - Routing Burn Floodplain Interaction

4.19.2 Mitigation Assessment – Structures, Culverts and Diversions

Proposals include a bridge structure across the Routing Burn watercourse. It is identified that the detailed design proposals for the bridge structure include a 31m span over the watercourse with abutments being set at least 4.5m from the top of bank. The soffit level of the structure is not less than the 100 year flood water level plus 600mm freeboard. It is confirmed that there are no piers within the watercourse channel. Figure 4.19.2-1 depicts the location of the structure.

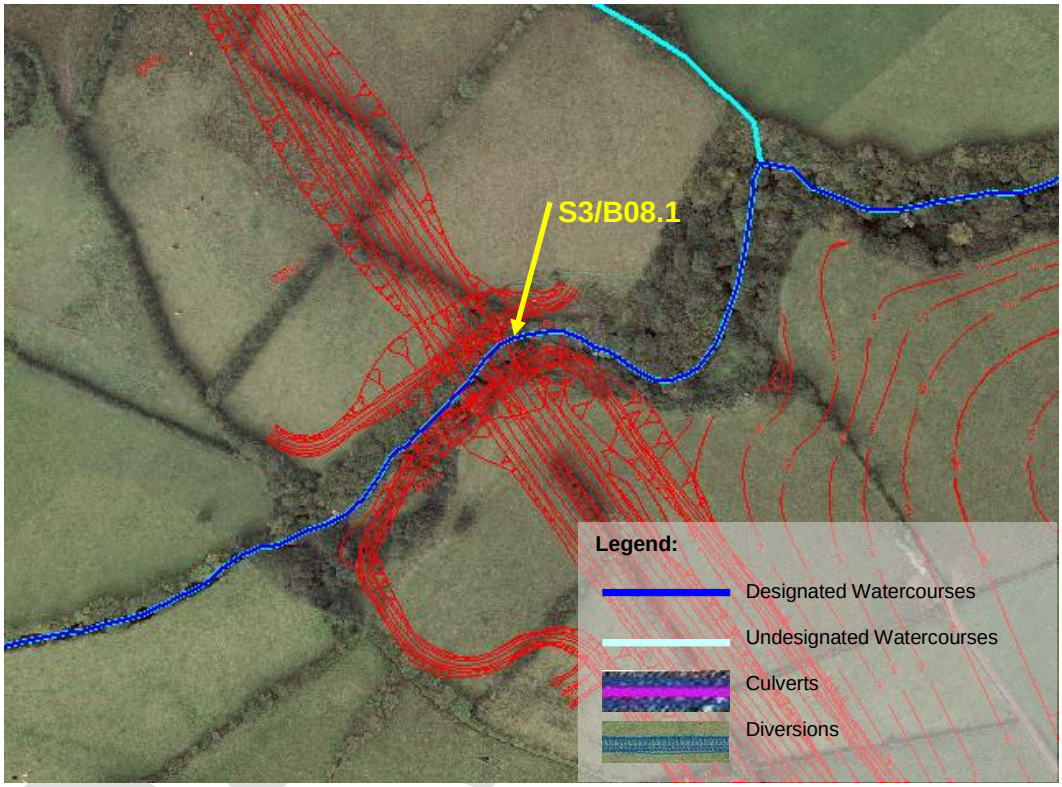

Figure 4.19.2-1 - Plan of Routing Burn Bridge Crossing Location (S3/B08.1)

Modelling was undertaken to evaluate the effectiveness of the proposed bridge structure. Table 4.19.2-1 outlines the bridge parameters.

Table 4.19.2-1 - Model M.P/M.Q, Routing Burn Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
252386 361830	Routing Burn	S3/B08.1	31	105.64

The general arrangement of the bridge structure can be seen in Drawing 718736-1700-D-0515.

The Proposed Scheme includes culverting works for one undesignated crossing and river diversion works for two undesignated watercourses within the extents of the model. The proposed arrangements aim to minimise the number of and

the length of culverts required, through perpendicular crossings. These arrangements can be seen in Figure 4.19.2-2.

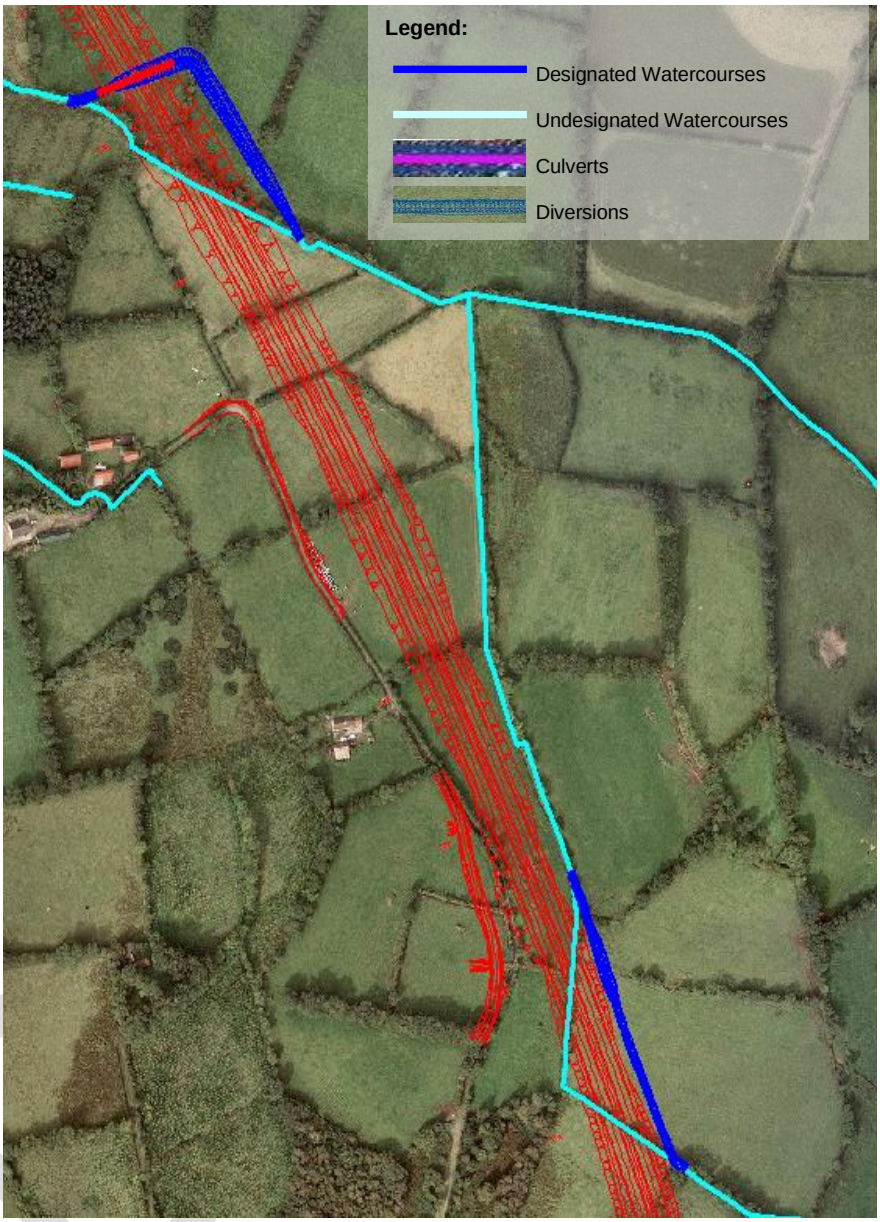

Figure 4.19.2-2 - Plan of Undesignated Watercourses Diversions (S3-WD-21 and S3-WD-22) and Culvert Arrangement (S3-PC-22)

The culvert has been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.19.2-2 below provides a summary of the modelled culvert sizes for the watercourses within this model. These sizes are considered sufficient hydraulically and represent the minimum proposed culvert sizes.

Table 4.19.2-2 - Model M.P/M.Q, Routing Burn and Undesignated Tributary Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
252854 361157	S3-PC-22	Box	1.8	1.8

The proposed diversions have also been hydraulically modelled. Table 4.19.2-3 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.19.2-3 - Model M.P/M.Q, Routing Burn and Undesignated Tributary Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
252825 361268	S3-WD-21	Channel Length	186	223m
		Channel Gradient	1:65	1:63
353120 360662	S3-WD-22	Channel Length	280m	204m
		Channel Gradient	1:22. 1:60, 1:78	1:40,1:279, 1:10, 1:48

The culvert and diversion arrangements can be seen in Drawings 718736-S3-0500-0124, 718736-S3-0500-0104 and718736-S3-0500-0120.

A comparison of the water elevations, pre and post scheme, are shown in Tables 4.19.2-4 and 4.19.2-5 for specific points along the watercourse. These points can be seen in Figures 4.19.2-3 and 4.19.2-4:

Figure 4.19.2-3 – Model M.P, Points along Channel for Water Elevation Comparison

Table 4.19.2-4 - Predicted Impact for Model M.P Routing Burn for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	109.112	109.112	0.000
2	106.551	106.551	0.000
3	101.814	102.819	+0.005
4	100.273	100.255	-0.018
5	100.132	100.072	-0.060
6	98.639	98.699	+0.060

It is observed that for the 100 year event for the Routing Burn, the proposed bridge spanning the watercourse results in a negligible change in water levels at most locations along the length of the model. The minor impacts associated with the 100 year design event are considered localised. The model results show that for the worst case point location (point 6) there is a 60mm change in the 100 year flood water levels post Proposed Scheme.

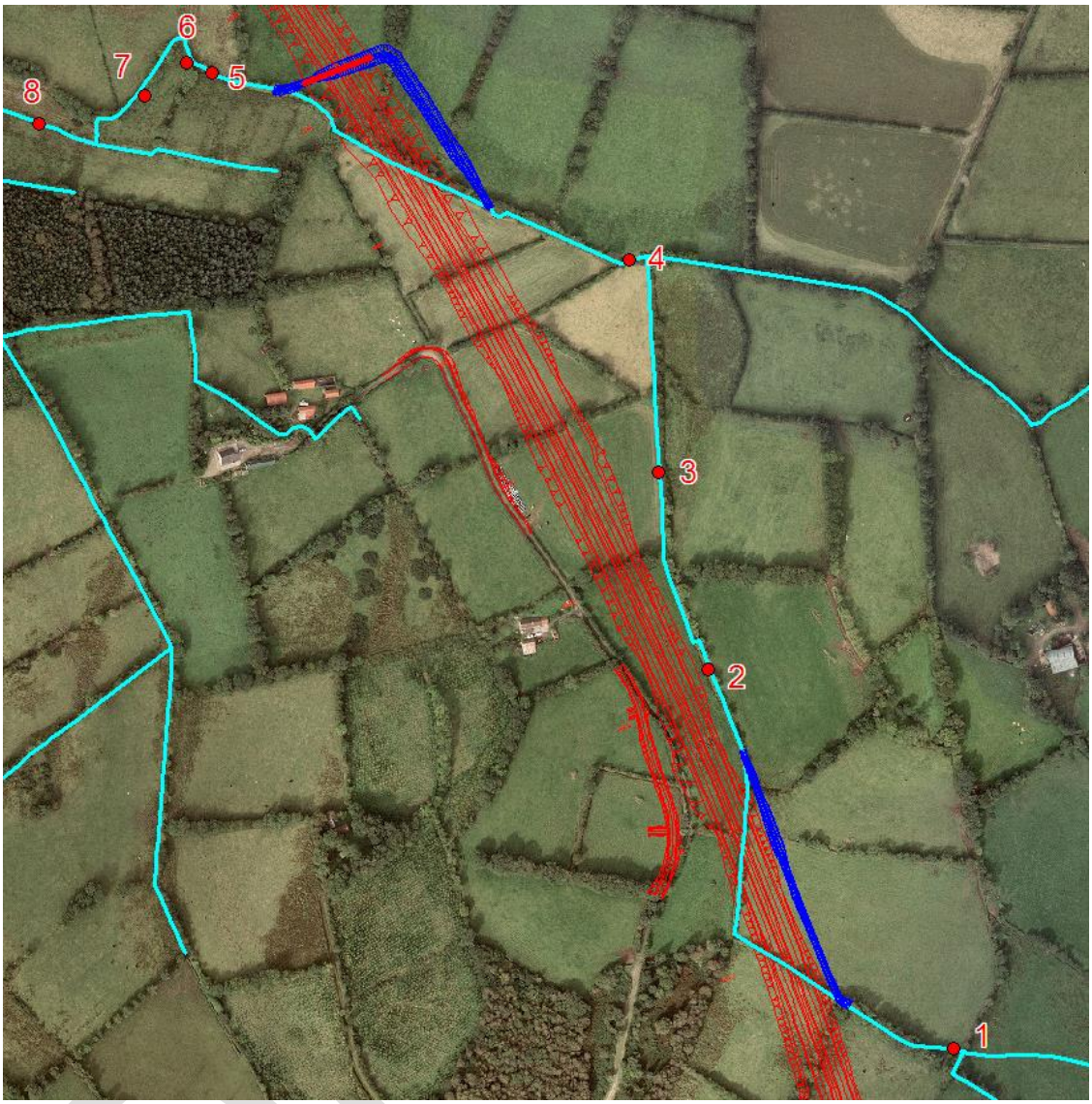

Figure 4.19.2-4 – Model M.Q, Points along Channel for Water Elevation Comparison

Table 4.19.2-5 - Predicted Impact for Model M.Q Undesignated for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	126.236	126.230	-0.006
2	115.576	115.576	0
3	113.235	113.235	0
4	110.519	110.503	-0.016
5	106.257	106.051	-0.206
6	105.453	105.363	-0.090
7	104.388	104.321	-0.067
8	102.774	102.706	-0.068

It is identified that for the 100 year event for this undesignated watercourse the proposed river engineering works result in a general reduction in water levels at most locations throughout the length of the model.

4.19.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.19.1, approximately 595m^3 of floodwater is displaced as consequence of the Proposed Scheme at the upstream undesignated tributary of the Routing Burn. Due to the location, geometry and gradient of the watercourse diversion S3-WD-21, the proposed scenario provides the required storage for 100 year water levels and water is held within the proposed channel for the length of the diversion. Therefore this negates the need for a separate compensatory storage measure, as storage is provided within the proposed diversion channel.

4.19.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Tables 4.19.4-1 and 4.19.4-2.

Table 4.19.4-1 – Model M.P Routing Burn Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Moderate Adverse	Slight

Table 4.19.4-2 – Model M.Q Undesignated Watercourse Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
3 (farm buildings)	Medium	Moderate Beneficial	Moderate

There are no residential or commercial properties situated in the Routing Burn floodplain and consequently the importance of the feature is characterised as Low. The model results show that along the Routing Burn watercourse there is a change in water levels post scheme of 60mm (worst case), the magnitude of which is considered to be Moderate Adverse. Therefore, the significance of impact on the floodplain is considered to be Slight for Routing Burn.

There are three farm buildings situated at the undesignated tributary floodplain extents and consequently the importance of the feature is characterised as Medium. It is observed that at this location there is generally a reduction in water levels post scheme, the magnitude of which is considered Moderate Beneficial. Therefore the significance of impact on the floodplain is considered to be Moderate for the undesignated tributary.

On review of the overall qualifying conditions for assessment score of flood risk, the score for Routing Burn is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to fewer than 10 industrial properties',* and for the upstream undesignated tributary is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm',* although benefits in relation to water levels are realised.

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S3-0500-0124, 718736-S3-0500-0104 and718736-S3-0500-0120 in Appendix A.

4.20 Model M.R - Undesignated Watercourse - Newtownsaville – Impact and Mitigation Assessment

4.20.1 Floodplain Interaction

The 100 year existing floodplain for this undesignated watercourse is attributable to localised topography, whereby land adjacent to the watercourse is extremely flat and low lying resulting in the shallow spread of flood water in the Beltany Bog area. It is also noted that there is a single property located within the predicted extents of the 100 year floodplain.

It is identified that the Proposed Scheme crosses the watercourse at four locations; two crossings associated side / access roads, one crossing associated with the main line and one instance where the watercourse meanders under the alignment. The road alignment does not infringe on any floodplain areas, however, river engineering works associated with the road do result in the loss of approximately 70m^3 of floodplain storage. This area is outlined in Figure 4.20.1-1.

Review of the proposed alignment indicates that there is no disruption of floodplain flowpaths / connectivity, refer to Figure 4.20.1-1.

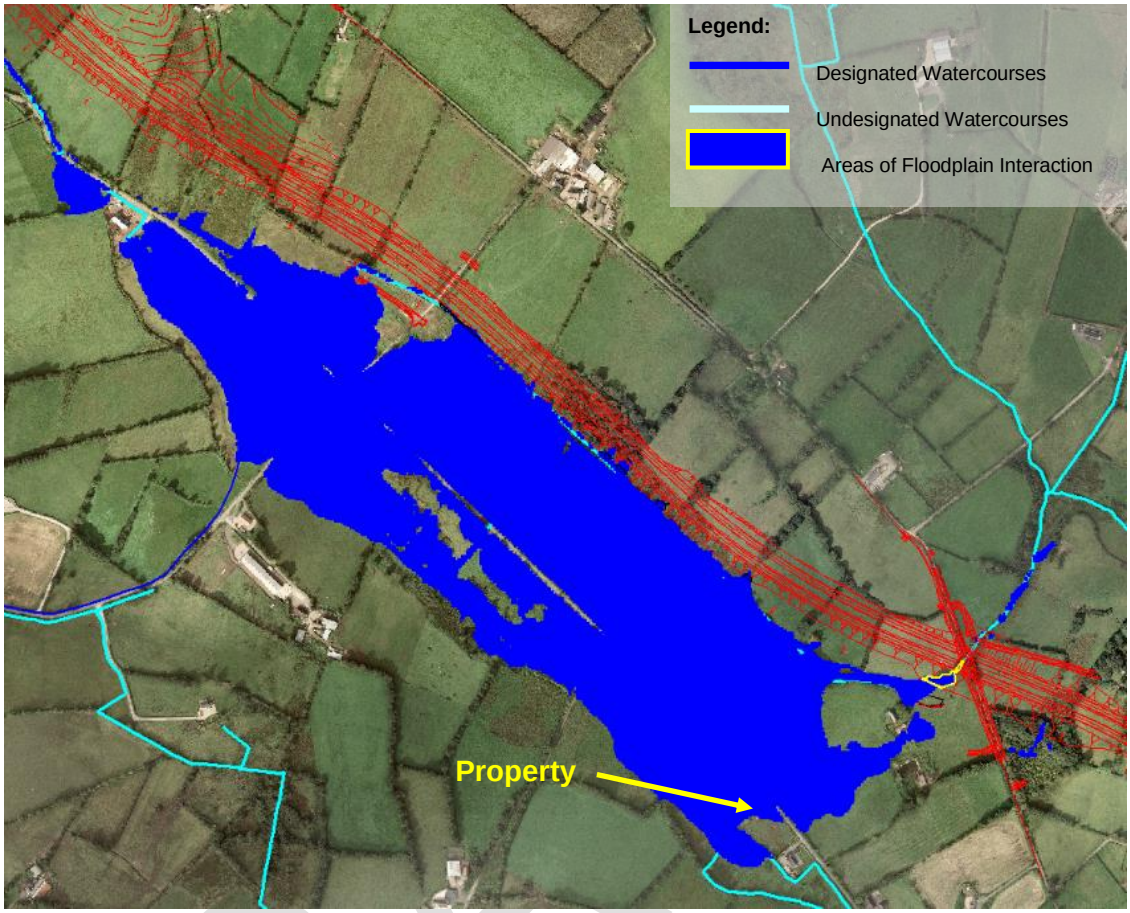

Figure 4.20.1-1 - Undesignated Watercourse Floodplain Interaction

4.20.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting and river diversion works for the undesignated watercourse crossing. The proposed arrangements aim to minimise the length of culvert required through perpendicular crossing, with a diversion proposed to remove the watercourse from the road footprint and minimise the length of culvert required. These arrangements can be seen in Figure 4.20.2-1 and 4.20.2-2.

There are no bridge structures proposed within the extents of the undesignated watercourse model.

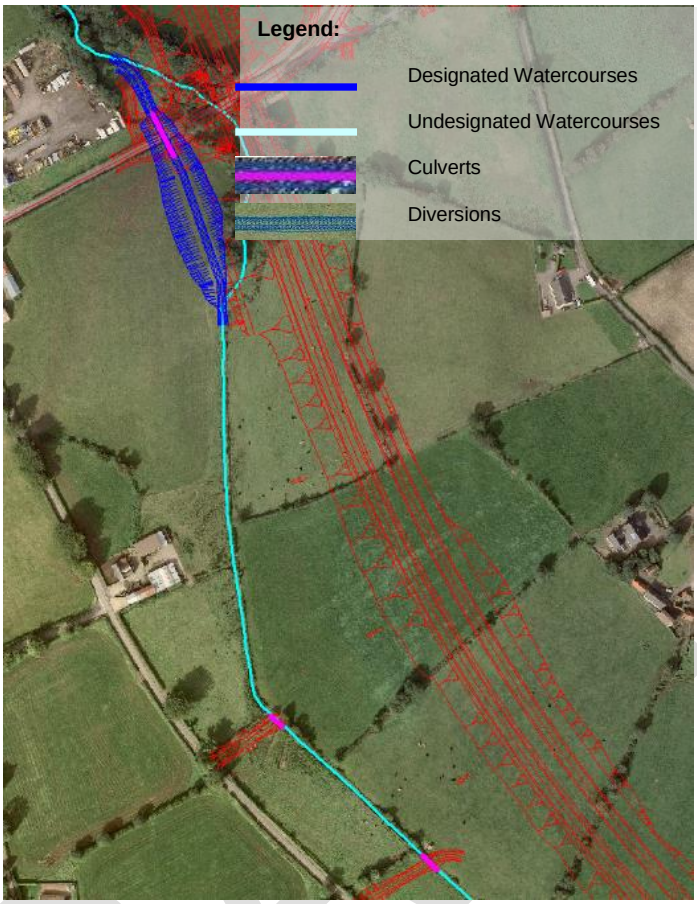

Figure 4.20.2-1 – Plan of Undesignated Watercourse Diversion (S3-WD-49) and Culvert Arrangement (S3-PC-23, S3-PC-64 and S3-PC-65)

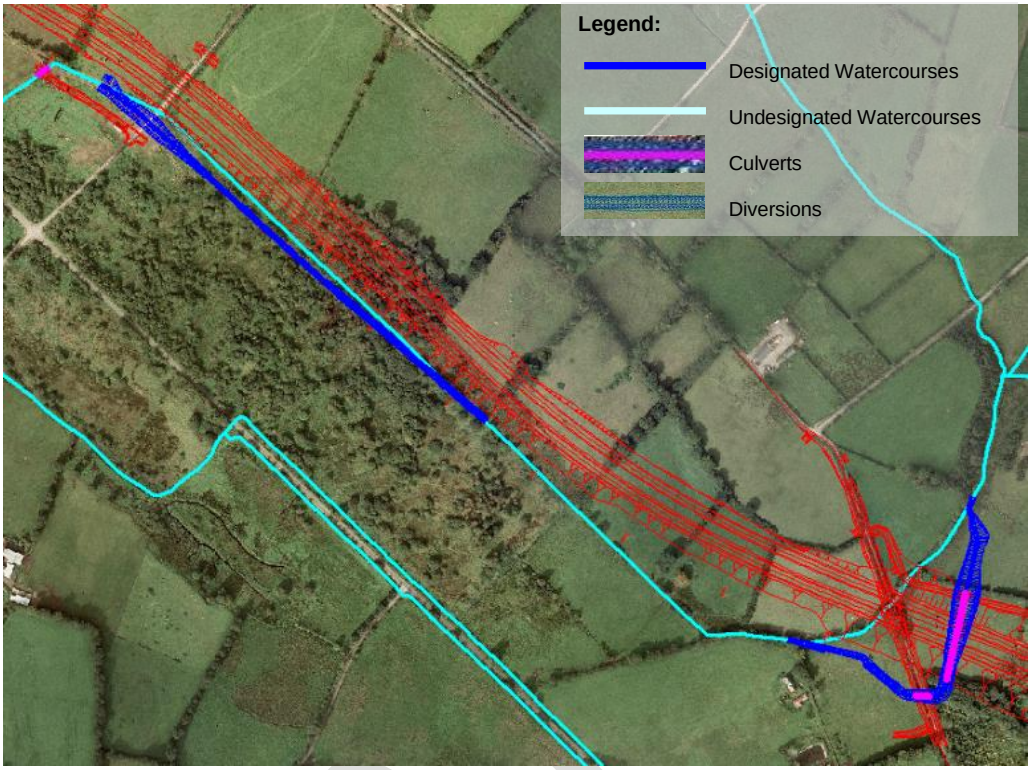

Figure 4.20.2-2 - Plan of Undesignated Watercourse Diversion (S3-WD-50 and S3-WD-51) and Culvert Arrangement (S3-PC-54, S3-PC-60 and S2-PC-72)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.20.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.20.2-1 - Model M.R Undesignated Watercourse Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
253335 359943	S3-PC-23	Box	2.7	2.1
253692 35956	S3-PC-64	Box	3.0	2.4
253485 359509	S3-PC-65	Box	3.0	2.4
254056 359125	S3-PC-72	Box	3.3	3.3
254908 358593	S3-PC-54	Box	2.4	2.1
254879 358542	S3-PC-60	Box	2.4	2.1

The proposed diversions have also been hydraulically modelled. Table 4.20.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.20.2-2 - Model M.R Undesignated Watercourse Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
253332 359909	S3-WD-49	Channel Length	233m	184m
		Channel Gradient	1:47	1:77, 1:25
254355 358891	S3-WD-51	Channel Length	567m	478m
		Channel Gradient	1:152	1:39, 1:289, 1:10, 1:48
254926 358659	S3-WD-50	Channel Length	240m	348m
		Channel Gradient	1:99	1:63, 1:100, 1:500

The culvert and diversion arrangements can be seen in Drawings 718736-S3-0500-0115 to 718736-S3-0500-0117 and718736-S3-0500-0105.

A comparison of the water elevations pre and post scheme is shown in Table 4.20.2-3 for specific points along the watercourse. These points can be seen in Figures 4.20.2-3 and 4.20.2-4:

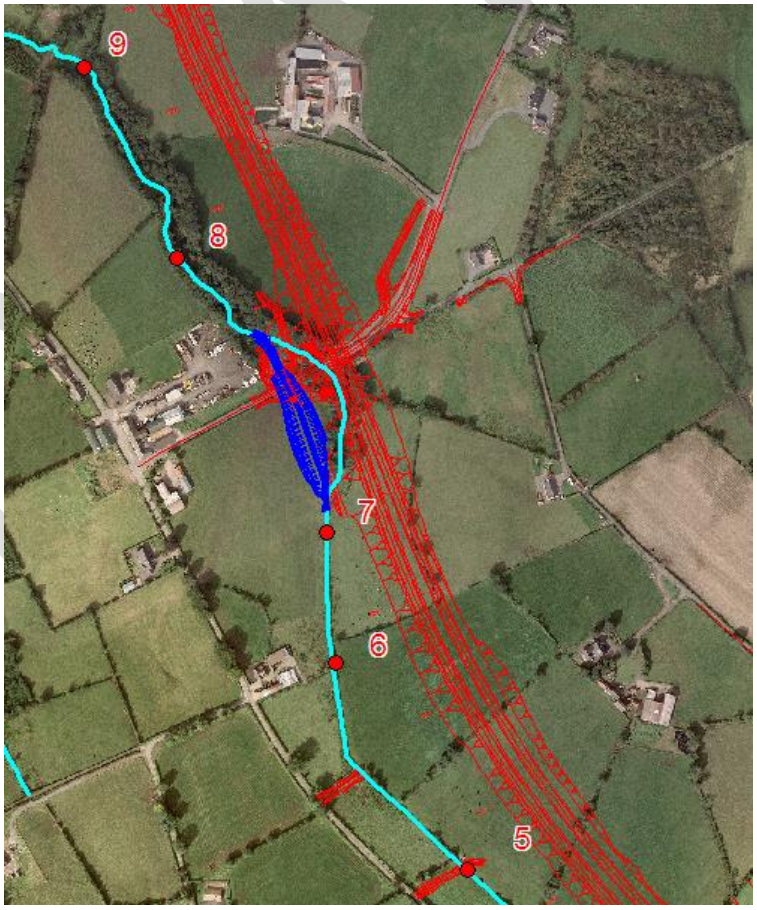

Figure 4.20.2-3 – Model M.R, Points for Water Elevation Comparison

Figure 4.20.2-4 – Model M.R, Points for Water Elevation comparison

Table 4.20.2-3 - Predicted Impact for Model M.R for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	145.429	145.386	-0.043
2	139.865	139.841	-0.024
3	135.608	135.542	-0.066
4	135.579	135.498	-0.081
5	134.638	134.633	-0.005
6	134.299	133.781	-0.518
7	133.284	133.507	+0.223
8	125.686	125.673	-0.013
9	121.11	121.096	-0.014

It is identified that the combined effect of the proposed culverts and diversions along the undesignated watercourse is a general reduction in water levels over the length of the watercourse. It is observed that at point 7 there is an increase of 223mm associated with local geometry changes at the proposed diversion.

4.20.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.20.1, approximately 70m^3 of floodwater is displaced as consequence of the Proposed Scheme; this displacement is at the upstream

reach of the undesignated watercourse. The compensatory storage location for this model can be seen in Figure 4.20.3-1.

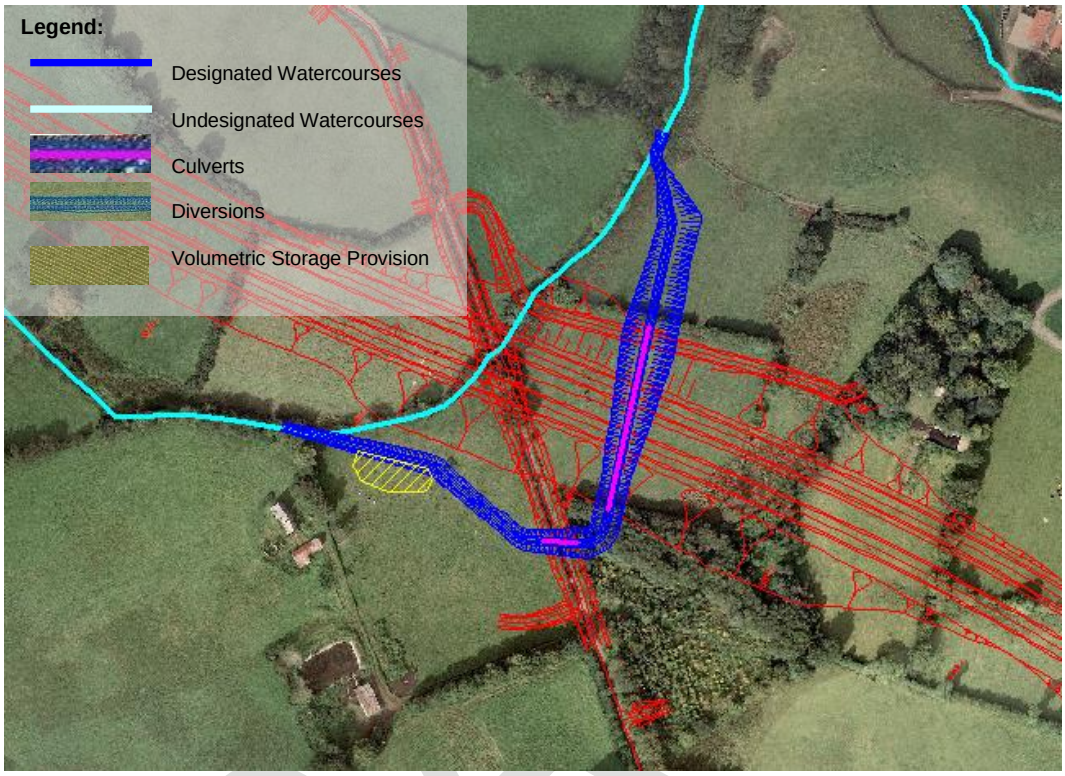

Figure 4.20.3-1 – Model M.R, Plan of Volumetric Floodplain Storage Provision (S3-CS-08)

Table 4.20.3-1 identifies the volumetric storage requirements; Drawing 718736-0500-D-00250 illustrates the application of this in detail.

Table 4.20.3-1 – Model M.R, Undesignated Watercourse (Newtownsaville) Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^2)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-08	254813	358574	~70	~70	~205	Undesignated

4.20.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects

are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.20.4-1 and Table 4.20.4-2.

Table 4.20.4-1 – Model M.R Undesignated Watercourse Flood Risk Assessment – Upstream Reach

No. of Properties within Floodplain	Importance	Magnitude	Significance
1 (Residential)	High	Minor Beneficial	Slight / Moderate

Table 4.20.4-2 – Model M.R Undesignated Watercourse Flood Risk Assessment – Downstream Reach

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Major Adverse	Slight / Moderate

It is identified that there is one residential property located within the extent of the floodplain and consequently the importance of the feature at this location is characterised as High. The model results show that for the upstream reach of the watercourse there is a general reduction in water levels of 24 to 81mm for the 100 year event. The magnitude of the impact is considered Minor Beneficial. Therefore, the significance of impact on the floodplain is considered to be Slight / Moderate.

There are no residential or commercial properties situated in the downstream watercourse reach consequently the importance of the feature is characterised as Low. The model results show that along this section of watercourse there is a change in water levels post scheme of 223mm (worst case), the magnitude of which is considered to be Major Adverse. Therefore, the significance of impact on the floodplain is considered to be Slight / Moderate.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the undesignated watercourse (Newtownsaville) is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to fewer than 10 industrial properties',*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S3-0500-0115 to 718736-S3-0500-0117 and718736-S3-0500-0105 in Appendix A.

4.21 Model M.S - Undesignated Watercourse - Kilgreen – Impact and Mitigation Assessment

4.21.1 Floodplain Interaction

The 100 year existing floodplain for this undesignated watercourse (Kilgreen) is linear in its shape, extending slightly from the river banks along the length of the watercourse.

It is identified that the Proposed Scheme crosses the watercourse at three locations. For the 100 year flood event, modelling indicates that approximately 25m^3 of floodwater is displaced as the result of the Proposed Scheme, refer to Figure 4.21.1-1.

Figure 4.21.1-1 – Undesignated Watercourse Floodplain Interaction

4.21.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting and river diversion works for the undesignated watercourse. The proposed arrangements aim to minimise the length of culvert required through perpendicular crossing, with a diversion proposed to remove the watercourse from the road footprint and minimise the length of culvert required and further engineering works aimed to rationalise watercourse crossings. These arrangements can be seen in Figure 4.21.2-1.

There are no bridge structures proposed within the extents of the undesignated watercourse model.

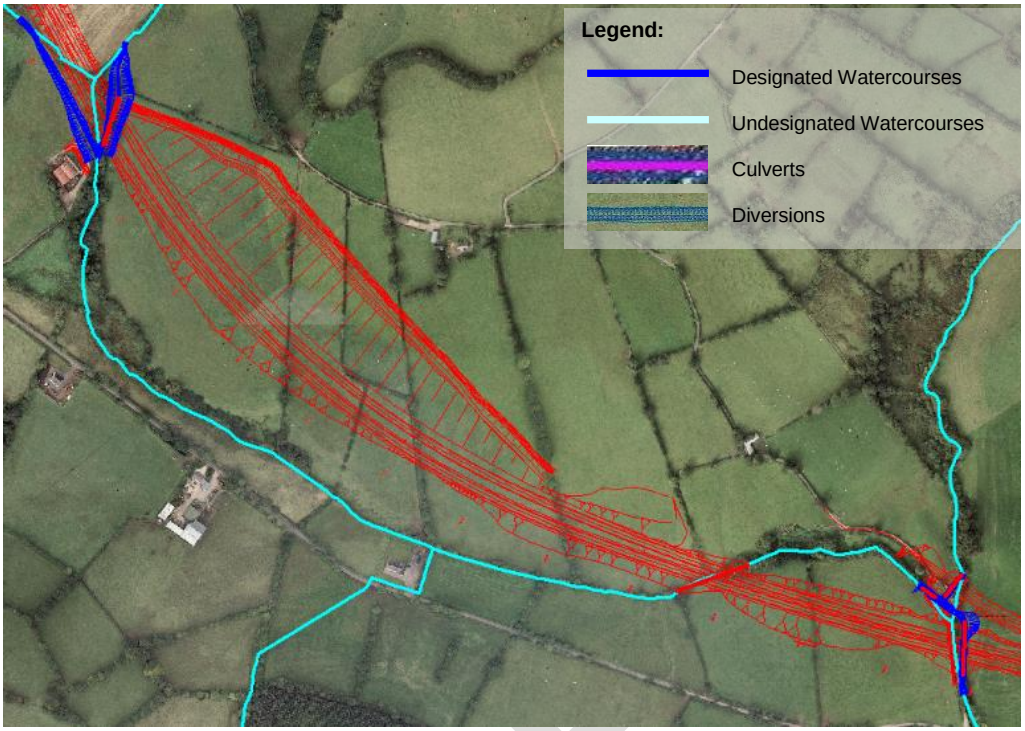

Figure 4.21.2-1 - Plan of Undesignated Watercourse Diversion (S3-WD-54, S3-WD-27 and S3-WD-28)and Culvert Arrangement (S3-PC-55, S3-PC-29, S3-PC-85, S3-PC-30 and S3-PC-31)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.21.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.21.2-1 - Model M.S Undesignated Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
255631 357832	S3-PC-55	Box	1.8	1.8
256351 357329	S3-PC-29	Box	2.1	2.1
256559 357298	S3-PC-85	Box	2.8	1.8
256592 357295	S3-PC-30	Box	2.1	2.1
256599 357232	S3-PC-31	Box	3.6	2.1

The proposed diversions have also been hydraulically modelled. Table 4.21.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.21.2-2 - Model M.S Undesignated Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
256583 357298	S3-WD-27	Channel Length	56m	39m
		Channel Gradient	1:26	1:86
256600 357269	S3-WD-28	Channel Length	131m	151m
		Channel Gradient	1:50	1:25, 1:44
256600 357269	S3-WD-54	Channel Length	156m	138m
		Channel Gradient	1:30	1:18

The culvert and diversion arrangements can be seen in Drawings 718736-S3-0500-0127, 718736-S3-0500-0121 and 718736-S3-0500-0122. A comparison of the water elevations pre and post scheme is shown in Table 3.20.2-3 for specific points along the watercourse. These points can be seen in Figure 4.21.2-2:

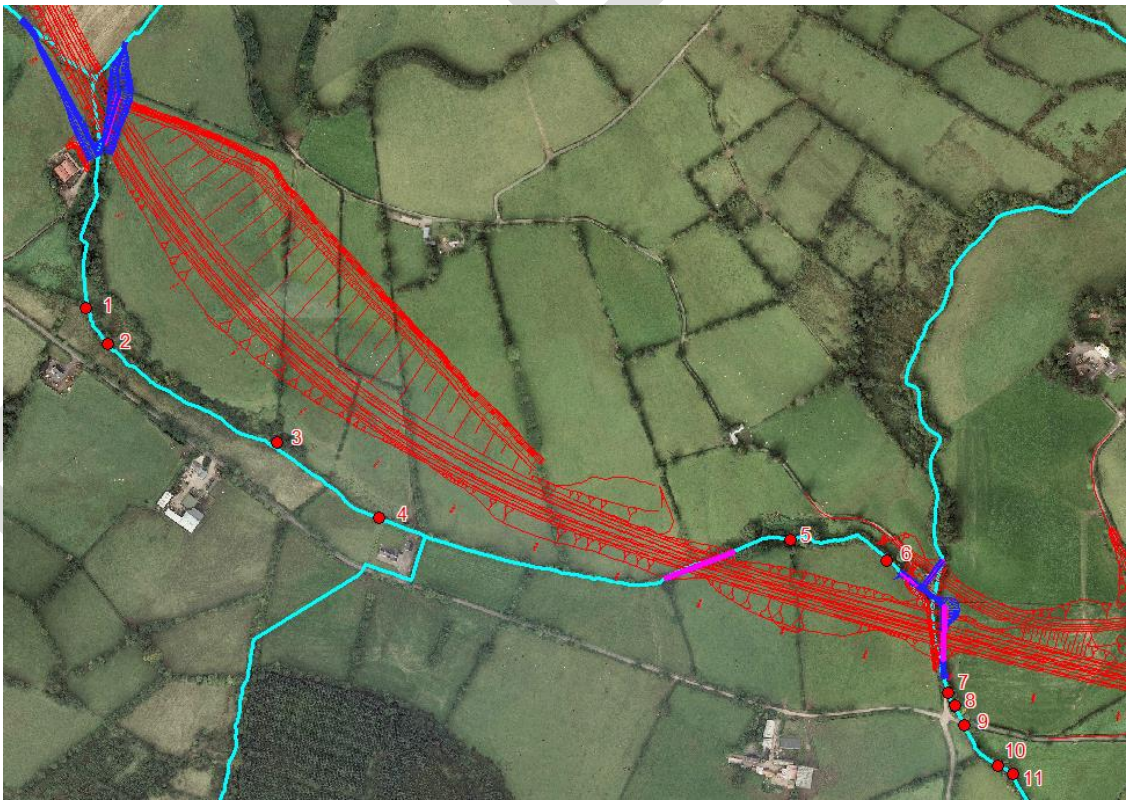

Figure 4.21.2-2 – Model M.S, Points along Channels for Water Elevation Comparison

Table 4.21.2-3- Predicted Impact for Model M.S for Proposed Scheme

	Existing Water	Post Road Water Elevation	Impact (m)
Point ID	100 Year	100 Year	100 Year
1	144.692	144.692	0
2	143.954	143.956	+0.002
3	134.561	134.650	+0.089
4	128.381	128.381	+0.021
5	116.816	116.816	+0.019
6	114.175	114.181	+0.006
7	109.308	109.312	+0.004
8	108.908	108.905	-0.003
9	108.661	108.661	0
10	107.684	107.684	0
11	107.276	107.276	0

It is identified that the combined effect of the proposed culverts and diversions result in a slight increase in water levels at most locations throughout the length of the model. The minor impacts associated with the 100 year design are attributed to the slight changes in the local geometry of the watercourse predicted post scheme. The model results show that for the worst case point location (point 3) there is an 89mm change in the 100year flood water levels post Proposed Scheme.

4.21.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.7.1, 25m^3 of floodplain associated with the alignment of the Proposed Scheme is displaced in relation to this watercourse, provision has been made within the proposed river diversion to accommodate this additional storage.

4.21.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.21.4-1.

Table 4.21.4-1 – Model M.S Undesignated Watercourse Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Moderate Adverse	Slight

There are no residential or commercial properties within the extent of the floodplain and consequently the importance of the feature is characterised as Low. The model results show that in general there is a slight increase in water levels for the 100 year flood water levels post scheme, with the worst case increase of 89mm. Therefore, the magnitude is considered to be Moderate Adverse. This significance of impact on the floodplain is considered to be Slight.

On review of the overall qualifying conditions for assessment score of flood risk, the score for this undesignated watercourse is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to fewer than 10 industrial properties'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S3-0500-0127, 718736-S3-0500-0121 and 718736-S3-0500-0122 in Appendix A.

4.22 Model M.T - Roughan River – Impact and Mitigation Assessment

4.22.1 Floodplain Interaction

The 100 year existing floodplain for the Roughan River is diffuse in its shape, with out of bank flow extending / accumulating in low lying areas extending significantly from the river banks. It is also noted that there is a single property located within the predicted extents of the 100 year floodplain.

It is identified that the mainline alignment for the Proposed Scheme crosses the Roughan River floodplain at one location. A proposed side road also crosses the Roughan River at one location, the side road also crosses an undesignated tributary at one location; refer to Figure 4.22.1-1.

For the 100 year flood event, modelling indicates that approximately 4,985m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.22.1-1.

It is further observed that the Proposed Scheme bisects a portion of the Roughan River floodplain and consequently has the potential to disrupt flowpaths and floodplain connectivity.

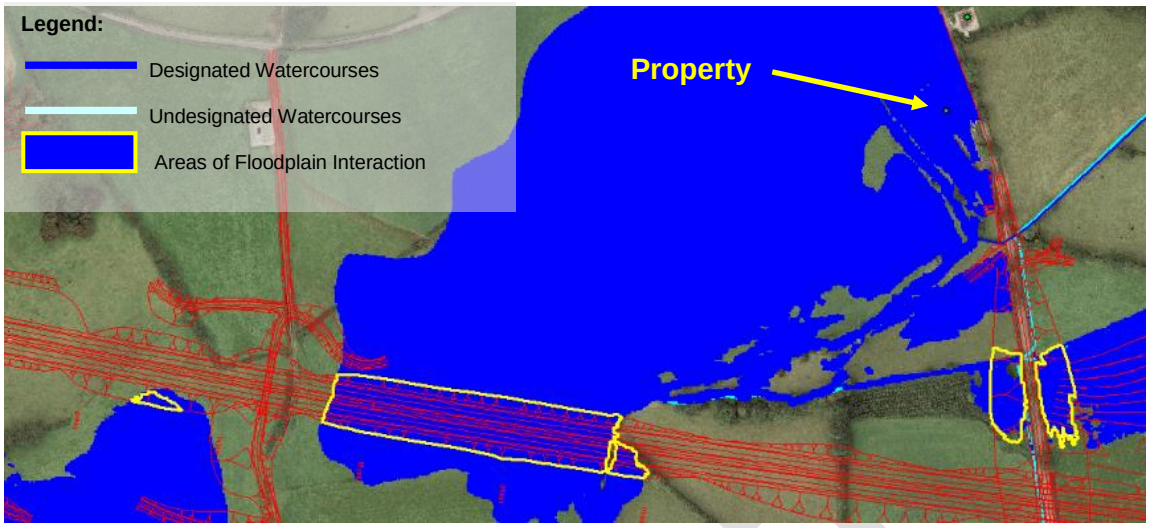

Figure 4.22.1-1 - Roughan Floodplain Interaction

4.22.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes culverting and river diversion works of the Roughan River and an undesignated watercourse. The proposed arrangements aim to minimise the length of culverts required, through perpendicular crossings. These arrangements can be seen in Figure 4.22.2-1.

There are no bridge structures proposed within the extents of the Roughan River model.

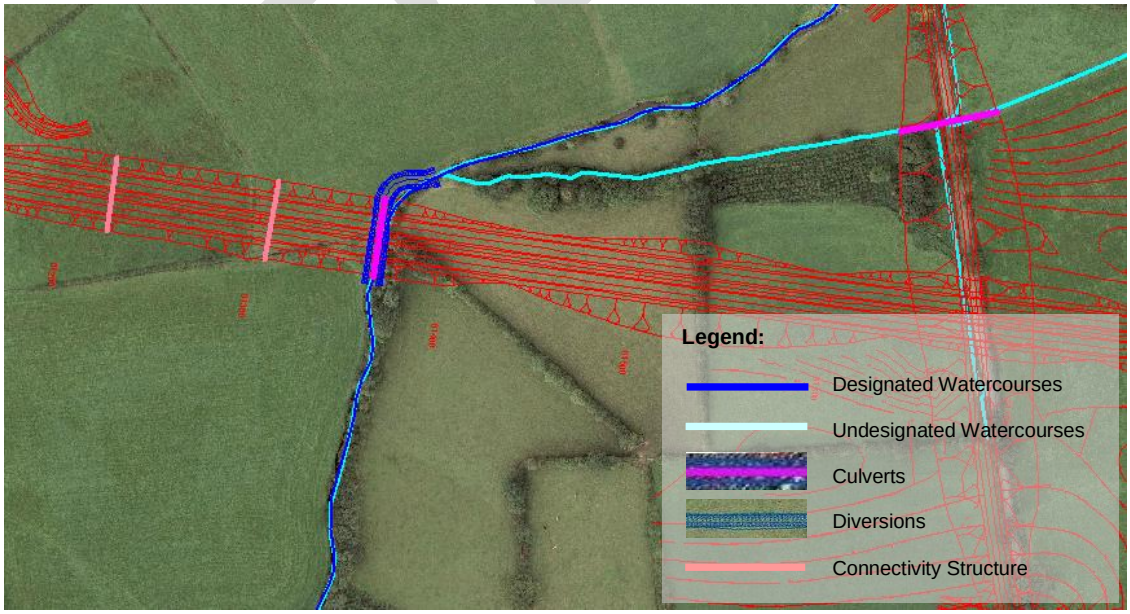

Figure 4.22.2-1 - Plan of Roughan River and Undesignated Watercourse Diversion (S3-WD-90), Culvert Arrangement (S3-PC-34 and S3-PC-68) and Connectivity Culvert Arrangement (S3-CC-01 and S3-CC-02)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.22.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.22.2-1 - Model M.T – Roughan Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
259701 356608	S3-PC-34	Box	5.7	2.4
260002 356654	S3-PC-68	Box	2.1	2.1

The proposed diversion has also been hydraulically modelled. Table 4.22.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient. The culvert and diversion arrangements can be seen in Drawing 718736-S3-0500-0106.

Table 4.22.2-2 - Model M.T – Roughan Diversion Characteristics``

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
259708 356624	S3-WD-90	Channel Length	70m	78m
		Channel Gradient	1:167	1:216

It is proposed that floodplain conveyance structures are provided to mitigate the potential impacts arising from loss of natural flow-paths. The proposed connectivity structures, located through the embankment, facilitate the conveyance of floodwaters under the proposed alignment thus minimising the impact of loss of storage area. Details of these structures are shown in Table 4.22.2-3 below and the location of the culverts can be seen in Drawing 718736-S3-0500-0106.

Table 4.22.2-3 – Model M.T Roughan Modelled Connectivity Structures`

Location	Connectivity Structures Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
259559 356619	S3-CC-01	Box	1.2	1.2
259642 356605	S3-CC-02	Box	1.2	1.2

A comparison of the water elevations pre and post scheme is shown in Table 4.22.2-4 for specific points along the watercourse. These points can be seen in Figure 4.22.2-2:

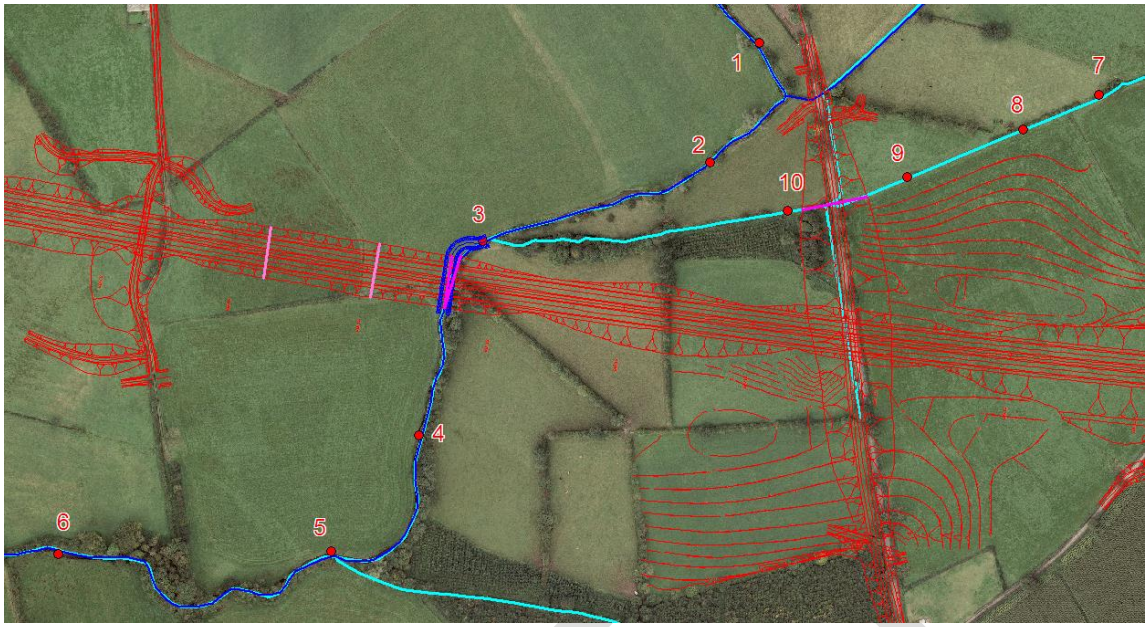

Figure 4.22.2-2 – Model M.T, Points along Channel for Water Elevation Comparison

Table 4.22.2-4 - Predicted Impact for Model M.T for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	68.746	68.744	-0.002
2	67.978	67.982	+0.004
3	67.076	67.005	-0.071
4	66.218	66.219	+0.001
5	65.179	65.180	+0.001
6	63.429	63.430	+0.001
7	67.595	67.597	+0.002
8	67.186	67.087	-0.099
9	67.163	67.032	-0.131
10	67.082	67.016	-0.066

It is observed that for the 100 year event for the Roughan watercourse, the river engineering proposals results in a general reduction in water levels at most locations throughout the length of the model. The minor impacts associated with the 100 year design event are considered localised.

4.22.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.22.1, approximately 4,985m^3 of floodwater is displaced as consequence of the Proposed Scheme. The compensatory storage location (reference S3-CS-09) for this model can be seen in Figure 4.22.3-1 below.

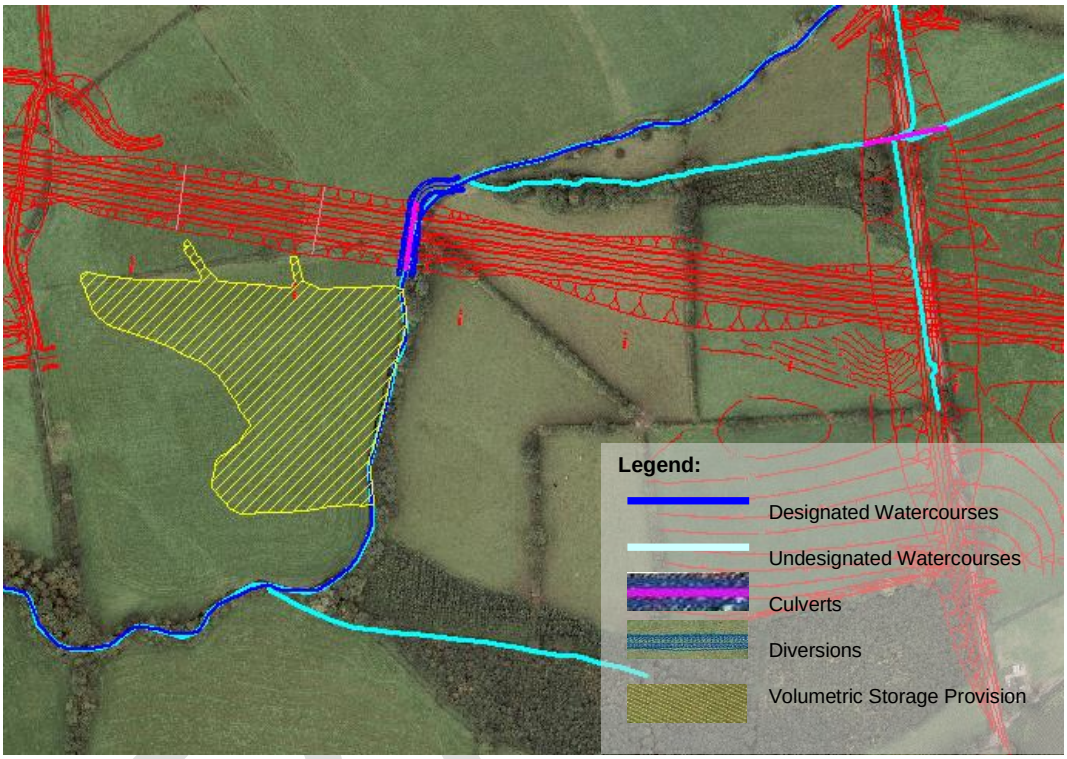

Figure 4.22.3-1 – Model M.T, Plan of Volumetric Floodplain Storage Provision (S3-CS-09)

Table 4.22.3-1 identifies the volumetric storage requirements; Drawing 718736-0500-D-00251 illustrates the application of this in detail.

Table 4.22.3-1 – Model M.T, Roughan River Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^2)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-09	259631	356521	~4985	~4985	~14,440	Roughan

4.22.4 Residual Post Scheme Flood Risk

Assessment methodologies (Annex IV) within the DMRB (45/09) have been used to categorise residual post scheme flood risk, whereby the importance of

the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact. This information can be seen in Table 4.22.4-1.

Table 4.22.4-1 – Model M.T Undesignated Watercourse Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
1 Residential	High	Negligible	Neutral

There is one residential property within the extent of the floodplain and consequently the importance of the feature is characterised as High. The model results show that along the length of the Roughan River there is a localised increase (4mm) in predicted water levels, as such the magnitude of impact is considered negligible. The significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Roughan River is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0106 in Appendix A.

4.23 Model M.U - Ballygawley River – Impact and Mitigation Assessment

4.23.1 Floodplain Interaction

In the locality of the Proposed Scheme the 100 year existing floodplain for the Ballygawley River is extensive with flood defences (construction 2013) being provided to St. Ciaran's High School and residential properties at Tullybryan Road. However, the Proposed Scheme only interacts with the floodplain at two locations. The following figures depict the potential extent of the Proposed Scheme interaction with the Ballygawley Water floodplain south of the existing A4 road.

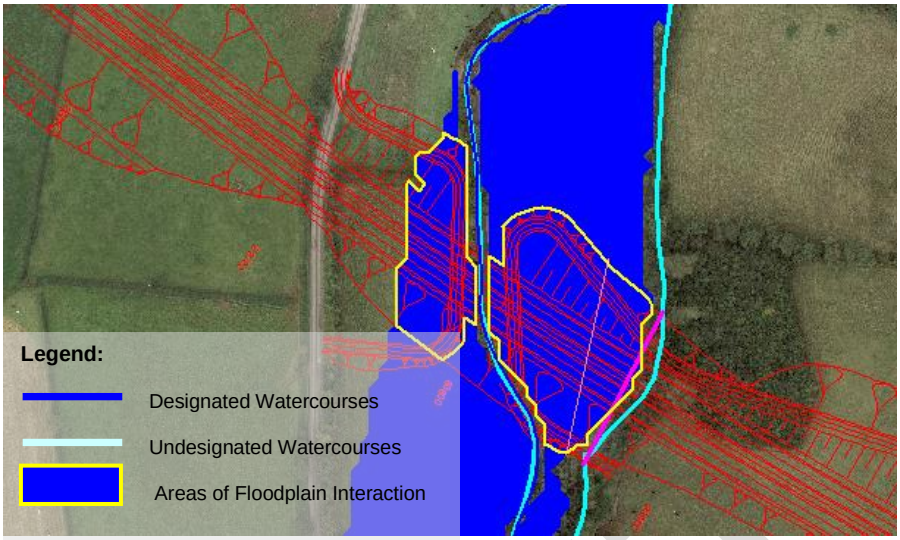

Figure 4.23.1-1 – Ballygawley Water System Floodplain Interaction

South of the existing A4 the A5 WTC crosses perpendicular to the Ballygawley Water and its associated floodplain. It is identified that the combined alignment has the potential to affect conveyance along the Ballygawley Water if proposed crossing structures are not sized appropriately and also interfere with floodplain flow-paths adjacent to the river if connectivity is not provided.

The Proposed Scheme would also interact with the existing floodplain in the vicinity of the A4 road. However, current flow-paths/connectivity would not be altered.

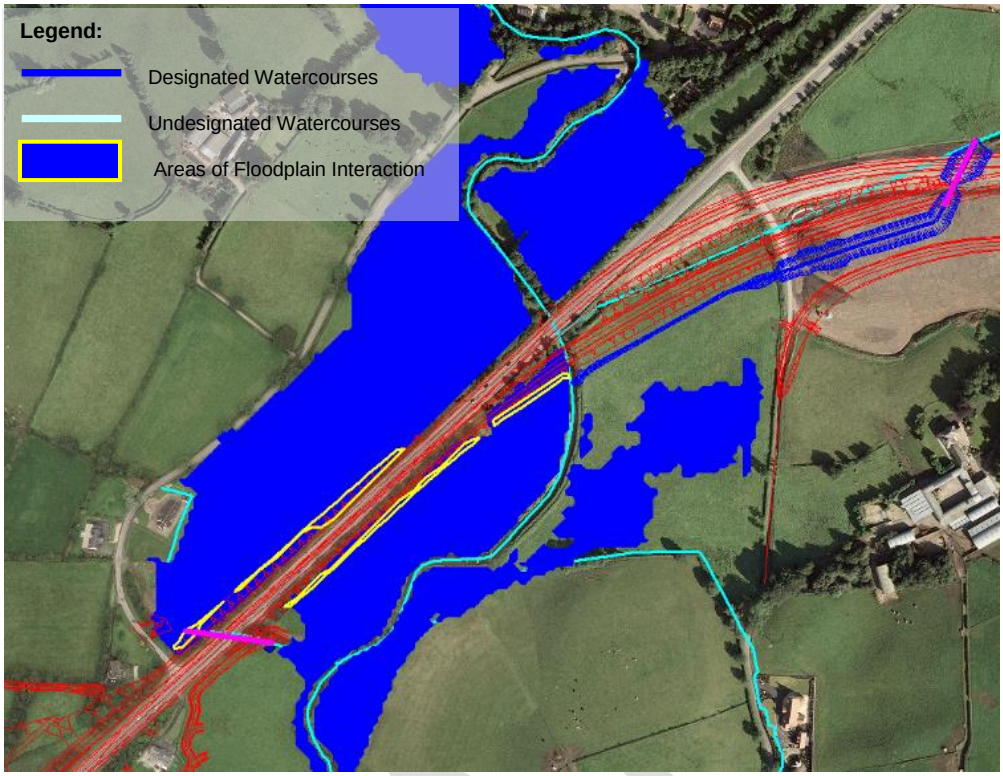

Figure 4.23.1-2 – Ballygawley Water System Floodplain Interaction

The displacement of flood water arising from Figure 4.23.1-1 and Figure 4.23.1-2 is approximately 5,820m^3.

It is further identified that as the Proposed Scheme involves an upgrade to the existing A4 road there is no additional disruption to floodplain flow-paths or connectivity.

4.23.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes a new bridge at the A4 road across the Ballygawley River to approximately match the dimensions of the existing A4 crossing, Figure 4.23.2-1. Further to this and to maintain the existing hydraulic operation of the Ballygawley Water south of the A4 / A5 proposed roundabout the proposals include a new bridge crossing of the river. This arrangement can be seen in Figure 4.23.2-2 and Table 4.23.2-2.

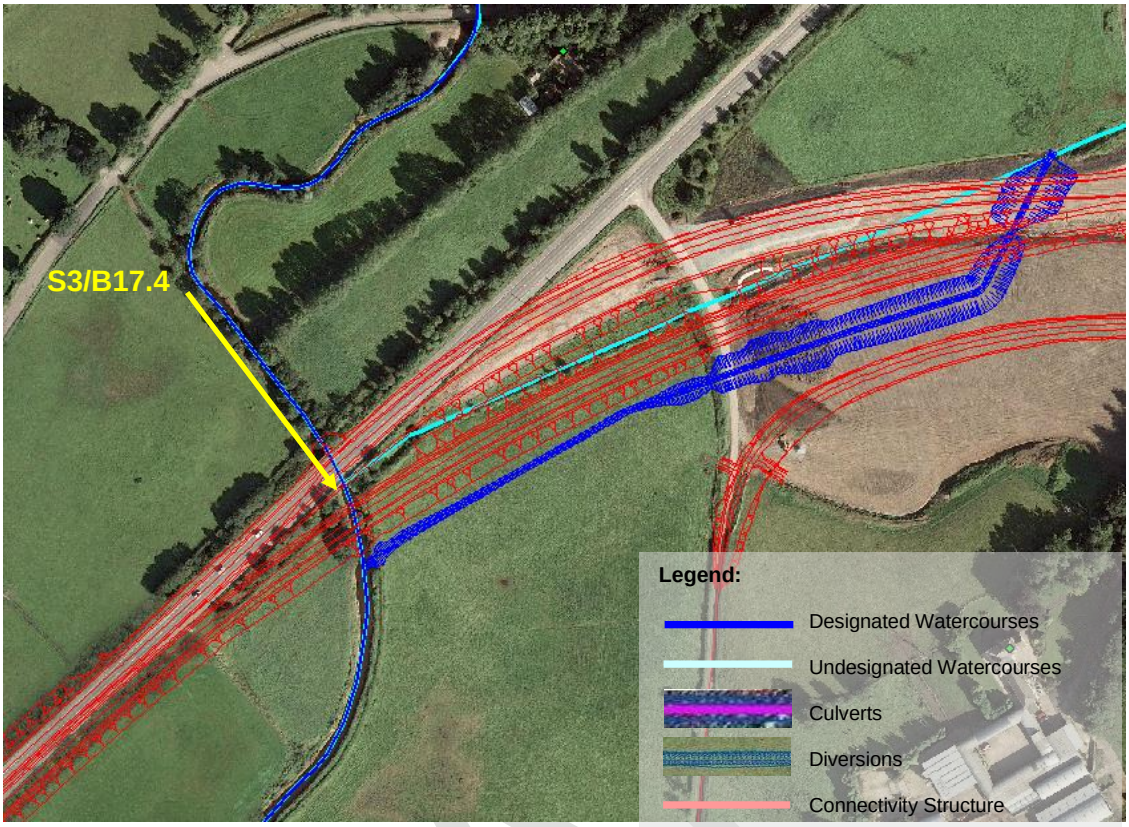

Figure 4.23.2-1 - Plan of Ballygawley River Bridge Structure (S3/B17.4)

(Note: the undesignated tributaries in the above image has not been included within the model)

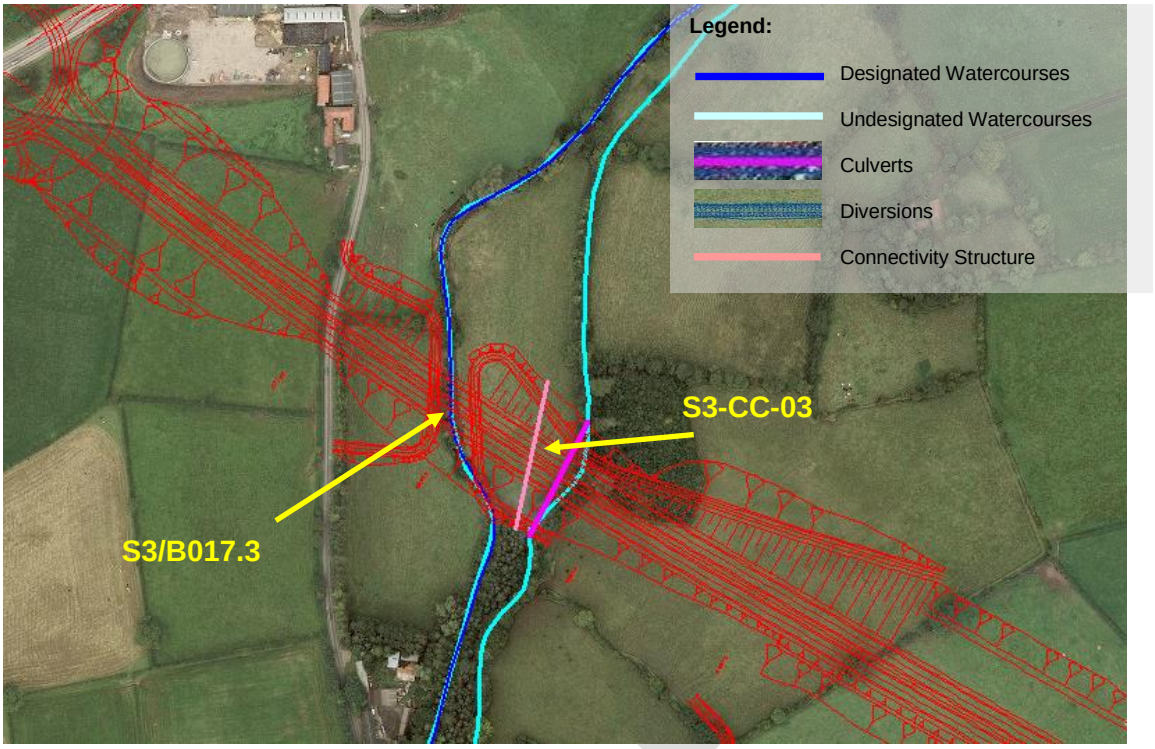

Figure 4.23.2-2 – Plan of Ballygawley Water Bridge Crossing Location (S3/B017.3) and Connectivity Culvert arrangement (S3-CC-03)

Table 4.23.2-1 – Model U– Ballygawley Water System Bridge Structure Arrangement

Location Grid Reference	Watercourse Name	Bridge Reference	Bridge Span (m)	Min. Design Soffit Level (mAOD)
261919 355779	Ballygawley Water	S3/B017.3	13+25+13	60.57
262366 356539	Ballygawley Water	S3/B17.4	12	63.8

The general arrangement of the bridge structures can be seen in Drawings 718736-1700-D-0520 and 718736-1700-D-0514.

As identified in Section 4.23.1 the Proposed Scheme south of the A4 has the potential to disrupt the conveyance of floodplain flows and floodplain connectivity unless suitable mitigation is provided. A floodplain conveyance structure is proposed as detailed below in Table 4.23.2-2. The conveyance structure arrangement can be seen in Drawings 718736-S3-0500-0114, 718736-S3-0500-0107 and 718736-S3-0500-0108.

Table 4.23.2-2 - Model U – Ballygawley Water River System Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
261952 355757	S3-CC-03	Box	4.0	1.5

4.23.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.23.1, approximately 5,520m^3 of floodwater is displaced as consequence of the Proposed Scheme. The compensatory storage location (reference S3-CS-10) for this model can be seen in Figure 4.23.3-1 below.

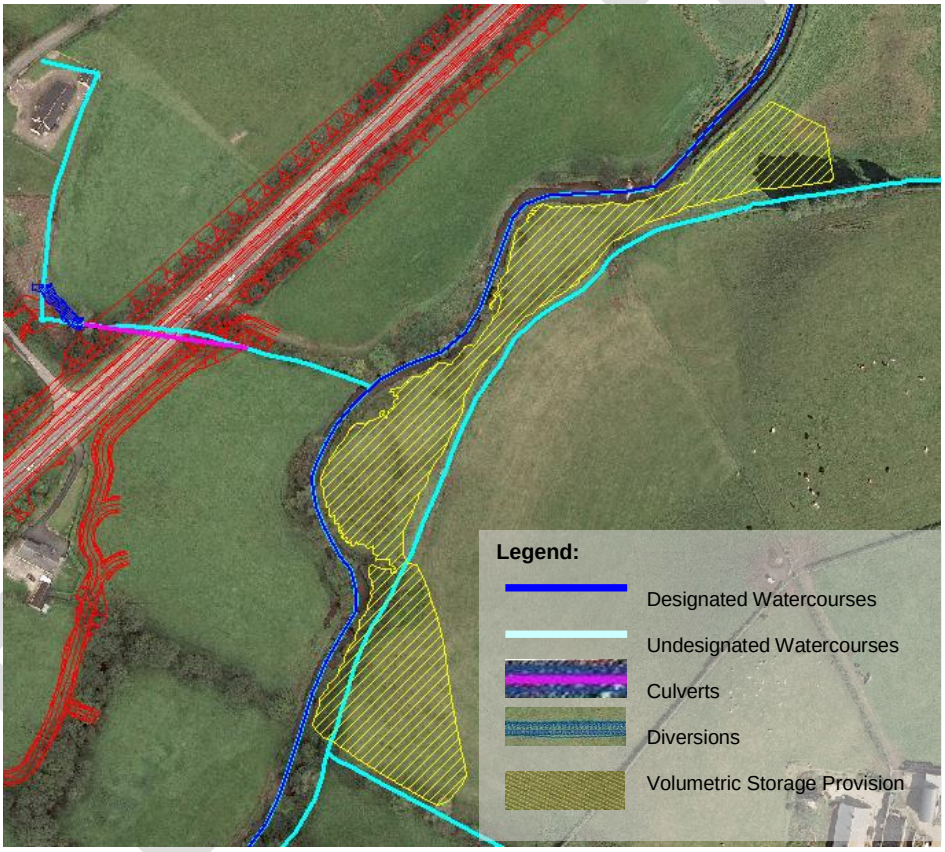

Figure 4.23.3-1 – Model M.U, Plan of Volumetric Floodplain Storage Provision (S3-CS-10)

Table 4.23.3-1 below details the storage compensation proposals for the Ballygawley Water for the Proposed Scheme. Drawing 718736-0500-D-00253 illustrates the application of this in detail.

Table 4.23.3-1 – Model M.U, Ballygawley Water Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^2)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-10	262302	356355	~5820	~5820	~8010	Ballygawley River

4.23.4 Residual Post Scheme Flood Risk

A comparison of the water elevations pre and post scheme is shown in Table 4.23.4-1 for specific points along the watercourse. These points can be seen in Figure 4.23.4-1:

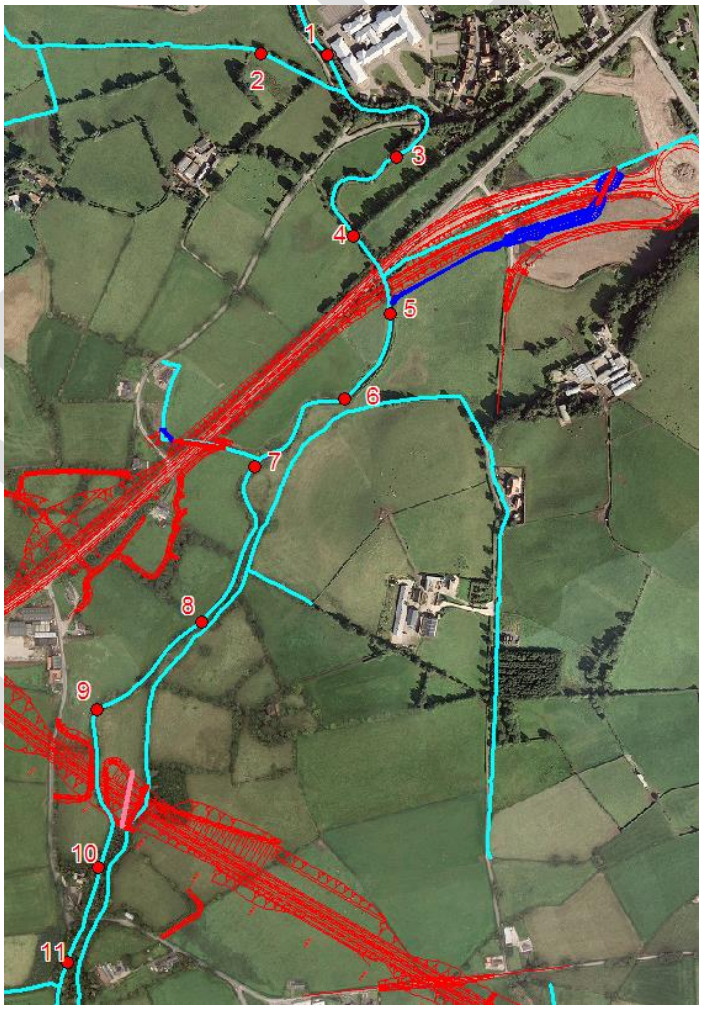

Figure 4.23.4-1 – Model M.U, Points along Channel for Water Elevation Comparison

Table 4.23.4-1 - Predicted Impact for Ballygawley Water for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	64.352	64.353	+0.001
2	64.278	64.279	+0.001
3	63.395	63.423	+0.028
4	63.125	63.202	+0.077
5	62.325	62.399	+0.074
6	61.685	61.727	+0.042
7	61.34	61.29	-0.05
8	60.476	60.479	+0.003
9	59.908	59.969	+0.061
10	59.569	59.536	-0.033
11	59.121	59.087	-0.034

It can be seen in Table 4.23.4-1 that the impacts vary at each point ID along the main river channels, and the maximum difference in water level impacts along the channels is 77mm. This is considered to be due to the proposed bridge structure associated with Proposed Scheme.

In consideration of the nature of this floodplain and the overall variability in water depths across the floodplain, the residual post mitigation flood impacts are presented for the floodplain areas (taken from 2D model output).

Figure 4.23.4- 2 depicts the 100 year event impacts for the A5 WTC Proposed Scheme floodplain. Generally, impacts vary upon floodplain location, however, to simplify the presentation of this information, impact values are shown in key locations which are indicative of the impacts across discrete floodplain areas, and in some cases the impacts vary within these discrete areas.

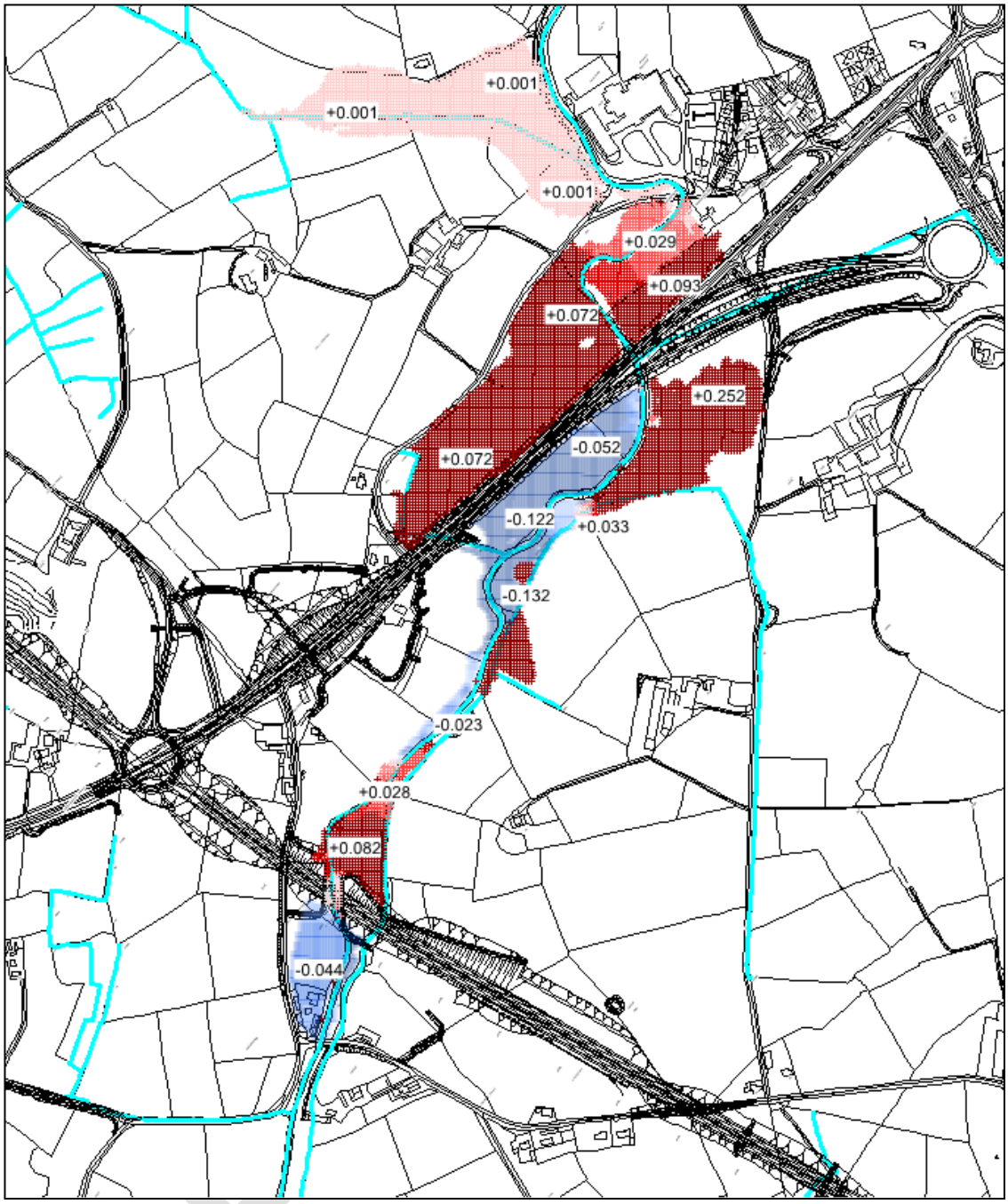

Figure 4.23.4-2 – Model M.U, Flood Impact Assessment Areas

It is observed that there are both increases and decreases in relation to peak predicted water levels (design event), therefore, the impact of the proposed scheme, incorporating bridge structures and storage compensation, is to modify the dynamics of inundation.

It is identified that there are afflux effects associated with both of the proposed structures; it is observed that the design of bridge structure S3/B17.4 is constrained by the arrangements currently in place at the A4 and that proposals

for S3/B17.3 encompass a 41.5m span structure with an additional 4m connectivity conveyance structure.

Furthermore, the alteration of ground levels to facilitate storage compensation modify the flooding mechanisms along the left bank of the river downstream of the A4 road, resulting in a more extensive floodplain area and additional storage of flood waters within agricultural fields outside of the identified storage compensation areas.

Assessment methodologies (Annex IV) within the DMRB have been used to categorise residual post scheme flood risk, whereby the importance of the floodplain, the magnitude of impact and the significance of potential effects are assessed to collectively categorise significance of residual impact.

The overall residual post scheme flood risk for the A5 WTC comprising the Proposed Scheme is presented in Table 4.23.4-2 below.

Table 4.23.4-2 – Model M.U Ballygawley Water Flood Risk Assessment

Flood Water Level Impact (mm)	No. of Properties within Floodplain	Importance	Magnitude	Significance	Overall Assessment Score for Flood Risk
+252	0	Low	Major Adverse	Slight/Moderate	Slight Adverse
+93	0	Low	Moderate Adverse	Slight	Slight Adverse
+82	0	Low	Moderate Adverse	Slight	Slight Adverse
+72	Flood Defence Feature	High	Moderate Adverse	Moderate/Large	Moderate Adverse
+33	0	Low	Minor Adverse	Neutral	Slight Adverse
+29	0	Low	Minor Adverse	Neutral	Slight Adverse
+28	0	Low	Minor Adverse	Neutral	Slight Adverse
+22	Flood Defence Feature	High	Minor Adverse	Slight/Moderate	Slight Adverse
+1	Flood Defence Feature	High	Negligible	Neutral	Neutral
-23	0	Low	Minor Beneficial	Neutral	Slight Beneficial
-44	1 residential	High	Minor Beneficial	Slight/Moderate	Slight Beneficial
-52	0	Low	Moderate Beneficial	Slight	Slight Beneficial
-122	0	Low	Major Beneficial	Slight/Moderate	Slight Beneficial
-132	0	Low	Major Beneficial	Slight/Moderate	Slight Beneficial

**Includes the effects of compensatory storage re-profiling*

The modelling output indicates that the largest representative water level increase of 252mm occurs in compensatory storage areas or within agricultural lands without any property occurrence, therefore, the overall assessment score at these locations is considered Slight Adverse.

In the vicinity of the A4 Annaghilla Road where a property or flood defence attribute is located there is a peak water level increase of 72mm, the overall impact of which is considered Moderate Adverse.

It is further observed that downstream of the proposed A5WTC where a property is located within the floodplain there is a reduction in peak water levels (design event) of 44mm, the overall impact of which is considered Slight Beneficial.

It is concluded that in overall terms the influence of the road on flood risk is slight, accounting for the interaction of potential water level changes and occurrence of residential properties.

On review of the overall qualifying conditions for assessment score of flood risk based on the worst case, the score for the Ballygawley Water floodplain area is Moderate Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) …. > 50mm resulting in an increased risk of flooding to 1 – 10 residential properties.'*, however, benefits in relation to water levels are also realised.

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S3-0500-0114, 718736-S3-0500-0107 and 718736-S3-0500-0108 in Appendix A.

4.24 Model M.V – MW4230 Tullyvar Drain – Impact and Mitigation Assessment

4.24.1 Floodplain Interaction

Based on the flood model formed entirely from LiDAR data the 100 year existing floodplain for Tullyvar drain is attributable to localised topography whereby land adjacent to the watercourse is flat and low lying, resulting in the spread of flood water either side of the river banks.

For the 100 year flood event, modelling indicates that approximately 3,825m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figure 4.24.1-1:

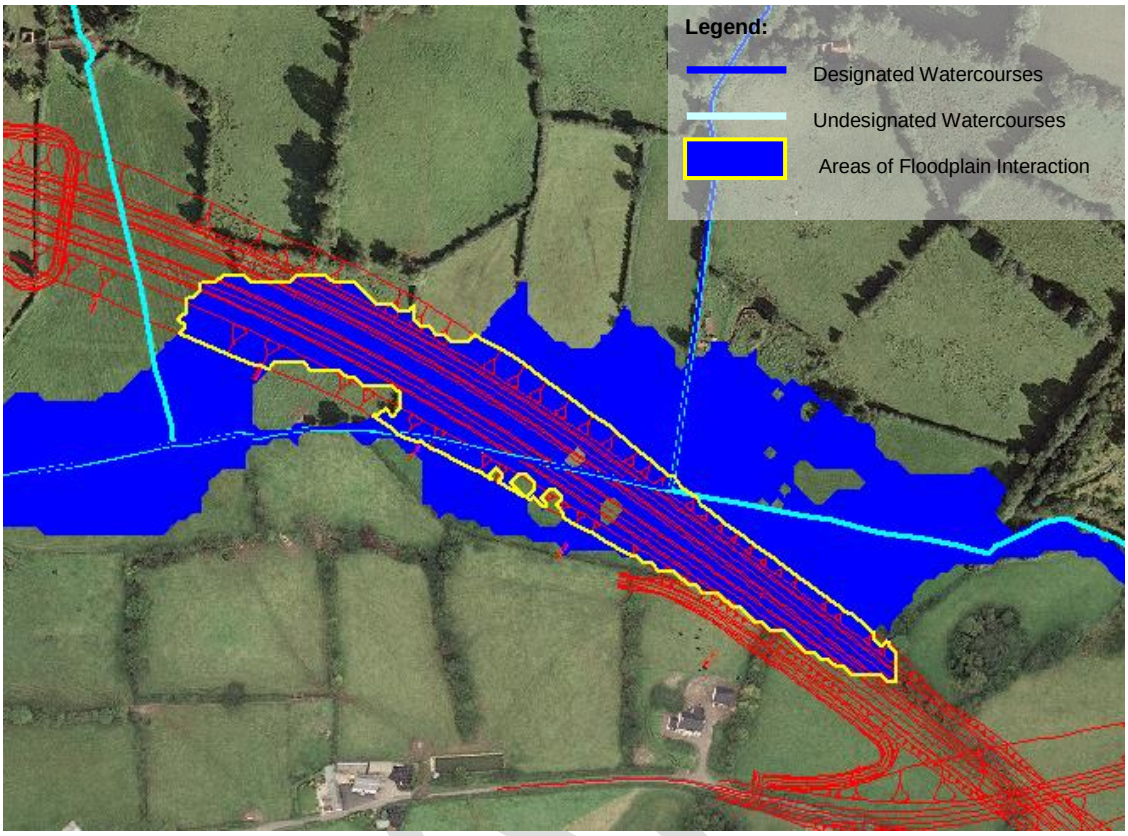

Figure 4.24.1-1 - Tullyvar Floodplain Interaction

4.24.2 Mitigation Assessment – Structures, Culverts and Diversions

There are two diversions associated with the Tullyvar model. Both diversions aim to minimise the length of culverts required as the watercourses will be culverted perpendicularly to the Proposed Scheme. This arrangement can be seen in Figure 4.24.2-1.

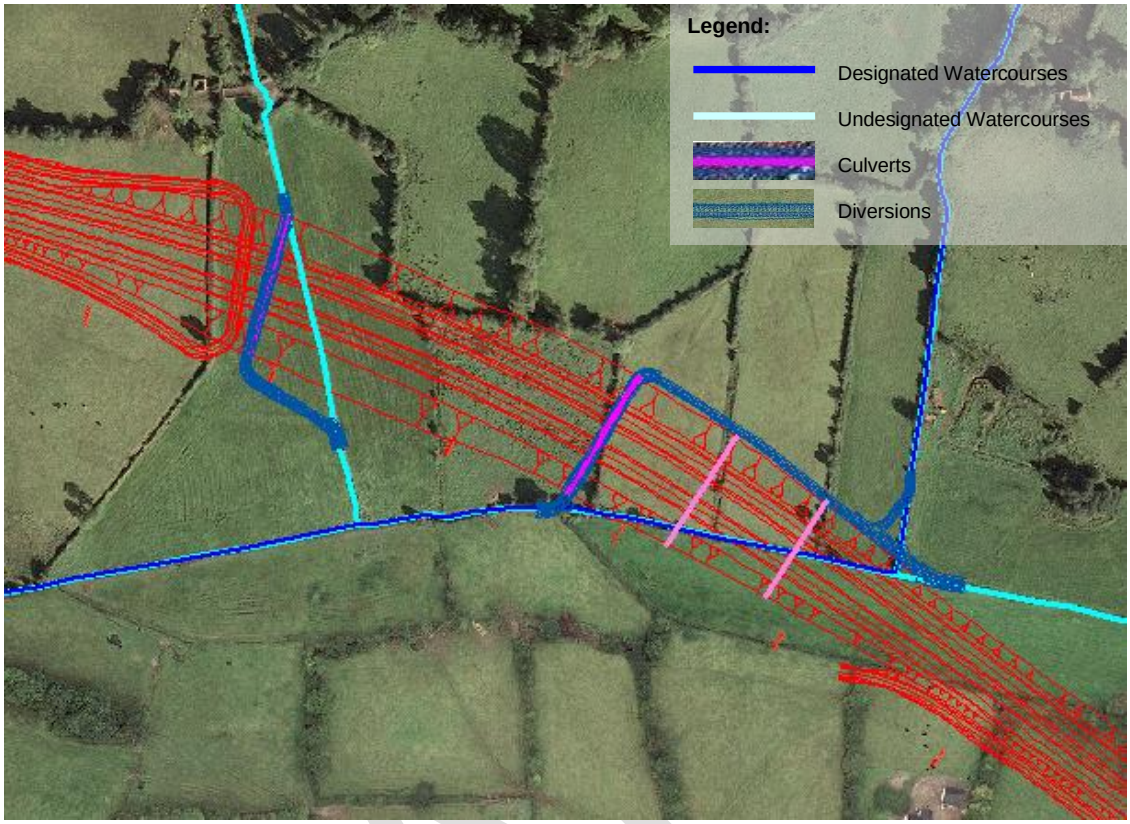

Figure 4.24.2-1 - Plan of Tullyvar Diversion (S3-WD-73, S3-WD-33 and S3-WD-34) and Culvert Arrangement (S3-PC-39 and S3-PC-40) and Connectivity Culvert Arrangement (S3-CC-04 and S3-CC-05)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.24.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.24.2-1 - Model M.V – Tullyvar Drain Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
263803 354889	S3-PC-39	Pipe	-	1.5 Ø
263970 354816	S3-PC-40	Box	3.9	2.4

The proposed diversions have also been hydraulically modelled. Table 4.24.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.24.2-2 - Model M.V - Tullyvar Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
263798 354847	S3-WD-73	Channel Length	115m	155m
		Channel Gradient	LiDAR	1:40, 1:180, 1:80
264118 354781	S3-WD-33	Channel Length	27m	35m
		Channel Gradient	LiDAR	1:123.5
264055 354811	S3-WD-34	Channel Length	177m	284m
		Channel Gradient	1:73	1:63, 1:500

The culvert and diversion arrangements can be seen in Drawing 718736-S3-0500-0109.

It can be observed in Figure 4.24.1-1 that floodplain connectivity is potentially affected by the Proposed Scheme. It is proposed that floodplain conveyance structures are provided for this model to mitigate the reduction in floodplain connectivity due to the location of the Proposed Scheme. Details of these structures are shown in Table 4.24.3-3 below:

Table 4.24.2-3 – Model M.V Tullyvar Drain Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
264028 354791	S3-CC-04	Box	1.5	1.5
264077 354758	S3-CC-05	Box	1.5	1.5

A comparison of the water elevations pre and post scheme is shown in Table 4.24.4-4 for specific points along the watercourse. These points can be seen in Figure 4.24.4-2:

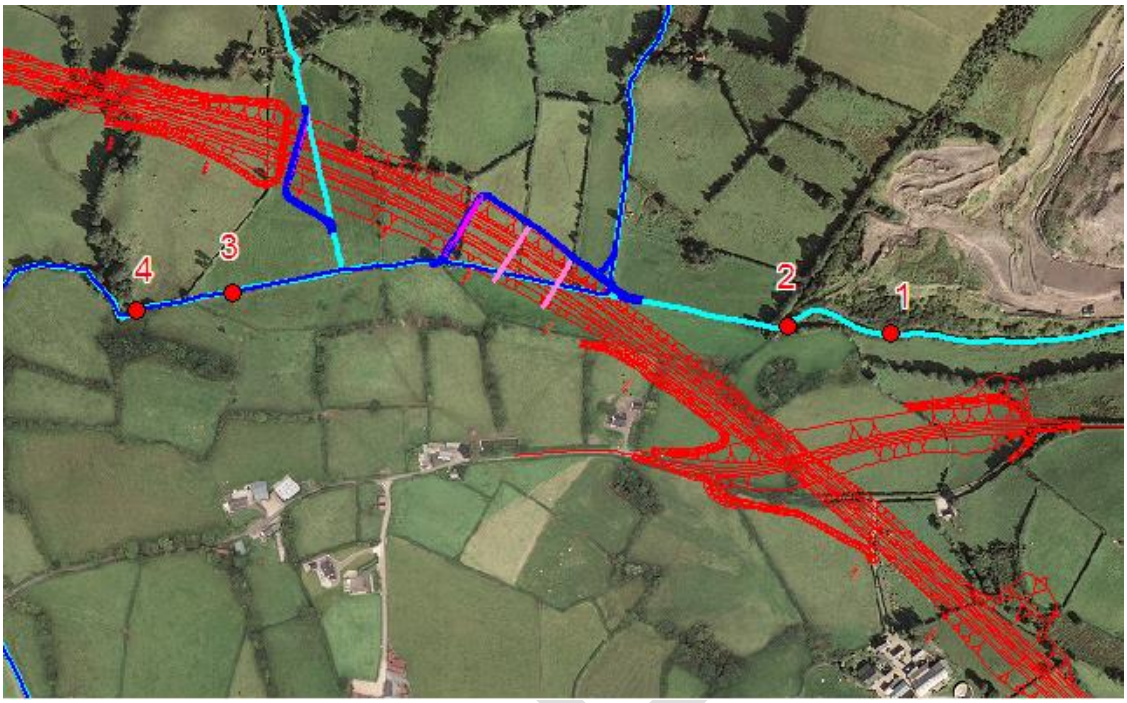

Figure 4.24.2-2 – Model M.V, Points along Channel for Water Elevation Comparison

Table 4.24.2-4 - Predicted Impact for Model M.V Tullyvar Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	69.607	69.607	0
2	68.731	68.731	0
3	65.684	65.685	0.001
4	65.532	65.533	0.001

It is observed that for the 100 year event for the Tullyvar watercourse, the river engineering proposals result in a negligible increase in water levels at downstream locations in the model. The minor impacts associated with the 100 year design event are considered localised.

4.24.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As mentioned in Section 4.23.1, approximately 3,825m^3 of floodwater is displaced due to the Proposed Scheme. Therefore, areas of land are proposed for compensatory storage. The compensatory storage locations (references S3-CS-11.1, S3-CS-11.2 and S3-CS-12) for this model can be seen in Figure

3.24.3-1 below and Drawing 718736-S3-0500-0109 with more detailed information in Drawings 718736-0500-D-00255 and 718736-0500-D-00256.

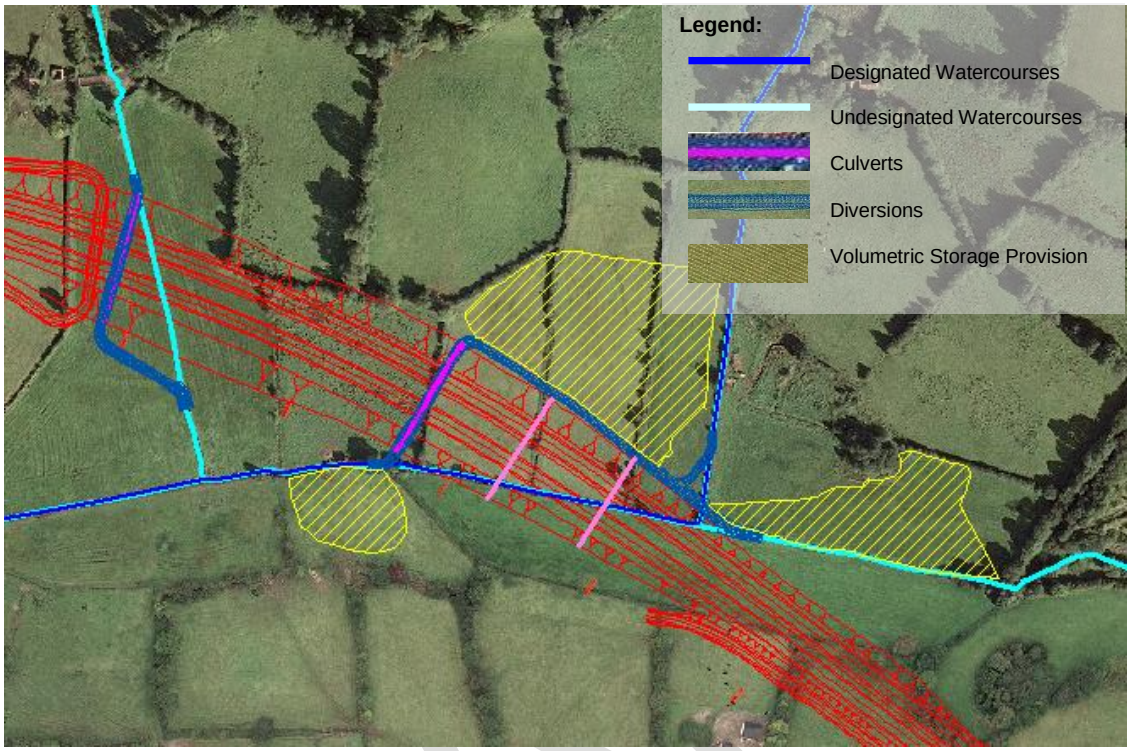

Figure 4.24.3-1 – Model M.V, Plan of Volumetric Floodplain Storage Provision (S3-CS-11.1, S3-CS-11.2 and S3-CS-12)

Table 4.24.3-1 below details the storage compensation proposals for the Tullyvar Drain for the Proposed Scheme

Table 4.24.3-1 – Model M.V; Tullyvar Drain Water Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-11.1	264082	354861	~3825	~3825	~2345	UD_101
S3-CS-11.2	264240	354749			~5185	UD_101
S3-CS-12	263930	354752			~2424	Tullyvar
					Total = ~9955	

4.24.4 Residual Post Scheme Flood Risk

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed. This information can be seen in Table 4.24.4-1:

Table 4.24.4-1 – Model M.V Tullyvar Drain Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Negligible	Neutral

There are no residential or commercial properties within the extent of the floodplain and the importance of the feature is Low. The model results show that there is minimal change in predicted water levels, as such the magnitude of impact is considered Negligible. The significance of impact on the floodplain is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for Tullyvar Drain is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0109 in Appendix A.

4.25 Model M.W – Ravella Drain – Impact and Mitigation Assessment

4.25.1 Floodplain Interaction

For the 100 year flood event, modelling indicates that there is no floodplain associated with the watercourse at this location and consequential there is no floodwater displaced as the result of the Proposed Scheme, refer to Figure 4.25.1-1. However, it is observed that flooding within the vicinity of the scheme is indicated within Rivers Agency Flood Maps, as referenced within A5 WTC Flood Risk Assessment Report 2. Rivers Agency maps indicate that these predictions are based on strategic modelling of river reaches and it is therefore considered that these do not have the same level of confidence as applied to those modelled in detail.

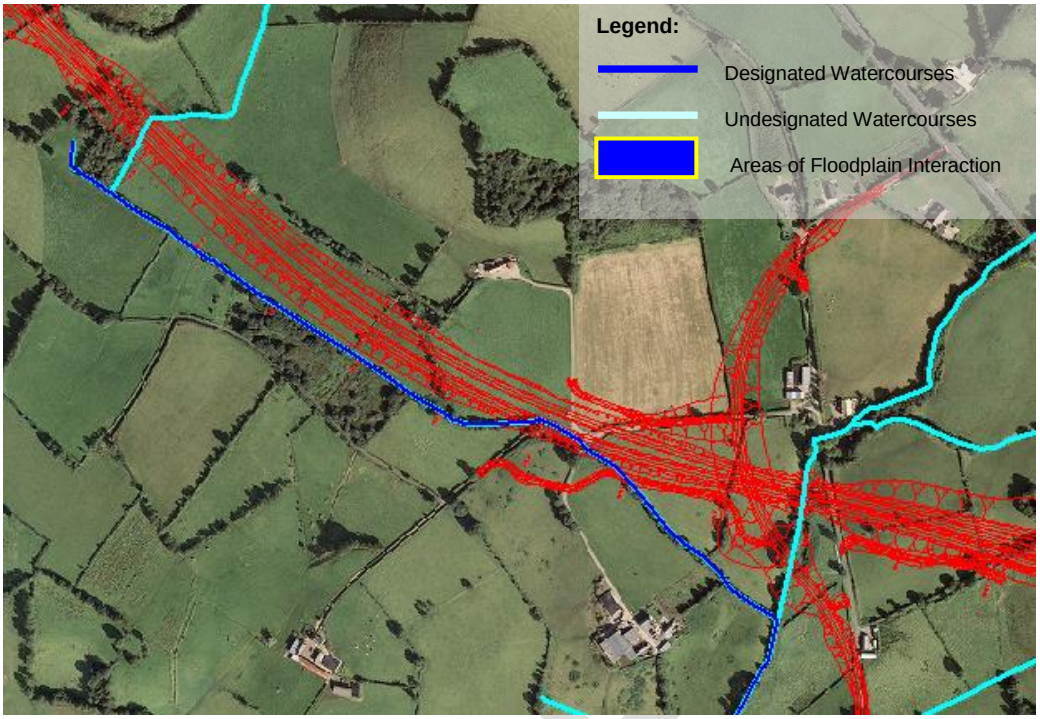

Figure 4.25.1-1 - Ravella Drain Floodplain Interaction

4.25.2 Mitigation Assessment – Structures, Culverts and Diversions

There are two proposed culverts and one diversion associated with the Ravella Drain. The diversion is required to remove the watercourse from the Proposed Scheme footprint. The culvert and diversion arrangement can be seen in Figure 4.25.2-1.

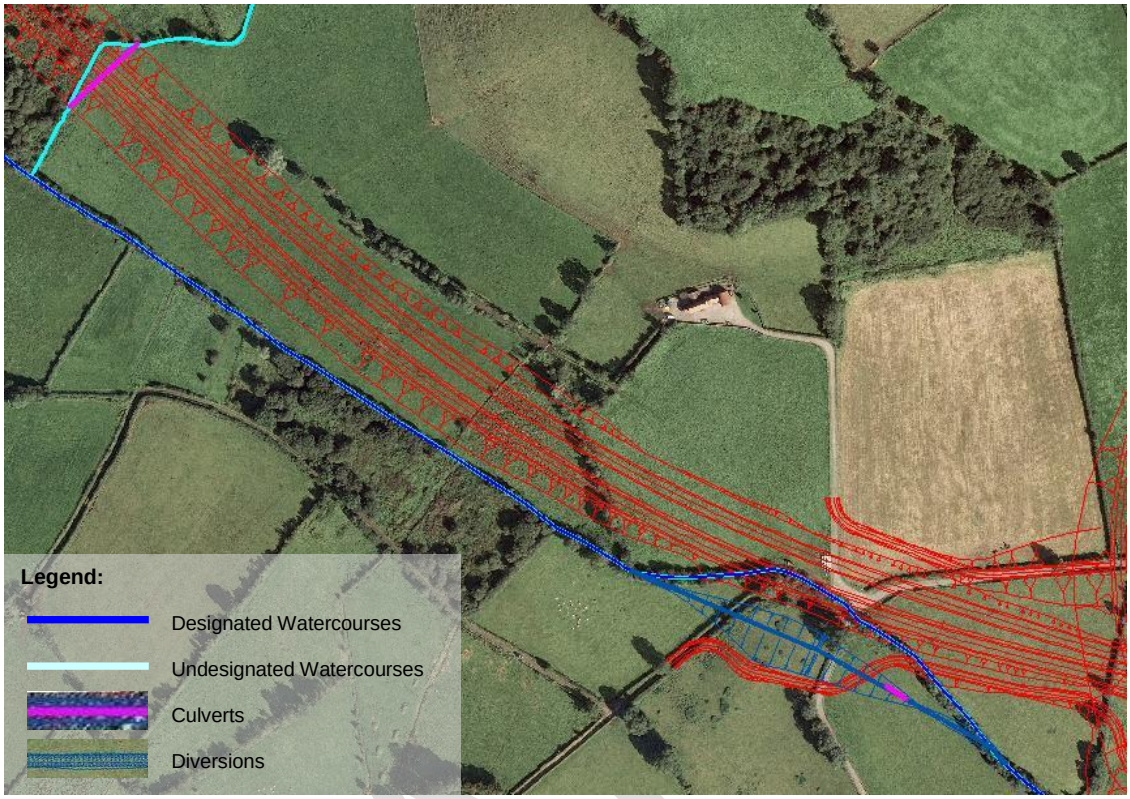

Figure 4.25.2-1 - Plan of Ravella Drain Diversion (S3-WD-62) and Culvert Arrangement (S3-PC-41 and S3-PC-57)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.25.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.25.2-1 – Model M.W – Ravella Drain Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
264683 354246	S3-PC-41	Box	2.1	1.8
265166 353868	S3-PC-57	Box	2.1	1.8

The proposed diversion has also been hydraulically modelled. Table 4.25.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.25.2-2 - Model M.W – Ravella Drain Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
265094 353903	S3-WD-62	Channel Length	276m	259m
		Channel Gradient	1:114	1:170, 1:44

The culvert and diversion arrangement can be seen in Drawing 718736-S3-0500-0110.

A comparison of the water elevations pre and post scheme is shown in Table 4.25.2-3 for specific points along the watercourse. These points can be seen in Figure 4.25.2-2:

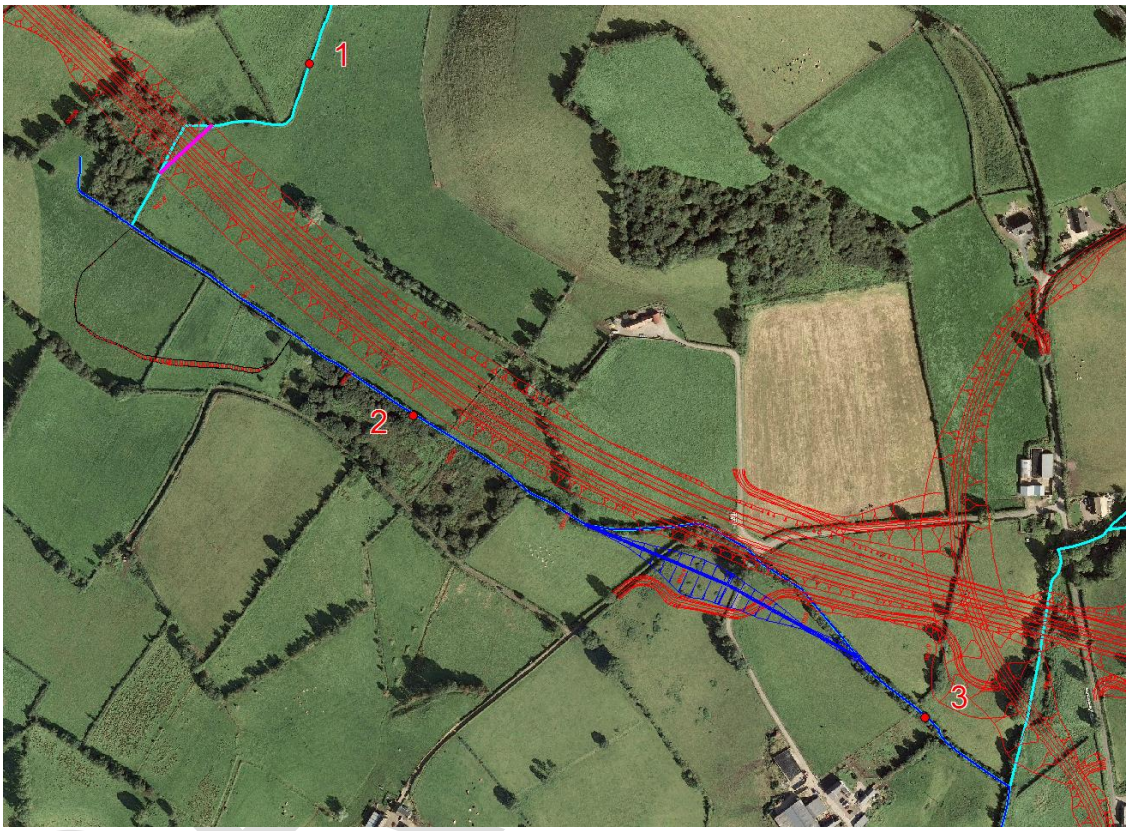

Figure 4.25.2-2 – Model M.W, Points along Channel for Water Elevation Comparison

Table 4.25.2-3 - Predicted Impact for Model M.W Ravella Drain for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	69.615	69.449	-0.166
2	64.315	64.283	-0.032
3	59.781	59.780	-0.001

It is observed that for the 100 year event for Ravella Drain, the river engineering proposals result in a general reduction in water levels throughout the length of the model. The minor impacts associated with the 100 year design event are considered localised and attributable to the slight changes in the local geometry post scheme (gradient, alignment and channel cross section).

4.25.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As mentioned in section 4.25.1, detailed hydraulic modelling indicates that no floodwater is displaced due to the Proposed Scheme. It is considered that river engineering proposals mitigate flood risk impacts associated with the Proposed Scheme. However, as floodplain is indicated on the Rivers Agency Strategic Flood Maps an area of land has been identified for compensatory storage, it is anticipated that this requirement will be reviewed during later value engineering stages. The compensatory storage location (reference S3-CS-13) for this model can be seen in Figure 4.25.3-1 below and Drawing 718736-S3-0500-0110. Table 4.25.3-1 provides supplementary information.

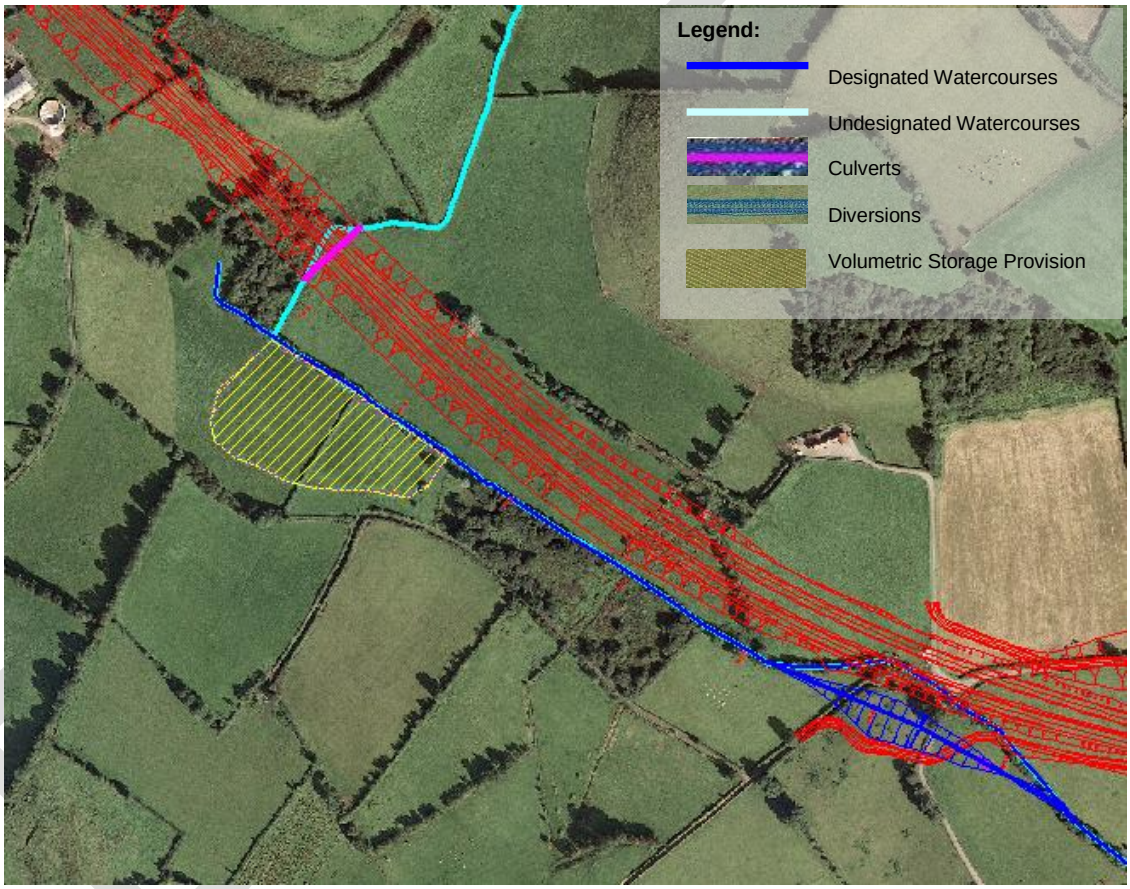

Figure 4.25.3-1 – Model M.W, Volumetric Floodplain Storage Provision (S3-CS-13)

Table 4.25.3-1 – Model M.W; Ravella Drain Water Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-13	264676	354100	-	-	Indicative Area	UD_86.1

4.25.4 Residual Post Scheme Flood Risk

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed. This information can be seen in Table 4.25.4-1:

Table 4.25.4-1 – Model M.W Ravella Drain Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Negligible	Neutral

On the basis of the hydraulic modelling undertaken for the Proposed Scheme it is identified that there is no floodplain associated with the Ravella Drain at this location; furthermore there are no residential or commercial properties within the extent of the Rivers Agency Strategically mapped floodplain. Consequently the importance of the feature is characterised as Low. The model results show that there is minimal change in water levels, as such, the magnitude of impact is considered to be Negligible. The significance of the potential effects is Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Ravella Drain is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0110 in Appendix A.

4.26 Model M.X – Undesignated Watercourse – Impact and Mitigation Assessment

4.26.1 Floodplain Interaction

The 100 year existing floodplain for this undesignated watercourse is linear in its shape, extending slightly from the river banks.

It is identified that where the Proposed Scheme crosses the undesignated watercourse there is no notable out of channel flooding for the 100 year event and consequently there is no displacement of floodplain, as shown in Figure 4.26.1-1.

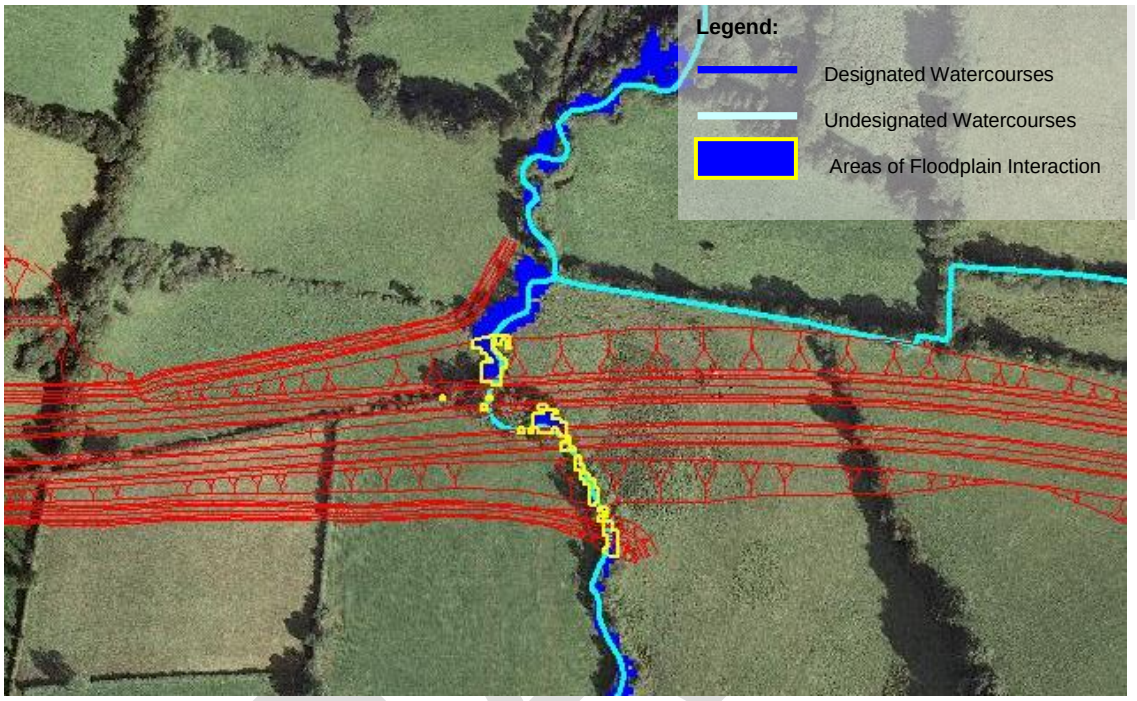

Figure 4.26.1-1 - Undesignated Watercourse Floodplain Interaction

4.26.2 Mitigation Assessment – Structures, Culverts and Diversions

The Proposed Scheme includes a culvert and river diversion for the undesignated watercourse. The proposed arrangement aims to minimise the length of culvert required. This arrangement can be seen in Figure 4.26.2-1.

There are no bridge structures proposed within the extents of the undesignated watercourse model.

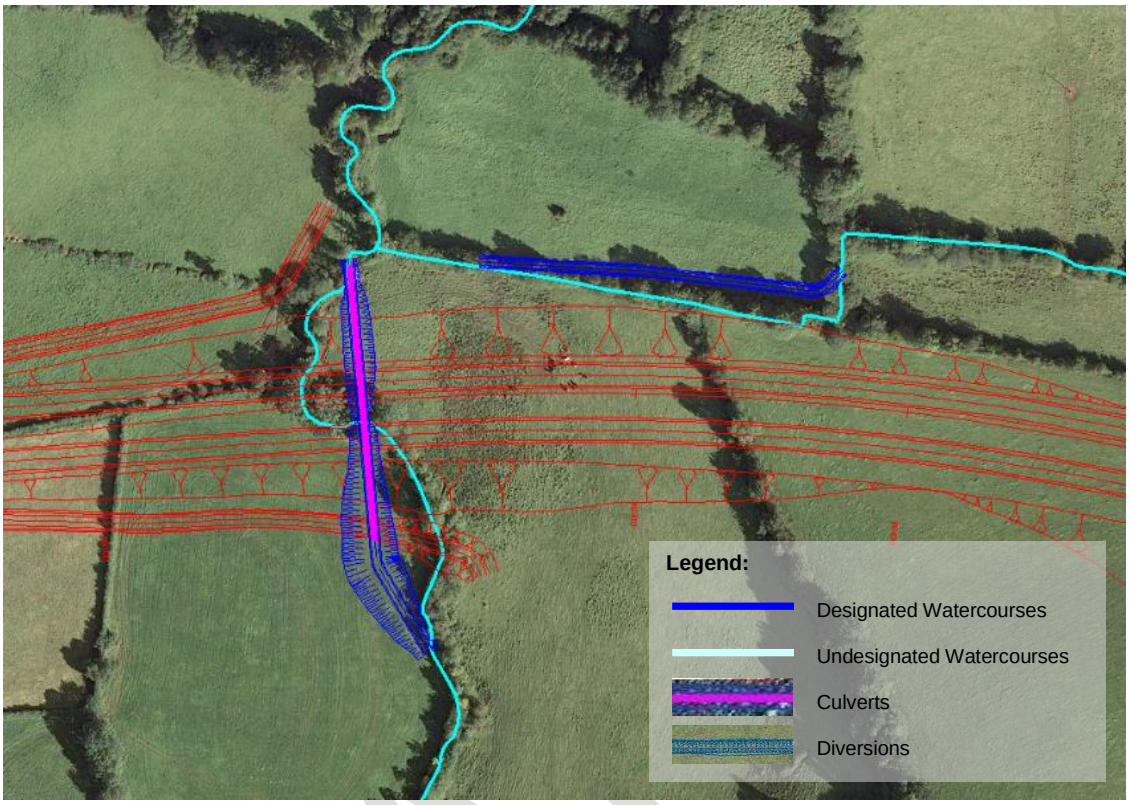

Figure 4.26.2-1 - Undesignated Watercourse Diversion (S3-WD-36) and Culvert Arrangement (S3-PC-44)

The culvert has been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.26.2-1 below provides a summary of the modelled culvert size for the watercourse within this model.

Table 4.26.2-1 - Model M.X Undesignated Watercourse Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
266723 353580	S3-PC-44	Box	3.9	2.1

The proposed diversion has also been hydraulically modelled. Table 4.26.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.26.2-2 - Model M.X – Undesignated Watercourse Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
266730 353531	S3-WD-36	Channel Length	152	150
		Channel Gradient	1:96	1:55

The culvert and diversion arrangement can be seen in Drawing 718736-S3-0500-0123.

A comparison of the water elevations pre and post scheme is shown in Table 4.26.2-3 for specific points along the watercourse. These points can be seen in Figure 4.26.3-1:

Figure 4.26.2-2 – Model M.X, Points along Channel for Water Elevation Comparison

Table 4.26.2-3 - Predicted Impact for Model M.X Undesignated Watercourse for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	67.36	67.36	0
2	65.41	65.41	0
3	64.73	64.79	+0.060
4	61.04	61.04	0

It is identified that the combined effect of the proposed culvert and diversion for the undesignated watercourse results in a minimal impact on water levels throughout the length of the model. The model results show that for the worst case point location (point 3) there is a 60mm increase in the 100 year flood water levels post Proposed Scheme, this change is considered localised.

4.26.3 Mitigation Assessment – Volumetric Floodplain Storage Provision

As detailed in Section 4.26.1 there is no loss of floodplain storage as a consequence of the Proposed Scheme.

4.26.4 Residual Post Scheme Flood Risk

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed. This information can be seen in Table 4.26.4-1:

Table 4.26.4-1 – Model M.X Undesignated Watercourse Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Moderate Adverse	Slight

There are no residential or commercial properties within the extent of the floodplains and consequently the importance of the feature is characterised as Low. The model results show that along the undesignated watercourse there is a change in water levels post scheme (60mm), the magnitude of which is considered to be Moderate Adverse. The significance of the potential effects is considered to be Slight.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the undesignated watercourse is Slight Adverse (Table A4.6, Annex IV, HD 45/09) – *'An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to fewer than 10 industrial properties.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawing 718736-S3-0500-0123 in Appendix A.

4.27 Model Y – MW4222 Lisadavil River – Impact and Mitigation Assessment

4.27.1 Floodplain Interaction

In the locality of the Proposed Scheme the 100 year existing floodplain for the Lisadavil River is extensive, particularly within the downstream sections of the model. It is observed that the Proposed Scheme interacts with the floodplain at two locations; at a modelled undesignated tributary, south of the Rehaghy Road, the Proposed Scheme crosses the watercourse obliquely and displaces minor floodplain areas as outlined in Figure 4.27.1-1, further south the Proposed Scheme enters a larger area of floodplain associated with the Lisadavil River and some undesignated tributaries, crossing the floodplain obliquely before continuing over the river as outlined in 4.27.1-2.

For the 100 year flood event, modelling indicates that approximately 3,020m^3 of floodwater is displaced as the result of the Proposed Scheme. These areas are outlined in Figures 4.27.1-1 and 4.27.1-2.

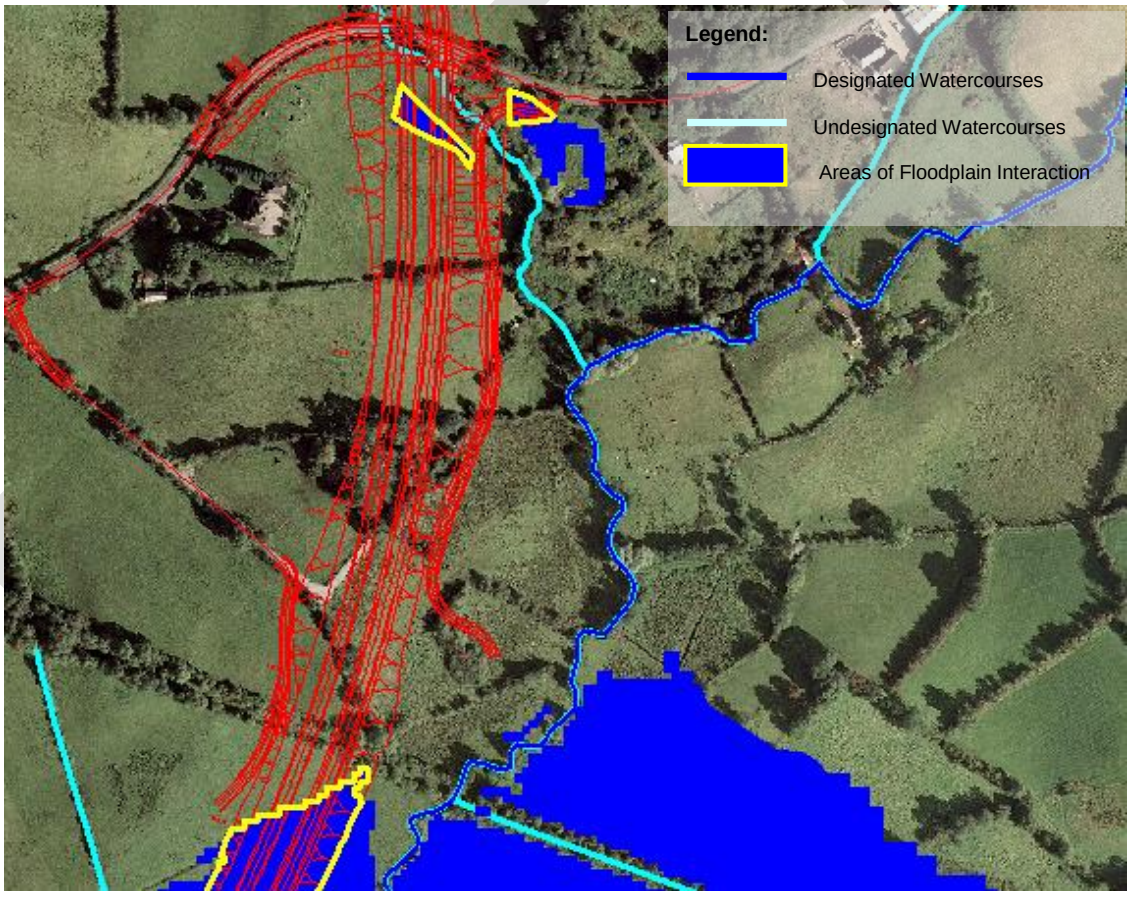

Figure 4.27.1-1 - Lisadavil River Floodplain Impact

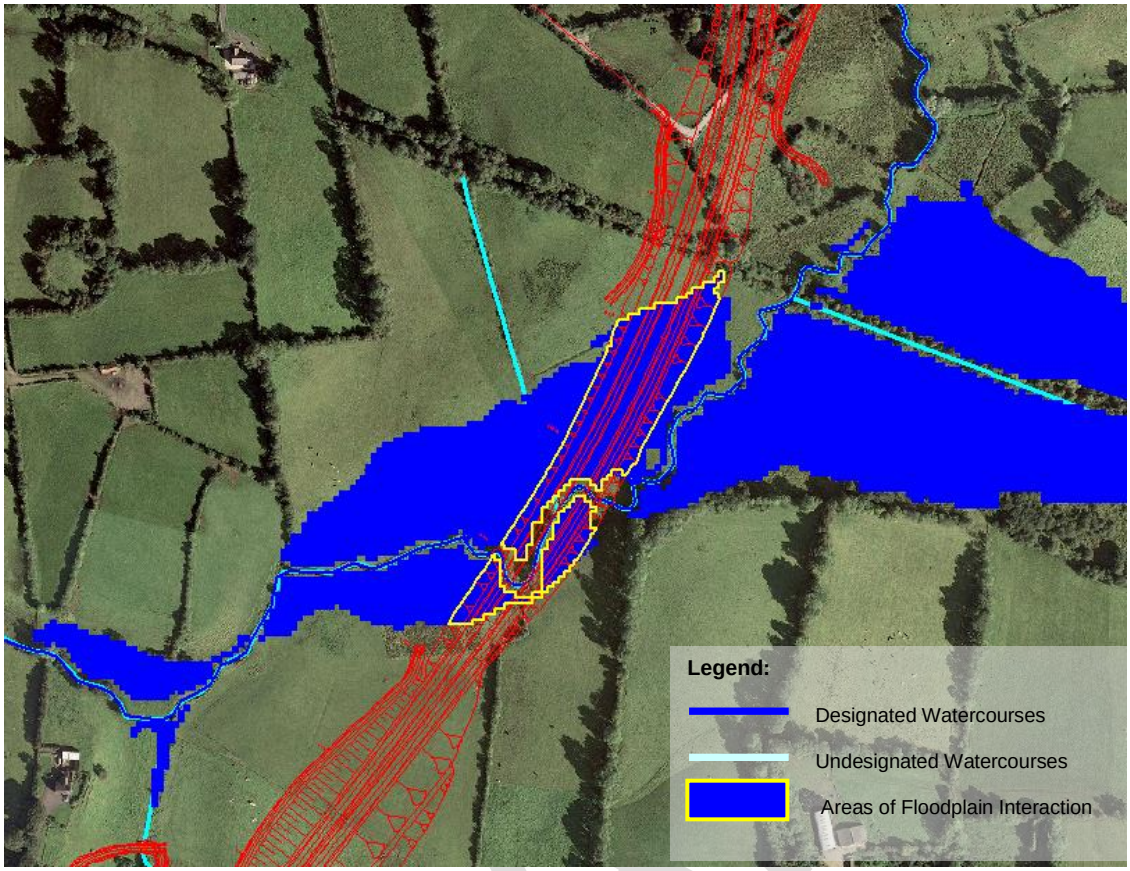

Figure 4.27.1-2 - Lisadavil River Floodplain Impact

4.27.2 Mitigation Assessment – Structures, Culverts and Diversions

Proposals for this modelled location, incorporating two undesignated watercourses and the Lisadavil River, include various culverting and river engineering works; in total it is proposed to culvert the various watercourses at six locations with river diversionary works generally being associated with each culvert. Culverting proposals aim to facilitate the conveyance of flow for each watercourse, minimise the overall length of culverting required (taking account of local topography) and forming part of the overall flood risk mitigation proposals. The following is a summary of the proposals commencing at the most northern undesignated tributary progressing southward along the Proposed Scheme.

The arrangement for the proposed diversion and culverting for the northern undesignated tributary, in the vicinity of the Carnteel Road, can be seen in Figure 4.27.2-1.

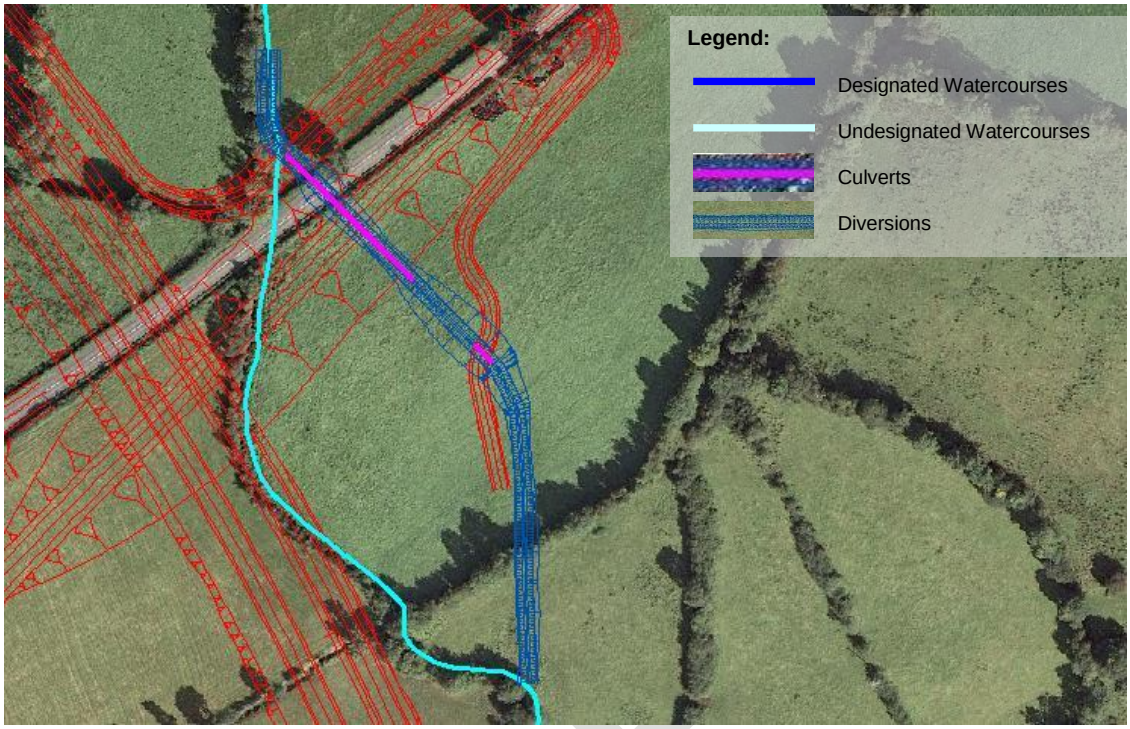

Figure 4.27.2-1 - Plan of Undesignated Watercourse Diversion (S3-WD-37) and Culvert Arrangement (S3-PC-88 and S3-PC-45)

Continuing downstream along the undesignated tributary and Figure 4.27.2-2 illustrates the proposed river engineering arrangements in the vicinity of the Rehaghy Road.

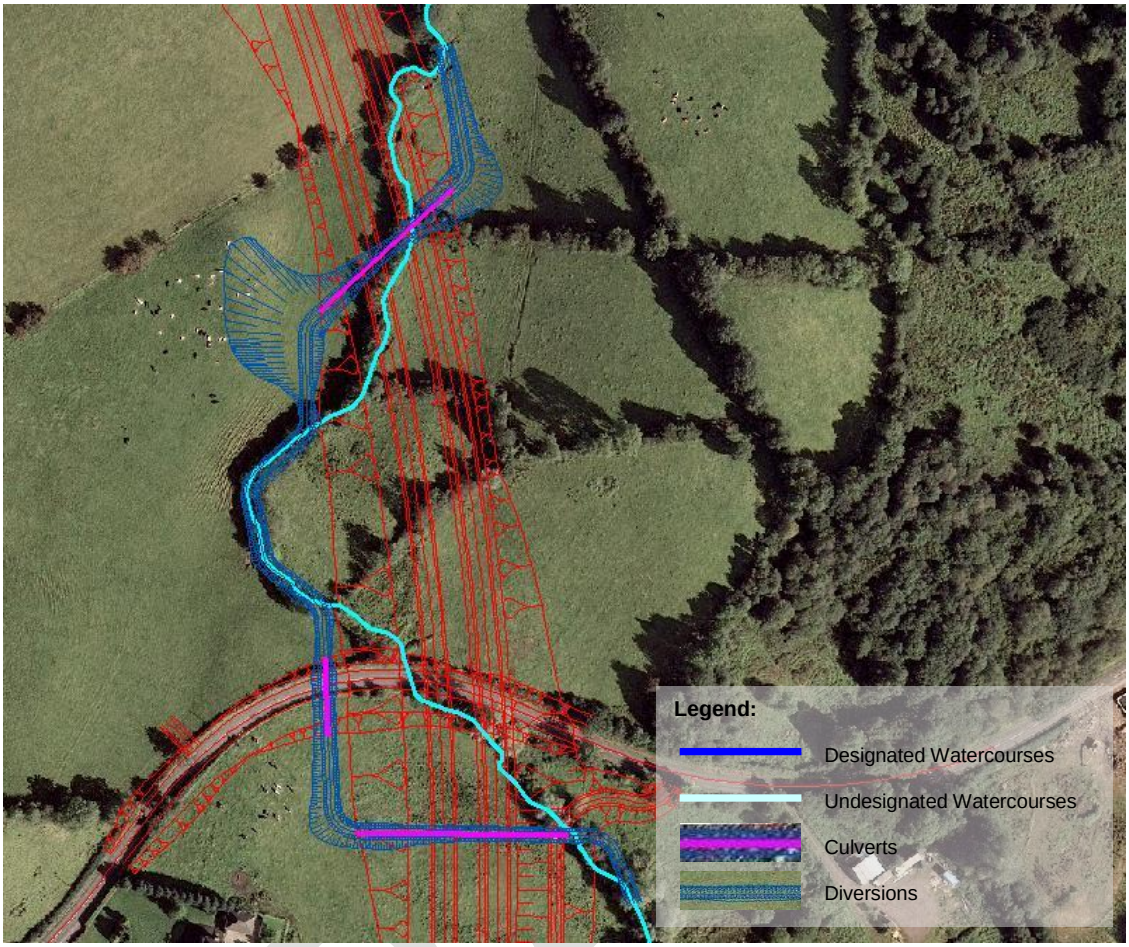

Figure 4.27.2-2 - Plan of Undesignated Watercourse Diversion (S3-WD-60, S3-WD-38 and S3-WD-61) and Culvert Arrangement (S3-PC-46, S3-PC-47 and S3-PC-62).

Finally culverting and river engineering works are proposed for the Lisadavil River and an adjoining undesignated watercourse where the Proposed Scheme crosses the main river, these arrangements can be seen in Figure 4.27.2-3.

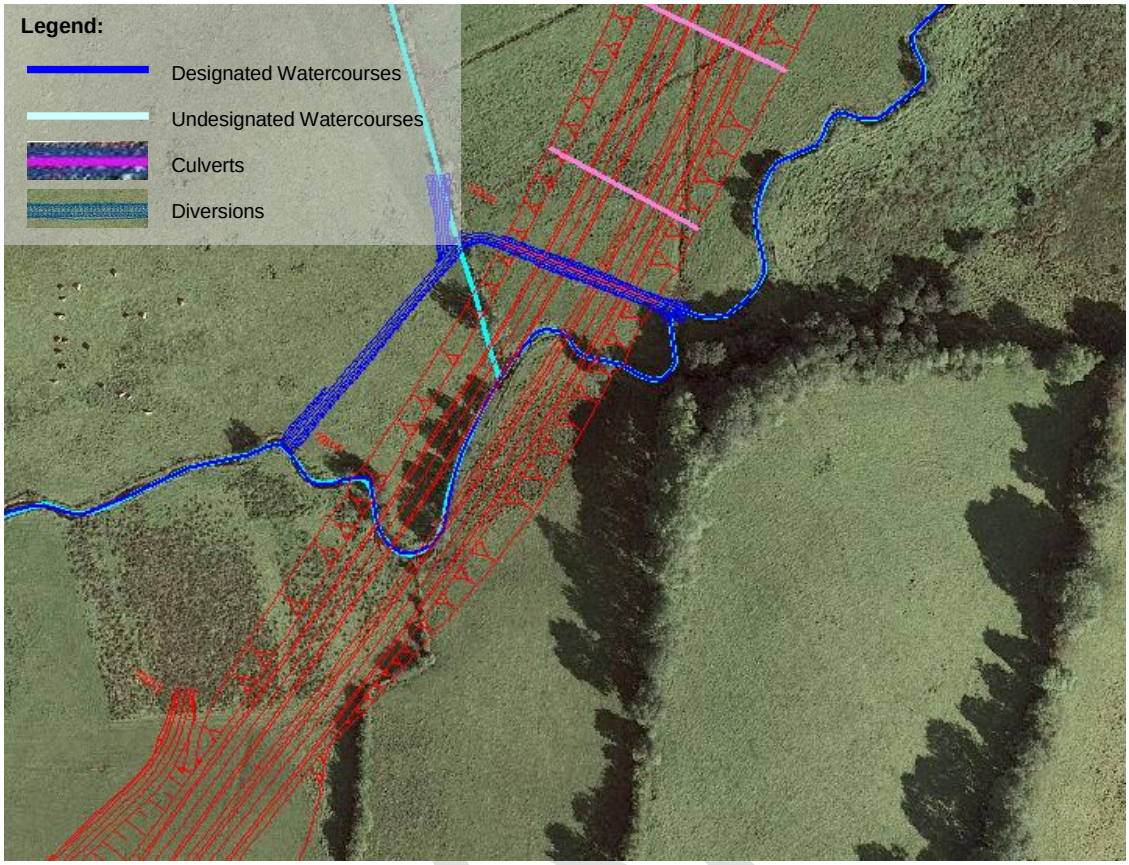

Figure 4.27.2-3 - Plan of Lisadavil River and Undesignated Watercourse Diversion (S3-WD-39 and S3-WD-40), Culvert Arrangement (S3-PC-48) and Connectivity Culvert Arrangement (S3-CC-06 and S3-CC-07)

The culverts have been modelled hydraulically for the 100 year event with 600mm freeboard allowance. Table 4.27.2-1 below provides a summary of the modelled culvert sizes for the watercourses within this model.

Table 4.27.2-1 - Model M.Y - Lisadavil Modelled Culvert Sizes

Location Grid Reference	Culvert Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
267804 352803	S3-PC-46	Box	2.4	1.8
267781 352635	S3-PC-62	Box	2.7	1.5
267846 352584	S3-PC-47	Box	2.7	2.4
267694 352049	S3-PC-48	Box	3.9	2.7
267713 353197	S3-PC-88	Box	2.1	1.8
267777 353130	S3-PC-45	Box	2.1	1.8

The proposed diversion has also been hydraulically modelled. Table 4.27.2-2 provides a general comparison, pre and post diversion, of the channel length and gradient.

Table 4.27.2-2 - Model M.Y - Lisadavil Diversion Characteristics

Location Grid Reference	Diversion Reference	Characteristic	Existing Scenario	Proposed River Diversion
267830 352850	S3-WD-38	Channel Length	180m	57m
		Channel Gradient	1:30	1:95
267795 353078	S3-WD-37	Channel Length	253m	255m
		Channel Gradient	1:68	1:82, 1:114, 1:98, 1:24
267754 352698	S3-WD-60	Channel Length	88m	150m
		Channel Gradient	1:35	1:61
267783 352588	S3-WD-61	Channel Length	145m	193m
		Channel Gradient	1:49	1:31, 1:34
267657 352078	S3-WD-39	Channel Length	80m	28m
		Channel Gradient	1:50	1:32
267634 352045	S3-WD-40	Channel Length	149	168m
		Channel Gradient	1:50	1:620

The culvert and diversion arrangements can be seen in Drawings 718736-S3-0500-0125, 718736-S3-0500-0126 and 718736-S3-0500-0111.

It is further proposed that floodplain conveyance structures are provided at this location to mitigate the reduction in floodplain connectivity due to the location of the Proposed Scheme. Details of these structures are shown in Table 4.27.2-3 below:

Table 4.27.2-3 – Model M.Y Lisadavil Modelled Connectivity Structures

Location	Connectivity Structure Reference	Culvert Type	Culvert Width (m)	Culvert Height (m)
267747 352141	S3-CC-06	Box	1.5	1.5
267722 352090	S3-CC-07	Box	1.5	1.2

A comparison of the water elevations pre and post scheme is shown in Table 4.27.2-4 for specific points along the watercourse. These points can be seen in Figure 4.27.2-4.

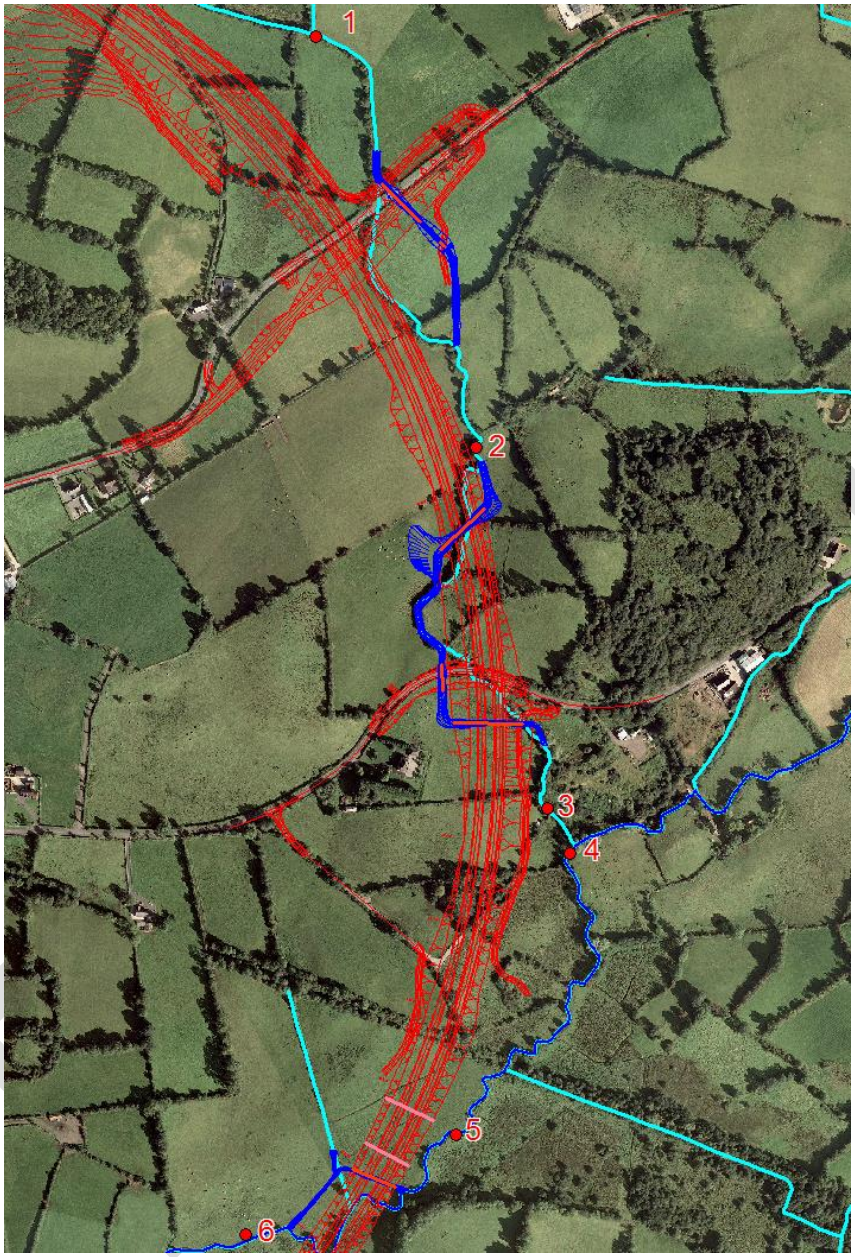

Figure 4.27.2-4 – Model M.Y, Points along Channel for Water Elevation Comparison

Table 4.27.2-4 - Predicted Impact for Model M.Y Lisadavil for Proposed Scheme

	Existing Water Elevation (m AOD)	Post Road Water Elevation (m AOD)	Impact (m)
Point ID	**100 Year**	**100 Year**	**100 Year**
1	73.718	73.721	+0.003
2	65.409	65.412	+0.003
3	52.507	52.508	+0.001
4	49.832	49.838	+0.006
5	48.881	48.867	-0.014
6	48.687	48.671	-0.016

It is identified that the combined effect of the proposed culverts, watercourse diversions and connectivity arrangements for the watercourse results in a minimal change water levels throughout the length of the model. The minor impacts are considered localised and mainly attributable to the slight changes in the local geometry post scheme (gradient, alignment and channel cross section).

4.27.3 Mitigation Assessment - Volumetric Floodplain Storage Provision

As mentioned in Section 4.27.1, approximately 3,020m^3 of floodwater is displaced due to the Proposed Scheme. Therefore, an area of land is proposed for compensatory storage. The compensatory storage locations (references S3-CS-14, S3-CS-15.1 and S3-CS-15.2) for this model can be seen in Drawings 718736-S3-0500-0125, 718736-S3-0500-0126 and 718736-S3-0500-0111.

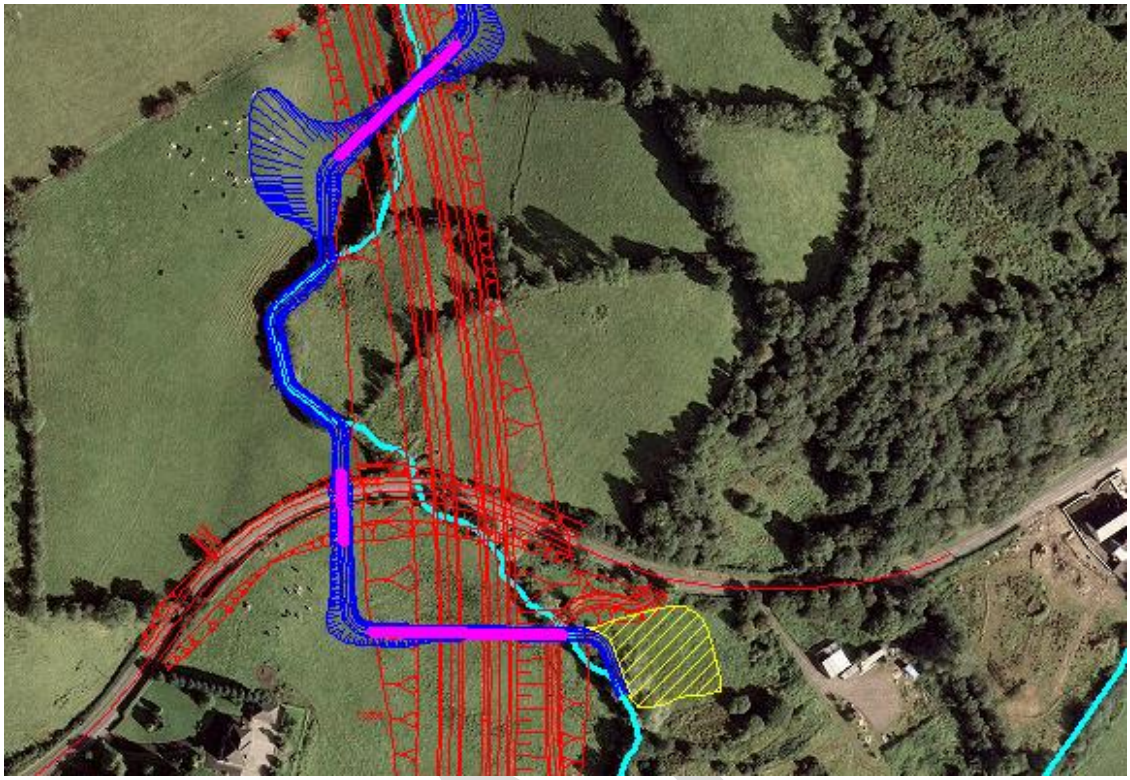

Figure 4.27.3-1 – Model M.Y, Volumetric Floodplain Storage Provision (S3-CS-14)

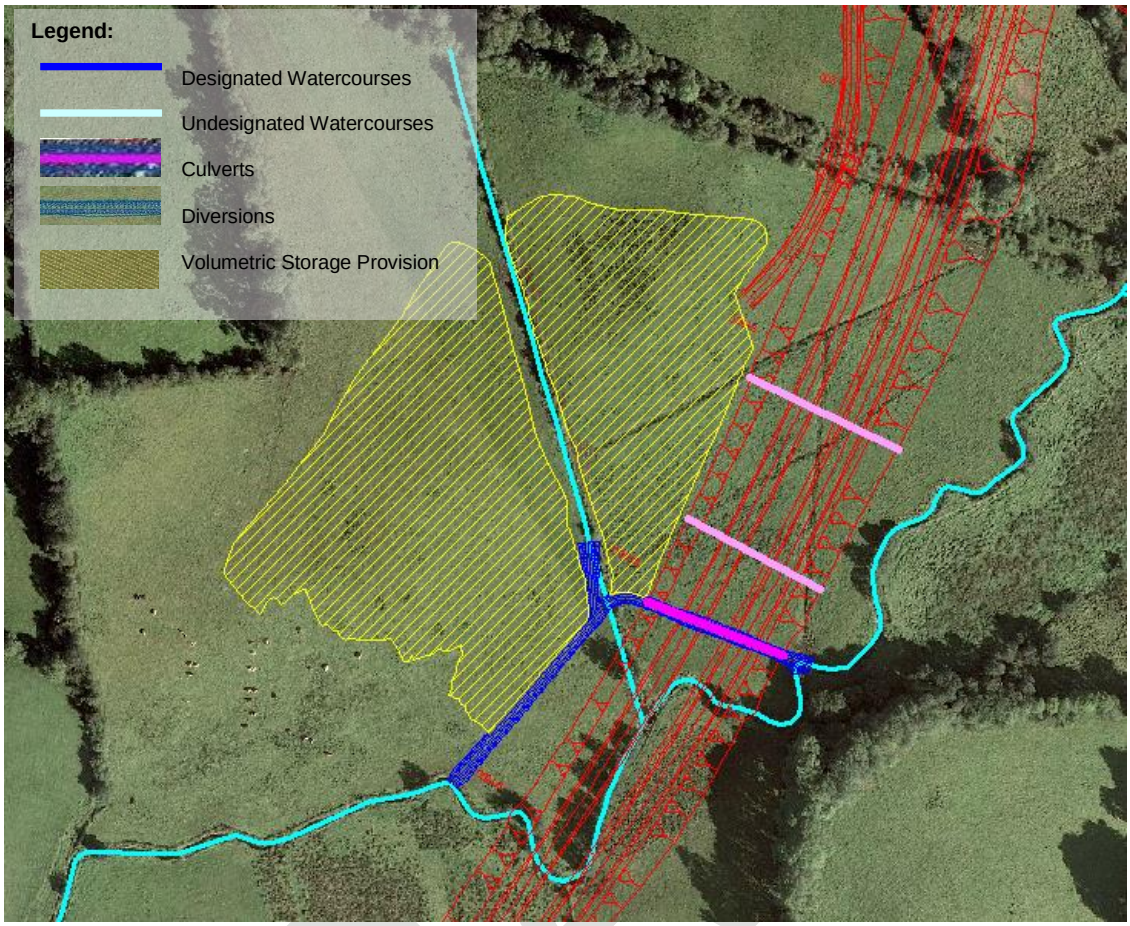

Figure 4.27.3-2 – Model M.Y, Volumetric Floodplain Storage Provision (S3-CS-15.1 and S3-CS-15.2)

Table 4.27.3-1 identifies the volumetric storage requirements. Drawings 718736-0500-D-00259 to 718736-0500-D-00260 illustrate the application of this in detail.

Table 4.27.3-1 – Model M.Y; Lisadavil Water Volumetric Storage Provision Details

Storage Comp ID	Storage Comp Location		Floodplain Volume Displaced by A5WTC (m^3)	Storage Compensation Proposals		Receiving Watercourse
	X	Y		Minimum Volume Replaced (m^3)	Total Volume Excavated (m^3)	
S3-CS-14	264792	353570	~3020	~3020	~245	UD_92.1
S3-CS-15.1	267585	352137			~7350	Lisadavil
S3-CS-15.2	267684	352162			~7585	Lisadavil
					Total = ~15,180	

4.27.4 Residual Post Scheme Flood Risk

The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed. This information can be seen in Table 4.27.4-1:

Table 4.27.4-1 – Model M.Y Lisadavil River Flood Risk Assessment

No. of Properties within Floodplain	Importance	Magnitude	Significance
0	Low	Negligible	Neutral

There are no residential or commercial properties within the extent of the floodplains and consequently the importance of the feature is characterised as Low. The model results show that along the Lisadavil River watercourse there is a maximum change in water levels post scheme of 6mm; the magnitude of which is considered to be Negligible. The significance of the potential effects is considered to be Neutral.

On review of the overall qualifying conditions for assessment score of flood risk, the score for the Lisadavil River is Neutral (Table A4.6, Annex IV, HD 45/09) – *'negligible change in peak flood (1% annual probability) <+/- 10mm'.*

A comparison of the 100 year existing flood outline and predicted post Proposed Scheme Outline can be seen in Drawings 718736-S3-0500-0125, 718736-S3-0500-0126 and 718736-S3-0500-0111 in Appendix A.

5 Summary

This report is number three of the A5 Western Transport Corridor (A5 WTC) Flood Risk Assessment (FRA) Reports and provides a summary of the impact of the A5 WTC in relation to flooding and the mitigation options for the Proposed Scheme. This report follows FRA 1 - *Assessment Parameters and Preliminary Flood Risk Assessment* and FRA 2 – *Hydraulic Model Build Report* and details information in relation to impact identification, assessment of mitigation options, integration of mitigation into hydraulic models and discussion of the modelling results.

The design process for the Proposed Scheme involved an iterative approach between various disciplines. Input from drainage and flooding engineers formed part of this multidisciplinary iterative design process. It is not the purpose of this document to report on every design iteration, but rather to present the engineering features for the Proposed Scheme, assess potential impacts should the scheme be constructed and review the mitigation proposals.

Water levels and associated existing floodplain extents were evaluated and mapped for a range of return periods, focusing on the 'design' event; 100 year [1% AEP] for fluvial floodplains and 200 year plus climate change [0.5+cc% AEP] for tidal floodplains. FRA Reports 1 and 2 provide full details in relation to the identification of floodplains and the development of hydraulic models to identify water levels. These models and extents have been used to identify any impacts arising from the A5 WTC proposals and where appropriate to assess flood mitigation proposals.

Generally, flood impacts have been mitigated using measures which include some, or all, of the following:

- Avoidance of floodplains as far as reasonably practicable whilst incorporating multi-discipline engineering and non-engineering factors,
- Minimisation of road footprint as far as reasonably practicable whilst incorporating multi-discipline engineering and non-engineering factors,
- Appropriately sized culverts,
- Large span structures where feasible,
- Provision of floodplain connectivity structures to maintain floodplain conveyance where floodplains are bisected by the road alignment, and

- Provision of compensatory storage where material volumetric floodplain encroachment remains.

Consultations have been held with Rivers Agency throughout the development of the Proposed Scheme Flood Risk Assessment including impacts and proposed mitigation.

This FRA 3 provides a summary for each of the hydraulic models; features such as culvert sizing, diversion alignments, structure arrangements, connectivity structure location and sizing and compensatory storage are discussed. A comparison of the water elevations, pre and post scheme, for specific points along the watercourses are provided for each of the modelled reaches. The importance of the floodplain, the magnitude of impact and the significance of potential effects were assessed along with the qualifying conditions for the overall assessment score for flood risk in accordance with the DMRB guidance.

It is detailed that the Proposed Scheme Flood Risk Assessment is completed with reference to guidance provided within the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10, HD 45/09 Road Drainage and the Water Environment for each of the modelled locations. To assist in the determination of residual, post scheme flood risk, assessment methodologies identified within appendices of the DMRB where used, whereby the importance of the floodplain, the magnitude of the impact and the significance of the potential effects have been defined as per the guidance tables A4.3 HD 45/09, A4.4 HD 45/09 and A4.5 HD 45/09. Finally, the qualifying conditions for the overall assessment score for residual, post mitigation flood risk from Table A4.6 HD 45/09 have been applied and a summary of these for each of the modelled areas is provided in the table below:

Table 5-1 - Summary of A5 Western Transport Flood Risk Assessment Qualifying Conditions for Overall Assessment Scores

Section	Watercourse (Model Reference)	Overall Assessment Score
1	Gortin Hall Drain (M.A)	Slight Adverse
	Blackstone Burn (M.B)	Slight Adverse
	River Foyle, River Finn, Mourne River, Deele River, Swilly Burn, Glenmornan & Burndennet Rivers (M.1, M.2 and M.3)	Slight Adverse
2	Undesignated Watercourse (M.D)	Slight Adverse
	Derg River (M.5)	Neutral
	Coolaghy Burn (M.E)	Slight Adverse
	Back Burn (M.F)	Neutral
	Undesignated Watercourse (M.G)	Slight Beneficial

Table 5-1 - Summary of A5 Western Transport Flood Risk Assessment Qualifying Conditions for Overall Assessment Scores

Section	Watercourse (Model Reference)	Overall Assessment Score
	Tully Drain (M.H)	Slight Adverse
	Omagh (including Fairy Water, Aghamoyle Drain, Coneywarren Drain, Tully Drain and Strule River (M.4)	Slight Adverse
	Fireagh Lough Drain (M.I)	Slight Adverse
	Drumragh River (M.6)	Slight Adverse
3	Ranelly Drain (M.L)	Slight Adverse
	Letfern Watercourse (M.M)	Neutral
	Undesignated Watercourse (M.N)	Neutral
	Undesignated Watercourse (M.O)	Slight Adverse
	Routing Burn (M.P)	Slight Adverse
	Routing Burn Ext (M.Q)	Neutral
	Undesignated Watercourse (Newtownsaville) (M.R)	Slight Adverse
	Undesignated Watercourse (Kilgreen) (M.S)	Slight Adverse
	Roughan River (M.T)	Neutral
	Ballygawley River (M.U)	Moderate Adverse
	Tullyvar Drain (M.V)	Neutral
	Ravella Drain (M.W)	Neutral
	Undesignated Watercourse (M.X)	Slight Adverse
	Lisadavil River (M.Y)	Neutral

It is observed that impacts can vary across floodplains and that assessment scores are generally based on the worse case assessment; it is therefore highlighted that at some locations benefits in relation to water levels are realised.

Finally, in reference to the DMRB methodology; the overall the impact of the Proposed Scheme on floodplains and flood risk (scheme wide) is Slight Adverse. In consultation with DMRB categorisation: one has been predicted to be Moderate Adverse risk, fifteen have been predicted to have a Slight Adverse risk, nine have been predicted risk neutral and one has been predicted to be Slight Beneficial.

It should be noted that ongoing value engineering exercises will be conducted in relation to the Proposed Scheme; any refinements will be provided through the appropriate approval process in later stages of the project.