Appendix C11.03

Section 3 Flood Risk Assessment

Co-financed by the Connecting Europe Facility of the European Union

Appendix C11.03

Section 3 Flood Risk Assessment Report

TEN-T Priority Route Improvement Project, Donegal



Section 3 Flood Risk Assessment Report
March 2026

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1 INTRODUCTION

In January 2017, Donegal County Council appointed joint venture RPS/Barry Transportation as design consultants for the Trans-European Network - Transportation (TEN-T) Priority Route Improvement Project (PRIP), Donegal; hereafter referred to as the proposed development in this report.

The TEN-T PRIP, involves the targeted and appropriate intervention on three sections of the Ten-T/National Road network in Donegal. The intervention includes online improvement and upgrade, bypass of three urban centres, route realignment and complete, independent and integrated active travel network.

The project is divided into three sections as illustrated in Figure 1:

- **Section 1 – N15/N13 Ballybofey/Stranorlar Urban Region**
  Full active travel, modal hubs, urban bypass
- **Section 2 – N56/N13 Letterkenny to Manorcunningham**
  Full active travel, online/upgrade, route realignment, urban bypass (Letterkenny), modal hub
- **Section 3 – N14 Manorcunningham to Lifford/Strabane/A5 Link**
  Full active travel, route realignment, urban bypass (Lifford) and cross border connection (Lifford/Strabane), modal hubs.

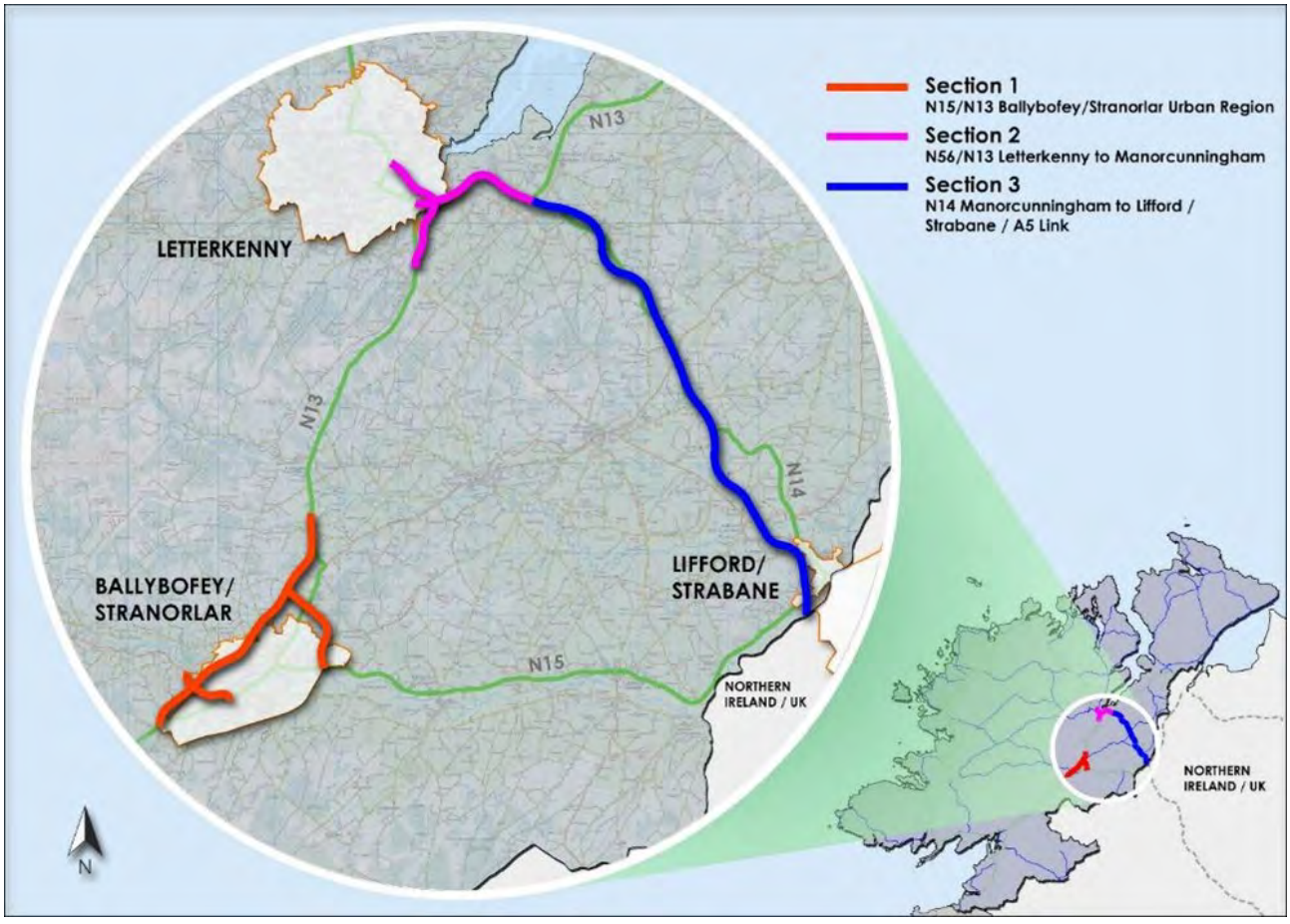


Figure 1 Ten-T Priority route improvement project, Donegal

The three sections of the proposed development are being considered as three components of one project. This Flood Risk Assessment report, considers Section 3 only.

The proposed route for Section 3 lies within the Lough Swilly and the River Foyle Catchments, Hydrometric Areas 39 and 01, respectively. It crosses the Deele River, the Swilly Burn, and the River Finn. In addition to

these three significant rivers, in the vicinity of Manorcunningham, the route crosses the Leslie Hill Stream, which flows into Lough Swilly.

This FRA has been undertaken in accordance with The Planning System and Flood Risk Management – Guidelines for Planning Authorities (Dept. of the Environment, Heritage and Local Government and The Office of Public Works, Nov 2009).

Chapter 2 of this report outlines the flood risk management policies and guidelines used for this assessment. Chapter 3 presents a description of the road project and its relevant drainage features. Chapter 4 presents the flood risk assessment that includes flood risk identification and preliminary flood risk assessment for screening purposes, followed by a detailed Flood Risk Assessment of the identified risks and mitigation.

2 FLOOD RISK MANAGEMENT POLICY

2.1 EU Floods Directive

The European Floods Directive 2007/60/EC on the assessment and management of flood risk aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. This directive applies to both inland waters and coastal waters across the whole territory of the European Union.

The directive requires all member states to undertake a national preliminary flood risk assessment in order to identify areas where significant flood risk exists or might be considered likely to occur and to prepare flood hazard and flood risk maps for such areas by December 2013. The Directive requires the preparation of catchment-based Flood Risk Management Plans (FRMPs) by 2015, which will set out flood risk management objectives, actions and measures. These Flood Risk Management Plans are to include measures to reduce the probability of flooding and its potential consequences. Implementation of the EU Floods Directive is required to be coordinated with the requirements of the EU Water Framework Directive and current River Basin Management Plans.

2.2 National Flood Policy Review

2.2.1 Background

Historically management of flooding was implemented by drainage commissioners and focused on the protection and improvement of land for agricultural purposes and this is reflected in the various Drainage Acts passed (1842, 1867, 1925, 1928, and 1945).

The Brown Commission (Report of the Drainage Commission 1938-1940) which examined flooding and improvement of land through drainage resulted in the development of the Arterial Drainage Act, 1945. The Brown Commission recommended the establishment of a single national drainage authority with a remit to embark on a national drainage programme. The Office of Public Works (OPW) became the Statutory Authority responsible for implementing arterial drainage schemes nationally.

The emphasis of the 1945 act was improvement of agricultural land and following the act a priority list of river basins was set out and a programme of drainage works commenced and continued up until the early 1990's. This drainage act was amended in 1995 to allow the OPW to implement localised flood relief schemes for reliving flooding in urban areas. This amendment recognised that urban flooding had become a significant problem and signalled a departure away from arterial drainage of lands with no new arterial drainage schemes being implemented.

The various drainage districts and arterial drainage schemes, local flood relief schemes carried out under the drainage act continue to be maintained today by the OPW and Local Authorities.

2.2.2 Report of the Flood Policy Review Group

In 2003 a review of the National Flood Policy was carried out by a review group of relevant stakeholders. The review focuses on fluvial (river) and tidal flooding and concentrates on the roles of the state agencies in these areas. The scope of the review included the following:

- Causes, extent and impacts of the flooding problem
- Current roles and responsibilities of the main state bodies
- International best practice
- Future flood policy
- Proposals for future organisational structures and responsibilities
- Resource requirements and strategic programme.

The review group prepared a report by December 2003 that was approved by government and published in September 2004. The adopted policy has many specific recommendations, including:

- Minimise the national level of exposure to flood damages through identification and management and future flood risks in an integrated, proactive and river basin based approach.
- The OPW is to be the lead agency in delivering this policy.
- All future expenditure in the area of flood relief will need to satisfy strict prioritisation criteria.
- A two-pronged approach to flood management is to be pursued with a greater level of importance attributed to non-structural flood relief measures supported where necessary by traditional structural flood relief measures.
- River basin flood management plans to be developed along with comprehensive Flood Hazard Maps and all information made available to the Dept. of the Environment, Heritage and Local Government now known as Housing, Planning and Local Government to inform future planning and development processes.
- Programmes of necessary hydrological research were identified and included the update of the Flood Studies Report and river basin (hydrological) modelling, analysis of potential impact of climate change on flood frequency and severity and Meteorological forecasting.

2.3 National CFRAM

The OPW is the lead agency for flood risk management and part of its responsibility is the coordination and implementation of Government Policy on the management of flood risk in Ireland. The SI No. 122 on the European Communities (Assessment and Management of Flood Risks) 2010 identifies the Commissioners of Public Works as the competent authority with overall responsibility for the implementation of the Floods Directive (2007/60/EC).

In order to comply with the Floods Directive (2007) and the National Flood Policy Review Group (2004) a national Catchment Flood Risk Assessment and Management (CFRAM) programme commenced in 2011 and flood risk and hazard mapping was completed in 2015; in addition, the catchment management plans and the Strategic Environmental Assessment (SEA) process was completed in 2016. This followed preparatory studies involving the Preliminary Flood Risk Assessment mapping and AFA (areas for further assessment) identification and followed a number of Pilot Catchment studies including the Lee Catchment FRAMs (commenced 2006), the River Dodder FRAMS (commenced 2007) and the Fingal East Meath FRAMS (commenced 2008) to refine the approach and methodologies to be adopted. The areas deemed to be at significant risk are identified as AFAs and more detailed assessment on the extent and degree of flooding was undertaken in the CFRAM studies and involved detailed survey hydrological and hydraulic modelling, flood mapping, flood risk management plans and supporting Strategic Environmental Assessments.

2.4 Planning Guidelines Concerning Flood Risk Management

2.4.1 Background

In November 2009, the OPW and DoEHLG jointly published the Planning System and Flood Risk Management - Guidelines for Planning Authorities which are aimed at ensuring a more consistent, rigorous and systematic approach to fully incorporate flood risk assessment and management into the planning system.

The core objectives set out in these guidelines are to:

- Avoid inappropriate development in areas of flood risk.
- Avoid new developments that may increase flood risk elsewhere.
- Ensure effective management of residual risks for developments permitted in floodplains.
- Avoid unnecessary restriction of national, regional or local economic growth.
- Improve the understanding of flood risk among the relevant stakeholders.
- Ensure that the requirements of EU and National law in relation to the natural environment and nature conservation are compiled with at all stages of flood risk management.

The key principles to be adopted by regional and local authorities, developers and their agents are to:

- Avoid the risk, where possible.
- Substitute with less vulnerable uses, where avoidance is not possible.
- Justify that the need for the development is a strategic need, where avoidance and substitution are not possible.
- Mitigate and manage the risk.

Decision Making Process

Management of flood hazard and potential risks in the planning system is based on:

1. Sequential Approach.

2. Justification Test.

2.4.2 Sequential Approach

The aim of the sequential approach is to guide new development away from areas at risk from flooding into areas at low risk of flooding. The approach makes use of flood risk zones and classifications of vulnerability of property to flooding but ignores the presence of flood protection structures. The sequential approach should be applied to all stages of the planning process, particularly at the plan making stage.

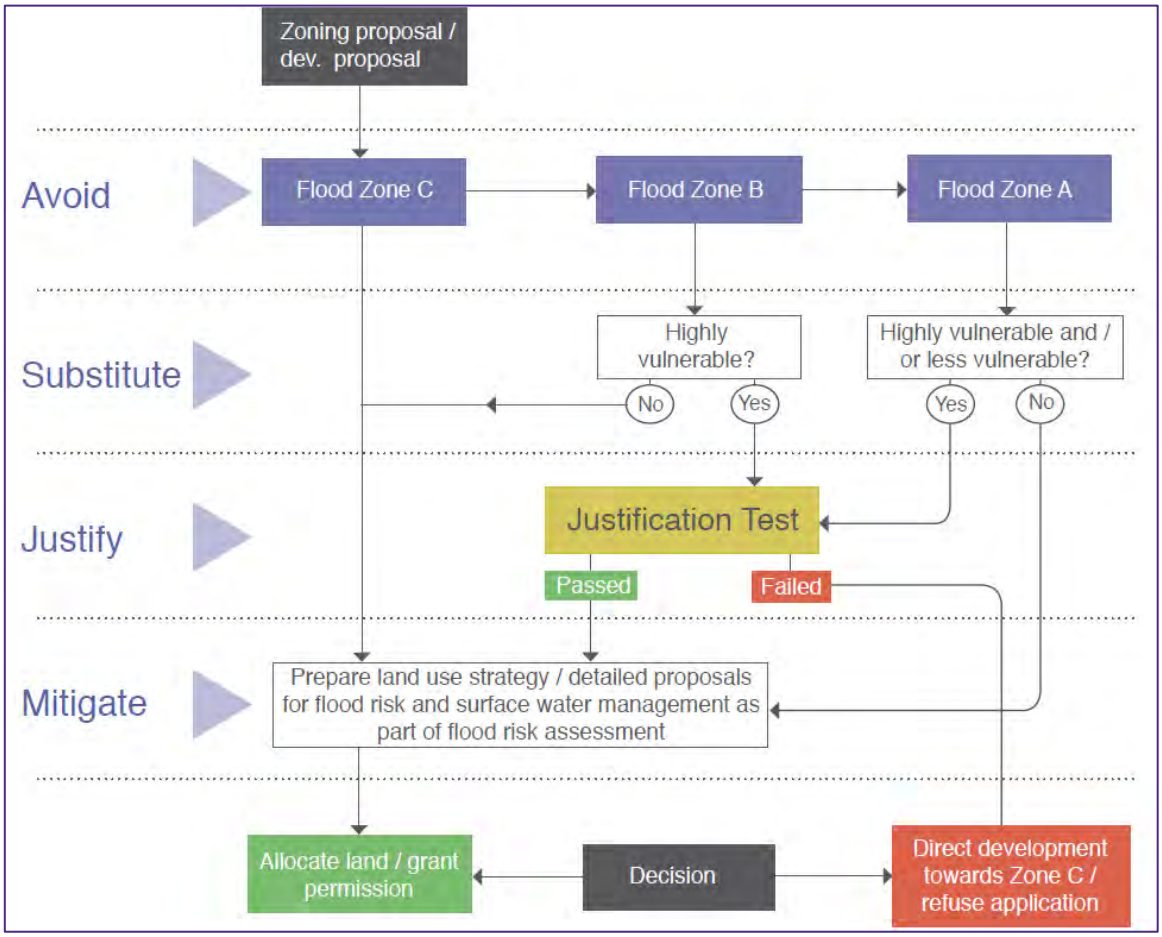


Figure 2 Sequential approach mechanism in the planning process (Fig. 3.2 from The Planning System and Flood Risk Management Guidelines)

The Sequential Approach is based on the following principles:

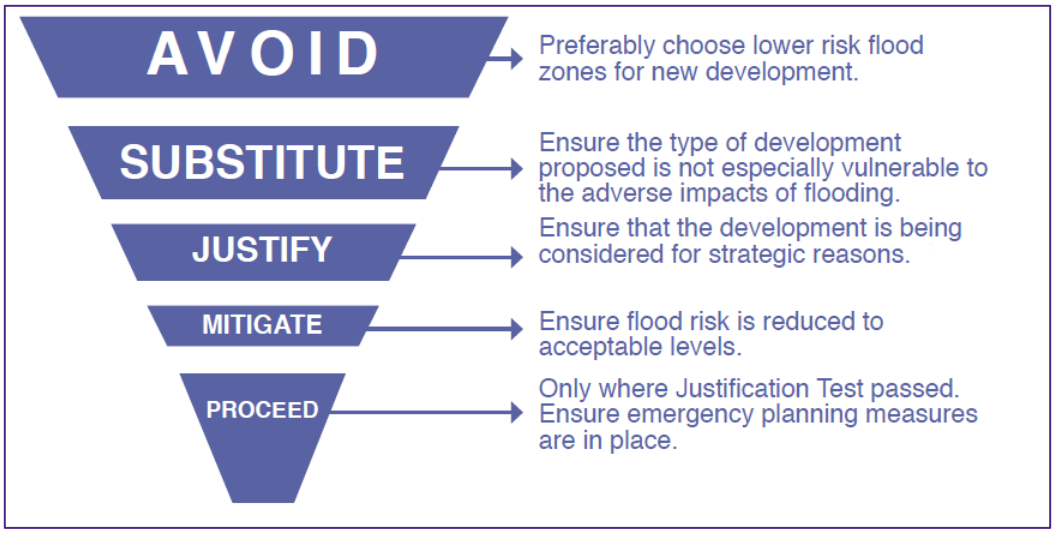


Figure 3 Sequential approach principles in flood risk management (Fig. 3.1 from The Planning System and Flood Risk Management Guidelines)

2.4.3 Flood Risk Zones

Definitions of flood risk zones in the planning guidelines are based on probability of occurrence with three flood risk zones (High, Moderate and Low) defined. These flood zones are as follows:

- Zone A High Probability: Highest risk of flooding: More than 1% probability of river flooding and more than 0.5% probability of tidal flooding. Development should be avoided and/or only considered through application of a justification test. Most types of development would be considered inappropriate in this zone. Development in this zone should be avoided and/or only considered in exceptional circumstances, such as in city and town centres, or in the case of essential infrastructure that cannot be located elsewhere, and where the justification test has been applied.

- Zone B Moderate Probability: Between 1 and 0.1% probability of river flooding or between 0.5 and 0.1% probability of coast flooding. Development should only be considered in this zone if adequate land or sites are not available in Zone C or if development in this zone would pass the Justification Test. Highly vulnerable development would generally be considered inappropriate in this zone, unless the requirements of the Justification Test can be met. Less vulnerable development and water-compatible development might be considered appropriate in this zone. In general however, less vulnerable development should only be considered in this zone if adequate lands or sites are not available in Zone C and subject to a flood risk assessment to the appropriate level of detail to demonstrate that flood risk to and from the development can or will adequately be managed.

- Zone C Low Probability: Less than 0.1% probability of river or coastal flooding. Development in this zone is appropriate from a flood risk perspective (subject to assessment of flood hazard from sources other than rivers and the coast) but would need to meet the normal range of other proper planning and sustainable development considerations.

These flood zones are determined on the basis of the probability of river and coastal flooding only and should be prepared by suitably qualified experts with hydrological experience. The derivation of these zones is broadly in line with those in common usage internationally. They are based on the current assessment of the 1% and the 0.1% fluvial events and the 0.5% and 0.1% tidal events, without the inclusion of climate change factors.

The provision of flood protection measures in appropriate locations, such as in or adjacent to town centres, can significantly reduce flood risk. However, the presence of flood protection structures should be ignored when determining the flood risk zones.

This is because areas protected by flood defences still carry a residual risk of flooding from overtopping or breach of the defences and the fact that there may be no guarantee that the defences will be maintained in perpetuity. The likelihood and extent of this residual risk needs to be considered, together with the potential impact on proposed uses, at both development plan and development management stages, as well as in emergency planning. In particular, the finished floor levels within protected zones will need to take account of both urban design considerations and the residual risk remaining.

2.4.4 Development Type Vulnerability Classification

In determining the suitability of the Development within the various flood zones the vulnerability class of the development is taken into consideration. Three categories of vulnerability are considered as described in Table 1 and 2 below:

Table 2-1 Classification of Vulnerability of Different Types of Development

Vulnerability Class	Land uses and types of development which include*:
Highly Vulnerable development(including essential infrastructure)	• Garda, ambulance and fire stations and command centres required to be operational during flooding. • Hospitals. • Emergency access and egress points. • Schools. • Dwelling houses, student halls of residence and hostels • Residential institutions such as residential care homes, children's homes and social services homes. • Caravans and mobile home parks. • Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility • Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less Vulnerable development	• Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; • Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste). • Mineral working and processing. • Local transport infrastructure.
Water-compatible development	• Flood control infrastructure; • Docks, marinas and wharves; • Navigation facilities; • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; • Water-based recreation and tourism (excluding sleeping accommodation);

- Lifeguard and coastguard stations;
- Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and
- Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).

* Uses not listed here should be considered on their own merits

Table 2-2 Requirement for Justification Test based on Vulnerability Group and Flood Zone Category

Vulnerability Class	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

2.4.5 Justification Test

Further sequentially based decision making should be applied when undertaking the Justification Test for development that needs to be in flood risk areas for reasons of proper planning and sustainable development:

1. within zone or site, development should be directed to areas of lower flood probability.
2. where impact of the development on adjacent lands is considered unacceptable the justification of the proposal or zone should be reviewed.
3. where the impacts are acceptable or manageable, appropriate mitigation measures within the site and if necessary elsewhere should be considered.

A justification test is required where a planning authority is considering the future development of areas at a high or moderate risk of flooding, for uses or development vulnerable to flooding that would generally be inappropriate as set out above within the flood zones. In such cases the planning authority must be satisfied that it can clearly demonstrate on a solid evidence base that the zoning or designation for development will satisfy the justification test outline in Box 4.1 of the guidelines as presented below in Plate 1.

Box 4.1: Justification Test for development plans

Where, as part of the preparation and adoption or variation and amendment of a development/local area plan[1], a planning authority is considering the future development of areas in an urban settlement that are at moderate or high risk of flooding, for uses or development vulnerable to flooding that would generally be inappropriate as set out in Table 3.2, all of the following criteria must be satisfied:

1 The urban settlement is targeted for growth under the National Spatial Strategy, regional planning guidelines, statutory plans as defined above or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act, 2000, as amended.

2 The zoning or designation of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in particular:

(i) Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement[2];

(ii) Comprises significant previously developed and/or under-utilised lands;

(iii) Is within or adjoining the core[3] of an established or designated urban settlement;

(iv) Will be essential in achieving compact and sustainable urban growth; and

(v) There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.

3 A flood risk assessment to an appropriate level of detail has been carried out as part of the Strategic Environmental Assessment as part of the development plan preparation process, which demonstrates that flood risk to the development can be adequately managed and the use or development of the lands will not cause unacceptable adverse impacts elsewhere.

N.B. The acceptability or otherwise of levels of any residual risk should be made with consideration for the proposed development and the local context and should be described in the relevant flood risk assessment.

Figure 4 Justification Test for Development Plans

2.4.6 Flood Risk Assessment

A staged approach to flood risk assessment that covers both the likelihood of flooding and the potential consequences is recommended in carrying out a Flood Risk Assessment (FRA). The stages of appraisal and assessment are:

Stage 1 Flood Risk Identification

Stage 2 Initial Flood Risk Assessment

Stage 3 Detailed Flood Risk Assessment

Stage 1 Flood risk identification – to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and local area plans (LAPs) or a proposed development site that may warrant further investigation at the appropriate lower level plan or planning application levels.

Stage 2 Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the requirements of the detailed assessment should be scoped.

Stage 3 Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

All stages may not be needed in the FRA in order to inform the decision making process and often a Stage 2 assessment is sufficient at the strategic level to inform the decision making process. This will depend on the level of risk, the level of conflict with the proposed development and the scale of mitigation measure being proposed. For the purposes of applying the sequential approach, once a flood risk has been identified it can be avoided. Where development is planned in flood risk areas, a detailed assessment may be carried out within the FRA, so that the potential for development of the lands and their environmental impact can be assessed.

The FRA of the Ten-T Priority Route Improvement Project will:

- Identify the broad nature of flood risk (type and source) within the study area;
- Provide an improved understanding of flood risk issues along the route of the proposed road development; and
- Provide a more detailed assessment and management strategy for the transport infrastructure within the identified flood risk areas.

3 THE PROPOSED DEVELOPMENT

The drainage and hydrological characteristics of the proposed Ten-T Priority Route Improvement Project for Section 3 is presented in this chapter.

The proposed route is approximately 17.6km long and it commences at the N13/N14 junction in Manorcunningham and terminates next to the existing N15 in Lifford/Strabane/A5. The proposed development intercepts a number of watercourses that will require culverting and river bridge crossings.

The study area lies within the Lough Swilly and the River Foyle Catchments, Hydrometric Areas 39 and 01 respectively. The division between both these catchments runs South West to North East and crosses the study area slightly to the North of the Regional Route the R236.

The major sub catchments within the Foyle catchment are those attached to the Deele, the Swilly Burn and the River Finn. Within the Foyle Catchment, the majority of the potentially affected waters of the study area are within the River Swilly Sub-Catchment.

The proposed route for Section 3 crosses the Deele River, the Swilly Burn, and the River Finn. In addition to these three significant rivers, in the vicinity of Manorcunningham, the route crosses the Leslie Hill Stream, which flows into Lough Swilly.

3.1 River Deele Bridge Crossing

Detailed hydraulic modelling was performed to assess the pre and post development flood risk and to ensure that the proposed bridge designs are compliant with Section 50 of the Arterial Drainage Act 1945. For further detail refer to Section 4.4.

A three span bridge is proposed at the River Deele which is located northwest of the towns Murlog and Lifford. This structure will clear span the entire river channel with a central skew span of 60 m with a pier on each bank of the river. In order to minimize impacts generated by the road construction and impact on the properties upstream of the bridge, two additional back spans with a skew distance of 24 m and a culvert system including 4 arched culverts were modelled under the road. These flood relief culverts were only modelled under the road on the northern side of the bridge.

As the proposed bridge is skewed, the distance between piers for the central span was modelled as 54.3 m which is the real width of the channel measured in the flow direction and for the back spans the square distance between the piers and the abutments is 20.6 m each.

The following figure shows the plan layout of the modelled structures to cross the Deele channel and the floodplain.

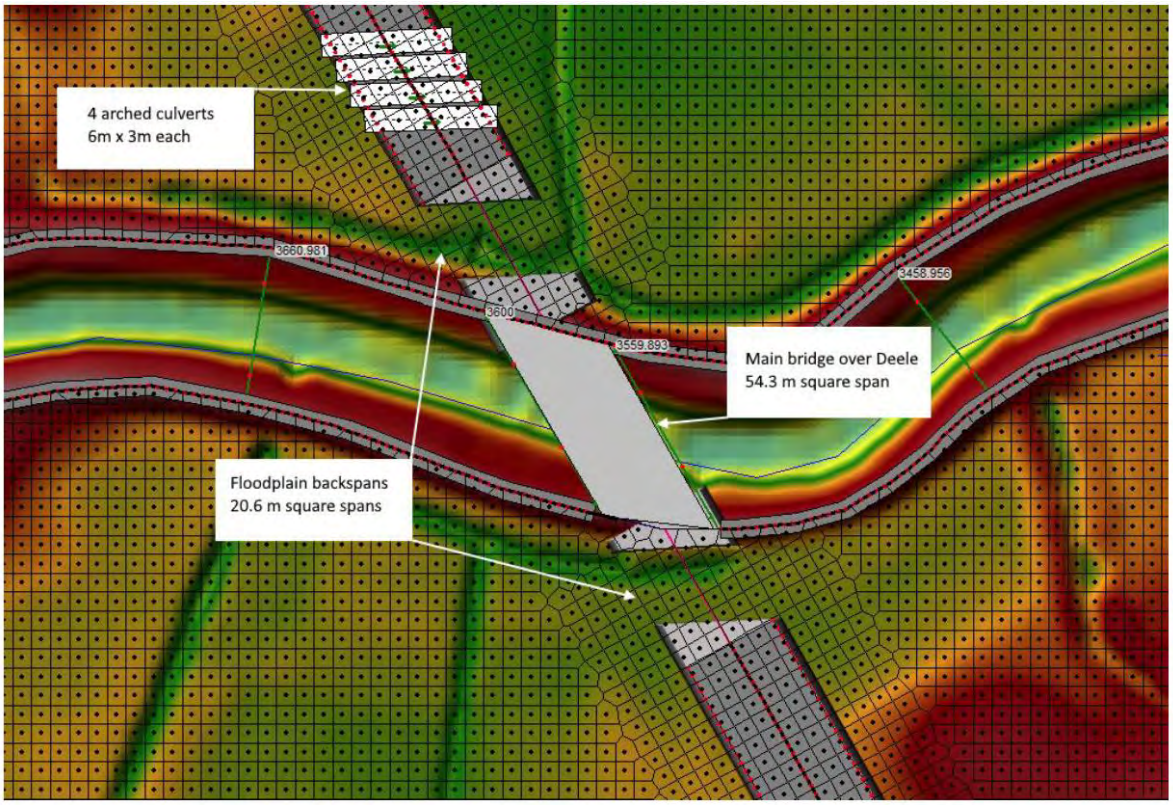


Figure 5 Post Development Structures with flood relief measures

3.2 River Swilly Burn Bridge Crossing

The Swilly Burn River is intercepted by the proposed N14, approximately 4 km east of Raphoe, Co. Donegal. A Section 50 Assessment for a proposed bridge structure has been prepared in accordance with OPW Guide to Applying for Consent under Section 50 and Section 50 of the Arterial Drainage Act, 1945. For further detail refer to Section 4.4.

Detailed hydraulic modelling was performed to assess the pre and post development flood risk that the new structure and the proposed road present for the river .

The proposed structure is a single span bridge with a clear skew span of 29.6 m and with the abutments on the river banks. There is also a Section 50 Culvert (S3-CUL.29) that discharges to one of the rivers' channels which runs parallel to the river. This culvert is considered as a flood relief culvert within the model.

The following figure shows the bridge location and the river.



Figure 6 Swilly Burn Crossing- Site Location

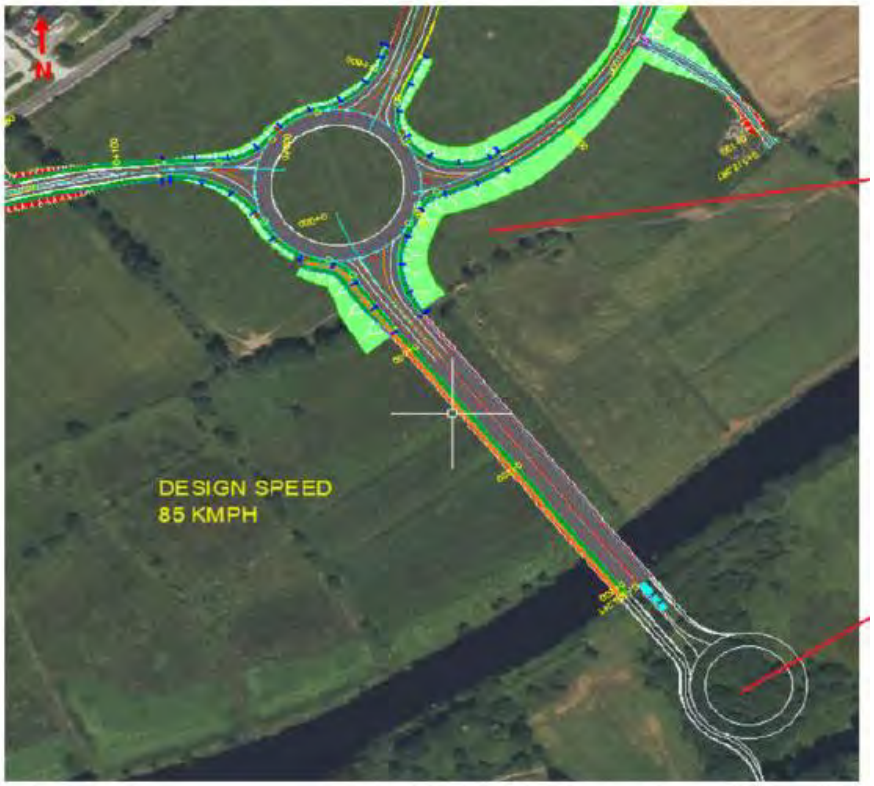
3.3 A5 Link/River Finn

The proposed River Finn crossing is to be provided at the end of Section 3. Detailed hydraulic modelling was performed to assess the pre and post development flood risk with different scenarios and to ensure that the proposed bridge design is compliant with Section 50 of the Arterial Drainage Act 1945.

The proposed structure is a multi-span bridge that will be located to the southwest of Lifford town, Co.Donegal. The bridge is approx. 290m long and connects a proposed roundabout on the A5 Western Transport Corridor in Co. Tyrone with the proposed Manorcunningham Roundabout on the Ten-T project. The Finn Valley is a broad valley overlooked by residential development on the rising slopes of the N15 at Coneyburrow/ Curraghalane.

On the north-west side of the River Finn at the proposed crossing location (Co. Donegal), there is a wide flood plain extending up to the existing N15 carriageway. This floodplain area consists of agricultural grassland and hedgerows with a few trees. The proposed roundabout is located on the south-east side of the existing N15 carriageway.

On the south-east side of the River Finn (Co. Tyrone) at the proposed crossing location, the floodplain extends to the location of the proposed roundabout. This floodplain area consists of agricultural grassland, hedgerows, and a few trees. For further detail, refer to Section 4.4 below.



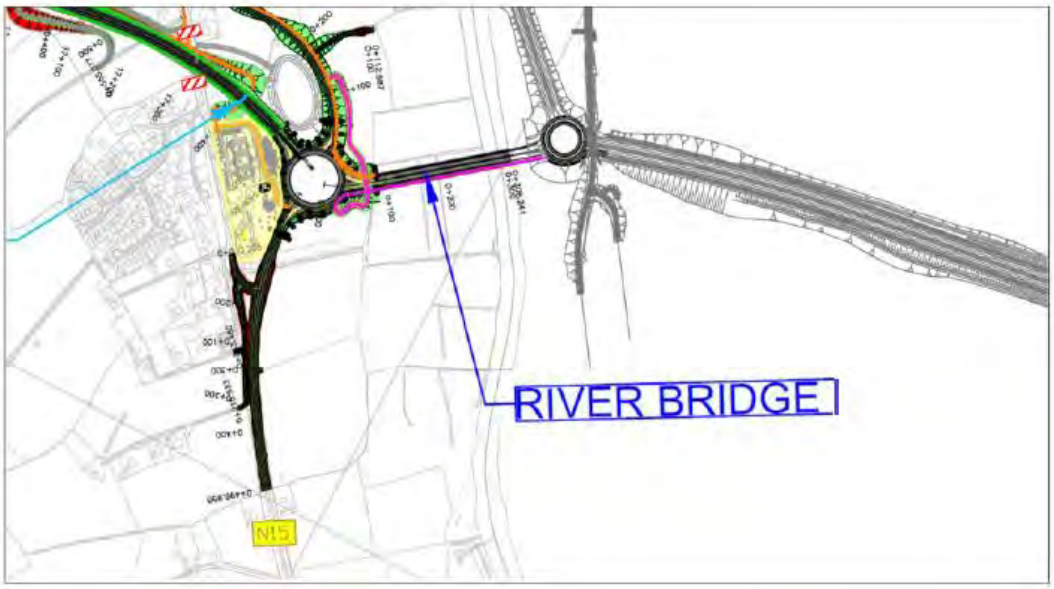


Figure 7 River Finn Crossing

3.4 Manorcunningham Culvert Crossings

There are 6 box culverts proposed at the start of the scheme in Manorcunningham where the proposed road intercepts an existing stream and a drainage ditch. Three of these culverts are proposed under the new mainline, while two will be located under the existing N14.

Three of these culverts provide flow connectivity on the existing stream/river, while the other three are located on a drainage ditch and work as flood relief culverts when a storm event for the 100 year return period occurs. Refer to Section 4.4 below for further detail.

This area was identified as a flood risk area for a 100 year return period storm event so a flood modelling was carried out to determine the sizes of these culverts and the flood impact that the new development would have in the flood plain. As they are all part of the same flood assessment and on the same river, they have been separated from the other culverts that cross existing rivers/streams.

Refer to Figure 8 below for the locations of these culverts.



Figure Proposed Culverts Locations

The table 3-1 below shows details of these culverts

Table 3-1 Proposed Culverts Manorcunningham

Culvert Ref.	Mainline Chainage	Type	Watercourse Reference	Stream name	Referenced Mainline / Side Road	Culvert Diameter (m) / Width (m) x Height (m)	Approx. Length (m)
S3-CUL.01	0+574	Box	W3-01	Drainage ditch tributary to W3-02	Access Road	4.0 x 3.0	25.80
S3-CUL.02	0+535	Box	W3-01	Drainage ditch tributary to W3-02	Mainline	4.0 x 3.2	52.70
S3-CUL.03	0+500	Box	W3-01	Drainage ditch tributary to W3-02	Link South-Existing N14	4.0 x 4.0	66.80

S3-CUL.04	0+722	Box	W3-02	Leslie Hill Stream_020	Mainline and Access Road	8.0 x 3.8	60.00
S3-CUL.05	0+670	Box	W3-02	Leslie Hill Stream_020	Existing N14	8.0 x 3.6	58.00
S3-CUL.06	1+100	Box	W3-02	Leslie Hill Stream_020	Mainline	12.0 x 3.2	60.00

3.5 Culvert Crossings along Proposed Road

Separate to the proposed culverts at Manorcunningham as listed above, there are 27 other culverts which require Section 50 consent.

Culverts S3-CUL.07,08,09,10,11,12,13,14,15,16 and 17 contribute to the Lough Lough Swilly Catchment while the remaining flow in a southernly direction into the Foyle Catchment.

The catchment areas of these watercourses vary from < 0.5 km2 to 13.850 km2.

All these Culverts are subject to Section 50 Consent. These watercourse crossings are summarised below in Table 3-2.. For further detail refer to Section 4.4 below.

Table 3-2 Proposed Culverts Details

Culvert Reference	Chainage	Type	Watercourse Reference	Referenced Mainline / Side Road	Culvert Diameter (m) / Width (m) x Height (m)	Approx. Length (m)
S3-CUL.07	2+035	Box	W3-04	Mainline	4.2 x 3.5	69.50
S3-CUL.08	0+401	Box	W3-05	LX 3014 Drumoghill	1.8 x 1.4	24.50
S3-CUL.09	2+663	Box	W3-05	Mainline	1.8 x 1.4	79.10
S3-CUL.10	0+100	Box	W3-05	LX 3014 Drumoghill	2.0 x 1.8	53.50
S3-CUL.11	0+021	Box	W3-05	Access Road 3.12	2.0 x 1.7	19.00
S3-CUL.12	4+100	Pipe	W3-07	Mainline	1.2	62.00
S3-CUL.13	0+288	Pipe	W3-07	LX 3014 Doorable	1.2	31.80
S3-CUL.14	0+500	Box	W3-08	LX 3014 Doorable	4.2 x 1.9	23.23
S3-CUL.15	4+477	Box	W3-08	Mainline	3.7 x 2.2	60.00
S3-CUL.16	0+097	Box	W3-08	Access Road 3.22	3.7 x 2.3	22.71
S3-CUL.17	5+715	Pipe	W3-09	Mainline	1.2	49.82
S3-CUL.18	6+550	Box	W3-10	Mainline	2.0 x 1.8	48.40
S3-CUL.19	0+683	Box	W3-10	LX 3014 Sheshkinapoll	2.0 x 1.8	36.00
S3-CUL.20	7+418	Box	W3-11	Mainline	3.2 x 1.9	60.00
S3-CUL.21	0+271	Box	W3-12A	Access Road 3.32	2.8 x 1.4	16.50
S3-CUL.22	8+185	Box	W3-12A	Mainline	2.8 x 1.5	34.60
S3-CUL.23	0+457	Box	W3-12A	R236 LX 3014 Link South	2.2 x 1.5	23.66
S3-CUL.24	0+032	Box	W3-12	L2374 Whitecross	6.0 x 2.5	17.70
S3-CUL.25	0+911	Box	W3-13	LX 3014 Tullyrap	2.0 x 1.9	50.20
S3-CUL.26	10+055	Box	W3-13	Mainline	2.2 x 1.9	59.00
S3-CUL.27	10+395	Bottomless	W3-13	Mainline	9.5 x 2.9	36.20

Culvert Reference	Chainage	Type	Watercourse Reference	Referenced Mainline / Side Road	Culvert Diameter (m) / Width (m) x Height (m)	Approx. Length (m)
		Culvert				
S3-CUL.28	11+930	Box	W3-16	Mainline	2.0 x 1.8	60.00
S3-CUL.29	11+641	Box	W3-15	Mainline	2.8 x 2.2	54.50
S3-CUL.30	1+500	Box	W3-17A	L2444 Ballindrait	2.0 x 1.8	66.00
S3-CUL.31	14+935	Box	W3-18	Mainline	1.8 x 1.8	70.50
S3-CUL.32	15+140	Pipe	W3-19	Mainline	1.2	44.50
S3-CUL.33	15+556	Pipe	W3-20	Mainline	1.2	50.70

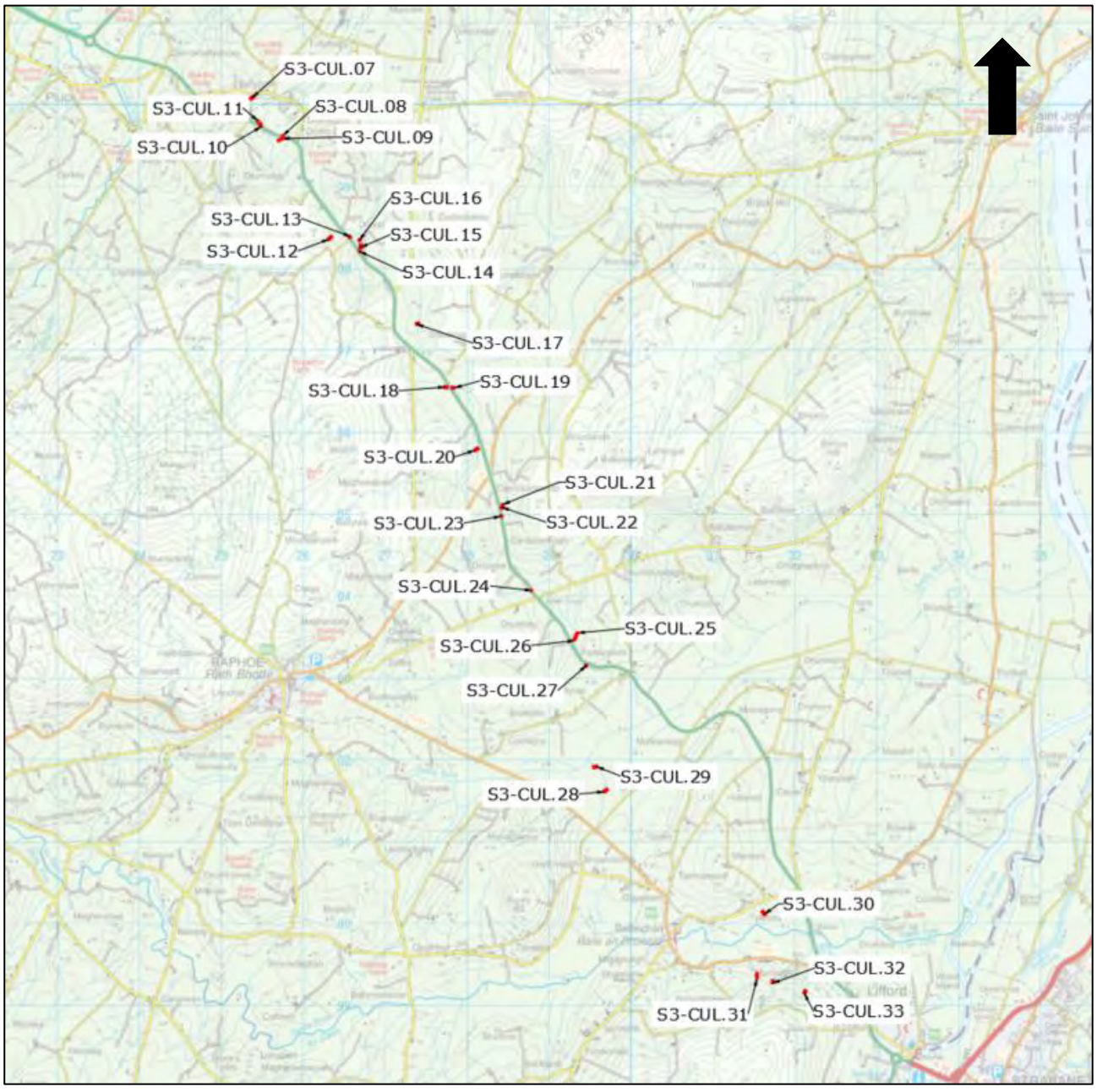


Figure 8 Location Map of Culverts

3.6 Proposed Road Drainage Features

There are a total of 18 main drainage outfalls for the proposed road development which discharge to surface watercourses. There are also a number of outfalls discharging to groundwater through infiltration trenches from small side roads or sections of side roads.

The largest surface water outfall services a paved area of 6.83 ha. A summary of the proposed road drainage outfalls discharging to surface watercourses is presented in Table 3-3.

Table 3-3 Proposed Road Drainage Outfalls

Drainage Network Ref.	Mainline / Side Road (No.)	Chainage	Total Catchment Drainage Area (ha)	Pavement Area (ha)	Outfall
S3-ML-DN-01	Mainline	0+071 to 1+880	5.40	3.74	Outfall 02
S3-SR-DN-01	N13/N14 Pluck Roundabout	3+655 to 3+759	2.65	1.15	Outfall 01
	N13 Pluck Tie-in	0+000 to 0+116			
	LX 3014 Link North	0+000 to 0+452			
	N13 Derry Tie-in				
S3-SR-DN-02	L1294 Manorcunningham Local Road	0+000 to 0+599	0.95	0.92	Outfall 02
	LX 3014 Link North	0+116 to 0+420			
S3-SR-DN-03	L1274 Drumoghill Link	0+000 to 0+430	0.46	0.29	Outfall 03
S3-ML-DN-02	Mainline	1+880 to 2+625	1.72	1.63	Outfall 04
S3-SR-DN-04	Drumoghill Junction North Link	0+000 to 0+156	0.87	0.75	Outfall 05
	LX 3014 Drumoghill	0+000 to 0+482			
S3-ML-DN-03	Mainline	2+625 to 3+920	4.00	3.10	Outfall 06
S3-SR-DN-05	L5574 Moodooey Lower	0+000 to 0+308	0.44	0.22	Outfall 06
S3-ML-DN-04	Mainline	3+920 to 4+390	1.44	1.07	Outfall 07
S3-SR-DN-06	Drumoghill Junction South Link	0+000 to 0+198	0.91	0.75	Outfall 07
	LX 3014 Doorable	0+088 to 0+280			
S3-SR-DN-07	Mondooey	0+000 to 0+392	0.38	0.28	Outfall 07
S3-ML-DN-05	Mainline	4+390 to 5+630	4.05	2.93	Outfall 07
S3-SR-DN-08	L1214 Galdonagh	0+000 to 0+305	0.55	0.46	Outfall 08
		0+000 to 0+254			
S3-ML-DN-06	Mainline	5+630 to 6+550	3.21	2.43	Outfall 09
S3-SR-DN-09	LX 3014 Sheshkinapoll	0+212 to 0+710	0.40	0.40	Outfall 09
S3-ML-DN-07	Mainline	6+550 to 7+570	3.18	3.00	Outfall 10
	Ballinalecky Junction Link North	0+000 to 0+083			
	R236 LX 3014 Link North	0+000 to 0+255			
	R235 Ballinaleckey Tie-in West	0+385 to 0+732			
	Ballinalecky Junction Link South	0+000 to 0+183			
S3-SR-DN-10	R236 Ballinalecky	0+145 to 0+385	0.17	0.17	Outfall 10
S3-SR-DN-11	R236 LX 3014 Link South	0+134 to 0+603	0.58	0.39	Outfall 11
S3-ML-DN-08	Mainline	7+570 to 9+400	5.50	4.03	Outfall 12
S3-SR-DN-12	LX 3014 Tullyrap	0+000 to 0+573	0.62	0.53	Outfall 12

Drainage Network Ref.	Mainline / Side Road (No.)	Chainage	Total Catchment Drainage Area (ha)	Pavement Area (ha)	Outfall
S3-SR-DN-13	LX 3014 Tullyrap	0+573 to 1+071	0.44	0.40	Outfall 12
S3-SR-DN-14	LX 3014 Tullyrap	1+071 to 1+567	1.12	0.31	Outfall 12
S3-ML-DN-09	Mainline	9+400 to 11+400	6.06	4.72	Outfall 13
S3-ML-DN-10	Mainline	11+400 to 13+417	6.72	5.25	Outfall 13
S3-SR-DN-15	L6104 Broadlea	0+000 to 0+266	0.18	0.18	Outfall 13
S3-SR-DN-16	L2424 Mullinavegh	0+000 to 0+321	0.24	0.21	Outfall 13
S3-SR-DN-17	L2414 Tamnawood	0+268 to 0+396	0.29	0.25	Outfall 13
S3-ML-DN-11	Mainline	13+417 to 14+480	3.41	2.50	Outfall 14
S3-SR-DN-18	Ballindrait Link North	0+000 to 0+231	0.30	0.21	Outfall 15
S3-SR-DN-19	L2444 Ballindrait	0+000 to 0+435	0.82	0.57	S3-PED-IT-07
S3-SR-DN-20	L2444 Ballindrait	0+435 to 1+520	1.84	1.35	Outfall 16
S3-SR-DN-21	L2444 Ballindrait BLX 3014 Rossgeir BLX 3014 Rossgeir Link North	1+520 to 2+004 0+000 to 0+192 0+000 to 0+148	1.11	1.01	Outfall 17
S3-SR-DN-22	Ballindrait Junction Link South	0+000 to 0+144	0.21	0.20	Outfall 14
S3-ML-DN-12	Mainline	14+480 to 15+746	5.90	3.74	Outfall 14
S3-SR-DN-23	R264 Murlog	0+000 to 0+227	0.23	0.16	Outfall 14
S3-ML-DN-13	Mainline L6144 Lifford Common Road Lifford Junction N15 West Link N15 Lifford Tie in West N15 Lifford Tie in East	15+746 to 17+540 0+000 to 0+192 0+000 to 0+497 0+000 to 0+038 0+000 to 0+443	9.23	6.83	Outfall 18

Attenuation ponds will be provided at all major surface water outfalls along the length of the proposed road. They will be designed as hybrid wetlands, so they provide both an attenuation function and a water treatment function. Discharge from these attenuation facilities will be provided at the green-field runoff rate.

The total number of attenuation ponds in Section 3 is 23.The majority have a depth of 1m, with the deepest being 1.5m.

The flood risk from these ponds in the event of a blockage, will be mitigated by providing a pond overflow. The water from the pond overflows will be directed to an adjacent interceptor ditch or watercourse. The residual flood risk will also be managed through a program of regular inspection and maintenance. A controlled overflow facility will be provided at each pond in the event that the outflow throttle device (hydrobrake, vortex control or orifice plate) becomes blocked and freeboard allowance is provided for each pond to prevent overtopping.

There are also a number of attenuation ditches/swales which drain small areas of side roads before discharging into watercourses.

Attenuation facilities have been provided for some of the more significant side road realignments (i.e. Ballindrait). In cases where flood attenuation is to be provided to an existing road, this will be an improvement from the pre-development condition. For the more minor side roads and access tracks where attenuation ponds or ditches are not being provided, a degree of attenuation will be provided by the interceptor ditches that connects the drainage network outfall headwall with the connection point on the existing watercourse.

4 FLOOD RISK ASSESSMENT

4.1 Background

A Strategic Flood Risk Assessment was developed by RPS in January 2021 for the Proposed Variation to the County Donegal Development Plan 2018-2014 in respect of the Ten-T Priority Route Improvement Project, Donegal. The report was prepared in accordance with the requirements of "The Planning System and Flood Risk Assessment Guidelines for Planning Authorities (2009) Circular PL02/2014 (August 2014)."

The SFRA provided an assessment of all types of flood risk surrounding the TEN-T PRIPD preferred route corridor regions and was provided to Donegal County Council (DCC) to make informed strategic land-use planning decisions and formulate flood risk policies. A Stage 1 Flood Risk Identification was undertaken to identify any flooding or surface water management issues related to the TEN-T PRIPD preferred route corridors that may warrant further investigation. As part of this stage the best available data at the time of preparation was acquired from the Office of Public Works (OPW) North Western Catchment Flood Risk Assessment Management (CFRAM) Study. The North Western CFRAM has generated flood zone mapping which has been deemed suitable as a Stage 2 Initial Flood Risk Assessment. The SFRA examines the Flood Zones A, B and C identified in the North Western/Neagh Bann CFRAMs study. This flood risk information has enabled the application of 'The Guidelines' sequential approach, and where necessary the Justification Test, to appraise locations where the preferred corridor traverses the flood zones and identify how flood risk can be managed as part of the development plan. The preferred TEN-T PRIPD route corridors are to be included as a variation in the County Development Plan.

Information from the SFRA was taken to develop this section but further information was included as a result of the development of the scheme and to take into account any changes made along the way.

4.2 Stage 1 – Identification of Sources of Flooding

- The Route Option Selections Report for the Ten-T Road Development Project assessed the potential for flood risk from fluvial, coastal, pluvial and groundwater flooding as a result of the proposed road development. This involved consulting the following sources. The OPW National Preliminary Flood Risk Assessment (pFRA) Mapping.
- The OPW CFRAM North Western Catchment Flood Risk Assessment Management Study and mapping for the Areas for Further Assessment (AFA).
- Irish Coastal Protection Strategic Study (ICPSS) prepared flood maps (ICPSS, 2013).
- OPW Preliminary Flood Risk Assessments Groundwater Flooding Report.
- OPW Pluvial Flooding Risk Assessment study and maps.
- Indicative fluvial flood maps.
- Known historical flooding areas and extents.
- OSI Historical Mapping.

A review of historical flood data was carried out for the North Western CFRAMs using information provided on floodmaps.ie and in consultation with DCC.

The Preliminary Flood Risk Assessment (PFRA) is a national screening exercise completed by the OPW in 2012 based on available and readily derivable information. The PFRA aimed to identify areas where there may be a significant risk associated with flooding. Indicative fluvial flood maps were produced to help identify these areas. The mapping did not account for flood defences, channel structures or channel works. Areas where the risks associated with flooding might be significant were identified and are referred to as Areas for Further Assessment, or 'AFAs'. More detailed assessment of the AFA's is being undertaken through the CFRAM Studies to more accurately assess the extent and degree of flood risk, and, where the risk is significant, to develop where possible measures to manage and reduce the risk.

The Northwestern CFRAM study includes Letterkenny, Lifford and Ballybofey/Stranorlar as AFAs and therefore the CFRAMs flood mapping provided for in the Flood Risk Management Plans is adequate to accurately assess

the extent and degree of flood risk for the areas within the extents of the AFAs that may be affected by the proposed development.

For those areas of the proposed road that are outside the above AFAs, the PFRA flood mapping was used. The main sources of flooding in the study area are fluvial and coastal.

4.2.1 Tidal and Coastal Flooding

- Manorcunningham.

The North of the study area affects the Lough Swilly Catchment (HA 39). Lough Swilly is a glacial fjord inlet into which the River Swilly flows (a different watercourse from Swilly Burn mentioned in the paragraph below which is within a different Hydrometric area). A watercourse named the Pluck crosses the study area three times along its length before joining Lough Swilly to the North of the Study area.

- Swilly Burn to East of Raphoe.

The Swilly Burn has a small catchment that crosses the scheme from West to East. A significant tributary of this river approaches from the North, running parallel to the existing N14. Due to its alignment, this tributary is significantly impacted by the study area. The catchment for the Swilly Burn is largely agricultural.

- River Deele to West of Lifford.

The River Deele is a medium sized catchment (134 km^2) that forms part of the greater Foyle Catchment and originates in the hilly area to the west of the village of Convoy. The catchment is largely agricultural land with some peat and forest land coverage. The River Deele flows into the River Foyle approximately 2.8 km downstream of the River Finn/River Foyle confluence.

- River Finn at Lifford.

The River Finn is one of the major tributaries of the greater Foyle catchment (HA 01) and emanates from the Bluestack and Glendowan Mountains in the interior of Donegal. The River Finn flows into the River Mourne to form the River Foyle at Lifford/Strabane. The Finn catchment is a medium to large sized catchment (502 km^2) with a mixture of peat, pasture and forest coverage. In terms of plan area, the study area only affects a small portion of the River Finn, which is adjacent to the confluence of the River Finn and the Foyle at the Southern Extent of the scheme.

4.2.2 Fluvial Flooding

There were four areas identified where the proposed road coincide with areas which are at significant risk of fluvial flooding:

- Manorcunningham.
- Swilly Burn to East of Raphoe.
- River Deele to West of Lifford.
- River Finn at Lifford.

Streams and catchments described in section above.

4.2.3 Groundwater Flooding

The Groundwater Flood Risk Map produced by the Geological Survey Ireland in Figure 10 below shows that ground water flooding is not a risk for Section 3 .

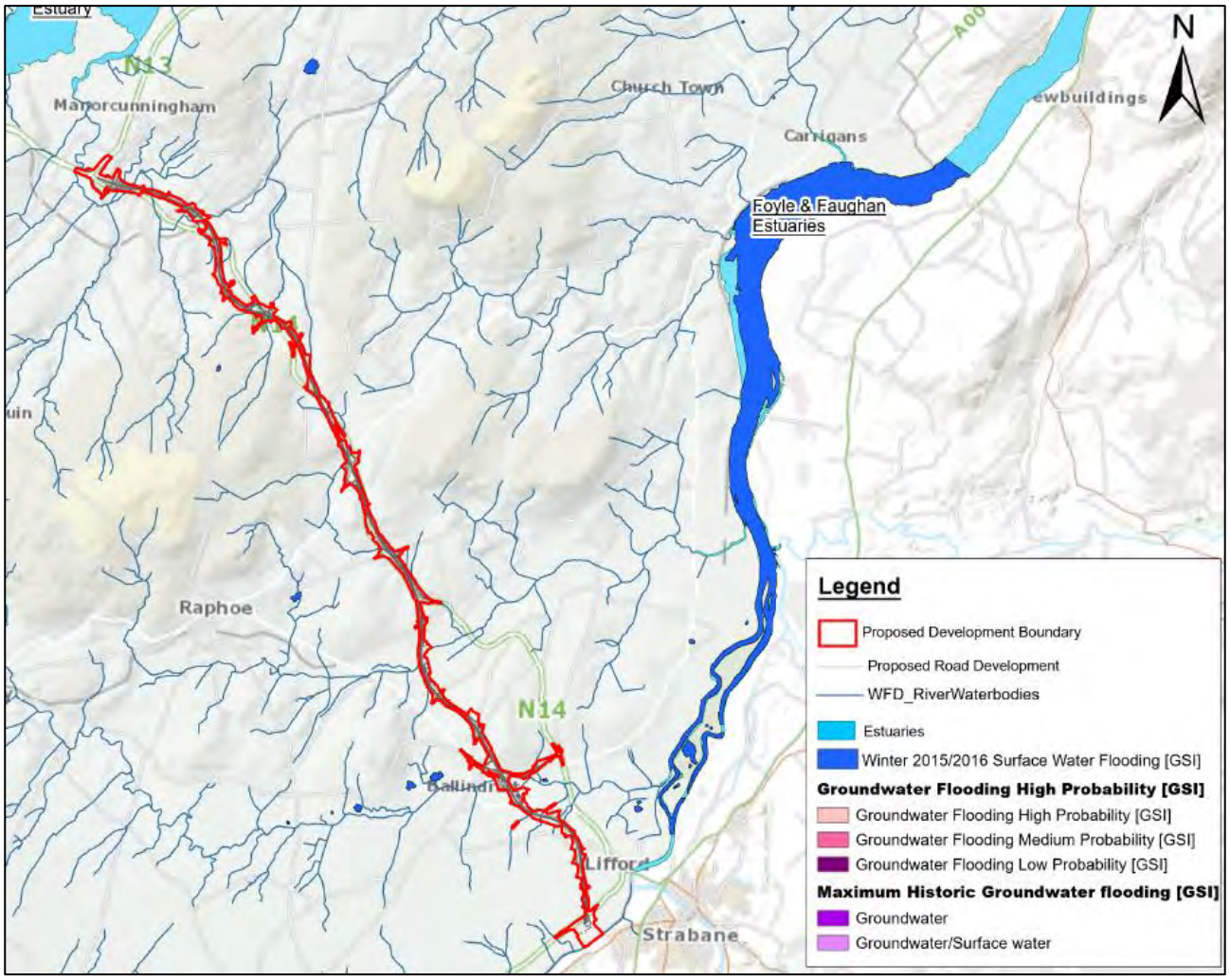


Figure 9 Groundwater Flood Risk Map

4.2.4 Pluvial Flooding

The OPW Pluvial Flooding Risk Assessment study provides a national level pluvial screening of areas that are at potential risk of pluvial flooding. During the Stage 1 FRA assessment the following location in Section 3 was identified;

- Lifford.

4.3 Stage 2 Initial Flood Risk Assessment

This Stage 2 assessment investigated in more detail the flood risk implications for the proposed road development from available sources. It was carried out to confirm sources of flooding that could affect the development, and to appraise the adequacy of existing information and to scope the extent of the risk of flooding.

The North Western CFRAM has generated flood zone mapping which have been deemed suitable as a Stage 2 Initial Flood Risk Assessment. The SFRA examined the Flood Zones A, B and C identified in the North Western/Neagh Bann CFRAMs study. This flood risk information enabled the application of 'The Guidelines'

sequential approach, and where necessary the Justification Test, to appraise locations where the proposed road traversed the flood zones

By the nature of transport infrastructure, the crossing of watercourses (rivers, estuaries and floodplains) is often unavoidable as the purpose is to link lands that are likely to be separated by a number of watercourses. A sequential approach has been adopted in respect to a route selection process for the project which takes into account many environmental factors which include flood risk and hydrology in order to select the most suitable route.

In Section 3, Lifford has been identified as an Area for Further Assessment (AFA) in the OPW PFRA in 2012. Under the Northwest -Neagh Bann CFRAM study (OPW, 2016) flood levels in all high priority watercourses (River Finn and River Deele, Finn-Deele Subcatchment), located within this AFA were estimated through a detailed hydrological and hydraulic modelling. Also, under the OPW NIFM Project (2020), predictive flood extent maps were produced for all watercourses with catchment area greater than 5 km^2, and for which flood maps were not produced under the National CFRAM Programme. For example, the River Swilly Burn and the Leslie Hill Stream Subcatchment at the proposed Section 3 road crossings were not modelled under the CFRAM study, however, predictive flood extent maps were prepared for these watercourses under the NIFM study.

The above studies showed that the proposed Section 3 crosses/encroaches the 1% AEP & 0.1%AEP flood extents at a number of locations.

As part of the SFRA, Flood zone maps (Zones A, B and C) for the scheme study area were derived mainly from the Northwestern – Neagh Bann CFRAM and NIFM studies prepared flood maps. The SFRA includes maps which shows the Flood Zone Maps (Current Climatic Scenario) for all watercourses likely to be impacted by the proposed development scheme. Under the SFRA, two locations within Section 3 were identified where the proposed route is crossing existing floodplains:

1. Swilly Burn to east of Raphoe.,

2. River Deele to west of Lifford.

Through a justification test, it has been demonstrated that there are no other suitable alternatives road route of lesser flood risk in these areas.

At a later stage, two more areas were identified where the proposed route was crossing existing floodplains.

- Leslie Hill Stream Subcatchment, Manorcunningham.
- River Finn, Lifford.

These two areas are at each end of the proposed road for Section 3. which it also demonstrates that there are no other suitable alternatives road route of lesser flood risk in these areas.

All the areas above are tidally impacted so they were modelled under the Irish Coastal Protection Strategy Study (ICPSS, OPW, 2013). This model was updated in 2018 under the Irish Coastal Wave Water Study (ICWWS, OPW, 2018). The OPW produced coastal flood mapping indicated that Leslie Hill Stream, River Swilly Burn, River Deele and River Finn are impacted by tidal events. The mapping indicated that these rivers were impacted by the 0.5%AEP and 0.1 % AEP tidal event.

In the SFRA it was recommended that the following measures be implemented to ensure that the Proposed Project does not give rise to unacceptable adverse impacts elsewhere:

- A detailed hydraulic model for the associated river channel and floodplains should be carried out to assess this impact and an appropriate mitigation measure should be implemented. A section 50 application will also be required for the subject river crossing.
- Existing open spaces and water compatible uses in flood zones A and B should be retained to maintain flood storage areas.

- The detailed FRAs for the preferred option demonstrate that road level is designed for the 0.1% AEP level plus suitable freeboard. The recommended level of freeboard is 500 mm for fluvial flood levels.

4.4 Stage 3 Detailed Flood Risk Assessment

The extents of the CFRAM mapping, the NIFM (National Indicative Fluvial Mapping) and the National Coastal Flood Hazard Mapping (NCFHM) in the vicinity of the proposed route shows that there are locations where the proposed route impacts on the flood events modelled as part of these studies. Where considered necessary, more detailed flood studies have been carried out as part of the Schemes Flood risk Assessment for Section 3. Table 4-1 below shows these locations.

Table 4-1 Road Route Predictive Flood Risks

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
0+000	Fluvial and Coastal	Leslie Hill Stream	Imperceptible	Imperceptible	Part of the proposed Attenuation Pond 01 to the North of the proposed N13/N14 Pluck Roundabout encroaches on the 0.1% AEP flood extents (National Indicative Fluvial Mapping) and on the 10% , 0.5 % and 0.1% AEP Coastal Flooding (National Coastal Flood Hazard Mapping). However, this is a small pond in comparison to the flood extends and the impact on the flood levels is considered minor. In addition, the pond is raised high enough above the flood levels.
0+420 to 0+775	Fluvial	Leslie Hill Stream	Moderate	Minor	The existing N14, the proposed route of the N14, the attenuation pond to the North of the mainline at Chainage 0+500, a proposed access track to the north of the alignment together with the proposed cycleways to the North and South of the proposed N14 impact on the 1.0% AEP flood extents (NIFM). A detailed flood risk assessment has been carried out to determine the size of the new culverts and the impact on the flood plain.
1+050 to 1+120	Fluvial	Leslie Hill Stream	Moderate	Minor	The proposed N14 imposes on the 1.0% AEP flood event (NIFM). A detailed flood risk assessment has been carried out to determine the size of the culvert and the impact on the flood plain.
1+880 to 2+030	Fluvial	Leslie Hill Stream	Imperceptible	Imperceptible	The proposed N14 and Attenuation pond 03 encroach on the 1.0% AEP flood event (NIFM). The NIFM shows localised ponding rather than a full flood plain. Also, the area taken by the pond and by the road embankment are considered small so the impact is considered imperceptible. This stream crosses the proposed road through S3-CUL.07 which conveys the design flows and meets the OPW requirements without causing significant hydraulic changes on the watercourse.
9+200 to 10+400	Fluvial	Swilly Burn Tributary	Minor	Minor	The proposed N14 Mainline, the existing N14, the proposed sideroad the LX 3014 (Tullyrap), the proposed sideroad the LX3024 (Whitecross), the proposed sideroad the L2374(Whitecross) and the proposed attenuation pond 09 at Mainline Chainage 9+400 encroach on the 1.0% AEP flood extents (NIFM). Whilst these encroachments are substantial in places, the existing watercourse which was the cause of this flooding is to be diverted between Mainline Chainages 9+200 and 10+200. The new watercourse diversion has more capacity than the existing stream, and a flooding assessment has determined that the diverted watercourse will prevent out of bank flooding during the 1.0% AEP flood event.
11+250 to 12+200	Fluvial and Coastal	River Swilly Burn	Moderate	Minor	The proposed N14, the attenuation pond 11 at Ch 11+600, and a proposed access track, impact on the 1.0% AEP flood event (NIFM) and 0.5 % (NCFHM) of the River Swilly Burn. A detailed flood risk assessment has been carried out to size the bridge and determine the impact on the flood plain.

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
14+200 to 14+620	Fluvial and Coastal	River Deele	Significant	Minor	The proposed N14 mainline has a significant encroachment on the 1.0% AEP and the 0.1% AEP fluvial flooding extents (CFRAM) and 0.5 % AEP coastal flooding (NCFHM). The proposed 2.0-kilometre long Ballindrait Sideroad Realignment has a slight impact on the 1.0% AEP and the 0.1% AEP flooding extents (CFRAM). The attenuation pond 14 at Chainage 1+300 (on the Ballindrait Sideroad Realignment), has a slight impact on the 0.1% AEP flooding extents (CFRAM). The attenuation pond 13 at Mainline Chainage 14+500 has a moderate impact on the on the 1.0% AEP and 0.1% AEP flooding extents (CFRAM). A detailed flood risk assessment has been carried out to size the bridge and determine the impact on the flood plain.
17+540	Fluvial and Coastal	River Finn	Minor	Minor	The proposed Lifford Junction has a slight impact on the 1.0% AEP flooding extents (CFRAM). The N15 Lifford Tie in East has a slight impact on the 0.1% AEP flooding extents (CFRAM). The A5 Link Bridge crossing the Finn has a slight impact on the 1.0% AEP fluvial flooding extents (CFRAM) and 0.5 % AEP coastal flooding extents (NCFHM) .

4.4.1 River Deele Bridge Crossing

A Section 50 application was submitted to the OPW for the proposed bridge crossing of the River Deele near Lifford. A copy of the Section 50 Application is contained in Appendix A. As part of the Section 50 report a detailed flood risk assessment was conducted, so that it could be demonstrated that the proposed bridge crossing did not have any significant adverse effects. A Flood Risk Review was carried out using historical and predictive information that identifies any sources of potential flood risk to the site.

In accordance with the OPW requirements the design flows are based on the 1% AEP event but also includes a factorial standard of error (FSE), and a factor for climate change (1.2). The relevant factors are indicated on Table 4-2 below. Both the 68% and 95% CI values are included but as there are properties identified as being at risk, the 95% CI will be adopted for the Section 50 estimates. As the FSU method includes the arterial drainage works within the catchment descriptors, the additional factor of 1.6 to account for these works does not need to be included.

The following peak flow is used in the modelling to predict flood data levels at the River Deele Bridge site which is downstream of a pivotal gauge named Sandy Mills. The gauge information has been adopted from the Lifford Flood Relief Scheme (FRS) Hydrology Report. The inundation maps for the 100 year with climate change allowance is presented in Figure 11.

Table 4-2 Section 50 Design Flows

Method	Peak Flow (m3/s)
FSU 1% AEP Event	179.67
1% AEP + Climate Change	215.60
1% AEP + 68% confidence interval (1.2*1.16)	250.50
1% AEP + 95% confidence interval (1.2*1.36)	**293.68**

The proposed carriageway includes structures crossing both the Deele channel and floodplain. The proposed bridge (within the channel) is a three span structure with the piers on each bank of the river. As the proposed

bridge is skewed, the distance between the piers was modelled as 54.3m which is the real width of the channel measured in the flow direction.

In order to minimize impacts generated by the road construction and the impact on the properties upstream of the bridge as well as to comply with Section 50 regulation concerning the maximum afflux of 150mm , two additional backspans and a culvert system was modelled under the road on both left and right floodplain.

The backspans have a distance between piers and abutments of 24m, having a square span of 20.6m each. The culvert system includes 4 arched culverts on the left floodplain having 6m span x 3m rise.

There is no increase in flood risk, as the peak flow is contained by the bridge. There is no significant change of the current hydraulic characteristics and dynamics of the river system. Dwellings in the Ballindrait settlement are not adversely affected as the increase in water level is less than 1mm and there is no increase in extent/flood risk.

The freeboard under the soffit of the bridge is 7.71 m and 473 mm freeboard within the relief culverts which is in compliance with the Section 50 requirements.

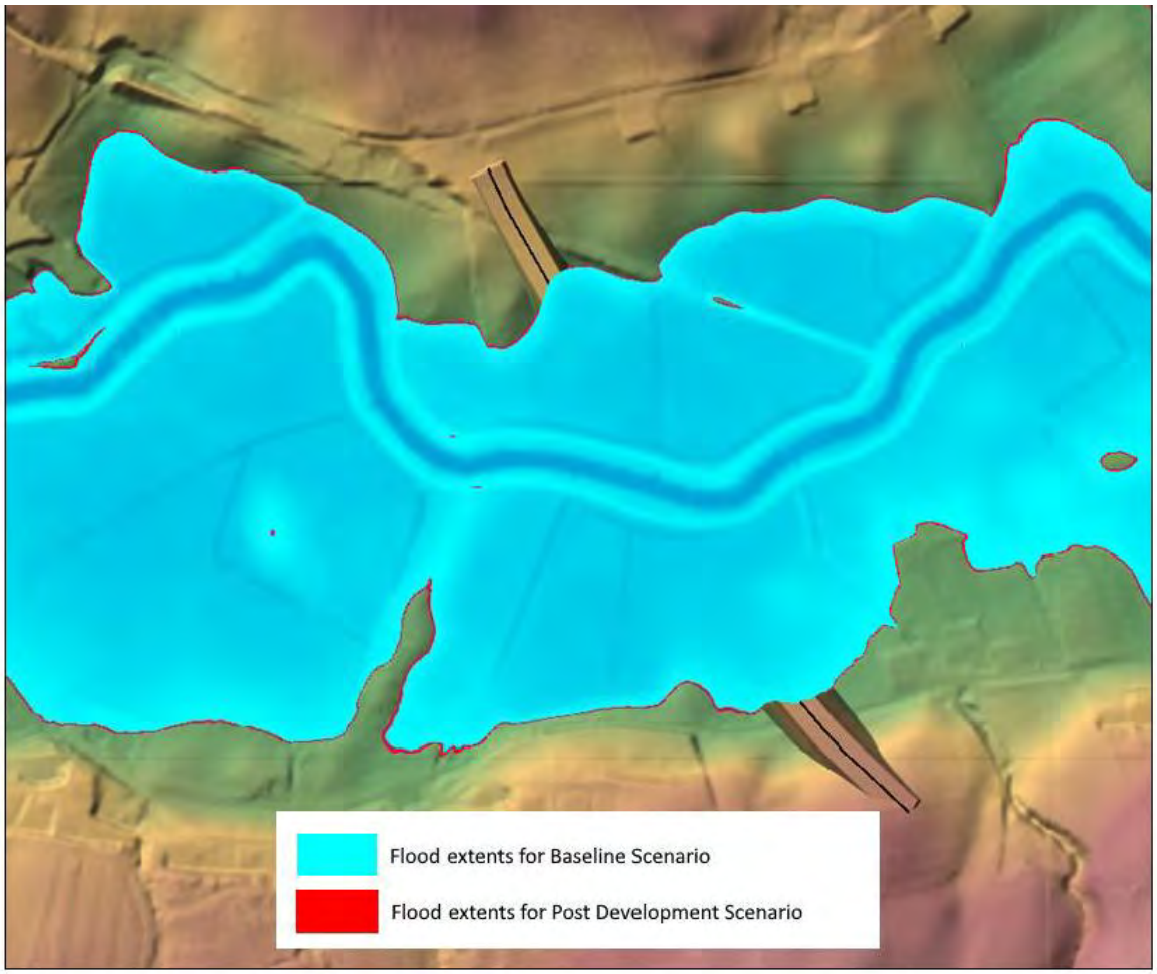


Figure 10 Flood extents comparison near the proposed bridge

The design flows estimated were compared with other studies such as the Lifford Flood Relief Scheme (FRS) and the CFRAM .

The River Deele was modelled as part of the Lifford Flood Relief Scheme (FRS). The flows used in the Section 50 Application were compared and concluded that the design flows estimated were more conservative than the estimated in the Lifford FRS.

4.4.2 River Swilly Burn Bridge Crossing

A Section 50 Assessment was prepared for a proposed Swilly Burn Bridge Structure. A copy of the Section 50 report is included in Appendix B and a summary of the findings is included below.

A Flood Risk Review was carried out using historical and predictive information that identified any source of potential flood risk to the site.

The FSU method and the FSU Small Catchments (SC) method were used as the catchment size is on the limit of the FSU minimum size. For the FSU method, two gauges were considered as pivotal sites. However, due to their characteristics and adjustment factors, the conservative approach was taken to base the FSU Method on the catchment descriptors. Also, it was recommended that the FSU flows are to be applied even though the catchment is slightly below the recommended size for the FSU method, as it is the most conservative approach.

In accordance with the OPW requirements the design flows are based on the 1% AEP event but also include a factorial standard of error (FSE), and a factor for climate change (1.2). The relevant factors are indicated on Table 4-3 below. Both the 68% and 95% CI values are included but there are noproperties identified as being at risk so the 1.36 or 68% factor has been used. As the FSU method includes the arterial drainage works within the catchment descriptors, the additional factor of 1.6 to account for these works does not need to be included.

Table 4-3 Section 50 Design Flows

Method	Peak Flow (m3/s)
FSU 1% AEP Event	15.02
1% AEP + Climate Change	18.02
1% AEP + 68% confidence interval (1.2*1.36)	**24.51**
1% AEP + 95% confidence interval (1.2*1.85)	33.34

Detailed hydraulic modelling was performed to assess the pre and post development flood risk and to ensure that the proposed bridge designs are compliant with Section 50 of the Arterial Drainage Act 1945.

The proposed structure for this Section 50 assessment is a bridge having a flat deck and two abutments (one on each bank). The width between the abutments is 29.6m (clear skew span).

The simulations revealed that when comparing the pre and post development, the proposed bridge is not generating any significant afflux on the upstream face of the structure. The new bridge will convey the design flows with 3270 mm freeboard.

A flood extent map was generated using the results of the 1D model showing that there is no flooding in the vicinity of the proposed bridge, but a flooded area can be observed about 600m upstream of the proposed site.



Figure 11 Inundation boundary

There is no increase in flood risk, the peak flow is contained by the bridge. There is no significant change of the current hydraulic characteristics and dynamics of the river system.

4.4.3 A5 Link/River Finn

A Section 50 Application for the proposed bridge was prepared by Barry Transportation. WSP carried out the hydraulic modelling as the proposed A5 WTC (Western Transport Corridor) project has the potential to impact the existing hydraulic regime of the river. During the preparation of this Section 50 Application, details of the proposed bridge structure and the Ten-T earthworks extents were provided to WSP, so they could model the effect the A5 Link Bridge and the Ten-T project would have on the River Finn.
A copy of the Section 50 report is included in Appendix C and a summary of the findings is included below.

The report calculated the design fluvial flows based on the Flood Estimation Handbook (FEH) methods for the modelled watercourse; flows have been calculated using both the Statistical and the Revitalised Flood Hydrograph 2 (ReFH2) methods for the watercourse.

The design event used in the FRA report included in **Appendix C** as the Annual Exceedance Probability (AEP) and the associated return period, correspond to the values shown in the Table 4-4.

Table 4-4 Hydrological Design Events

Annual Exceedance Probability (AEP)	Return Period
50%	1 in 2 year
20%	1 in 5 year
10%	1 in 10 year
4%	1 in 25 year

2%	1 in 50 year
1%	1 in 100 year
0.5%	1 in 200 year
0.2%	1 in 500 year
0.1%	1 in 1000 year

In terms of the climate change allowances, the "Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland" published by DFL Water and Drainage Policy Division in February 2019 has been applied. The hydraulic model has been run for both the 1% AEP + 20% climate change allowance and 1% AEP + 35% climate change allowance events.

The inflow hydrology obtained for the River Finn is summarised in the below Table 4-5.

Table 4-5 Peak flow estimate for design return period

River Catchment	Size (Km2)	100 year + 35% CC peak flow (m3/s) 2021 Analysis
River Finn	495	940.3

A single hydraulic model for the Foyle River System was carried out which comprises the following seven key rivers:

- River Mourne.
- River Finn.
- River Ballymagorry.
- River Dennet.
- River Deele.
- River Swilly Burn.

The River Foyle system is a complex area hydraulically, being at the confluence of Rivers Mourne, Finn and Foyle as well as a number of minor watercourses. The Foyle is tidally influenced so the flood levels are influenced by the combined effect of river flows and tidal surge.

A fully dynamic and linked 1D / 2D hydraulic model was therefore required to accurately assess the complex flooding patterns within the Foyle River System. Four different scenarios were developed:

- **Baseline (No Ten-T):** This is the modelling of the River Finn/Foyle, which does not include the proposed changes to the topography and landscape due to the A5 WTC and Ten-T projects. This was only modelled for the 35% climate change scenario.
- **A5 Spec Des (No Ten-T):** This is the modelling of the River Finn/Foyle which includes the landscape and topography changes due to the proposed A5 WTC project. Only the 35% climate change scenario was modelled in this instance.
- **Baseline with Ten-T:** This is the modelling of the River Finn/Foyle which includes the landscape and topography changes due to the proposed A5 Link Bridge(N14R175) and the Ten-T project only. The 35% climate change scenario and the 20% climate change were modelled in this instance.
- **A5 Spec Design with Ten-T:** This is the modelling of the River Finn/Foyle which includes the landscape and topography changes due to the proposed A5 Link Bridge(N14R175) and the Ten-T project together with the A5 WTC project. The 35% climate change scenario and the 20% climate change were modelled

in this instance. As this is the most onerous of all the scenarios, it has been chosen as the design flood. Figure 13 below shows the flood extend for this scenario.

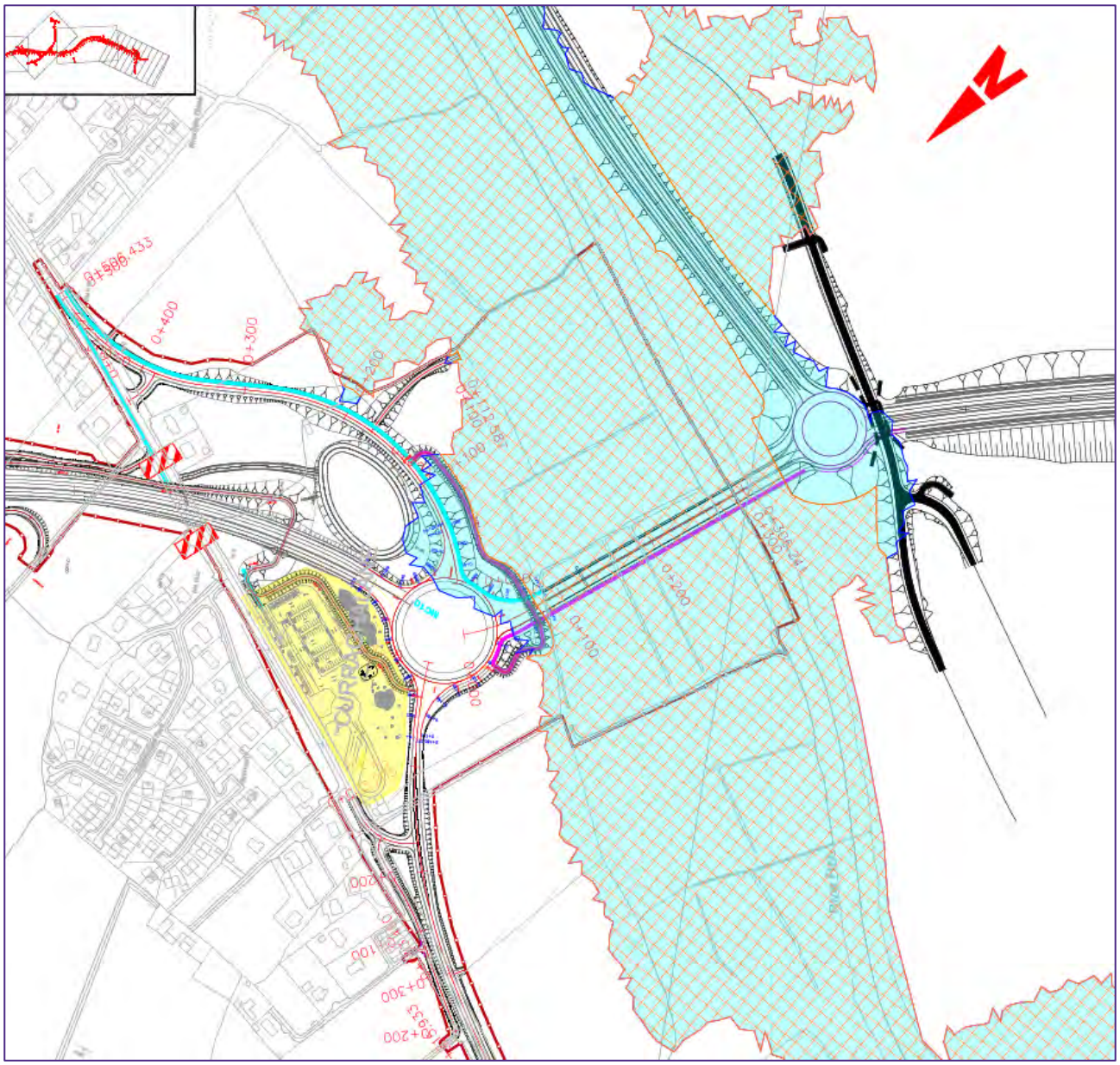


Figure 12 Flood Extent

The river and floodplain (County Donegal) is a Special Area of Conservation (SAC). To minimise the impacts on the River Finn channel and the flood plains, the Environmental Risk Assessment proposed a clear span bridge. The bridge has been designed in accordance with the recommendations of the Lough's Agency and the IFI. Both bodies were consulted with in relation to the bridge design.

As a result, the proposed structure is an eight span bridge with a span of 33 m for six of them, 63 m for the span that crosses the river channel and 26 m for the first span connecting to the Ten-T roundabout. The bridge has a minimum freeboard for a 1 in 100 Year Flood event of 2.778 m.

4.4.4 Manorcunningham Culvert Crossings

The Section 50 Application for the six culverts at Manorcunningham includes a flood risk assessment . The existing and proposed flood levels and the potential impact on flooding by the proposed culverts and the

proposed road were assessed. This report is included in Appendix D and a summary of the findings is included below. Section 50 approval for all the proposed culverts are subject to OPW Consent.

The proposed culverts were hydraulically assessed in terms of flow capacity and resultant upstream and downstream flood levels using HEC-RAS. Specific topographical channel surveys were conducted to provide the geometry information for the modelling exercise. Other sources of topographical information were used, including a lidar survey to define the geometry of the floodplain area.

The main stream affected is the Leslie Hill Stream_020 which is within the Lough Swilly catchment. This watercourse wasn't assessed as part of the Northwest -Neagh Bann CFRAM study (OPW, 2016) but predictive flood extent maps were produced under the OPW NIFM Project (2020).

The streams are ungauged and so the design flows have been estimated using OPW approved flood flow estimation methods.

Further to a review of the flow regimes in the vicinity of the proposed culverts, the study area for this application was divided into five separate catchments. A section of these streams form part of the OPW Arterial Drainage Scheme.

The design flood flow considered for each of the culverts is the estimated 100-year return period flood flow with a 20% Climate Change allowance

Two separate models were developed and two scenarios run (Predevelopment and Post development). Both models are on the same river but relate to different locations and the extents of both models are indicated below. Refer to Figure 14 below.

The proposed road (mainline, access road, cycle track and the attenuation pond) as well as the existing N14 encroaches on the 1% AEP flood event but as shown in Figure 14 below the proposed culverts in Model 2 improves the conveyance of the existing watercourses while in Model 1 the water level increases slightly upstream.

However, as the Attenuation Pond 02 is within the flood plain in Model 2 at an invert level of 4.50 m and the flood level in the post development scenario was estimated at 5.63 m, the top of the pond is required to be bunded 500 mm above the post development flood level.

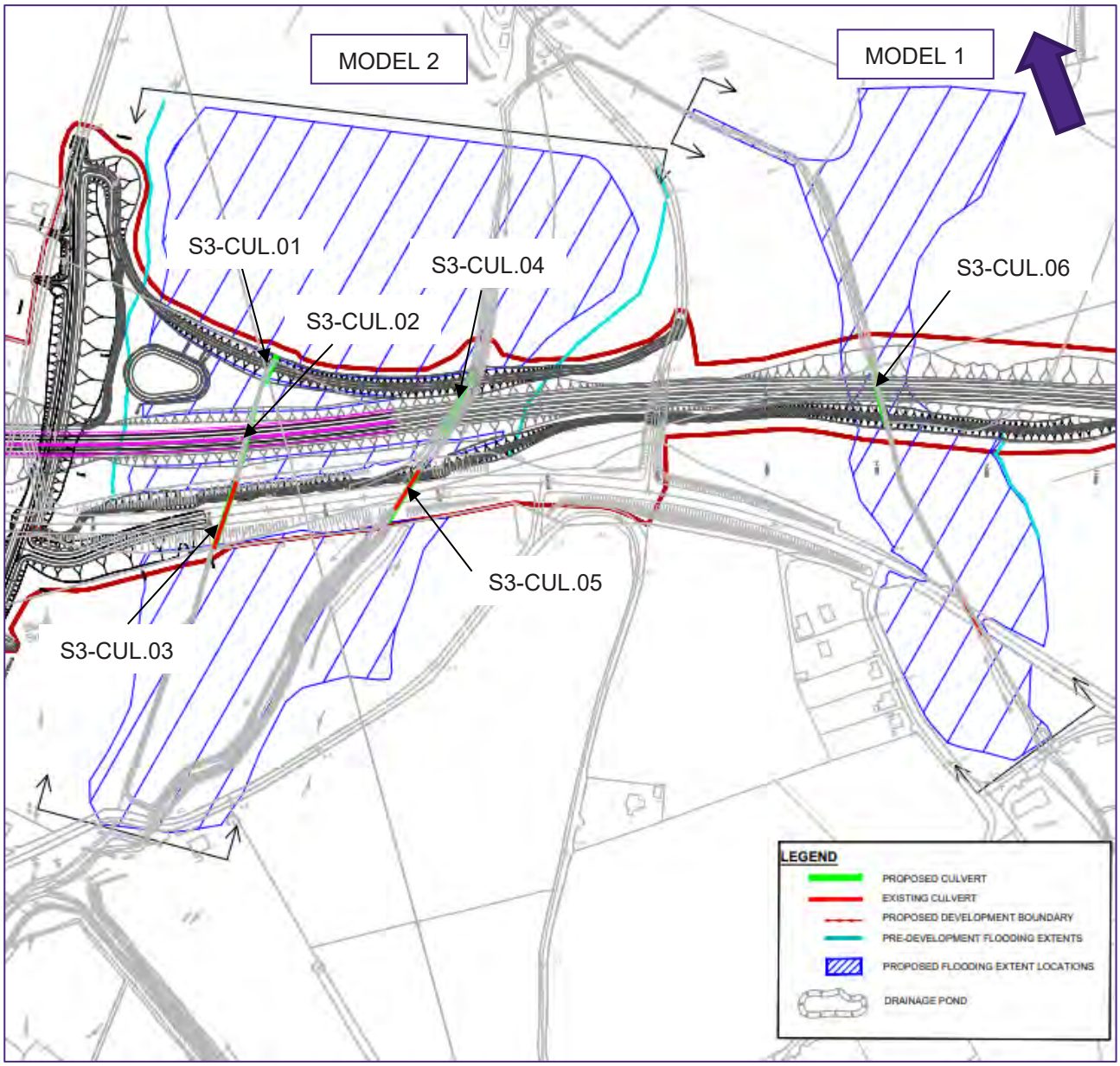


Figure 13 Flood Extents in Pre and Post Development Scenarios

A summary of the results for the culverts is provided below in Table 4-6 below.

Table 4-6 Proposed Culvert Sizes & Hydrological Calculation Outputs

Culvert Ref.	Type	Length	Size		Depth of embedment	USIL (Top of embedment)	DSIL (Top of embedment)	Culvert gradient	Freeboard Achieved US	Freeboard Achieved DS
			Width	Height (incl. embedment)						
		(m)	(m)	(m)	(m)	(mOD)	(mOD)	(1:x)	(m)	(m)
S3-CUL.01	Box	25.80	4.0	3.0	0.5	2.90	2.77	200.0	0.37	1.28
S3-CUL.02	Box	52.70	4.0	3.2	0.5	1.98	1.87	479.0	0.37	0.92
S3-CUL.03	Box	66.80	4.0	4.0	0.5	1.78	1.62	417.0	0.53	0.86
S3-CUL.04	Box	60.00	8.0	4.0	0.5	2.57	2.45	500.0	0.44	0.65
S3-CUL.05	Box	58.00	8.0	3.8	0.5	2.38	2.26	500.0	0.38	0.56
S3-CUL.06	Box	60.00	12.0	3.2	0.5	6.20	5.90	200.0	0.41	0.43

*Min. freeboard required: 0.3 m

4.4.5 Culvert Crossings along Proposed Road

A Section 50 Application for 27 culverts was submitted to OPW in accordance with the Section 50 of the Arterial Drainage Act, 1945, where the proposed road crosses an existing watercourse. This Section 50 Hydrology Report assessed the design flood for theses culverts, the existing and proposed flood levels and the potential impact on flooding by the proposed culverts and the proposed road. This report is included in Appendix E and a summary of the findings included below. Section 50 approval for all the culverts is subject to OPW Consent.

The proposed culverts were hydraulically assessed in terms of flow capacity and resultant upstream and downstream flood levels for the design flow condition using Culvert Master software. Specific topographical channel surveys were conducted to provide the geometry information for the modelling exercise. Other sources of topographical information were used, including a lidar survey.

The streams are ungauged and so the design flows have been estimated using several methods that take into account different parameters and the catchment size. These parameters were taken from the OPW website (Rainfall and Flood Estimation Applications) from ungauged locations. All the formulas used are approved by the OPW for estimation of design flows.

The design flood flow for each of the culverts is the 100-year return period flood flow with 20% Climate Change allowance. Where relevant the OPW arterial drainage scheme factor of 1.6 was used.

A summary of the results for each of the culvert references is presented below in Table 4-7 below.

Table 4-7 Proposed Culvert Sizes & Hydrological Calculation Outputs

Culvert Reference	Design Q100 (m3/s)	Type	Length (m)	Culvert Diameter (m) / Width (m) x Height (m)	Depth of Embedment (m)	USIL (Top of embedment) (mOD)	DSIL (Top of embedment) (mOD)	Culvert Gradient (1:x)	Freeboard Achieved US (m)	Freeboard Achieved DS (m)
S3-CUL.07	24.04	Box	69.50	4.2 x 3.5	0.5	22.92	22.57	200.0	0.34	1.51
S3-CUL.08	0.92	Box	24.50	1.8 x 1.4	0.5	41.20	41.10	245.0	0.31	0.38
S3-CUL.09	1.00	Box	79.10	1.8 x 1.4	0.5	41.05	40.67	200.0	0.30	0.36
S3-CUL.10	2.15	Box	53.50	2.0 x 1.8	0.5	35.60	35.33	200.0	0.38	0.61
S3-CUL.11	2.15	Box	19.00	2.0 x 1.7	0.5	34.90	34.80	190.0	0.31	0.54
S3-CUL.12	1.07	Pipe	62.00	1.2	0.3	84.20	83.60	100.0	0.42	0.42
S3-CUL.13	1.07	Pipe	31.80	1.2	0.3	73.50	73.17	100.0	0.44	0.44
S3-CUL.14	6.50	Box	23.23	4.2 x 1.9	0.5	72.26	72.05	111.1	0.31	0.45
S3-CUL.15	6.50	Box	60.00	3.7 x 2.2	0.5	71.80	71.60	303.0	0.32	0.43
S3-CUL.16	6.50	Box	22.71	3.7 x 2.3	0.5	71.45	71.30	151.5	0.32	0.33
S3-CUL.17	0.66	Pipe	49.82	1.2	0.3	85.60	85.30	166.6	0.52	0.52
S3-CUL.18	2.29	Box	48.40	2.0 x 1.8	0.5	82.51	82.27	200.0	0.35	0.79
S3-CUL.19	2.29	Box	36.00	2.0 x 1.8	0.5	80.55	80.37	200.0	0.36	0.69
S3-CUL.20	4.34*	Box	60.00	3.2 x 1.9	0.5	70.03	69.80	263.2	0.31	0.48
S3-CUL.21	1.58	Box	16.50	2.8 x 1.4	0.5	66.04	65.90	117.9	0.31	0.31
S3-CUL.22	1.58	Box	34.60	2.8 x 1.5	0.5	65.80	65.65	230.7	0.32	0.30
S3-CUL.23	1.58	Box	23.66	2.2 x 1.5	0.5	65.22	65.10	197.2	0.32	0.51
S3-CUL.24	15.06	Box	17.70	6.0 x 2.5	0.5	34.15	34.11	500.0	0.39	0.49
S3-CUL.25	2.59	Box	50.20	2.0 x 1.9	0.5	21.55	21.40	333.0	0.44	0.83
S3-CUL.26	2.59	Box	59.00	2.2 x 1.9	0.5	21.30	21.00	200.0	0.36	0.71
S3-CUL.27	18.95	Bottomless	36.20	9.5 x 2.9	0.5	19.03	18.85	200.0	0.60	0.60
S3-CUL.28	2.09	Culvert	60.00	2.0 x 1.8	0.5	1.69	1.39	200.0	0.36	0.40
S3-CUL.29	4.66	Box	54.50	2.8 x 2.2	0.5	0.63	0.36	202.0	0.51	0.90
S3-CUL.30	2.62	Box	66.00	2.0 x 1.8	0.5	4.50	3.50	66.0	0.34	0.39
S3-CUL.31	2.11	Box	70.50	1.8 x 1.8	0.5	25.78	19.35	12.0	0.39	0.98
S3-CUL.32	0.52	Pipe	44.50	1.2	0.3	37.30	35.70	27.8	0.77	0.77
S3-CUL.33	0.60	Pipe	50.70	1.2	0.3	49.13	44.69	10.9	0.80	0.80

*Min. freeboard required: 0.3 m

In a number of locations, watercourse diversions were required to facilitate the culvert crossing. These watercourse diversions are sized to accommodate the 1 in 100 year flood. Typically these diversions have a larger capacity than the existing stream, meaning there will be a light increase in conveying and attenuation capacity of the stream.

4.4.6 Road Drainage Outfalls and Attenuation Ponds

The proposed road development drainage solution involves the collection of pavement runoff and the discharge of this storm water to watercourses . All mainline outfalls incorporate attenuation ponds to reduce surface water flow to greenfield runoff rate, which will reduce the flood risk to the receiving streams. For minor side roads or sections of them and access tracks, flows are attenuated via infiltration trenches, attenuation

ditches and interceptor ditches. Attenuation features are sized for the 1 in 100year design storm event, and a controlled discharge not exceeding the existing greenfield flood runoff rate is achieved through use of a flow control such as a hydrobrake device or orifice plate on the outfall. Such mitigation has a residual flood risk associated with the attenuation pond and potential blockage of the flow control and overtopping of the pond. This flood risk is reduced by providing a controlled overflow facility to convey the storm flow to the receiving stream. Regular inspection of the ponds and their flow control outfall device is proposed and such inspections will significantly reduce the potential residual risk. The majority of the ponds have a design depth of 1m when full. The details of the attenuation ponds and infiltration trenches are provided in Table 4-8 and 4.9 below. The drainage system as designed will mitigate the flood risk due to the proposed development. A system of interceptor drainage will slow down and regulate overland flows not connected to the road drainage systems. The interceptor drains will include check dams, which will provide attenuation which did not exist in the pre-development condition. The road drainage layouts are provided in Appendix F.

Table 4-8 Attenuation Ponds & Outfalls Details

Ref. No.	Pond Easting	Pond Northing	Total Catchment Drainage Area (ha)	Greenfield Runoff Rate (l/s)	Pavement Area (ha)	Attenuation Pond – Volume of Storage (m3)	Invert Level of Attenuation Pond (m)	Outfall Easting	Outfall Northing
1	623,314	910,846	2.65	24.8	1.15	1,261	6.2	623,194	910,783
2	623,857	910,648	5.4	44.2	3.74	3,089	3.5	623,857	910,484
3	625,200	910,065	1.72	12.1	1.63	1,060	24	625,225	910,009
4	625,571	909,563	4	32.7	3.1	2,361	42	625,513	909,618
5	626,514	908,209	1.44	12.1	1.07	817	78	626,619	908,406
6	626,687	908,370	4.05	35.5	2.93	2,292	76	626,619	908,406
7	627,706	906,578	3.21	26.6	2.43	1,861	83.2	627,784	906,526.
8	628,063	905,580	3.18	22.9	3	1,949	71	627,973	905,558
9	628,990	903,989	5.5	42.6	4.03	3,258	29	629,802	903,097
10	629,519	902,357	6.06	49.6	4.72	3,536	3	629,509	902,128
11	629,553	901,975	6.72	54.9	5.25	3,918	3.9	629,509	902,128
12	630,929	899,922	3.41	28.9	2.5	1,953	9.6	631,177	899,723
13	631,260	899,643	5.9	54.3	3.74	3,287	5.5	631,177	899,723
14	631,357	899,995	2.34	15.68	1.35	959	7	631,462	899,978
15	631,570	900,196	1.22	8.17	1.01	742	8	631,462	899,978
16	632,547	897,349	9.23	81.4	6.83	7,776	7	632,679	897,086

Table 4-9 Infiltration Trenches

Reference	Approximate Length (m)	Side Road/Access Road
S3-PED-IT-01	20	L1294 Manorcunningham Local Road
S3-PED-IT-02	20.4	LX 3014 Sheshkinapoll
S3-PED-IT-03	20	R236 LX 3014 Link South
S3-PED-IT-04	44	L2414 Tamnawood
S3-PED-IT-05	17	L2414 Tamnawood
S3-PED-IT-06	172	L2444 Ballindrait
S3-PED-IT-07	65	L2444 Ballindrait

S3-PED-IT-08	29.5	L2444 Ballindrait- R236- Rapho
S3-PED-IT-09	25.5	L2444 Ballindrait- R236- Rapho
S3-PED-IT-10	57.2	L2444 Ballindrait
S3-PED-IT-11	54	L2444 Ballindrait- Ext_N14-S
S3-PED-IT-12	46.4	L2444 Ballindrait- Ext_N14-S
S3-PED-IT-13	11	L6144 Lifford Common Road
S3-PED-IT-14	78.7	AR 3.61

4.4.7 Beneficial Deposition Areas

A number of potential deposition areas have been highlighted for permanent placement of excess material across the scheme. The excess material resulting from the construction will be placed adjacent to the proposed road development at suitable locations within the proposed acquisition. The placement of the material could potentially impact on the flood risk in certain areas if it is placed within existing flood risk areas. A number of material deposition sites have been identified along the proposed route and generally these sites have avoided floodplain areas and flood risk areas. A drainage system for these deposit sites will be designed that achieves a SUDs response allowing these areas to discharge at natural greenfield runoff rates.

5 CONCLUSIONS AND SUMMARY

A Flood Risk Assessment of the proposed road development was carried out and the findings are summarised in Table 5-1 below:

Table 5-1 Proposed Road Development FRA Summary

SECTION 3	
Site Description	Section 3 proposed road is approximately 17.5 km long and runs from the Pluck Roundabout (Manorcunningham junction to the east of Letterkenny, interface with Section 2) to Lifford. Additionally, there is a cross border link with the A5, that will join with the proposed A5 Western Transport Corridor (WTC) to be constructed by Roads Service Northern Ireland (RSNI). The mainline will comprise of a Type 2 Dual Carriageway Road extending from Manorcunningham to Lifford with the provision of Active Travel infrastructure. The alignment of the proposed road development and its associated link roads cross several fluvial floodplain areas as a result of the nature of transport infrastructure which in some cases it is unavoidable. The main river crossings are the Swilly Burn, the Deele River and the River Finn. Also, Manorcunningham is an area with a predictive flood plain from the Leslie Hill Stream. The river bridge crossings normally have a clear span of the main river channel.
Vulnerability Category	The proposed road development is essential infrastructure and is therefore considered to be highly vulnerable development in accordance with the FRMPG.
Flooding Mechanisms	Fluvial flooding from the Rivers Leslie Hill Stream, Swilly Burn, Deele, Finn and smaller tributary drains. Coastal flooding is also presented as a source of flood risk that has been considered in some of the models such as the River Finn and Deele Crossings.
Benefitting from flood defences or flood relief scheme	A drainage scheme was carried out on the River Deele and Swilly Burn from 1957-1961, benefitting an area of approximately 3,500 acres. Another drainage scheme was also carried out on the Swilly Big Isle from 1961-68 , benefitting an area of 3,200 acres. This drainage scheme affects part of the Leslie Hill Stream that the proposed road crosses.
Historical Flooding	There have been a number of recorded flood events in the various areas discussed in the report that are considered flood risk areas. Manorcunningham has had a few flood events caused by high ground after heavy rain where the road is liable to flood and properties nearby are affected. Also, the River Deele overflows its banks every year after heavy rain and so the River Swilly Burn and the River Finn. Other flood events recorded in other rivers are the River Foyle that overflows its banks occasionally in Lifford and the River Corkey which overflows every year. There are other localised areas where owners have reported localised flood events.
Flood Risk	The two models carried out in Manorcunningham for the proposed six culverts show that Model 2 improves the flood plain upstream of the culverts while not causing any changes on the flood plain area downstream. Model 1 results show a permissible afflux upstream of the culvert and no changes downstream. The proposed road embankment and an attenuation pond encroach on the 1% AEP flood extents, but the new culverts can easily convey the design flows. The section of the River Swilly Burn, at the crossing point of the proposed road development and upstream of the bridge, there is no increase in flood risk and no significant change of the current hydraulic characteristics and dynamics of the river system. The proposed bridge for the River Deele and the culverts in the floodplain showed that there is no increase in flood risk and no significant change of the current hydraulic characteristics and dynamics of the river system. The road embankment encroaches on the 1% AEP flood extents, but the modelling results revealed that the post development scenario does not significantly change in comparison to the existing scenario. The proposed multi-span bridge for the River Finn proved that there are only some minor changes on the existing floodplain. The proposed roundabout, the eastern N15 link and the proposed attenuation pond for the Ten-T project slightly encroaches on the 1% AEP flood extents as well as the A5 WTC roundabout and eastern link. However, there is no increase in flood risk and no significant change of the current hydraulic characteristics and dynamics of the river system. A total of 27 culverts will be required where the proposed road development crosses existing watercourses. The topography and small catchment areas ensure that the associated flood zones to these streams are localised with relatively narrow floodplain widths along these streams. The proposed culvert sizes are very generous and will not result in any constriction to flow.

	Section 50 approval concerning flooding and flood capacity of all culverts and the River Bridges is subject to OPW Consent. Other localised sections where the proposed road crosses and encroaches on flood areas were identified. There are some attenuation ponds and sections of the road embankment that encroaches on fluvial and/or coastal flood extents for different AEP. They have been assessed to analyse the impact on flood areas and determine the minimum level of the road and attenuation ponds. The impact is generally minor or imperceptible. There is a section of the proposed road between Mainline Chainage 9+200 to 10+400 where there is an encroachment of the proposed road, the existing N14 and one of the proposed attenuation ponds on the 1.0% AEP flood extents (CFRAM). This encroachment has substantially been dealt with by diverting the existing watercourse which resulted in a minor residual flood risk impact. Road drainage outfalls discharging to receiving surface and groundwaters without flood flow attenuation could increase downstream and local flooding at the discharge points. This has been mitigated in the drainage design through suitably sized attenuation ponds and outlet flow controls for the mainline and large side roads.
Climate Change	The predicted increases in fluvial flood flows of 20% is generally considered and catered for in the design. For the River Finn model, 20 % and 35 % increase of fluvial flood flows are considered as it is in the border between Republic of Ireland and Northern Ireland (UK).
Mitigation Measures	• At all crossings, encroachments within the watercourse's floodplains have been minimised such that any increase in flood levels in the upstream or downstream vicinity due to flood volume storage loss would be minimal. • All bridge/culverts are sized for 1% AEP design flows such that net headlosses are less than the OPW section 50 Guidelines specified headloss of 300 mm, and also the available freeboards above the design flood levels are greater than the OPW section 50 Guidelines specified freeboard of 300 mm in all cases. Any deviations from this will be subject to approval by the OPW and subsequent Section 50 Consent. • Increased road runoff is proposed to be attenuated to greenfield runoff rates through attenuation ponds before discharging into the natural watercourses or infiltration trenches when discharging into the groundwater for small sections of side roads. • Rock armours have been proposed at the inlets/outlets of all culverts in order to reduce any risk of scouring in the channel beds. • Sustainable road drainage systems, e.g., filter drain, grass surface water channels are generally proposed in areas where the groundwater vulnerability risks are not high. • Provision of surface water collector drains parallel, and adjacent to, the toe of earth embankments. • Provision of granular drainage blankets (starter layers) at the base of earth embankments over sloping ground to minimise confinement of overland and/or near-surface flow on the upslope side of the embankment. • Flood relief culverts have been incorporated in the River Deele floodplain next to the bridge as necessary to comply with the OPW requirements. • Attenuation ponds within flood plains are to be bunded 500 mm above the flood level when required.
Residual Risk	Mitigation measures have been implemented as specified above and through the report for the flood risk areas but also for the impact that the proposed road involves in terms of causing flood risk. There is still a residual risk in some of the areas and elements of the proposed road: • Potential blockages to culverts and bridges on streams and the lack of maintenance could present a localised residual flood risk. • The construction of attenuation ponds and infiltration trenches along the proposed scheme development represent a potential source of flood risk should these ponds/infiltration trenches be overtopped or fail. • Residual risk of localised flooding on proposed road carriageway due to blockages/failure within drainage network. • The disposal of storm water via engineered infiltration trenches represents a potential source of flood risk should the discharge exceed the infiltration capacity of the trench or the reduction over time of the performance of the trench as a result of silt deposition etc.

EIAR APPENDIX C11.03

SECTION 3 FLOOD RISK ASSESSMENT REPORT

APPENDIX A:

RIVER DEELE SECTION 50 ASSESSMENT

River Deele, Ten-T Hydraulic Modelling Support, Co. Donegal

Section 50 Assessment

May 22

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S0-P01 / 11 Nov 2021	Initial draft	J.B. Barry
S3-P02 / May 2022	Update Hydrology and Hydraulics	J.B. Barry

Contract

This report describes work commissioned by J.B. Barry by a signed Acceptance Form dated 12/10/2020. Andrei Cozma, Orla Hannon and Ross Bryant of JBA carried out this work.

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Purpose

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1 Introduction

1.1 Terms of Reference and Scope

JBA was appointed to prepare a Section 50 Assessment for a proposed bridge structure as part of the Ten-T Priority Improvement Project. J.B Barry is responsible for Section 3 (N14 Manorcunningham to Lifford/A5 Link), approximately 18 kilometres of new dual carriageway, passing over the River Deele. In that sector, a bridge will be built requiring assessment according to Section 50 of the Arterial Drainage Act.

1.2 Section 50 Assessment; Aims and Objectives

The hydraulic design standards for a culvert that should be met under Section 50 according to the OPW Guide to Applying for Consent under Section 50 of the EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010 and Section 50 of The Arterial Drainage Act, 1945 are as follows:

- A bridge or culvert must be capable of passing a fluvial flood flow with a 1% annual exceedance probability (AEP) or 1 in 100-year flow without significantly changing the hydraulic characteristics of the watercourse.
- A culvert must be capable of operating under the above design conditions while causing a hydraulic loss of no more than 300 mm (excluding the culvert gradient).
- If the land potentially affected includes dwellings and infrastructure, it must be demonstrated that those dwellings and/or infrastructure are not adversely affected by constructing the bridge or culvert.
- A culvert diameter, height and width must not be less than 900 mm to facilitate maintenance access and reduce the likelihood of debris blockage.

If these conditions are not met, reasonable justification as to why the culvert may still be satisfactory is required.

1.3 Development Proposal

The proposed development is a dual carriageway, Section 3 (N14 Manorcunningham to Lifford/A5 Link), part of Ten-T Priority Improvement Project. The proposal will require the construction of a new bridge over the River Deele.

1.4 Report Structure

Section 2 of this report gives an overview of the study location and associated watercourses. Section 3 contains review of flood risk. Section 50 requirements and modelling results are discussed in Section 4. Conclusions and recommendations are highlighted in Section 5.

2 Site Background

2.1 Location

The subject site is located approximately 1.2 km N-W of Raphoe, Co. Donegal, where the River Deele is intersected by Section 3, a dual carriageway part of the Ten-T Priority Improvement Project. The area of analysis is extended around this point, upstream and downstream of Deele.

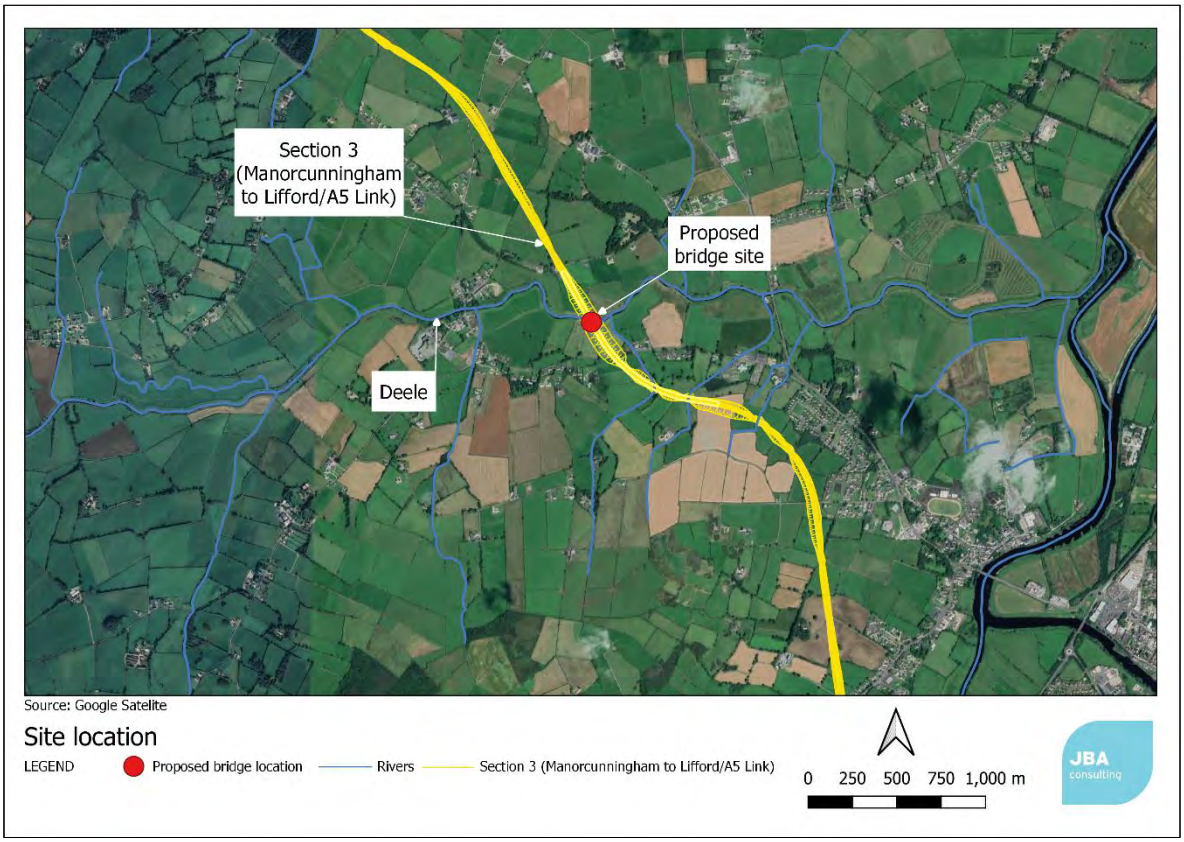


Figure 2-1 Site Location

2.2 Watercourses

The watercourse intersecting the proposed road alignment is the River Deele. It originates west of the proposed bridge location, flowing east for 3.5km towards its confluence with the River Foyle 1.7km N-W of Lifford.

3 Flood Risk Review

A brief review of the flood risk to the site is described below. This is conducted using historical and predictive information that identifies any sources of potential flood risk to the site and reviews historic flood information. The findings from the review are described in this section.

3.1 CFRAM Maps

The modelled sector of River Deele was part of North Western - Neagh Bann CFRAM Study. An extract of the flood extend map is presented in Figure 3-1.

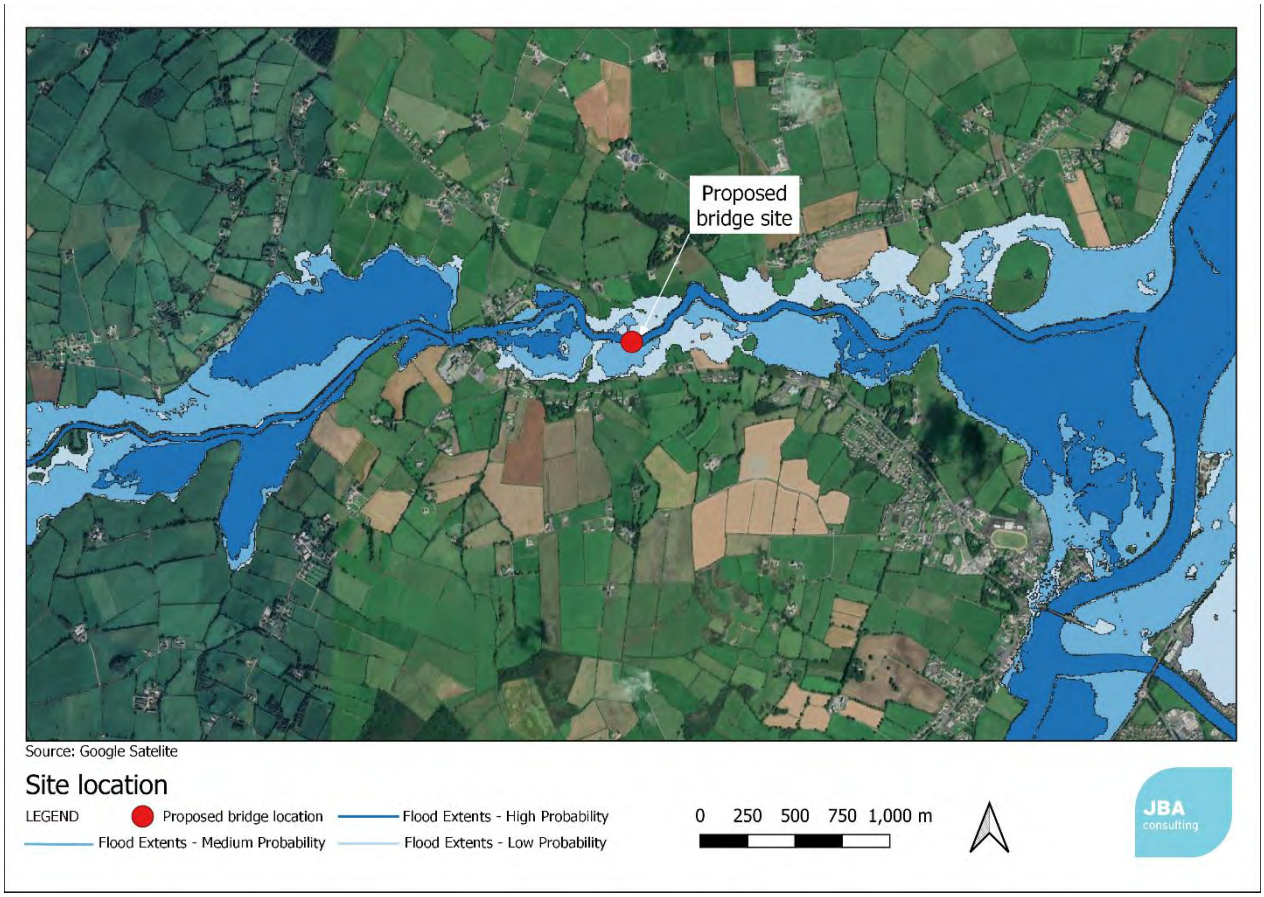


Figure 3-1 Deele River CFRAM Map

3.2 Flood History

The OPW host a National Flood hazard mapping website, www.floodinfo.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. The website highlighted recurring floods taking place in the vicinity of the site. An extract of the generated flood report is presented in Figure 3-2.

Flood ID 346 pinpoints single flood events in Rossgeir Townland near N14, showing a real concern that these floods are recurring.

Flood ID 11904 represents a report detailing the flooding in Banllindrait County Donegal on 26th of July 2013.

Flood ID 4051, located in Ballindrait, shows a series of articles referring floods of properties in the area a report stating that " River Deele overflows its banks every year after heavy rain. The road is liable to flood once every 5 years approximately".

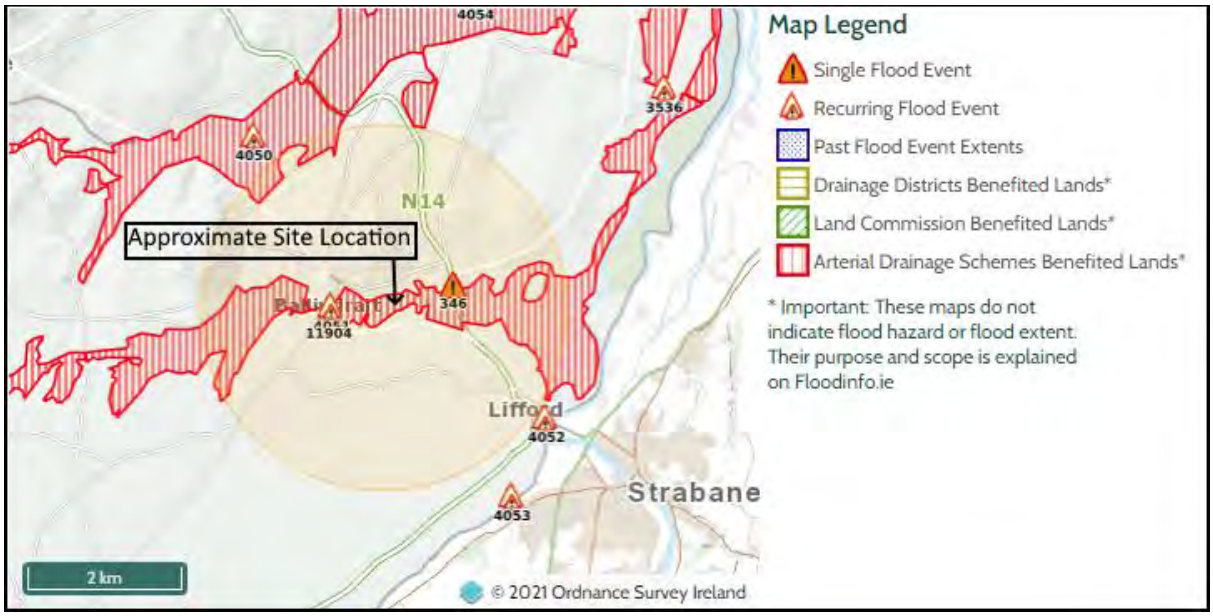


Figure 3-2 OPW Summary Map Generated by www.floodmaps.ie

3.3 Internet search

An internet search was conducted to gather information about whether the site was affected by flooding previously. No flooding incidents were recorded at the site.

4 Section 50 Assessment

This section will provide flow estimates and assess the capacity of the proposed bridge on site as part of the detailed assessment.

4.1 Hydrology

4.1.1 Catchment Characteristics

Table 4-1 and Figure 4-1 show the main descriptors of the catchment and the river network, catchment boundary and gauging stations from the immediate area, used for the hydrological assessment.

Table 4-1 Key catchment descriptors

Descriptor	01_1541_1	Parameter description
Area (km^2)	128.70	Slope based on the stream elevation at 10% and 85% along MSL
MSL (km)	37.194	Main Stream Length
S1085 (m/km)	6.0951	Slope between a point 10% upstream and 85% upstream
ArtDrain2	0.0765	Arterial drainage factor
SAAR (mm)	1301.28	Standardised Average Annual Rainfall
Soil	2=0.74 5=0.26	Soil index, which is a composite index determined from soil survey maps that accompany the Flood Studies Report
M5-2day (mm)	65	5-year return period rainfall for 2-day duration
r	0.3	Dimensionless ratio between M5-60 and M5-2 Day rainfall depths

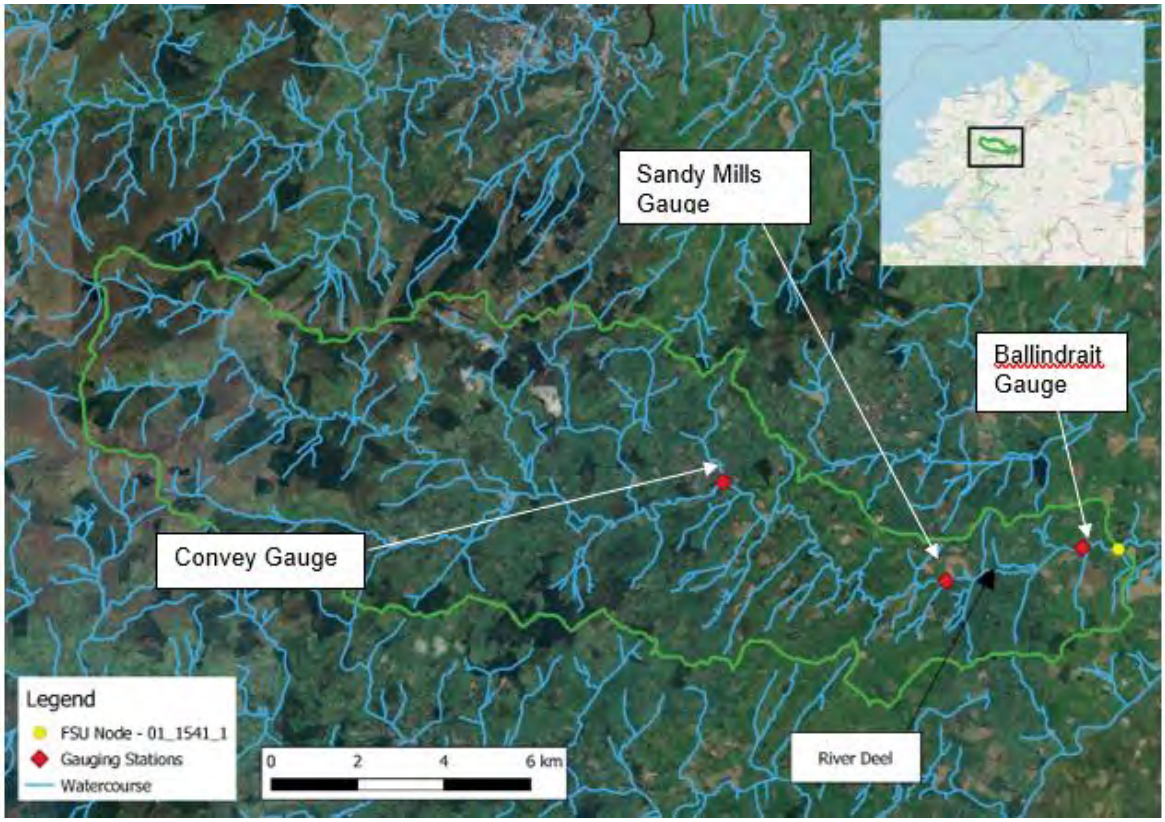


Figure 4-1 Catchment characteristics

As shown in Figure 4-2 below, the catchment is a medium sized catchment (130km^2) originating in the hilly area to the west of the village of Convoy. The catchment is largely agricultural land (68% pastures) with some peat (22%) and forest (14%) land coverage also. The modelled reaches of the Deele are fairly flat (S1085 ranging from 5 to 10).

Bedrock is Aghyaran & Killygordon Limestones (marble, quartzite, psammite; graphitic) and Mullyfa and Deele Formation (psammite, pebble beds, marble, schist) in the eastern section of the catchment, and Termon Formation (banded semi-pelitic & psammitic schist), Lough Eske Psammite Formation (feldspathic psammite; quartz, marble) and Killeter Quartzite Formation (Slightly impure quartzite) to the west.

A drainage scheme carried out on the River Deele from 1957-1961, benefitting an area of approximately 3,500 acres.

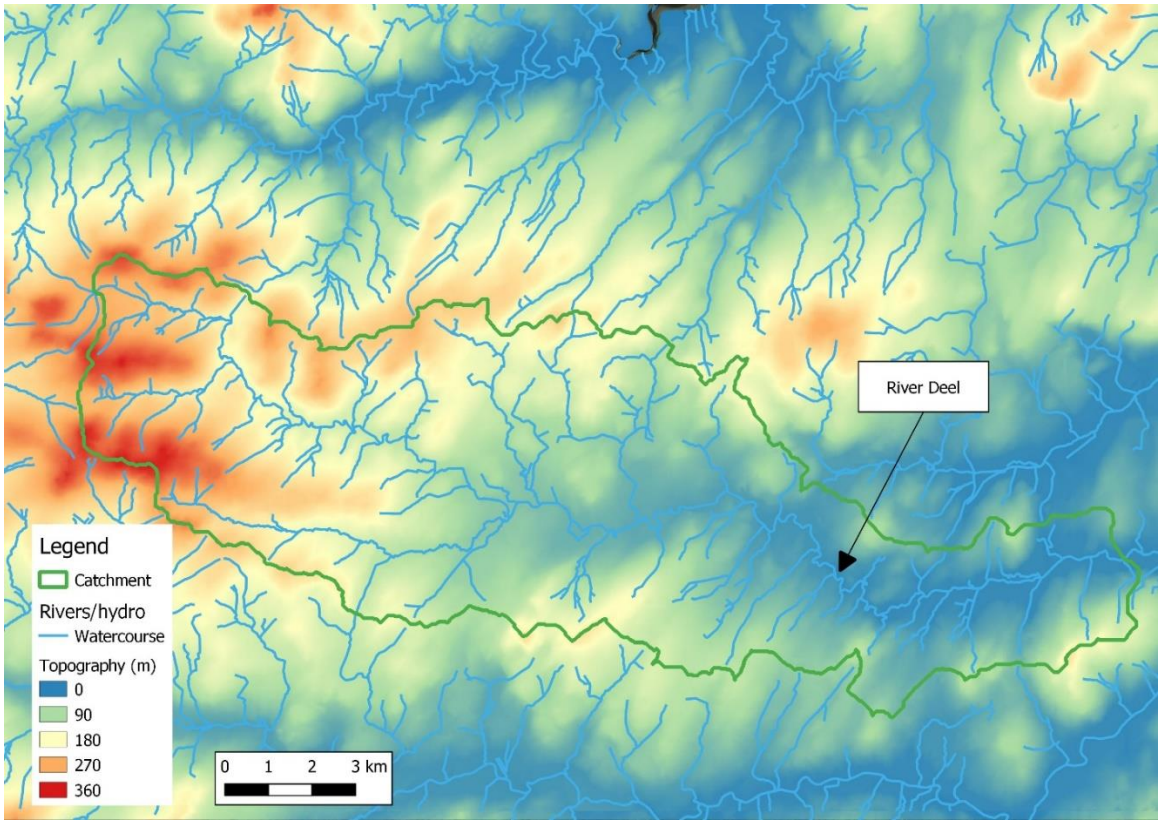


Figure 4-2 Topographical map of the catchment

4.1.2 Design peak flows

Table 4-2 compares a range of AEP flow estimates as calculated using the FSU method. Qmed was calculated using the Sandy Mills gauge as a pivotal site. The gauge information has been adopted from the Lifford Flood Relief Scheme (FRS) Hydrology Report following a detailed rating review completed as part of the study. The Lifford FRS growth curve was also adopted. This growth curve uses a combination of two methods; the Single Site Analysis growth curve for the Deele up to the 1:88yr event and a polled growth curve for events exceeding the 1:88yr event.

Table 4-2 FSU peak flow estimates

Annual Exceedance Probability (%)	Peak Flow (m3/s) Pooled Growth Curve
50%	**78.32**
20%	97.67
10%	109.80
5%	121.63
2%	137.45

1%	179.67
0.1%	280.46

4.1.3 Section 50 flows

According to the Section 50 requirements the design flows are based on the 1% AEP event but take into account a factorial standard of error (FSE) and a factor for climate change (1.2). As the FSU method includes the arterial drainage works within the catchment descriptors, the additional factor of 1.6 to account for these works does not need to be included.

The FSE for the QMED at the pivotal site (Sandy Mills) was calculated using a formula from Volume 2 Flood Frequency Estimate of the Flood Studies Update [1]. This formula gives the additive SE for the 68% Confidence Interval (CI) which can then be converted to the FSE. The 95% CI can then be calculated by multiplying the site flows twice by the final 68% CI FSE. Using this formula, the 95% CI FSE for the gauge to be applied to the QMED values is 1.116.

$$SE(QMED) \approx 0.369\, QMED / \sqrt{N}$$

To calculate the FSE associated with the growth curve for the pivotal site, a paper by A. Hammond, 'Sampling uncertainty of UK flood estimation' was reviewed.

Table 2 below is an extract from the paper which provides the FSE for ungauged QMED estimates and the mean FSE for the ungauged pooled estimated of longer return periods. The number of donor sites used in this instance is 1. To get the growth curve only component of the FSE (as the FSE for QMED has been calculated separately in the section above), the FSE for the Q100 is divided by the FSE for the Q2 in the table above. This value (the 68% CI) is then squared to get the final FSE for the 95% CI. The final Growth Curve 95% CI to be applied is 1.221.

Table 2 | Mean ungauged factorial standard errors

No. Dons	2	5	10	20	50	100	200	500	1,000
0	1.46	1.469	1.488	1.513	1.560	1.606	1.661	1.752	1.835
1	1.42	1.432	1.449	1.475	1.523	1.569	1.627	1.721	1.804
2	1.41	1.412	1.431	1.458	1.507	1.553	1.613	1.706	1.789

The FSE for the Section 50 application is based on the 1% AEP flows multiplied by the FSE for the gauge, the FSE for the growth curve and 20% climate change.

Table 4-3 below shows the final FSE values to be applied for the Section 50. Both the 68% and 95% CI values are included but as there are properties identified as being at risk the 95% CI will be adopted for the Section 50 estimates. The FSE is calculated using both the FSE for the gauge and the FSE for the growth curve.

Table 4-3 Section 50 design flows

Method	Peak Flow (m^3/s)
FSU 1% AEP Event	179.67
1% AEP + Climate Change	215.60
1% AEP + 68% confidence interval (1.2*1.16)	**250.50**
1% AEP + 95% confidence interval (1.2*1.36)	**293.68**

1 https://opw.hydronet.com/data/files/Technical%20Research%20Report%20-%20Volume%20II%20-%20Flood%20Frequency%20Estimation(1).pdf

4.2 Hydraulics

Detailed hydraulic modelling was performed to assess the pre and post development flood risk and to ensure that the proposed bridge designs are compliant with Section 50 of the Arterial Drainage Act 1945. The Section 50 flows considered in the modelling process are based on the 1% AEP event but take into account a factor for climate change (1.2) and an FSE (1.36) as presented in the previous section.

4.2.1 Proposed structures

The proposed carriageway includes structures crossing both the Deele channel and floodplain. To allow the river connectivity under the proposed road, new structures were included and tested in the hydraulic model.

4.2.1.1 Proposed bridge (within the channel)

The proposed structure for this Section 50 assessment is a bridge having a flat deck and abutment on each bank. The width between the abutments is 60m and the deck soffit is set at 12.75mOD. As the proposed bridge is skewed, the distance between the abutments was modelled as 54.3m which is the real width of the channel measured in the flow direction.

4.2.1.2 Additional culverts (within the floodplain)

In order to minimize impacts generated by the road construction and to comply with Section 50 regulation concerning the maximum afflux of 150mm and the impact on the properties upstream of the bridge two additional backspans and a culvert system was modelled under the road on both left and right floodplain.

The backspans have a distance between abutments of 24m, having a square span of 20.6m each.

The culvert system includes 4 arched culverts having 6m span x 3m rise and the invert set at 2.52mO. Due to constructive requirement, the culverts are at 20m distance from the backspan of the bridge.

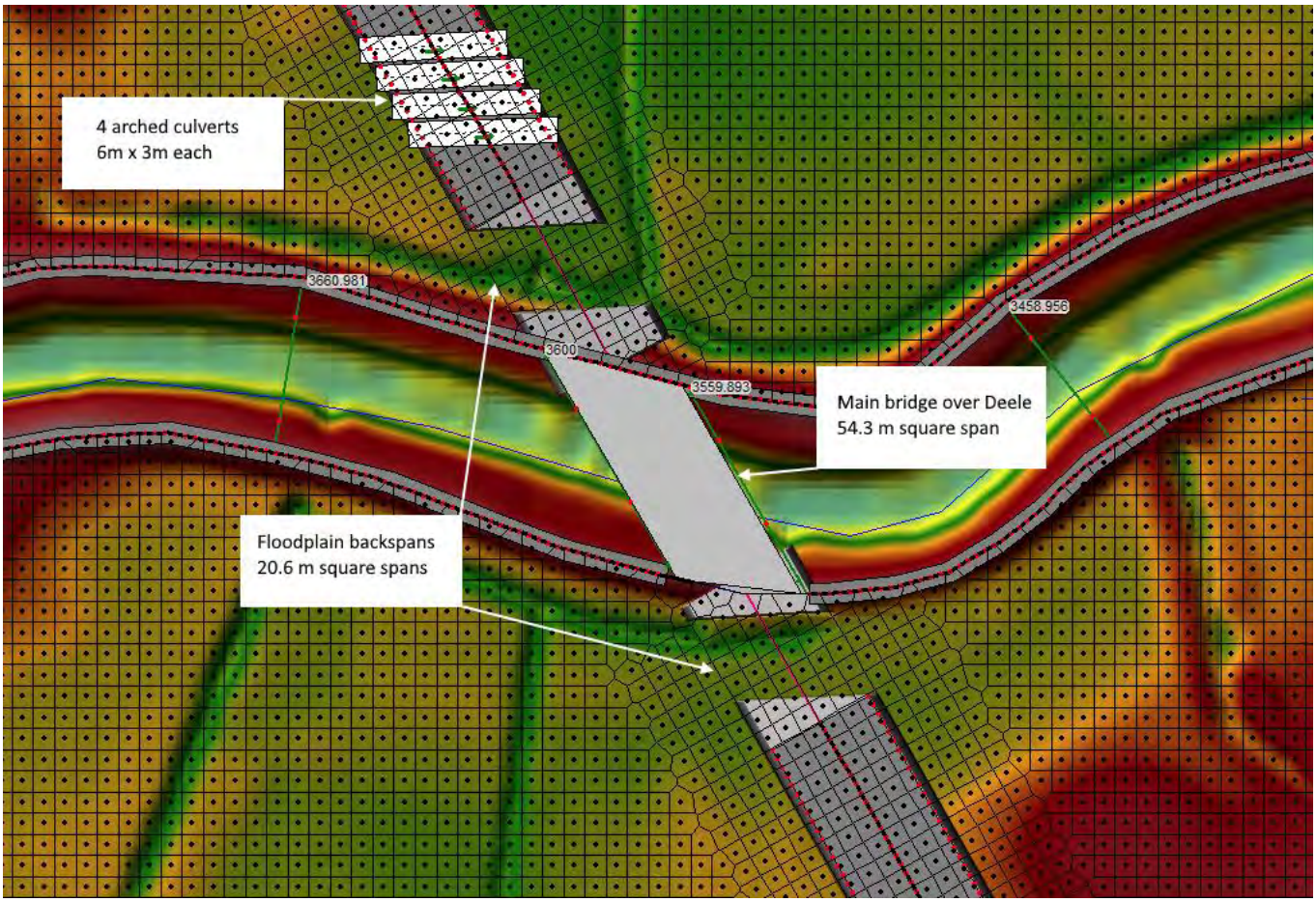


Figure 4-3 Post Development Structures with flood relief measures, as implemented in the model

4.2.2 Modelling approach

The hydraulic performance of the proposed structure was assessed by building a 1D-2D model using HEC-RAS modelling package. The hydraulic model built in the current project allows the estimation of water levels for a range of scenarios. HEC-RAS is designed to perform one-dimensional steady flow and one and two-dimensional unsteady flow calculations for a full network of natural and constructed channels overbank/floodplain areas, banks to protected areas etc. The software is internationally recognised and allows the efficient setup of multiple scenarios and analysis of outputs. HEC-RAS has a user-friendly interface with GIS compatibilities, numerous data entry capabilities, hydraulic analysis components, data storage and management capabilities.

Two different scenarios were undertaken to appraise the hydraulic capabilities of the river system and the efficiency of the proposed structure:

- **Scenario 1 -** Open channel without the structure in place. This scenario assesses the river channel conveyance based on the 1D-2D model built using survey data.
- **Scenario 2 -** Proposed bridge included (Post development). This scenario assesses the impact generated by the proposed structure. The representation of the proposed new bridge is added into the model to test design criteria,

4.2.3 Hydraulic Modelling Results

The hydraulic modelling results for both scenarios are presented below as cross-sectional view of the bridge and as longitudinal profile.

The simulations reveal that when comparing post-development scenario and the baseline, the proposed bridge is generating 680mm afflux in the upstream vicinity of the structure after the inclusion of the proposed bridge and after raising the road across the floodplain with no inclusion of the connectivity culverts. Some iterative runs were performed to determine the size of the backspans and the number of culverts needed for afflux minimization. The simulations showed that one backspan of the structure on each side of the floodplain with a square span of 20.6m and and

4 arched culverts having 6m span x 3m rise (all placed in the left) are the minimum needed to comply with the Section 50 requirements.

Modelling of the entire system of structures, the modelling results show that the design flows can be conveyed having a virtually no afflux (6.4mm) and 7.71m freeboard under the soffit (open air gap within the proposed bridge).

Figure 4-4 presents the cross-sectional view of the proposed bridge and the water level marks for post-development scenario. The comparison of the water surface elevation between all scenarios is presented on the longitudinal profile Figure 4-5. There is little to no difference between the two scenarios are shown in Figure 4-6.

As mentioned above, the afflux as a result of the proposed bridge is 6.4mm, which is within the Section 50 requirements. The water level increase adjacent to the upstream properties in Ballindrait is between less than 1mm, and so the dwellings in the area are not adversely affected as a result of the proposed bridge.

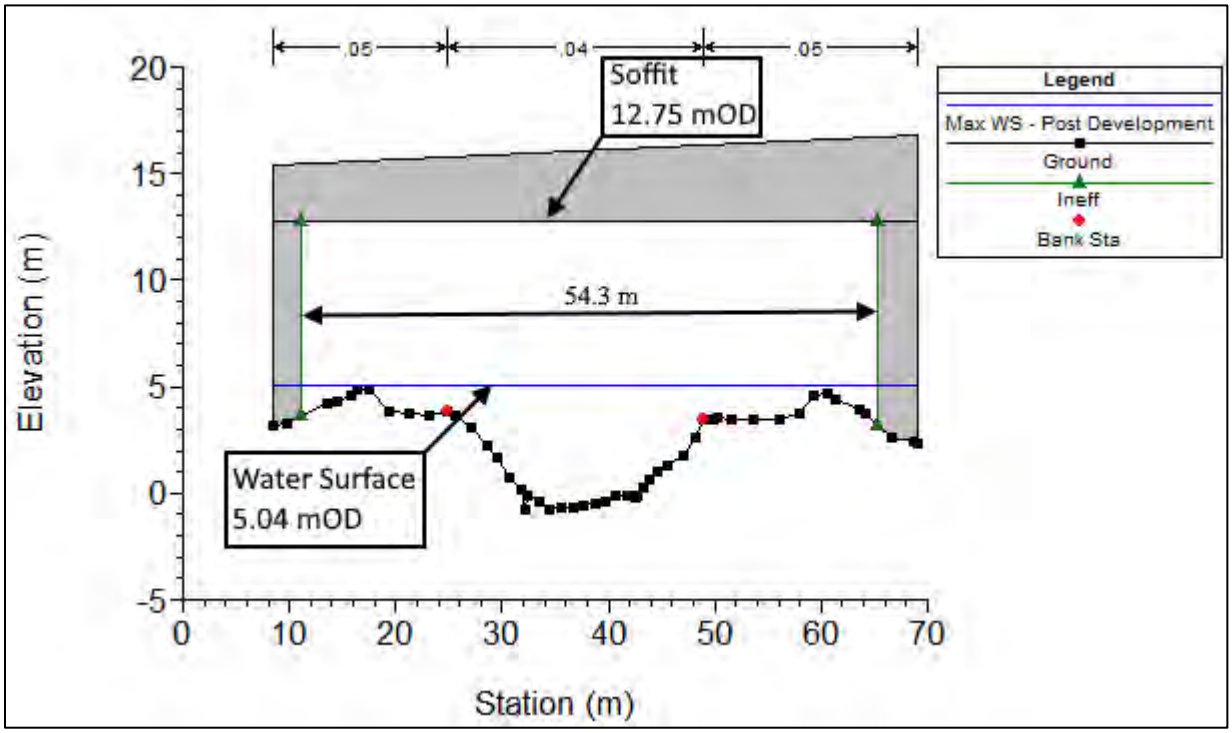


Figure 4-4 Cross section of the proposed bridge

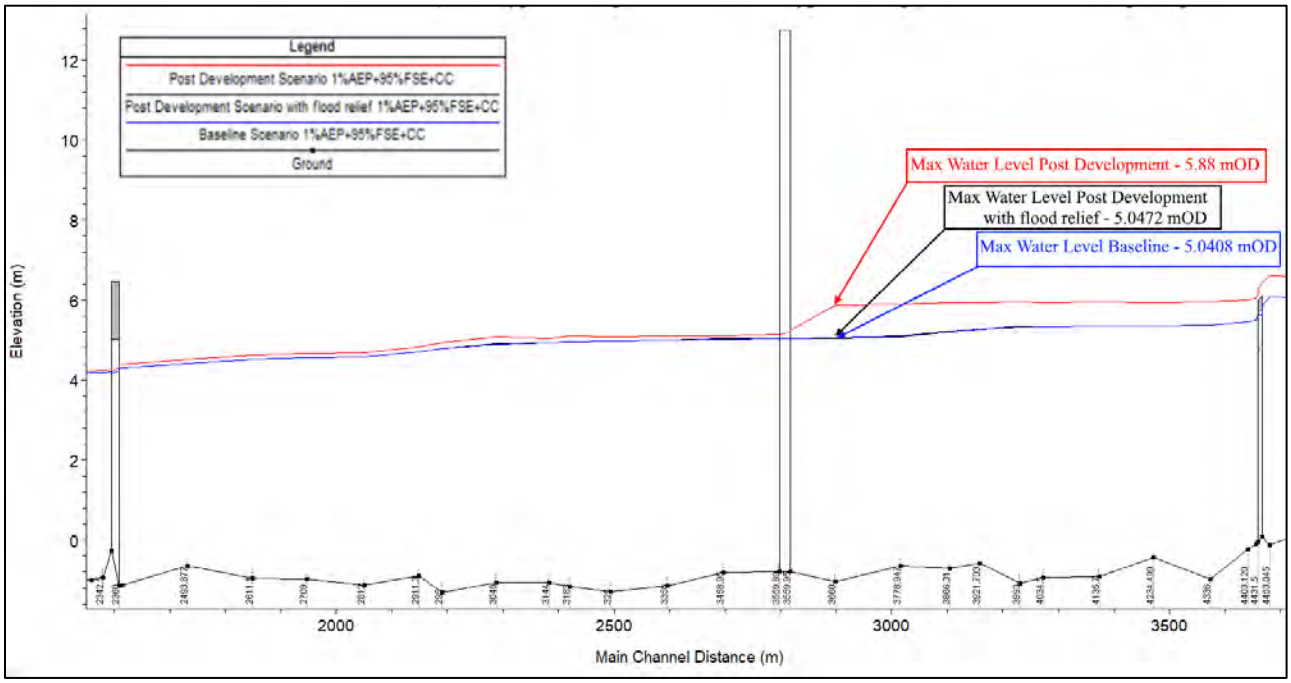


Figure 4-5 Longitudinal profile comparing water surface elevation

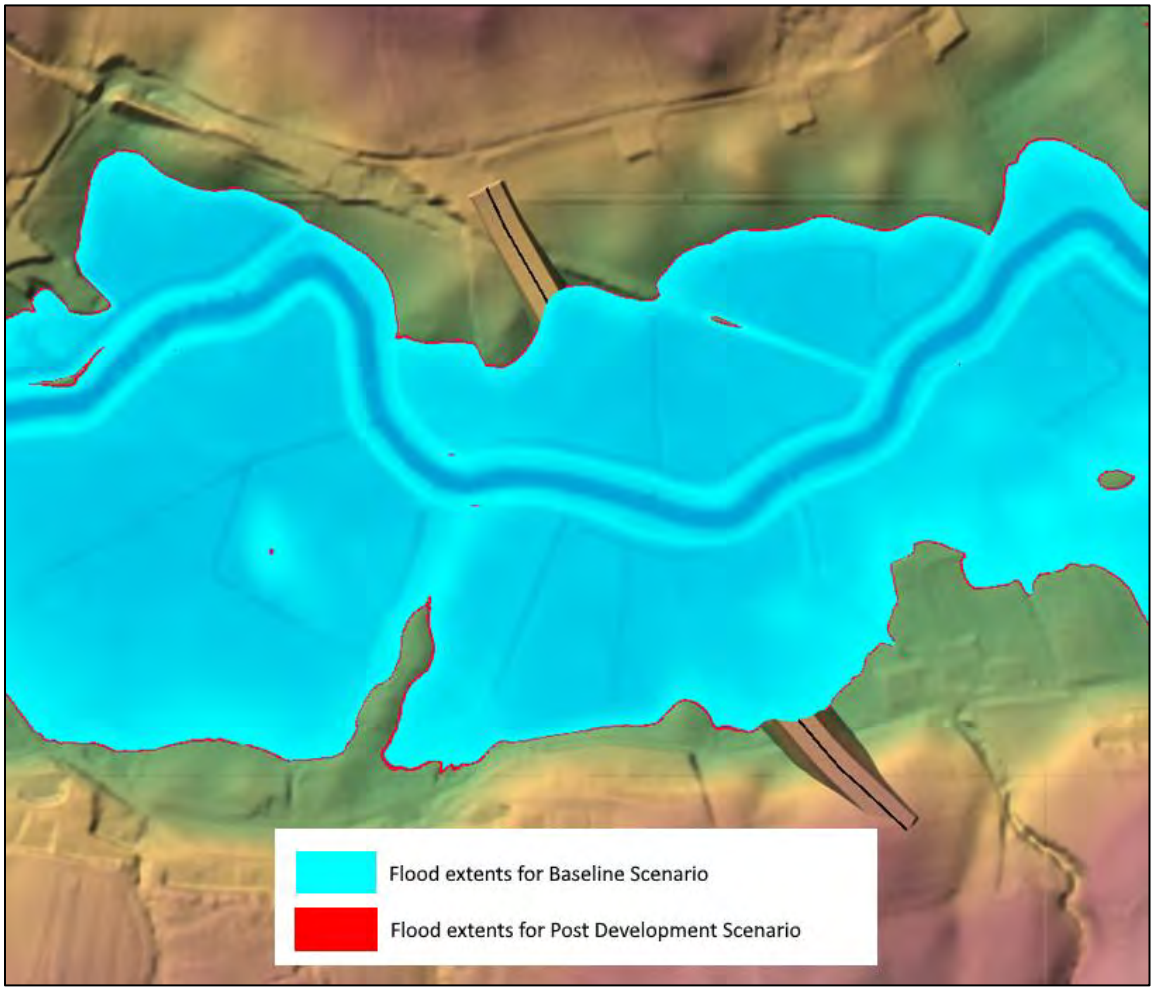


Figure 4-6 Flood extents comparison near the proposed bridge

4.2.4 Sensitivity Analysis

As there are no gauges along the watercourse near the site, no model calibration can be carried out. There are also no recorded flood extents or wrack marks available that can be used to calibrate or validate the model.

4.2.5 Downstream boundary condition

The sensitivity of the model to the downstream boundary condition (tidal condition from the Foyle River) was tested. The most pessimistic scenario was tested in the model by considering the 0.1%AEP flood level of Foyle River as downstream boundary condition. The simulation showed that the confluence has an impact only downstream of the bridge part of N14 roadway which is 1.2 km far from the proposed bridge. Therefore, the model is not sensitive to the downstream boundary condition in the site location.

4.2.6 Increase/Decrease in Manning's Roughness

To represent the current land use and associated roughness in the model, the Manning`s N values assigned to the river channel range from 0.030-0.04. This represents a channel which is generally clean, straight with some stones and weeds. In the floodplain values ranging from 0.035-0.05 were assigned. To test the sensitivity of the model to the Manning's N parameter, model scenarios were run with the roughness factor increased by 20%. Increasing the roughness by 20% within the 1D model domain generates an increase of the in-channel water levels by a maximum of 3.5cm. This 35mm sensitivity to the Manning's N value is contained within the bridge freeboard.

5 Conclusion

The aim of this technical report was to investigate whether the proposed bridge over the Deele River adheres to the requirements of Section 50 of the Arterial Drainage Act (1945). Table 5-1 shows how the requirements outlined have been addressed.

Table 5-1 Summary of the hydraulic model results in relation to the Section 50 requirements

Section 50 requirement	Response
A bridge or culvert must be capable of passing a fluvial flood flow with a 1% annual exceedance probability (AEP) or 1 in 100-year flow without significantly changing the hydraulic characteristics of the watercourse.	The proposed bridge has been shown to convey the design flows which is 1% AEP flow with 20% allowance for climate change and multiplied with FSE without altering the current hydraulic characteristics of the watercourse. The modelling results reveal that in post development scenario which includes the bridge in place and the culverts in the floodplain, the head loss is 6.4mm, showing that the structure does not significantly change the hydraulic characteristics of the watercourse and complying with Section 50 requirements.
A bridge must be capable of operating under the above design conditions while maintaining a freeboard of at least 300 mm.	The bridge allows 7.71m freeboard within the structure. The 4 culverts situated in the left floodplain allow 473m freeboard. This is in good agreement with the Section 50 provisions which recommends minimum 300mm. The new bridge can easily convey the design flows
If the land potentially affected includes dwellings and infrastructure, it must be demonstrated that those dwellings and/or infrastructure are not adversely affected by constructing the bridge or culvert.	There is no increase in flood risk, the peak flow is contained by the bridge. There is no significant change of the current hydraulic characteristics and dynamics of the river system. Dwellings in the Ballindrait settlement are not adversely affected as the increase in water level is less than 1mm and there is no increase in extent/flood risk.

Overall, this document highlights how the proposed designs of the bridge crossing the Deele River satisfies the requirements of Section 50, as it can safely convey the peak design flows and not increase flood risk.

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Flood estimation report: Ten-T River Deele

Introduction

This report template is based on a supporting document to the Environment Agency's flood estimation guidelines. It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

Approval

	Name and qualifications	Date
Method statement prepared by:	Orla Hannon	01/02/2022
Method statement reviewed by:	Tom Sampson	01/02/2022
Calculations prepared by:	Orla Hannon	01/02/2022
Calculations reviewed by:	Tom Sampson	01/02/2022

Revision History

Revision Ref/Date	Amendments	Issued to
S3-P01 / 11/01/2022	Initial issue	JB Barry
S3-P02 / 14/02/2022	Updated Design Flows and Section 50 flows after discussion with OPW	JB Barry

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Abbreviations

AM	Annual Maximum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FSR	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

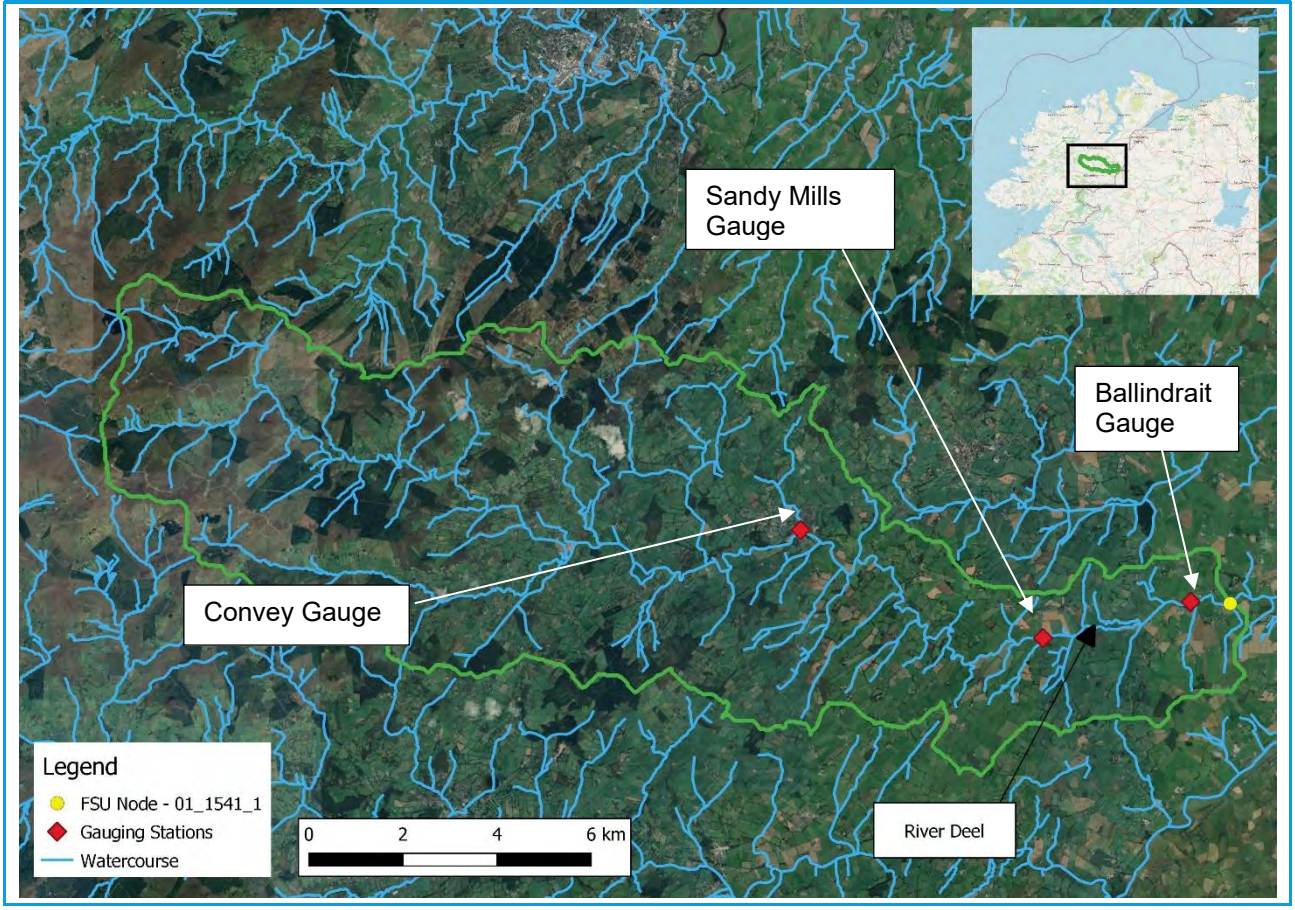
1 Method statement

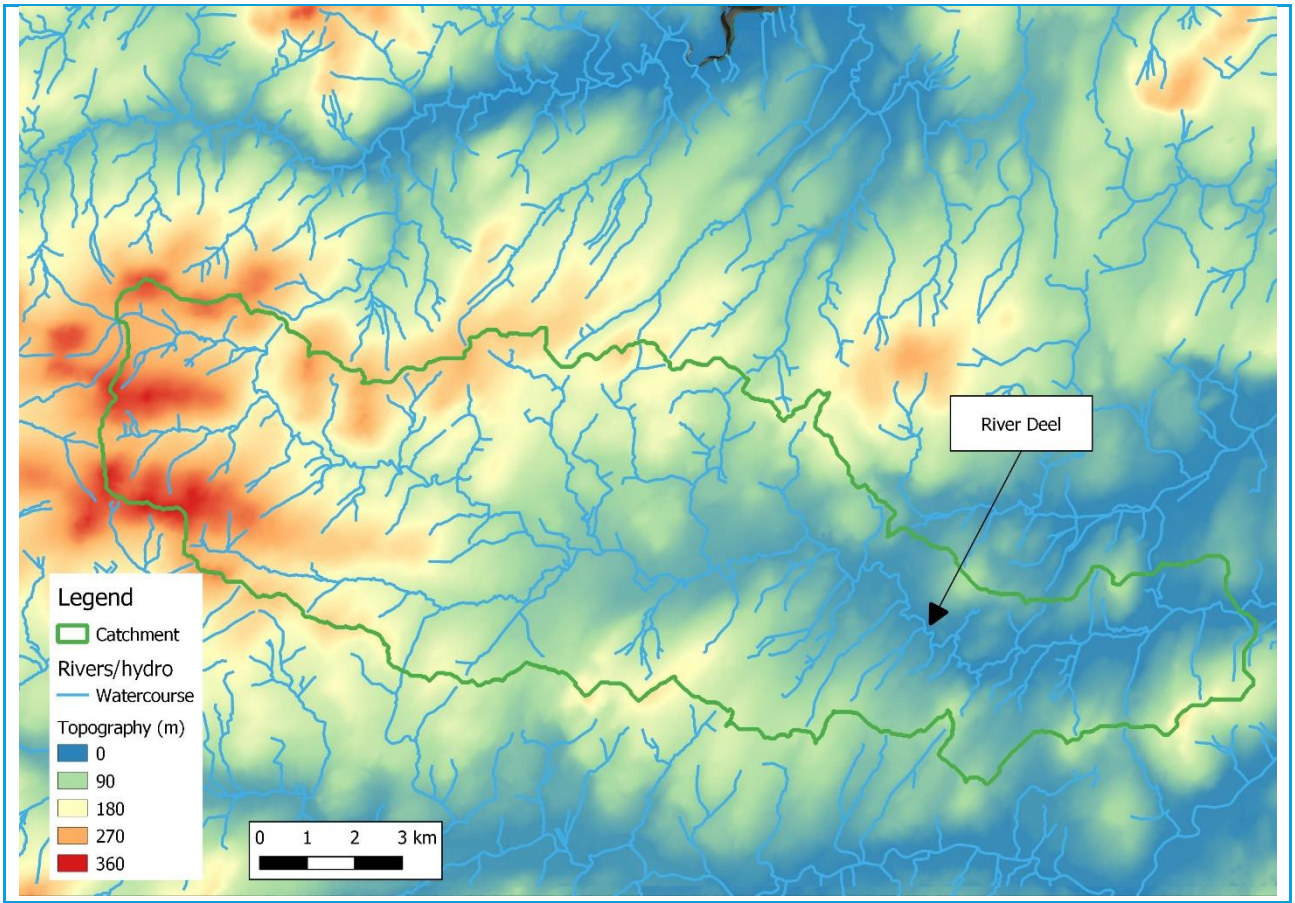
1.1 Requirements for flood estimates

Overview •	Proposed road alignment crosses the River Deele near Lifford, Donegal. Detailed hydraulic modelling and hydrological analysis will be required to assess the pre and post development flood risk and ensure that the proposed bridge designs are compliant with Section 50 of the Arterial Drainage Act 1945. The Section 50 flows will be based on the 1% AEP event but take into account a factor for climate change (1.2) and a factorial standard of error (FSE). .

1.2 The catchment

Map (Include river network, catchment boundary and gauging stations)





Description Include topography, climate, geology, soils, land use and any unusual features that may affect the flood hydrology.	The catchment is a medium sized catchment (130km2) originating in the hilly area to the west of the village of Convoy. The catchment is largely agricultural land (68% pastures) with some peat (22%) and forest (14%) land coverage also. The modelled reaches of the Deele are fairly flat (S1085 ranging from 5 to 10). Bedrock is Aghyaran & Killygordon Limestones (marble, quartzite, psammite; graphitic) and Mullyfa and Deele Formation (psammite, pebble beds, marble, schist) in the eastern section of the catchment, and Termon Formation (banded semi-pelitic & psammitic schist), Lough Eske Psammite Formation (feldspathic psammite; quartz, marble) and Killeter Quartzite Formation (Slightly impure quartzite) to the west. Drainage scheme carried out from 1957-1961.

1.3 Gauging stations (flow or level)

(at or very near to the sites of flood estimates)

Water-course	Station name	Gauging authority number	Gauging Authority	Catchment area (km²)	Type (rated / ultrasonic / level…)	Start of record and end if station closed
Deele	Convoy	01046	EPA	85.1	Staff Gauge	1979-1996
Deele	Sandy Mills	01041	OPW	116.2	Recorder	1973 - Active
Deele	Ballindrait	01048	EPA	125.5	Staff Gauge	1990 - 2002

1.4 Data available at each flow gauging station in Table 1.3

Station name	Start and end of FSU portal flood peak record	Update for this study? (CFRAM or latest data)	OK for QMED?	OK for pooling?	Data quality check needed?	Other comments on station and flow data quality
Convoy	NA	NA	NA	NA		Only 17 years of data ending in 1996
Sandy Mills	1973 - 2005	Yes	Yes	Yes		Still active, Additional AMAX data available
Ballindrait	NA	NA	NA	NA		Only 12 years of data ending in 2002
Tabulate any updated or revised flood peak series in the Annex. Give link/reference to any further data quality checks carried out.						

1.5 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Historic flood data Include chronology and interpretation of flood history in Annex or separate report.	Yes	Yes	Floodmaps.ie	OPW minutes of Meeting (Jan06); Ballindrait - River Deele overflows its banks every year after heavy rain. The road is liable to flood once every 5 years approximately.
			Floodmaps.ie	Letter to OPW (Dec2000) – Flooding problem near owners dwelling house in Rossgir, Ballindrait, Lifford.
Rainfall data for events	Yes	Yes	Met.ie	Daily rainfall data at Raphoe station c500m south of the catchment. Oct 2002 – Aug 2019
CFRAM study method & outputs	Yes	Yes	Floodinfo.ie	Flood outline, hydrology and hydraulics report
			OPW	Survey, LiDAR
Results from other previous studies	Yes	Yes	Old PFRA	Flood Outlines

1.6 Hydrological understanding of catchment

Outline the conceptual model	Main site of interest is directly upstream and downstream of the proposed road bridge. Peak flows most likely to cause flooding due to flat topography, volumes possibly an issue so this is also to be assessed in sensitivity runs of the hydrograph shape.
Any unusual catchment features to take into account?	Arterial Drainage Scheme carried out from 1957-1961.

1.7 Initial choice of approach

Is FSU appropriate? (it may not be for extremely heavily urbanised or complex catchments) If not, describe other methods to be used.	Yes.
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	FSU Method – CDs and Pooling - JFes most up to data, will still also consider FSU Portal. Hydrograph shape to be derived using FSU. Catchment will not be split into sub-catchment as it is a small model.
Software to be used (with version numbers)	FSU Portal / JBA's Flood Estimation Software (JFes) v.8 / JSpeed

2 Locations where flood estimates required

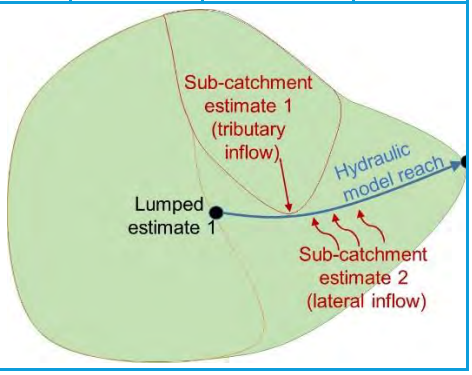
2.1 Summary of subject sites

Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA (km^2)
01_1541_3	L	River Deele	Directly US of proposed bridge	231283	399767	128.70

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required.

Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.



2.2 Important catchment descriptors at each subject site

Descriptor	01_1541_3
Centroid X	401430
Centroid Y	219030
Area	128.70
SAAR	1301.28
FARL	1
BFI Soil	0.3938
URBEXT	0.0078
MSL	37.194
S1085	6.0951
Stream Frequency	275
DrainD	1.46
ArtDrain2	0.0765
Soil (number)	2=0.74 5=0.26
SMDBAR	3
M5-2day	65
M5-1day	50
r	0.3

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (add maps if needed)	FSU catchment boundary checked against Ireland_Aligned DTM, Google terrain contours. No changes
Record how other catchment descriptors were checked and describe any changes. Include before/after table if necessary.	Catchment descriptors sourced from FSU database
Source of URBEXT	FSU descriptors
Method for updating of URBEXT	No change

3 FSU Statistical method

3.1 Overview of estimation of QMED at subject site

	Deele
Number	01_1541_3
Catchment area (km2)	128.696
Qmed (rural) m^3/s	52.95
Qmed (urban) m^3/s	53.57

3.2 Data transfer for QMED estimation

Table 3-1. Pivotal gauge options

	Sandy Mills	Curraghbonaun	Billa Bridge
Number	01041	34009	35002
FSU gauge quality ranking	B	A2	A2
Years of suitable data	43 years 1973-2018. Missing 2000-2001	33 years	35 years
Catchment area (km2)	116.18	117.11	88.82
Qmed gauged m3/s	87.51	27.48	49.74
Qmed(rural) m3/s	51.55	41.466	43.887
On same watercourse as subject site (Y/N)	Y	N	N
In same catchment as subject site (Y/N)	Y	N	N
Distance between catchment centroids (km)	2.1257	200	169.68
Hydrological similarity to ungauged location	0.1815	0.2227	0.5495
URBEXT	0.0086	0.0107	0
Any other catchment features (e.g. Arterial Drainage)	ArtDrain2 = 0.0086	ArtDrain2 = 0.0107	ArtDrain2 = 0
Gauge type	Level and Flow	Level and Flow	Level and Flow
Operator	OPW	OPW	OPW
Status	Active	Active	Active
Reasons for choosing or dismissing	Gauge upstream of site. B rating so suitable for Qmed estimation	Not as close or hydrologically similar as Sandy Mills gauge, although it is an A2 rating	Not as close or hydrologically similar as Sandy Mills gauge, although it is an A2 rating. No arterial drainage.

3.2.1 Discussion on gauge data, data transfer and pivotal sites

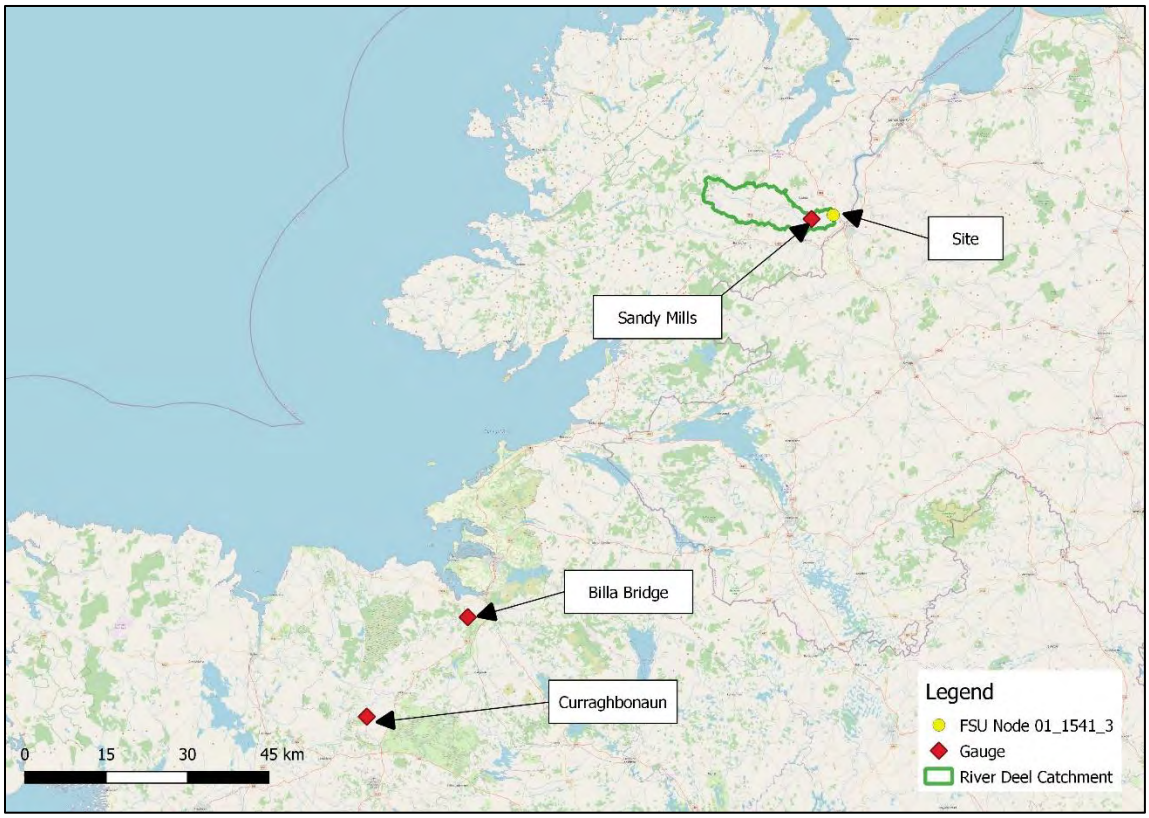


Figure 3-1: Gauge Locations

Of the three gauges reviewed 01041 Sandy Mills is recommended for use as a pivotal gauge as it is within the catchment on the same watercourse, has a sufficient gauge record length and is also impacted by arterial drainage works. The other two gauges, while both has A2 ratings, are located in different parts of the country and therefore the Sandy Mills gauge is a better representation of the Deele.

The Sandy Mills gauge has a record length of over 40 years. It is a B ranked gauge indicating that it is of suitable quality to estimate Qmed values. Although the high flows of 2015 could update this rating. Figure 3-2 shows the Gauge AMAX series and the seasonality plot. Review of the seasonality plot shows that higher flows are generally recorded during the Winter months rather than the Summer months.

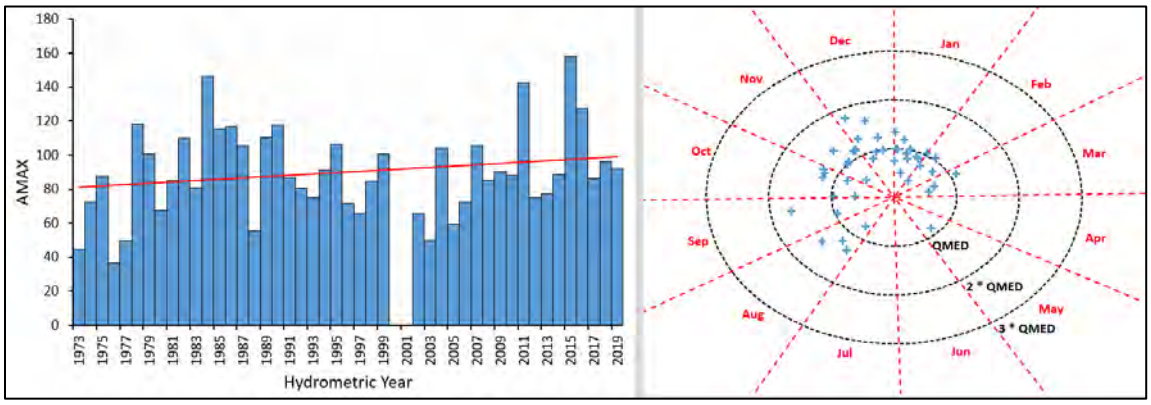


Figure 3-2: AMAX and seasonality plot

3.2.2 Lifford FRS

RPS undertook a rating review of the Deele at Sandy Mills gauging station due to noted uncertainty within the hydrometric data provided by the OPW and to attempt to validate (or otherwise) the peak flow estimation within the Lifford study area. Refer to Appendix D for relevant extracts from the Lifford FRS. The resulting design flows are based on a combination of the OPW rating up to 2004 and the new rating equation from 2004 onwards. On this basis the final design QMED value is taken as 75.23m3/s.

Following on from the JBA review of the Lifford FRS hydrology report and all the updated to the gauge information by the Lifford FRS, the adjustment factor used in the Lifford FRS was adopted for the JBA study.

Table 3-2. Pivotal sites chosen and QMED adjustment factors

Descriptor	01_1541_1	Pivotal site - JBA estimate (01041)	Pivotal Site – Lifford FRS (01041)
Area	128.70	116.18	114.2
SAAR	1301.28	1329.37	1330
FARL	1	1	1
BFI Soil	0.3938	0.3848	0.384
URBEXT	0.0078	0.0086	0.0086
MSL	37.194	32.582	32.582
S1085	6.0951	70.227	70.227
DrainD	1.46	1.469	1.469
ArtDrain2	0.0765	0.0447	0.0447
Hydrological similarity	-	0.1815	0.1815
FSU record	-	43yrs	43yrs
Qmed(rural) m3/s	52.9524	51.55	50.85
Qmed(gauged) m3/s	-	88.21	75.23
Adjustment factor		1.6895	1.479
Adjusted Qmed m3/s		90.50	78.32
FINAL SELECTED QMED m3/s	78.32		

3.3 Growth Curves

3.3.1 Derivation of flood growth curves at subject sites

Table 3-3. Selection of growth curve approach

Site code	Method (SS, P, ESS, J)	If P, ESS or J, name of pooling group	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Growth factor for 100-year return period
01_1541_1	P	Deele	GLO – appears like suitable fit, if using GEV distribution Q1000/Q100 is less than 1.2 which is below the recommended level	NA	1.81
01_1541_1	SS	Sandy Mills Gauge	GLO – fits best with 1st, 2nd and 4th AMAX values (Figure 3-3)	NA	1.89

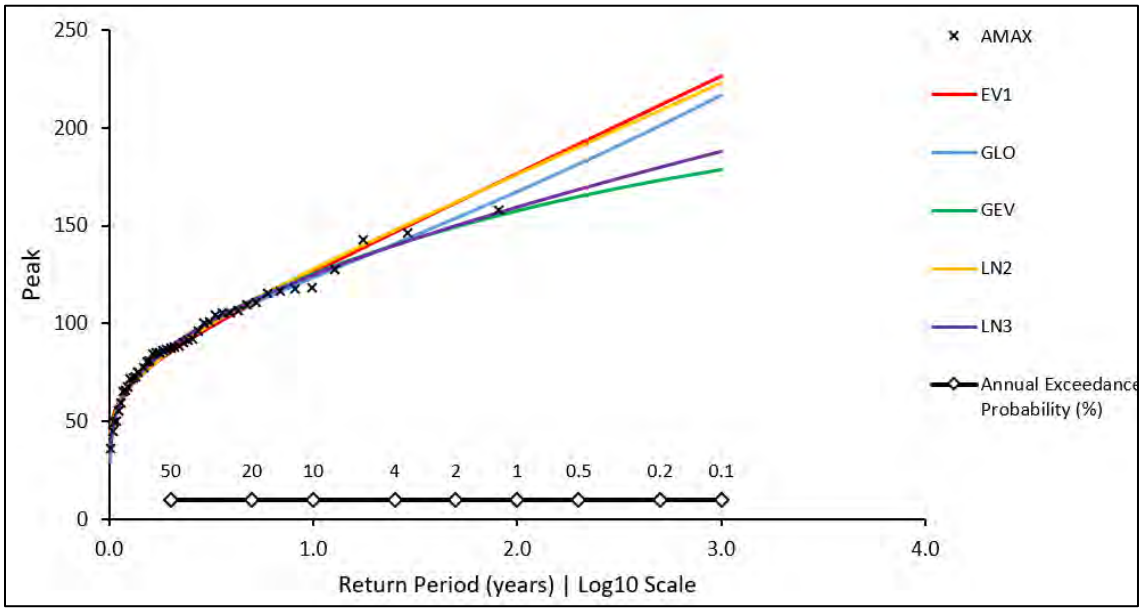


Figure 3-3: Sandy Mills Frequency Distribution

3.3.2 Derivation of pooling groups

Table 3-4. Pooling group details

Name of group	Site code from whose descriptors group was derived	No. of pooled years	No. of stations	Changes made to default pooling group, with reasons	Shape	Distribution	Scale
Deele	01_1541_1	507	13	None	-0.1153	GL	0.1344
	Note: Pooling groups were derived using the procedures from JFes V8						

3.3.3 Discussion on growth curves

A single pooling group was derived to establish a site-specific growth curve for the catchment. Table 3-5 show the growth curve and the flood frequency curve derived. For more information on the pooling group used refer to Appendix A.2.1. The growth curve for the single site analysis (SSA) was also analysed and is shown in Table 3-5. The two are very similar with the SSA slightly steeper.

Two growth curves were also completed by the Lifford FRS. The Deele at Sandy Mills has 44 AMAX years so the SSA growth curve is appropriate up to 1:88yr event. The growth factors up to the 1:50yr event for the Lifford FRS in the below table are based on the SSA. A pooled growth curve was selected for design flow estimates above and including the 1:100 yr event. Refer to Appendix D.1.3 for Lifford Growth Curve Development.

Table 3-5: Growth curves

AEP (%)	Pooled	SSA	Lifford FRS
50	1.00	1.00	1.00
20	1.20	1.24	1.25
10	1.34	1.40	1.40
5	1.52	1.54	1.55
2	1.66	1.74	1.76
1	1.81	1.89	2.29
0.1	2.42	2.45	3.58

3.4 Summary of FSU flood estimates

Table 3-6: FSU Flow Estimates

AEP (%)	Peak Flow (m3/s) PP Growth Curve	Peak Flow (m3/s) SSA Growth Curve	Peak Flow (m3/s) FRS Growth Curve
50	78.32	78.32	78.32
20	93.98	97.12	97.67
10	104.95	109.65	109.80
5	119.05	120.61	121.63
2	130.01	136.28	137.45
1	141.76	148.02	179.67
0.1	189.53	191.88	280.46

4 Discussion of flow estimations

4.1 Choice of Peak Flow

Table 4-1 shows a range of AEP flow estimates using the Lifford FRS adjustment factor with the FRS combined growth curve, using both pooled and SSA methods. This growth curve was selected as it based on the updated information for the SSA by the FRS and also pooled group for flows beyond that suited for the SSA.

Table 4-1: Flow Estimates

Annual Exceedance Probability (%)	FSU (m^3/s)
50%	78.32
20%	97.67
10%	109.80
5%	121.63
2%	137.45
1%	179.67
0.1%	280.46

5 Section 50 flows

After discussions with the OPW about the standard 95% CI value, and the resultant high flows proving difficult for bridge design, it was agreed that the FSE value for the Sandy Mills gauge would be calculated and applied to the subject site. The approach taken for calculating the FSE is discussed below.

5.1 Sandy Mills FSE

The FSE for the QMED at the pivotal site (Sandy Mills) was calculated using a formula from Volume 2 Flood Frequency Estimate of the Flood Studies Update [1]. This formula gives the additive SE for the 68% Confidence Interval (CI) which can then be converted to the FSE. The 95% CI can then be calculated by multiplying the site flows twice by the final 68% CI FSE, ie. (68% FSE)^2.

$$SE(QMED) \approx 0.369\ QMED\ /\sqrt{N}$$

The QMED for the site is 78.332m3/s and N, being the number of AMAX years, is 43. Therefore, the SE(QMED) is 4.41.

To convert the SE value to the 68% CI FSE, the following equation is applied:

1+ (SE/QMED).

1+(4.41/78.32) = 1.06

To get the 95% CI, the 68% CI value is squared = 1.116.

The 95% CI FSE for the gauge to be applied to QMED = 1.116.

5.2 Growth Curve FSE

To calculate the FSE associated with the growth curve for the pivotal site, a paper by A. Hammond, 'Sampling uncertainty of UK flood estimation' was reviewed.

Table 2 below is an extract from the paper which provides the FSE for ungauged QMED estimates and the mean FSE for the ungauged pooled estimated of longer return periods.

Table 2 | Mean ungauged factorial standard errors

No. Dons	2	5	10	20	50	100	200	500	1,000
0	1.46	1.469	1.488	1.513	1.560	1.606	1.661	1.752	1.835
1	1.42	1.432	1.449	1.475	1.523	1.569	1.627	1.721	1.804
2	1.41	1.412	1.431	1.458	1.507	1.553	1.613	1.706	1.789

The number of donor sites used in this instance is 1. To get the growth curve only component of the FSE (as the FSE for QMED has been calculated separately in the section above), the FSE for the Q100 is divided by the FSE for the Q2 in the table above. This value (the 68% CI) is then squared to get the final FSE for the 95% CI, see calculations below.

68% CI = 1.569/1.42 = 1.10

95% CI = 1.1^2 = 1.221

The Growth Curve 95% CI to be applied = 1.221

1 https://opw.hydronet.com/data/files/Technical%20Research%20Report%20-%20Volume%20II%20-%20Flood%20Frequency%20Estimation(1).pdf

5.3 Final Section 50 FSE

The FSE for the Section 50 application is based on the 1% AEP flows multiplied by the FSE for the gauge, the FSE for the growth curve and 20% climate change.

For the 95% CI the Section 50 flows are as follows:

179.67 * 1.116 * 1.221 * 1.2 = 293.22m³/s

Table 5-1 below shows the final FSE values to be applied for the Section 50. Both the 68% and 95% CI values are included but as there are properties identified as being at risk the 95% CI will be adopted for the Section 50 estimates. The FSE is calculated using both the FSE for the gauge and the FSE for the growth curve.

Table 5-1: Section 50 Flows

Flow Type	Flow (m³/s)
1% AEP	**179.67**
1% AEP + CC (1.2)	215.60
1% AEP + 68% CI (1.16)	208.75
Section 50 68% - (1.16*1.2)	250.50
1% AEP + 95% CI (1.36)	244.73
Section 50 95% - (1.36*1.2)	**293.32**

6 Hydrograph Shapes

6.1 FSU

The FSU was used to generate a hydrograph, generally suited for larger catchments as it replicates the longer responses expected for large flatter catchments.

Figure 6-1 shows the hydrograph shapes and durations recommended for each catchment. For the larger catchments there is an extended falling limb which replicates the larger catchment travel time as a flood event passes through.

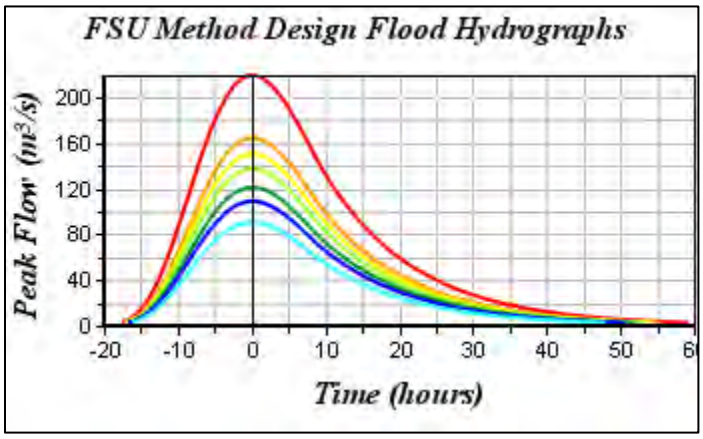
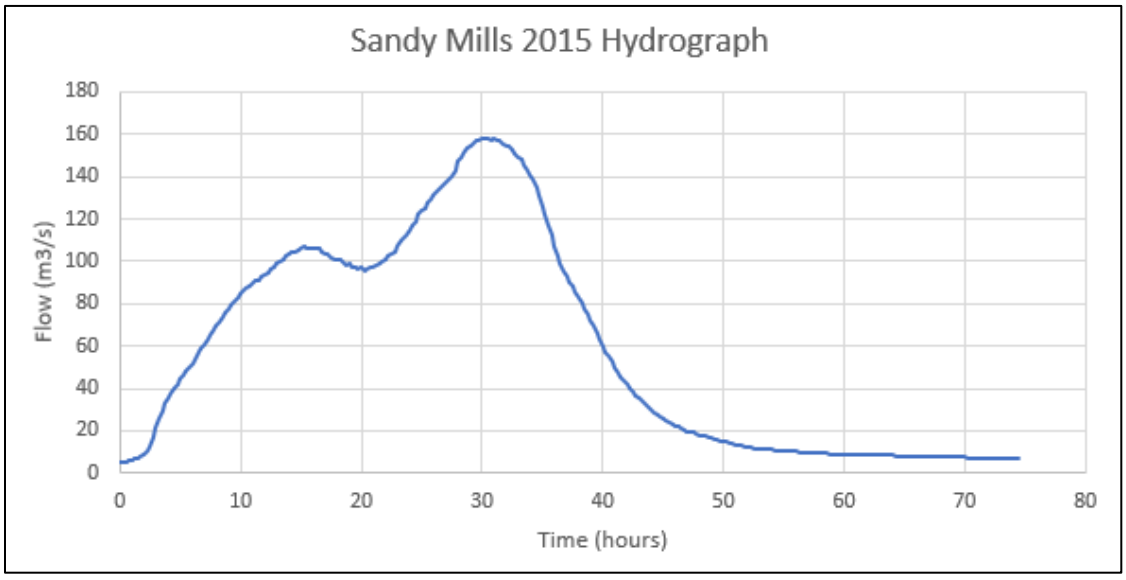


Figure 6-1: FSU Hydrograph

6.2 Sandy Mills Gauged Hydrographs

The Sandy Mills gauged events were reviewed to assess the hydrograph shape. In most flood events reviewed there is an initial peak followed a second some hours later. The rising limb does not have such a sharp rise as suggested in the FSU and the falling limb is much steeper suggesting a shorter travel. This hydrograph is a representation of the flooding further upstream and so is a better representation of what is occurring downstream at the subject site. The Sandy Mills gauged hydrograph shape will therefore be used as the hydrograph shape.



6.3 Final Choice

The two hydrographs are compared in Figure 6-2. The rising limb in the gauged hydrograph does not as sharp rise as suggested in the FSU and the falling limb is much steeper for the gauge suggesting a shorter travel. This hydrograph is a representation of the flooding further upstream and so is a better representation of what is occurring downstream at the subject site. The Sandy Mills gauged hydrograph shape will therefore be used as the hydrograph shape. A sensitivity test will also be carried out on the FSU gauge.

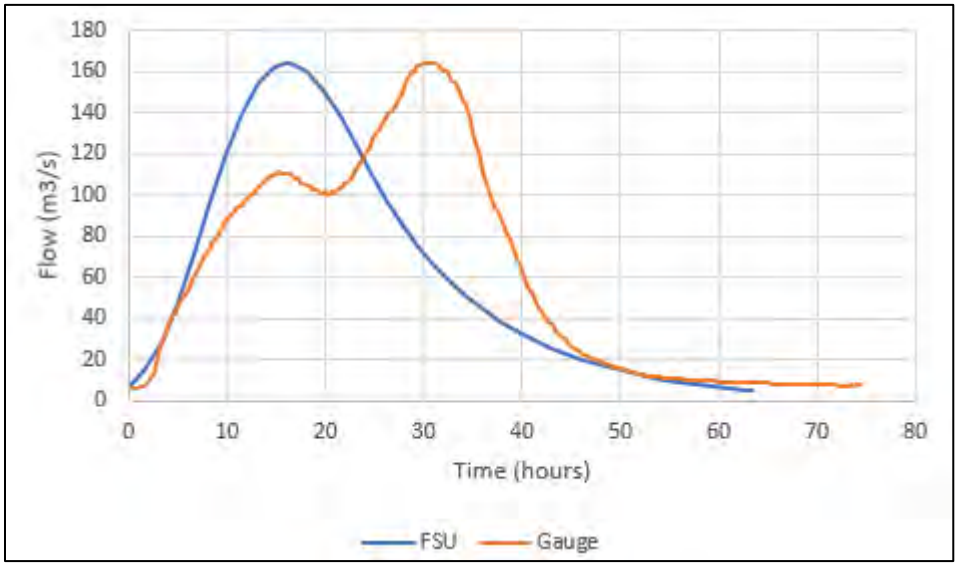


Figure 6-2: Hydrograph Comparison

7 Downstream Boundary

A HT boundary will be applied in the model based on levels in the CFRAM (to account for watercourse downstream).

8 Comparison with Other Studies

8.1 CFRAM

The CFRAM modelled this section of the River Deele. As seen in the extract below the Sandy Mills gauge was also used as a pivotal site.

The Sandy Mills gauging station (01041 – OPW) is located along the modelled reaches of the Deele approximately 10km downstream of the AFA. This station was given a B rating classification under FSU indicating there is confidence in the rating at Qmed and the rating review did not indicate that there was significant uncertainty in the existing Qmed value. This station was taken forward as a pivotal NW-NB CFRAM Study UoM 01 Hydrology Report - FINAL IBE0700Rp0006 72 F03 site under FSU and indicates the observed Qmed (derived from the AMAX series) is higher than the Qmed which is derived from catchment descriptors by a factor of 1.58 at the gauging station. Considering the confidence in the rating at Qmed and the long period of record (1973 – 2009) it is considered prudent that all of the Qmed values derived from catchment descriptors on this model are adjusted upwards in line with the adjustment factor at the gauging station.

The final flows used in the model are shown in table below. Flows are calculated at the Convoy gauge upstream of the site (2km2 smaller that subject catchment). Top up flows are applied between the gauge and node 01_1913_2 which is further downstream (6km2 increase in catchment size), refer to Figure 8-1. The subject size is about 1/3 downstream between the gauge and node 01_1913_2. It is noted that JBA flows are more conservative than the CFRAM. However,

JBA flows have been updated with information from the Lifford Flood Relief Scheme which supersedes the CFRAM study (discussed below).

Refer to Appendix C for further extracts from the CFRAM reports.

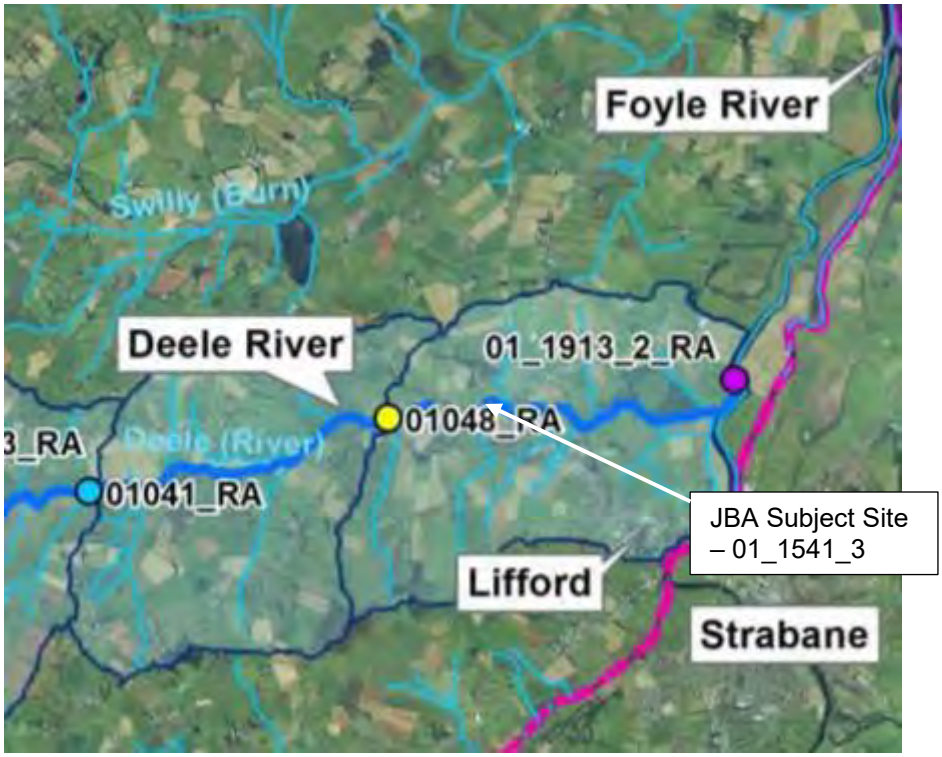


Figure 8-1: CFRAM Node Locations

Table 8-1: CFRAM Flows

Annual Exceedance Probability (%)	JBA (m^3/s)	CFRAM – Convoy Gauge (m^3/s)	CFRAM – 01_1913_2 (m^3/s)
50%	78.32	86.41	88.72
20%	97.67	105.41	108.24
10%	109.80	117.95	121.10
5%	121.63	130.65	134.14
2%	137.45	148.27	152.24
1%	179.67	162.53	166.88
0.1%	280.46	218.52	224.37

8.2 Lifford FRS

The River Deele was also modelled as part of the Lifford Flood Relief Scheme (FRS). The study included two HEP points along the River Deele, one at the Sandy Mills gauge (upstream extent of FRS model) and one at the downstream extent of the river (refer to Figure 8-2). As part of the study, a rating review was carried out on the Sandy Mills gauge (refer to Appendix D.1.1 for more information on the rating review). Further work was also done on the growth curves for the site, and the final growth curve is based on a combination of Single Site Analysis and a Pooled Growth Curve.

A comparison between the Lifford FRS and the JBA flows are shown in Table 8-2. As seen in the table, despite the JBA HEP point being located between the two FRS HEPs, the JBA flows are more conservative. This is due to the QMED estimation at the subject as the FRS adjustment factor for the Sandy Mills gauge and the growth curves have been adopted by JBA.

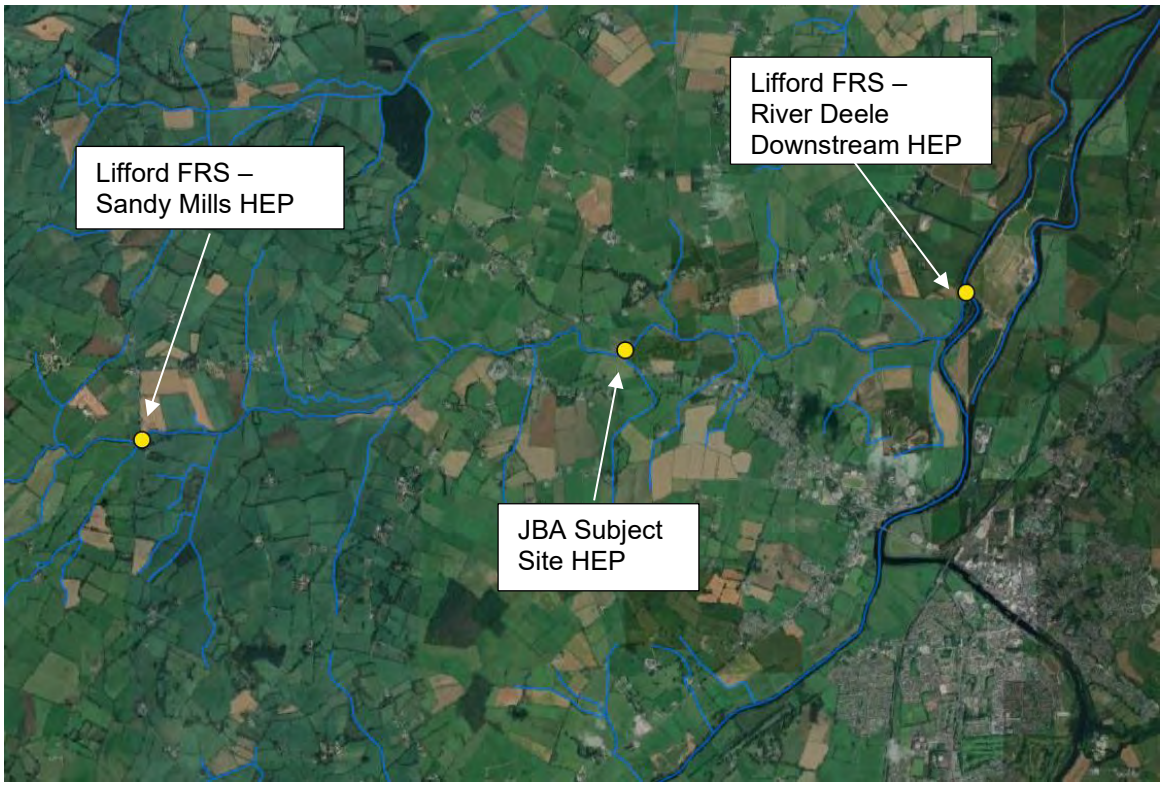


Figure 8-2: Lifford FRS HEPs

Table 8-2: Lifford FRS Flows

Annual Exceedance Probability (%)	JBA (m^3/s)	Lifford FRS Sandy Mills Gauge (m^3/s)	Lifford FRS River Deele Downstream (m^3/s)
50%	78.32	74.02	75.62
20%	97.67	92.33	94.30
10%	109.80	103.81	106.02
5%	121.63	114.99	117.44
2%	137.45	129.95	132.72
1%	179.67	169.86	173.48
0.1%	280.46	265.16	270.81

9 Discussion and summary of results

9.1 Final choice of method

Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	FSU was used for estimating the QMED based on catchment descriptors. This method is most up to date in Ireland and provides conservative yet representative flows for the watercourses considered. However, the adjustment factor was based on that carried out by the Lifford FRS, as well as the growth curve for the site.
Climate change allowance	+20% flow under OPW MRFS scenario
Section 50	1% AEP Event + Climate Change (1.2) + FSE (1.36 as calculated)
How will the flows be applied to a hydraulic model?	One single inflow point.
Recommended sensitivity tests for hydraulic model	Sensitivity test on the hydrograph length and downstream boundary.

9.2 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	Sandy Mills is a suitable pivotal site.
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	Relevant for use in further FRA work in the area however should be reviewed prior to use.

9.3 Checks

Have adjustments to catchment descriptor methods or gauge data been applied?	Yes
Is storm duration important?	Not likely but hydrograph sensitivity will be carried out to determine
Location of calculation sheets, data and records.	Project folder and Jfes online (search project number 2020s1405).

Appendices

A Methods

A.1 The FSU method

The Flood Studies Update (FSU) method to estimate Qmed as described in research reports produced from FSU work packages 2.2 and 2.3, has been used. Qmed can be estimated using a regression equation based on seven different physical catchment descriptors, in conjunction with an urban adjustment, developed in FSU work package 2.3.

The multivariate regression equation was developed on the basis of data from 199 gauged catchments, linking Qmed to a set of catchment descriptors.

$$QMED = 1.237 \times 10^{-5} AREA^{0.937} BFI_{soil}^{-0.922} SAAR^{1.306} FARL^{2.217} DRAIND^{0.341} S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$

Where:

- AREA is the catchment area (km2).
- BFIsoils is the base flow index derived from soils data
- SAAR is long-term mean annual rainfall amount in mm
- FARL is the flood attenuation by reservoir and lake
- DRAIND is the drainage density
- S1085 is the slope of the main channel between 10% and 85% of its length measured from the catchment outlet (m/km).
- ARTDRAIN2 is the percentage of the catchment river network included in the Drainage

The urban extent can be taken into account using the following equation:

$$Q_{MEDfinal} = Qmed\,(1 + URBEXT)^{1.482}$$

Where URBEXT is the percentage of the catchment covered by urban land use.

Following the calculation of QMED the calculated adjustment factor and a growth curve are applied to generate the peak flows for AEP events. In this case the growth curve produced by the FSU pooling group for the ungauged catchment has been applied.

The catchment descriptors can be used to determine Qmed. In order to improve on this initial estimate of QMED, the data transfer process can be used. In the terminology of the FSU research reports, the gauging station where the adjustment factor is calculated is referred to as a donor site. An adjustment factor for QMED is calculated as the ratio of the gauged to the ungauged estimate of QMED at the gauging station. This factor is then used to adjust the initial estimate of QMED at the hydrological estimation point.

The growth factors for this site are also calculated from the FSU using pooling groups.

For pooled analysis within the FSU, gauges are chosen on the basis of their similarity with the subject catchment according to three catchment descriptors, i.e. AREA, SAAR and BFIsoil. The report on FSU WP 2.2 presents two alternative equations for calculating the similarity of catchments according to these three descriptors. For this study, equal weight was given to each of these variables, applying the similarity distance formula given as Equation 10.2 in the report on FSU WP 2.2.

Not all gauges in Ireland were considered for use in pooling, because the analysis required to fit a flood growth curve makes use of the magnitude of each annual maximum flow, and thus it is

necessary that even the highest flows are reliably measured. This excludes gauges where there is significant uncertainty in the high flow rating.

Although there is some evidence from research on UK data that flood growth curves are affected by additional catchment descriptors such as FARL, the FSU research found that FARL was not a useful variable for selection of pooling groups (uncertainty was greater when FARL was included than when it was excluded) and therefore no attempt was made to allow for the presence of lakes in the composition of pooling groups. Similarly, no allowance was made for arterial drainage in selecting pooling groups.

For pooled growth curves, WP 2.2 recommends considering 3-parameter distributions, because the extra data provided by the pooling group ensures that the standard error is lower than it would be for single-site analysis. The report states that either the generalised extreme value (GEV) or generalised logistic (GL) distributions are worth considering. For this study, GEV has been fitted for the pooled analysis.

A.2 Workings and tables

A.2.1 Pooling group details.

Table 9-1. Pooling Group Details

Station No.	Name	Watercourse	Years	Cumulative years
25040	Roscrea	Bunow	35	35
16006	Ballinaclogh	Multeen	46	81
24022	Hospital	Mahore	35	116
26010	Riverstown	Cloone	48	164
16005	Aughnagross	Multeen	43	207
19020	Ballyedmond	Owennacurra	40	247
25044	Coole	Kilmastulla	51	298
26009	Bellantra Bridge	Black	48	346
29001	Rathgorgin	Raford	53	399
19001	Ballea	Owenboy	59	458
25027	Gourdeen Bridge	Ollatrim	51	509

B Historic Flooding

B.1 Floodmaps.ie



C CFRAM

C.1 Flows

Model 23 - Convoy

Node ID_CFRAMS	AREA (km²)	Qmed	Flows for AEP								Model number
			50% (2)	20% (5)	10% (10)	5% (20)	2% (50)	1% (100)	0.5% (200)	0.1% (1000)	
01_801_3_RA	81.87	78.86	78.86	96.21	107.65	119.24	135.33	148.34	162.46	199.45	Model 23
01_801_Int_1_RPS	82.20	78.86	78.86	96.21	107.64	119.24	135.32	148.33	162.45	199.43	Model 23
Top-up flow between 01_801_3_RA & 01_801_Int_1_RPS	0.33	0.27	0.27	0.34	0.38	0.43	0.50	0.56	0.63	0.81	Model 23
01_801_Int_2_RPS	83.10	78.92	78.92	96.29	107.73	119.33	135.43	148.45	162.58	199.60	Model 23
Top-up flow between 01_801_Int_1_RPS & 01_801_Int_2_RPS	0.90	0.69	0.69	0.86	0.98	1.10	1.28	1.43	1.61	2.09	Model 23
01046_RA	83.17	78.92	78.92	96.29	107.73	119.33	135.43	148.45	162.58	199.60	Model 23
Top-up flow between 01_801_Int_2_RPS & 01046_RA	0.07	0.06	0.06	0.08	0.09	0.10	0.12	0.13	0.15	0.19	Model 23
01_1518_1_RA	2.72	1.75	1.75	2.26	2.65	3.07	3.73	4.31	4.99	7.02	Model 23
01_1518_4_RA	4.72	2.81	2.81	3.65	4.27	4.95	6.00	6.94	8.03	11.30	Model 23
Top-up flow between 01_1518_1_RA and 01_1518_4_RA	2.00	1.26	1.26	1.51	1.69	1.84	2.06	2.24	2.42	2.91	Model 23
01_1557_3_RA	102.65	81.15	81.15	99.00	110.76	122.69	139.25	152.63	167.16	205.22	Model 23
Top-up flow between 01046_RA & 01_1557_3_RPS	14.76	8.00	8.00	9.85	11.09	12.37	14.18	15.69	17.32	21.73	Model 23
01041_RA	114.29	84.61	84.61	103.22	115.49	127.93	145.19	159.15	174.30	213.98	Model 23
Top-up flow between 01_1557_3_RPS & 01041_RA	11.65	6.04	6.04	7.37	8.25	9.13	10.37	11.36	12.44	15.28	Model 23
01048_RA	123.71	86.41	86.41	105.42	117.95	130.65	148.27	162.53	178.00	218.52	Model 23
Top-up flow between 01041_RA & 01048_RA	9.41	4.69	4.69	5.65	6.26	6.87	7.70	8.37	9.07	10.88	Model 23
01_1913_2_RA	134.00	88.72	88.72	108.24	121.10	134.14	152.24	166.88	182.76	224.37	Model 23
Top-up flow between 01048_RA - 01_1913_2_RA	10.29	4.88	4.88	5.78	6.38	6.96	7.76	8.39	9.05	10.74	Model 23

C.2 Extracts

SANDY MILLS (01041)

The Sandy Mills gauging station 01041 is located in County Donegal on the River Deele. The river reach represents the model connection between modelled reaches of the River Deele for the Convoy (upstream) and Lifford (downstream) AFA models.

The gauge is located approximately 15m upstream of the road bridge over the River Deele, on the Raphoe to Cloughfin road, which is approximately 3.5km upstream of the R264 bridge over the River Deele at Ballindrait. The gauge is in a cross section approximately 20m wide with a minimum bed level of 3.315m OD Malin and bank levels of 6.888m OD Malin (left bank) and 7.054 m OD Malin (right bank). The current ordnance datum level of the gauge zero was surveyed as 4.019m OD Malin which is 379mm above the previous stated OPW staff gauge zero level of 6.340m OD Poolbeg. It is not known why there is such a large discrepancy between the two staff gauge zero levels but the OPW staff gauge zero level was used to complete the rating review as the spot gauge and water level data produced by OPW relates to their zero level and any discrepancy is thought to be relative.



Figure 1: Modelled Reaches and Gauging Station Location

B1

The gauging station is managed by the OPW and is currently active. Continuous water level records have been provided from 1973 - 2011. Spot flow gaugings for the station have been provided with the highest flow gauging recorded at 34.67m^3/s relative to a stage height of 1.58m on the gauge board. The rating was given a classification of B under the national review undertaken for FSU Work Package 2.1. This indicates there is confidence in the rating up to Q_{med} which equates to a stage height of

The rating review modelled reach extends approximately 450m in the upstream direction and 3.5km downstream of the gauge. There is one bridge along this reach of the River Deele located just downstream of the gauge. The upstream and downstream approaches to the gauge have slight bends as the river gently meanders in the vicinity of the gauge. The one dimensional hydraulic model uses information from 32 original cross sections, including the bridge structure.

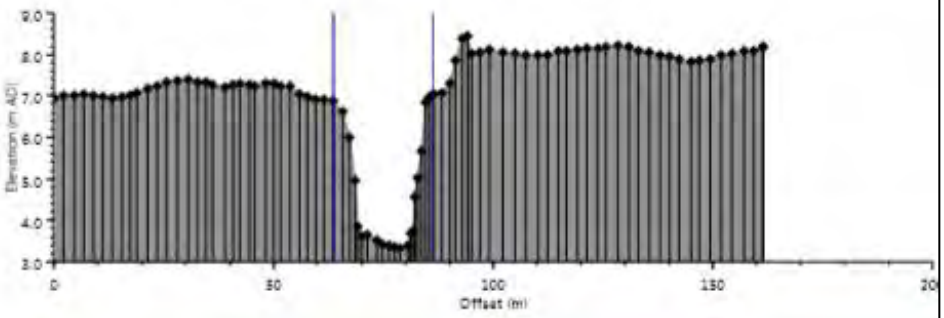




Figure 2: Model Cross-Section at Gauge Location (Top); Photo of gauge location (Bottom)

B2

The downstream boundary condition applied to the model was calculated as the normal flow Q-h relationship with the upstream boundary consisting of a hydrograph with a peak flow of 203 m^3/s representing an estimated 0.1% AEP flood event. This section of the River Deele is not represented by LiDAR and as such it was only possible to model the reaches in a 1D model. Due to the nature of the floodplain which is generally flat and at many locations having a level below the top of bank level it was considered that its inclusion within a 1D model would lead to flow within the floodplain at stage levels which are unrealistic and therefore only the flows that were contained within or near the banks were considered in the model calibration and rating curve creation. The model was calibrated by applying at the upstream boundary, lower flow gauged data, using spot gauge and the most up to date rating curve information for the Sandy Mills gauge. Adjustments were made to the Manning's n values for channel and bank roughness to reflect vegetation growth and channel roughness in order to develop a realistic model of the channel and flow conditions that is calibrated to the spot gaugings.

The results of the rating review are shown below in Figure 3 and Table 1. The graph demonstrates the derived RPS rating curve and shows the comparison between the OPW rating curve (which consists of 1 equation) and spot gaugings.

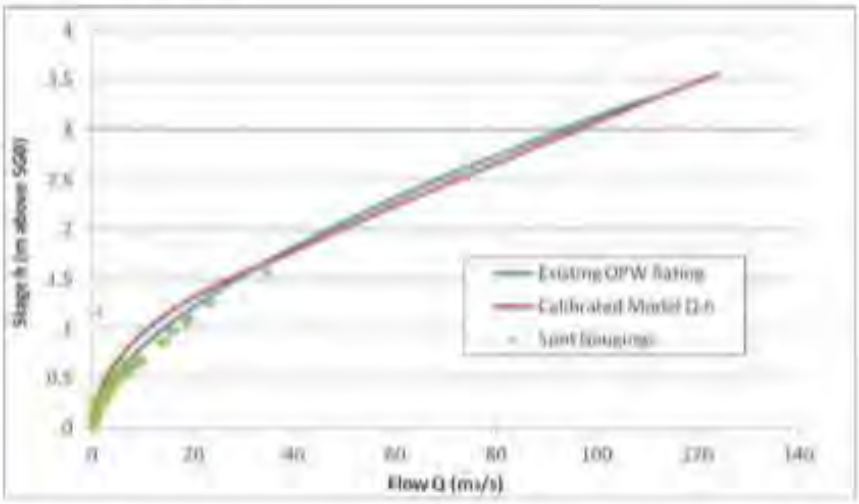


Figure 3: Comparison of Existing OPW Rating Curve and RP5 Rating Curve for all flows

Section	Min Stage (m)	Max Stage (m)	C	a	b
1	0.13	0.68	10.524	0.029	2.079
2	0.68	1.75	4.973	0.337	2.793
3	1.75	2.21	0.005	3.874	5.234
4	2.21	3.56	37.654	-0.737	1.148

Where: $Q = C(h+a)^b$ and h = stage readings (metres)

Table 1: Rating Equations for Gauge 01041

Figure 3 shows that the model fairly represents the OPW rating curve based on the flow gaugings up to the limit of the OPW rating at 110 m^3/s. Calibration at lower flows was found to be poor although the model provides a good fit to the highest spot flow gaugings. The best fit rating curve was achieved with a Manning's n value of 0.035. Analysis of the results show that floodwaters remain in bank at the gauged section until river flow exceeds 124 m^3/s or 7.2m (OD Malin). As the model was unable to represent out of bank flows accurately it has not been possible to extend the rating curve into the out of bank range with confidence. The modelled rating curve does not suggest uncertainty in the rating at the median flood flow.

D Lifford FRS Extracts

D.1.1 Sandy Mills Rating Review

2.3 Deele at Sandy Mills (01041)

The Deele at Sandy Mills represents a long duration record of the peak flows recorded for the River Deele, 6km upstream of Lifford. Prior to 2020 the station had been spot flow gauged up to just under 35 m^3/s, less than half the Q_{MED} value (87 m^3/s). Further spot gaugings have been undertaken in August 2020 and have been considered through the rating review reported in Section 2.6.3. The station was subject to rating review under the CFRAM Study which was poorly calibrated to the spot gauge data but nevertheless did not contradict the existing OPW rating at flood flows. Flows are contained within bank up to and above Q_{MED} at the gauging station reach. The entire AMAX record provides 44 hydrological years of peak flow data, presented in Figure 2-6.

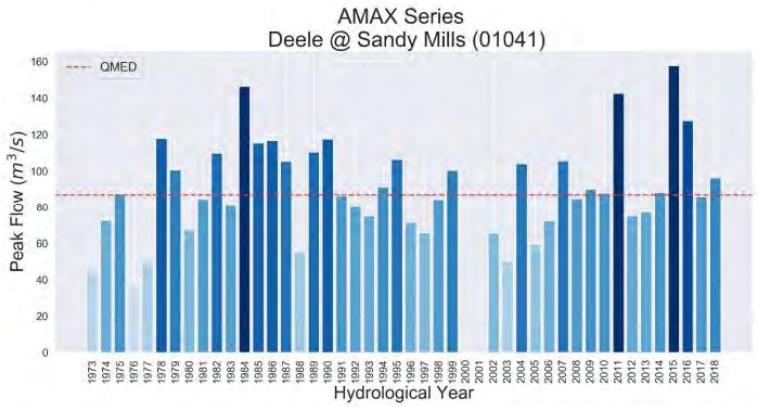


Figure 2-6 Deele at Sandy Mills (01041) – AMAX series

Two hydrological years (2000 & 2001) are missing from the series and therefore have not been included in the analysis. There are three relatively large events noticeable in the AMAX series which occurred in 1984, 2011 and 2015. At site flood frequency analysis was performed on this AMAX record. Common statistical distributions suited to modelling flood frequency behaviour were fitted to the observed data which concluded that the Generalised Logistic (GLO) provided the best fit. The resulting flood frequency curve for the Sandy Mills gauging station is presented in Figure 2-7 .

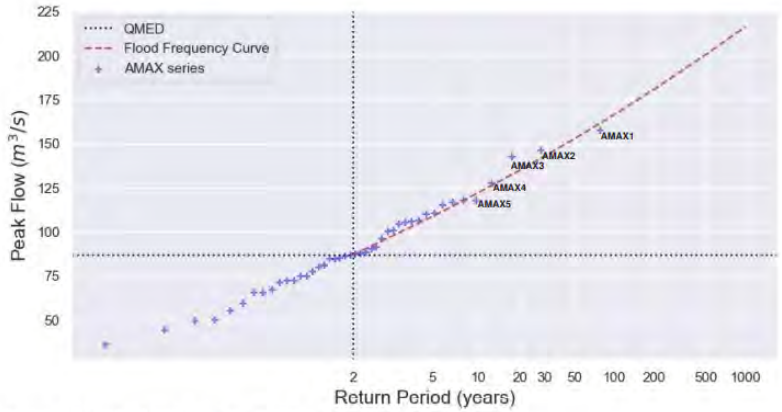


Figure 2-7 Deele at Sandy Mills - single site analysis

The GLO achieves an excellent fit to the AMAX data. Details of the five largest events recorded at the Sandy Mills gauging station is provided in Table 2.4.

Table 2.4 Deele at Sandy Mills - five largest events on record

AMAX index/rank	Hydrological year	Event date	Peak flow (m^3/s)	Estimated return period (years)
AMAX1	2015	05-Dec-15	158	60*
AMAX2	1984	21-Sep-85	146	40
AMAX3	2011	14-Dec-11	143	30
AMAX4	2016	23-Aug-17	128	15
AMAX5	1978	15-Nov-78	118	8

**Return period estimate to be treated with caution (record length < T years)*

The return period estimate of 1:60 years for the largest event on record (5th December 2015) should be treated with caution since it is derived from the AMAX series which comprises only 44 hydrological years of peak flow information.

2.6.3 Deele at Sandy Mills (01041)

RPS undertook a rating review of the Deele at Sandy Mills gauging station due to noted uncertainty within the hydrometric data provided by the OPW and to attempt to validate (or otherwise) the peak flow estimation within the Lifford study area. RPS performed a review of the current OPW rating derived from historical observations for the Deele at Sandy Mills (01041) gauging station.

The general form of any rating equation is:

$$Q = C(h + a)^{\beta}$$

Where,

Q = river flow (m^3/s)

C, a, β = rating equation constants

h = stage height (m)

The rating equation constants have physical significance and are originally derived from hydraulic theory. Rating equation parameters have been derived using the stage heights relative to the ordnance datum. The gauge is in a cross section approximately 42m wide with a minimum bed level of 3.642m OD Malin and bank levels of 7.451m OD Malin (left bank) and 7.255m OD Malin (right bank). The current ordnance datum level of the gauge zero was surveyed as 3.634m OD Malin. The surveyed staff gauge zero level was used to complete the rating review as any discrepancy is thought to be relative and the surveyed staff gauge zero level is consistent with the survey data from which the hydraulic model is constructed.

2.6.3.1 Hydraulic Modelling

The rating review modelling was carried out within the full Lifford FRS hydraulic model. The Deele at Sandy Mills gauging station is situated on top of the earthen embankment, on the right bank. Its location is outside of the tidal influence. The Deele River joins the River Foyle just short of 8km downstream of the gauge. The gauge is located directly upstream of a bridge, with a slight bend in the channel upstream and a sharper meander in the channel downstream of the bridge.

model Q-h relationship with the range of spot gaugings and adjusting model parameters as required, within appropriate bounds, until the Q-h and spot gaugings aligned.

Figure 2-24 shows the spot gauge data for the Sandy Mills gauge. In 2004, there was a staff gauge zero change from 6.450m OD Poolbeg to 6.345m OD Poolbeg. There appears to be a distinct visual shift between the spot gauge data from before and after this date.

It is believed that the Bridge 10m downstream acts as the significant hydraulic control affecting the stage discharge relationship at the gauging station. Spot gauge data recorded on 25/08/2020 noted that debris and a tree branch were washed down stream and stuck across the left bridge arch. In light of this the three largest spot gaugings shown in Figure 2-24 are thought to reflect a partial blockage scenario and all of the top six spot gaugings represent some degree of debris constricting flow at the bridge.

Following iterative modelling, attempts to simulate a Q-h relationship calibrated to the top three spot gaugings were abandoned; the three spot gaugings are considered to represent a level of blockage / debris build-up that is not typical of the normal flow conditions at the bridge downstream. The other spot gaugings were considered reflective of normal flow conditions and were more readily calibrated to in the model without having to revert to simulation of extreme blockage or headloss coefficients.

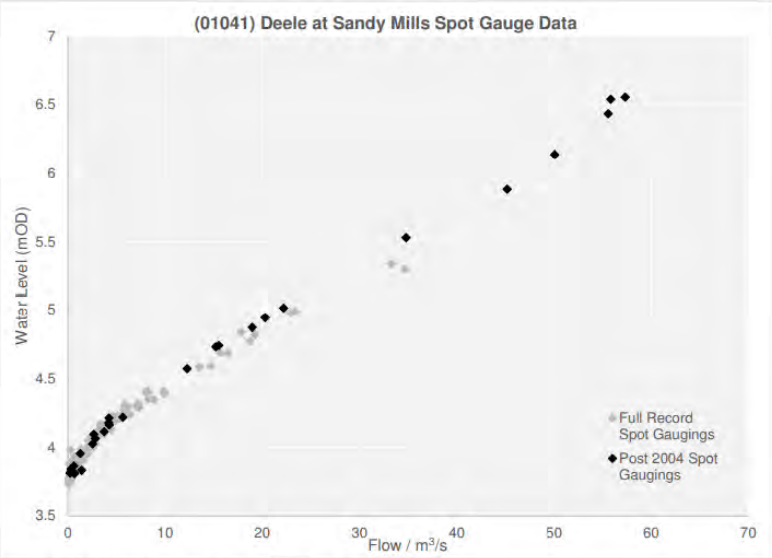


Figure 2-24 (01041) Deele at Sandy Mills Spot Gauge Data

to generate optimal parameters such that it limits the sum of the squared residuals (Chi Squared) of observed and predicted flow.

Table 2.17 an Table 2.18 below shows a comparison of the OPW rating review physical constants (C, a, β) and the physical constants that RPS derived for the new rating equation.

Table 2.17: OPW Physical Constant Parameters

Section	Min Stage (m)	Max Stage (m)	C	a	b
1	0	0.15	15.5	-0.05	1.66
2	1.5	0.18	15.5	-0.05	1.66
3	0.18	0.37	15.5	-0.05	1.66
4	0.37	1.7	15.5	-0.05	1.66
5	1.7	4.00	15.5	-0.05	1.66

Table 2.18: RPS Physical Constant Parameters

Section	Min Stage (m)	Max Stage (m)	C	a	b
1	0.000	1.424	16.090	-0.143	1.302
2	1.424	3.025	17.882	-0.244	1.31
3	3.025	3.910	13.983	-0.206	1.529
4	3.91	-	48.374	-2.196	1.407

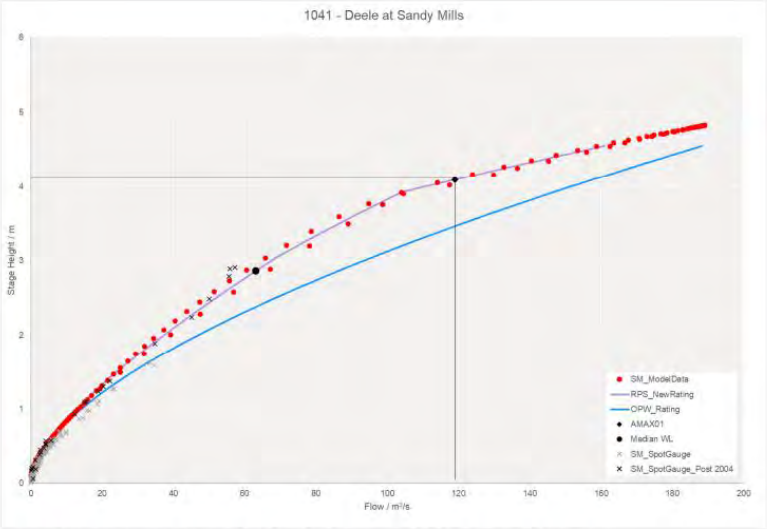


Figure 2-25 Comparison of OPW and RPS Rating Curves for Deele at Sandy Mills.

2.6.3.3 Rating Review Conclusions

RPS conducted the rating review in order to use the available data at the Sandy Mills gauge and to help validate the hydrology and hydraulic model. Prior to this rating review, the OPW rating was considered to be well validated against the spot gaugings at the time of the CFRAM Study (2014). It should be noted that at the time the majority of the high flow spot gaugings were collected prior to 2004.

Table 2.19 Percentage Difference between OPW and New RPS rating equations

	Date	Stage Height	OPW Rating Equations (1973 – Present)	New RPS Rating Equation (2014 – Present)	Percentage Difference
QMED			86	66	-24%
AMAX01	05-Dec-15	4.095	158	119	-25%
AMAX02	21-Sep-85	3.92	146	111	-25%
AMAX03	14-Dec-11	3.857	143	101	-29%

Table 2.19 compares the results for QMED, AMAX01, AMAX02 and AMAX03 when the OPW and New RPS rating equations are applied. The new RPS rating has reduced the QMED at the gauge by 24%. Note that this QMED is based on an AMAX series post 2004 onwards and it has not been applied to the entire record period.

From discussions with the OPW hydrometrics team the change in 2004 is not thought to have significantly altered the rating. The staff gauge was physically moved and lowered on 22/07/2004, from the left bank upstream abutment of the bridge to the north-eastern corner of the hut (right bank, upstream of the bridge). On that basis RPS attempted to apply the rating back before 2004. The resulting AMAX is relatively stable, supporting the idea that the rating has not changed significantly. Prior to 1978 there are a number of low values which may indicate issues with the data from before this date. The resulting QMED value from the extended AMAX (1978 – 2019) based on the new RPS rating is 64.3 m^3/s. Even extending the rating back to the commencement of the record in 1973 only results in a small reduction in QMED to 63.4 m^3/s. This suggests the rating is stable and can potentially be applied back to prior to 2004.

In considering the final QMED for design flow estimation RPS must consider the uncertainty in the rating. Achieving calibration to the spot gaugings, particularly the higher spot gaugings in 2020 required the implementation of high headloss coefficients on the bridge and roughness coefficients within the model. There is the possibility that the 2020 spot gaugings, even disregarding the top three, are not reflective of the normal flood flow conditions. The gaugings were collected in the summer when vegetation is at its thickest, increasing the amount of brash and debris in the channel. The rating therefore may be biased to summer flow conditions and a rating more typical of autumn or winter conditions, when vegetation is reduced, may exist which is less steep.

In order to ensure that the design flows are not overly reduced based on the steeper, potentially summer biased new rating equation, the design flows are based on a combination of the OPW rating up to 2004 and the new rating equation from 2004 onwards. On this basis the final design QMED value is taken as **75.23m^3/s**.

The revised AMAX series used as the basis of the design QMED is shown in Table 2.20.

Table 2.20 AMAX Series taken forward as the basis for design flow estimation at Sandy Mills (01041)

Hydrological Year	Event Date	Peak Flow (m^3/s)
1974	15/01/1975	*69.54*
1975	02/01/1976	*88.18*
1976	20/01/1977	*34.00*
1977	09/11/1977	*49.39*
1978	15/11/1978	*119.35*
1979	26/11/1979	*96.02*
1980	03/02/1981	*68.14*
1981	03/10/1981	*84.61*
1982	19/12/1982	*99.23*
1983	13/01/1984	*78.64*
1984	21/09/1985	*147.16*
1985	06/08/1986	*113.61*
1986	05/12/1986	*115.89*
1987	21/10/1987	*103.02*
1988	04/10/1988	*55.23*
1989	28/10/1989	*105.77*
1990	01/01/1991	*115.89*
1991	21/12/1991	*85.63*
1992	23/01/1993	*79.62*
1993	08/12/1993	*75.23*
1994	31/01/1995	*92.85*
1995	25/10/1995	*105.22*
1996	19/02/1997	*70.94*
1997	01/01/1998	*64.02*
1998	11/09/1999	*80.61*
1999	28/11/1999	*100.31*
2000	28/10/2000	*74.75*
2001	19/02/2002	*79.13*
2002	02/11/2002	*62.89*
2003	31/01/2004	*62.22*
2004	08/01/2005	71.75
2005	24/11/2005	51.31
2006	26/10/2006	51.91
2007	14/08/2008	74.78
2008	14/12/2008	62.40
2009	16/11/2009	65.59
2010	01/10/2010	-
2011	14/12/2011	101.28
2012	18/05/2013	56.11
2013	26/01/2014	57.50
2014	15/01/2015	64.29
2015	05/12/2015	119.26
2016	23/08/2017	91.08
2017	01/10/2017	62.99
2018	06/03/2019	69.35
2019	09/02/2020	66.74

n *italics* based on OPW rating

D.1.2 Design Flow

3 DESIGN FLOW ESTIMATION

The estimation of design flood flows will employ statistical techniques from the FEH and FSU. Design flow estimation aims to derive estimates of peak flows across the suite of return periods stipulated in the project brief. Firstly, the Q_{MED} values at HEPs are estimated and anchored to observed data where appropriate. Secondly, growth curves are formed which enable peak flows to be estimated for more extreme events.

3.1 HEP Physical Catchment Descriptors (PCDs)

The PCDs for sub-catchments in the UK were obtained from the FEH web service. Sub-catchments within the Republic of Ireland were obtained from FSU datasets. A summary of key PCDs for each sub-catchment are presented in Table 3.1.

Table 3.1 Lifford FRS – locations of HEPs and main catchment descriptors

HEP Name	Location	AREA (km^2)	SAAR	FARL	BFI	URBEXT/ URBEXT 2000
HEP01*	u/s extent of model on River Mourne.	1847.1	1288	0.977	0.448	0.0030
HEP02	u/s extent of Mourne/River Finn confluence	1861.9	1287	0.978	0.448	0.0034
HEP03**	d/s extent of model on River Finn.	314.0	1989	0.964	0.297	0.0012
HEP04	Check point on River Finn.	475.5	1731	0.974	0.334	0.0069
HEP05	Check point on River Finn.	501.6	1730	0.976	0.334	0.0070
HEP06	Check point on River Foyle	2364.3	1381	0.979	0.424	0.0030
HEP07***	u/s extent of River Deele.	114.2	1330	1.000	0.384	0.0086
HEP08	d/s extent of River Deele	133.9	1290	1.000	0.402	0.0085
HEP08A	Ballymagorry (Glenmornan) tributary	34.5	1114	1.000	0.502	0.0080
HEP09	u/s extent of Burn Dennet/Foyle confluence	149.3	1183	0.994	0.459	0.0004
HEP10	u/s extent of Swilly Burn/Finn confluence	60.1	1052	1.000	0.587	0.0110
HEP11	d/s extent of Unnamed Trib #1 at the confluence with River Foyle.	23.3	1025	1.000	0.597	0.0068
HEP12	d/s extent of Unnamed Trib #2 at the confluence with River Foyle.	50.0	1022	0.982	0.534	0.0000

**HEP located at the Mourne at Drumnabuoy House gauging station*

***HEP located at the Finn at Ballybofey gauging station*

****HEP located at the Deele at Sandy Mills gauging station*

3.2.1 Q_{MED} at Gauged Locations

The observed Q_{MED} at each gauging station was revealed through single site analyses in section 2. A summary of these observed values and the adjustment factor to be used at ungauged locations to improve Q_{MED} estimations is provided in Table 3.2.

Table 3.2 Q_{MED} at gauged locations

Gauge name	River/ catchment	Q_{MED} record period	Excluded Hydro-years	Observed Q_{MED} (m^3/s)	Q_{MED} estimation method	$Q_{MED, cd}$* estimate	Q_{MED} adjustment factor
Drumnabuoy House (201010)	Mourne	1982 - 2018	None	602.28	FEH	580.28	1.038
Ballybofey (01043)	Finn	1991 - 2018	None	258.21	FSU	256.09	1.008
Sandy Mills (010141)	Deele	1973 - 2018	2000 & 2001	75.23	FSU	50.85	1.479
Burn Dennet (201007)	Burn Dennet	1975 - 2017	None	82.70	FEH	63.40	1.325

* $Q_{MED, cd}$ – Q_{MED} derived from Catchment Descriptors

The FEH method for predicting Q_{MED} performs particularly well on the Mourne catchment. Similarly, the FSU equation performs very well on the Finn catchment at Ballybofey. The Deele and Burn Dennet catchments exhibit larger errors in Q_{MED} estimations for FEH and FSU methods respectively.

3.2.2 Q_{MED} at ungauged locations

For Q_{MED} estimation All HEPs were effectively treated as ungauged. The most appropriate pivotal site was chosen mainly based on whether or not the pivotal site represents the same catchment waterbody where the HEP is located. The estimation of Q_{MED} at all HEPs and their respective pivotal sites is detailed in Table 3.3.

Table 3.3 HEP design Q_{MED}

HEP	Method	$Q_{MED, cd}$	Pivotal Site	Adjustment factor	Adjusted Q_{MED} ($Q_{MED, adj}$) (m^3/s)
HEP01*	FEH	581.17	201010 Mourne at Drumnabuoy House	1.038	603.21
HEP02	FEH	586.52	201010 Mourne at Drumnabuoy House	1.038	608.76
HEP03**	FSU	257.07	01043 Finn at Ballybofey	1.008	259.20
HEP04	FSU	254.56	01043 Finn at Ballybofey	1.008	256.67
HEP05	FSU	266.48	01043 Finn at Ballybofey	1.008	268.68
HEP06	FEH	849.42	Area weighted average of: 01043 Finn at Ballybofey 201010 Mourne at Drumnabuoy House	1.034	877.91
HEP07***	FSU	50.05	01041 Sandy Mills at Deele	1.479	74.05
HEP08	FSU	51.12	01041 Sandy Mills at Deele	1.479	75.62
HEP08A	FEH	14.51	201007 Burn Dennet at Burndennet	1.325	19.23
HEP09	FEH	61.82	201007 Burn Dennet at Burndennet	1.325	81.93
HEP10	FSU	11.38	1041 Sandy Mills at Deele	1.479	16.84
HEP11	FSU	5.40	1041 Sandy Mills at Deele	1.479	7.98
HEP12	FSU	12.40	1041 Sandy Mills at Deele	1.479	18.35

**HEP located at the Mourne at Drumnabuoy House gauging station*

***HEP located at the Finn at Ballybofey gauging station*

****HEP located at the Deele at Sandy Mills gauging station*

D.1.3 Growth Curve Development

3.3 Growth Curve Development

Design Q_{MED} estimations have been derived for the Lifford FRS Study Area. Q_{MED} is the flood flow which is expected to have an annual exceedance probability (AEP) of 50% (1 in 2 year or 50% AEP). Flood frequency analysis entails a statistical approach to estimating less probable flood flows of greater magnitude. Typically, flood flows greater than Q_{MED} are those which can cause flooding and disruption.

The output of a flood frequency analysis is a growth curve. A growth curve defines the relationship between Q_{MED} and the various event probability peak flows (QT). With observed data, a growth curve can be defined from available AMAX data from a reliable gauging station. In the absence of observed data (i.e. at ungauged locations) the development of a growth curve relies on an elaborate statistical method which forms an estimated growth curve using key statistical characteristics of observed AMAX data from a group of hydrologically similar catchments. This procedure is known as a **pooled approach** and it facilitates the estimation of flood magnitude (peak flow) for events with return periods beyond Q_{MED}.

The FSU and FEH use the pooled approach, but each maintain their own separate databases of gauging station AMAX data from the various gauging stations throughout the Rep. of Ireland and the UK. The FSU database has not been updated since it was developed, resulting in the available AMAX data at the gauging stations only extending up to 2004. The National River Flow Archive (NRFA), which distributes the UK data for use in FEH, peak flow dataset uses a more regularly updated database, but it does not include stations in the Rep. of Ireland.

Hydrological analysis - and particularly flood flow estimation of extreme events - is inherently uncertain, which is mostly a result of the lack of observed flow data at locations of interest. To bridge this data gap and ensure the Lifford FRS benefits from the best and most up-to-date observed data, RPS compiled a composite database consisting of all stations necessary in both jurisdictions. Additionally, the AMAX series for each of the gauging stations was updated to include the most recent and relevant events that have directly impacted the Study Area.

The choice of final growth factors for design flow estimation considered the confidence in the ratings, the length of record and the return period under consideration. The table below is an extract from FEH which outlines the preferred decision framework in selecting the method of obtaining a design growth curve, where T is the design return period.

Table 3.4 FEH Framework for selection of growth factors/curves

Record Length	Single Site Analysis	Pooled Analysis	Preferred Method
< T/2 or 14 years	No	Yes	Pooled
T/2 to T years	For confirmation	Yes	Pooled
T to 2T years	Yes	Yes	Joint
> 2T years	Yes	For confirmation	At-Site

The "joint" method involves the use of the single site growth factors for return periods no more than double the available AMAX years available for the gauging station. For design events greater than this, a pooled approach is preferred and hence, the output growth curve is a hybrid of the two methods.

3.3.2 At Site Growth Curves

The single site analyses in section 2 estimated the flood frequency curves at the locations of the gauging stations within the Study Area. The growth curves are extracted from the flood frequency curves by taking the ratio of estimated peak flow - at each return period of interest - to the observed Q_{MED} value. Figure 3-1 shows the single site growth curves for the four existing gauges and the two synthetic gauges within the Study Area.

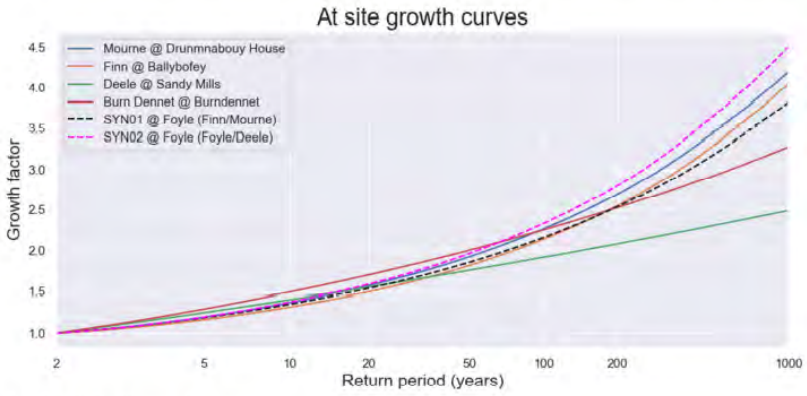


Figure 3-1 At site growth curves

The Deele exhibits the flattest growth curve, especially when contrasted with the Mourne and Finn growth curves. The Burn Dennet growth curve is slightly steeper with a 1:100 year growth factor almost equal to the Mourne and Finn. There is however a large divergence beyond the 1:200 year event return period. Table 3.6 presents the growth factors that form the growth curves shown above.

Table 3.6 Single site growth curves

	2yr	5yr	10yr	20yr	50yr	100yr	200yr	1000yr
Mourne at Drumnabuoy House	1.000	1.198	1.367	1.571	1.918	2.260*	2.693*	4.201*
Finn at Ballybofey	1.000	1.167	1.314	1.495	1.813	2.134*	2.549*	4.051*
Deele at Sandy Mills	1.000	1.247	1.402	1.553	1.755	1.913*	2.077*	2.486*
Burn Dennet at Burndennet	1.000	1.292	1.492	1.700	1.998	2.249*	2.524*	3.282*
SYN01 at Foyle (Finn/Mourne)	1.000	1.190	1.349	1.537	1.851	2.155*	2.535*	3.823*
SYN02 at Foyle (Foyle/Deele)	1.000	1.200	1.374	1.587	1.957	2.327*	2.803*	4.506*

**Event return period extends record beyond twice available AMAX years – use with caution*

Adopting growth curves using a single site analysis is not recommended for defining flood event magnitude with a return period more than twice the number of AMAX years available.

The **Deele at Sandy Mills** has 44 AMAX years. Therefore, the single site growth curve may be appropriate for defining the event magnitude up to a 1:88 year event. The gauging station has recently been spot gauged up to 1.2 times QMED and has been subject to a review of the rating through the CFRAM Study. It is therefore considered appropriate that the single site growth curve is used as the basis for design flow estimation up to the 1:50 year event and may be used as validation or in combination with a pooled analysis for the 1:100 year event. A pooled growth curve should be preferred for design flow estimation above the 1:100 year return period.

3.3.3 Pooled growth curves

Pooled growth curves were developed at HEPs that fall within the UK using the FEH procedures. The pooling groups were reviewed and adopted were necessary and in line with FEH guidelines. The list of UK gauging stations within the adapted pooling groups were then merged with the FSU database to create a master dataset of potentially suitable pooling candidates. FSU methodologies were then undertaken on HEPs located in the Rep. of Ireland using this master database and therefore considered a subset of potentially suitable and relevant gauging stations within the UK also.

The pooled approach was applied at several HEPs on the main watercourses and their output pooled growth factors are provided in Table 3.7.

The pooling groups developed for the Lifford FRS Study were based on the available FSU datasets with the addition of:

- Hydrological similar gauge records from Northern Ireland

- Updated station AMAX years for sites found to be hydrologically similar (i.e. within the pooling groups following initial selection).

For most stations this meant that AMAX years were updated to 2019 or 2020.

Table 3.7 HEP Pooled growth factors

HEP	River	2yr	5yr	10yr	20yr	50yr	100yr	200yr	1000yr
HEP02	Mourne	1.000	1.271	1.458	1.651	1.929	2.163	2.420	3.128
HEP05	Finn	1.000	1.274	1.460	1.641	1.881	2.065	2.251	2.694
HEP06	Foyle	1.000	1.249	1.416	1.586	1.824	2.020	2.232	2.798
HEP08	Deele	1.000	1.272	1.470	1.685	2.009	2.294	2.621	3.581
HEP09	Burn Dennet	1.000	1.300	1.522	1.763	2.129	2.453	2.826	3.933

3.3.4 At site vs pooled growth curves

A comparison of the growth curves derived at site (using the AMAX series directly in EVA) and the growth curves generated using the statistical (pooled) approach is presented in Figure 3-2.

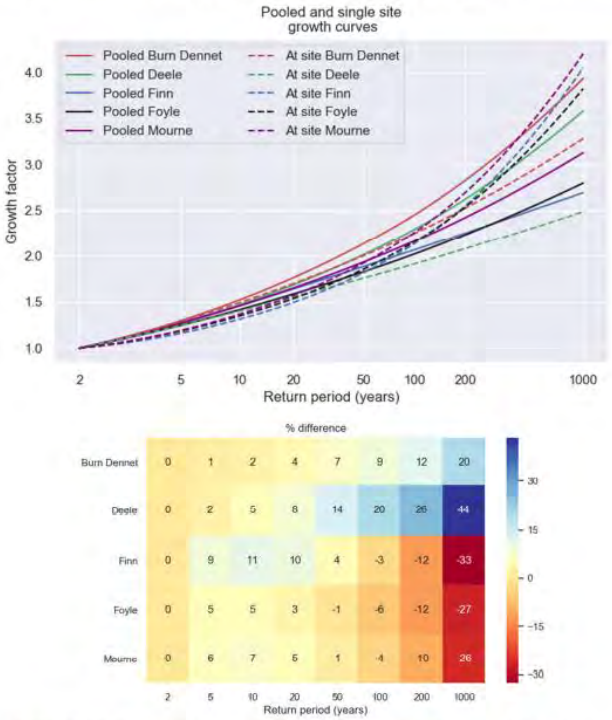


Figure 3-2 Pooled vs at site growth curves (above), percentage differences (below)

The Deele and Burn Dennet at site growth curves are consistently flatter than the pooled approach outputs throughout the entire suite of return periods. These stations have much higher confidence in their ratings above QMED and it is appropriate they are considered up to a point of statistical confidence based on their record lengths.

3.3.5 Final design growth curves

Following a review of the growth curves and consideration of the statistical limitation of single site growth curves coupled with uncertainty throughout hydrological analysis the following decisions were made regarding growth factors/curves:

- For the Rivers Mourne, Finn and Foyle, accept the pooled growth curve for the full suite of return periods due to uncertainty in the ratings. However growth factors in the lower return periods are generally supported with the at site growth factors.
- For the River Deele and Burn Dennet, Section 1.7.3.2 discussed the potential of using the single site growth curves derived from the available data the gauging stations. It concluded that the Deele at Sandy Mills and the Burndennet are the only stations with enough certainty in the rating to be used in flood frequency estimation, but only up to the 1:50 year design event. Adopt a "joint" growth curve, where the at site growth curves up to the 1:50 year are taken forward to design.

Table 3.8 provides the final growth factors taken forward for defining flood frequency in the Study Area.

Table 3.8 Lifford FRS final growth factors

Method	Watercourse	2yr	5yr	10yr	20yr	50yr	100yr	200yr	1000yr
Pooled	Mourne	1.000	1.271	1.458	1.651	1.929	2.163	2.420	3.128
Pooled	Finn	1.000	1.274	1.46	1.641	1.881	2.065	2.251	2.694
Pooled	Foyle	1.000	1.249	1.416	1.586	1.824	2.020	2.232	2.798
Joint	Deele	1.000*	1.247*	1.402*	1.553*	1.755*	2.294	2.621	3.581
Joint	Burn Dennet	1.000*	1.292*	1.492*	1.700*	1.998*	2.453	2.826	3.933

*Growth factor derived using at site EVA.

D.1.4 Lifford Final Design Flows

3.3.6 Lifford FRS Final Design Flows

Factoring the design Q_{MED} with design growth factors results in design flood flows for the full suite of return periods (Table 3.9).

Table 3.9 Lifford FRS final design flows

HEP	Q2	Q5	Q10	Q20	Q50	Q100	Q200	Q1000
HEP01	603.21	766.67	879.47	995.89	1163.58	1304.73	1459.76	1886.83
HEP02	608.76	773.73	887.57	1005.06	1174.30	1316.75	1473.20	1904.20
HEP03	258.88	329.82	377.97	424.83	486.96	534.60	582.75	697.43
HEP04	256.36	326.60	374.28	420.68	482.21	529.38	577.06	690.63
HEP05	268.68	342.30	392.28	440.91	505.39	554.83	604.80	723.83
HEP06	877.91	1096.51	1243.12	1392.36	1601.30	1773.37	1959.49	2456.38
HEP07	74.05	92.33	103.81	114.99	129.95	169.86	194.07	265.16
HEP08	75.62	94.30	106.02	117.44	132.72	173.48	198.21	270.81
HEP08A	16.68	21.55	24.88	28.35	33.32	40.91	47.13	65.59
HEP09	81.93	105.85	122.24	139.28	163.69	200.97	231.53	322.22
HEP10	16.84	21.00	23.61	26.15	29.56	38.63	44.14	60.31
HEP11	7.98	9.95	11.19	12.40	14.01	18.31	20.92	28.58
HEP12	18.35	22.88	25.72	28.49	32.20	42.08	48.08	65.69

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EIAR APPENDIX C11.03

SECTION 3 FLOOD RISK ASSESSMENT REPORT

APPENDIX B:

SWILLY BURN SECTION 50 ASSESSMENT

Swilly Burn, Ten-T Hydraulic Modelling Support, Co. Donegal

Section 50 Assessment

November 21

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Contract

This report describes work commissioned by J.B. Barry by a signed Acceptance Form dated 12/10/2020. Andrei Cozma, Orla Hannon and Ross Bryant of JBA carried out this work.

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Principal Analyst

Purpose

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1 Introduction

1.1 Terms of Reference and Scope

JBA was appointed to prepare a Section 50 Assessment for a proposed bridge structure as part of the Ten-T Priority Improvement Project. J.B Barry is responsible for Section 3 (N14 Manorcunningham to Lifford/A5 Link), approximately 18 kilometres of new dual carriageway, passing over the Swilly Burn. In that sector, a bridge or culvert will be built requiring assessment according to Section 50 of the Arterial Drainage Act.

1.2 Section 50 Assessment; Aims and Objectives

The hydraulic design standards for a culvert that should be met under Section 50 according to the OPW Guide to Applying for Consent under Section 50 of the EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010 and Section 50 of The Arterial Drainage Act, 1945 are as follows:

- A bridge or culvert must be capable of passing a fluvial flood flow with a 1% annual exceedance probability (AEP) or 1 in 100-year flow without significantly changing the hydraulic characteristics of the watercourse.
- A culvert must be capable of operating under the above design conditions while causing a hydraulic loss of no more than 300 mm (excluding the culvert gradient).
- If the land potentially affected includes dwellings and infrastructure, it must be demonstrated that those dwellings and/or infrastructure are not adversely affected by constructing the bridge or culvert.
- A culvert diameter, height and width must not be less than 900 mm to facilitate maintenance access and reduce the likelihood of debris blockage.

If these conditions are not met reasonable justification as to why the culvert may still be satisfactory is required.

1.3 Development Proposal

The proposed development is a dual carriageway, Section 3 (N14 Manorcunningham to Lifford/A5 Link), part of Ten-T Priority Improvement Project. The proposal will require the construction of a new bridge over the Swilly Burn.

1.4 Report Structure

Section 2 of this report gives an overview of the study location and associated watercourses. Section 3 contains review of flood risk. Section 50 requirements and modelling results are discussed in Section 4. Conclusions and recommendations are highlighted in Section 5.

2 Site Background

2.1 Location

The subject site is located approximately 4km east of Raphoe, Co. Donegal, where the Swilly Burn River is intersected by Section 3, a dual carriageway part of the Ten-T Priority Improvement Project. The area of analysis is extended around this point, upstream and downstream of Swilly Burn.

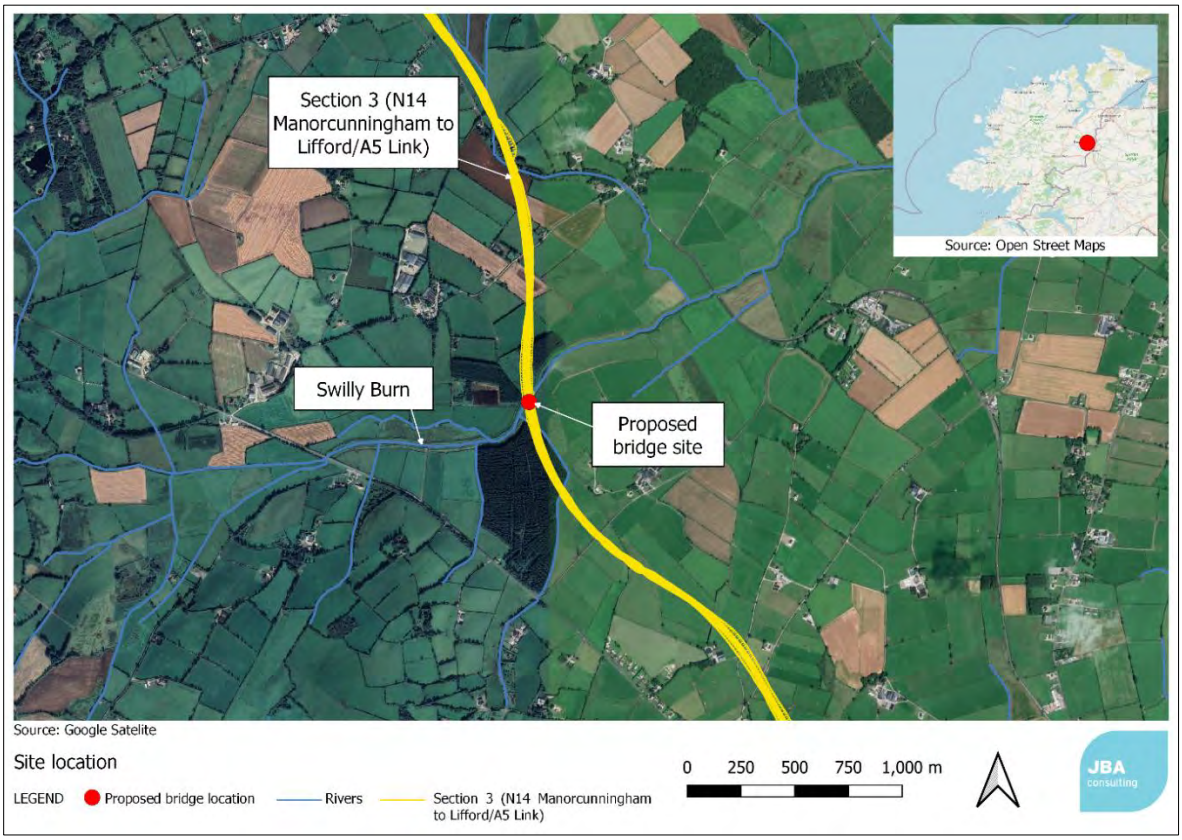


Figure 2-1 Site Location

2.2 Watercourses

The watercourse intersecting the proposed road alignment is the Swilly Burn. It originates 3.8km north-west of the proposed bridge location, flowing south for 3.2km and then east for 2.7km. After it intersects the road alignment, it flows 7.3km until it joins River Foyle, 6km north of Lifford/Strabane. An OPW drainage scheme was carried out on the Swilly Burn from 1957-1961.

3 Flood Risk Review

A brief review of the flood risk to the site is described below. This is conducted using historical and predictive information that identifies any sources of potential flood risk to the site and reviews historic flood information. The findings from the review are described in this section.

3.1 Flood History

The OPW host a National Flood hazard mapping website, www.floodinfo.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. The website highlighted recurring floods taking place in the vicinity of the site. An extract of the generated flood report is presented in Figure 3-1.

Flood ID 4050 is located in the general vicinity and simply states that "Mullnaveagh - River Swilly Burn overflows its banks every year after heavy rain.". No further detail is provided and since the channel is embanked it is not clear if this refers to other Arterial Drainage channels in the vicinity that impact a local road.

The Benefitted Lands flood extents are an indication of the area of land that would potentially benefit economically from inclusion within an Arterial Drainage Scheme. Since this Scheme has been implemented it is therefore not an indication of present day flooding.

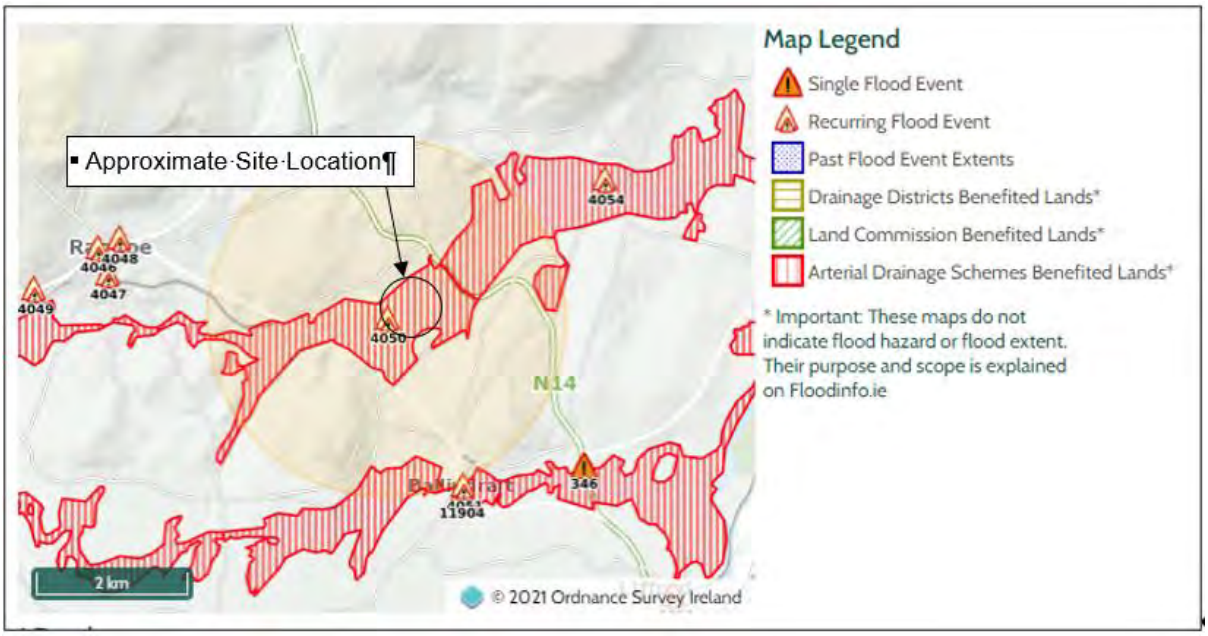


Figure 3-1 OPW Summary Map Generated by www.floodmaps.ie

3.2 Internet search

An internet search was conducted to gather information about whether the site was affected by flooding previously. No flooding incidents were recorded at the site.

4 Section 50 Assessment

This section will provide flow estimates and assess the capacity of the proposed bridge on site as part of the detailed assessment.

4.1 Hydrology

4.1.1 Catchment Characteristics

Table 4-1 and Figure 4-1 show the main descriptors of the catchment and the river network, catchment boundary and gauging stations from the immediate area, used for the hydrological assessment.

Table 4-1 Key catchment descriptors

Descriptor	01_1852_1	Parameter description
Area (km^2)	24.224	Slope based on the stream elevation at 10% and 85% along MSL
MSL (km)	9.206	Main Stream Length
S1085 (m/km)	17.32897	Slope between a point 10% upstream and 85% upstream
ArtDrain2	0.3469	Arterial drainage factor
SAAR (mm)	1065.55	Standardised Average Annual Rainfall
Soil	0.308	Soil index, which is a composite index determined from soil survey maps that accompany the Flood Studies Report
M5-2day (mm)	58	5-year return period rainfall for 2-day duration
r	35	Dimensionless ratio between M5-60 and M5-2 Day rainfall depths

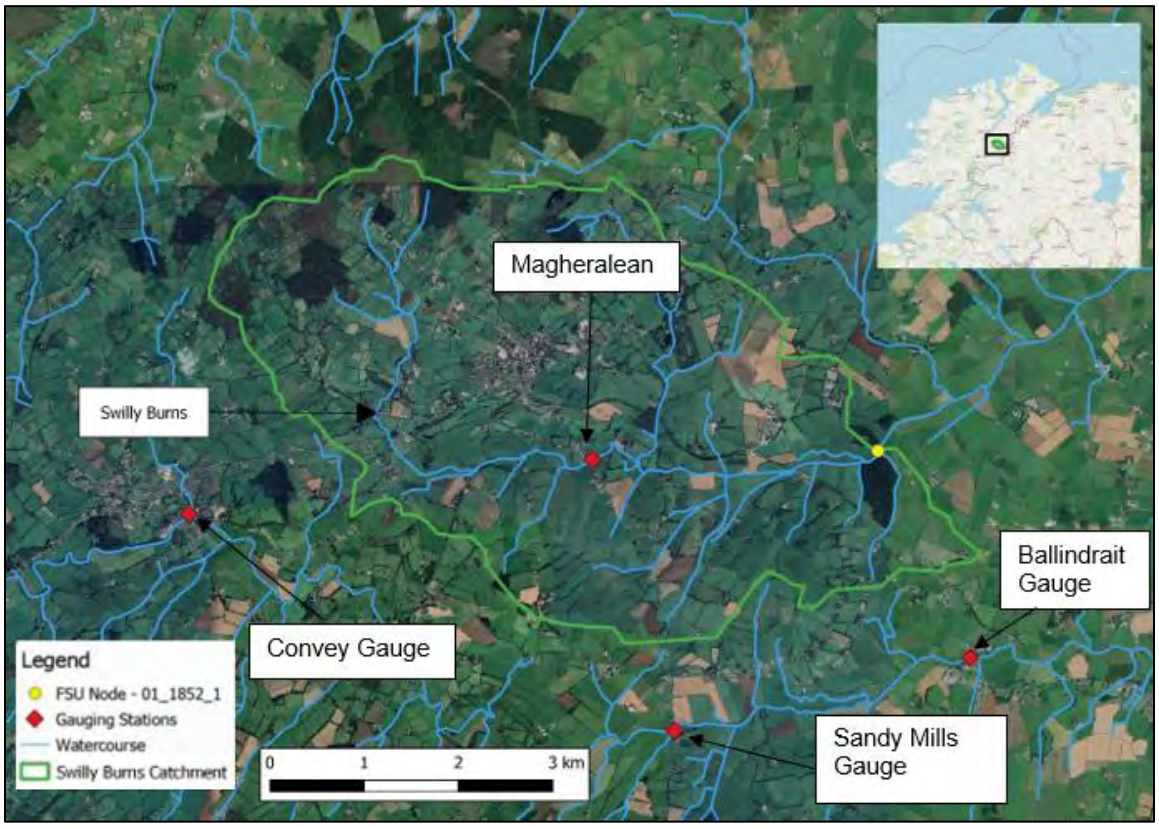


Figure 4-1 Catchment characteristics

As shown in Figure 4-2 below, the catchment is relatively steep in the north western section where ground levels drop from 270mOD to 30mOD in a southernly direction. Once the watercourse flows east, the catchment levels out. dropping from 30mOD to 7mOD.

The groundwater and geological maps of the site, provided by the Geological Survey of Ireland (GSI), have been studied. The bedrock is shown to consist of Aghyaran & Killygordon Limestones (marble, quartzite, psammite; graphitic) in the eastern section of the catchment, and Termon Formation (banded semi-pelitic & psammitic schist) and Killeter Quartzite Formation (Slightly impure quartzite). The soils are a mix across the entire catchment of Alluvium Minerals, Till derived from non-calcareous metamorphic rocks and non-calcareous bedrock at surface.

The land use of the catchment is mainly agricultural with some urban development at a town in the upper section and isolated rural housing dispersed across the catchment.

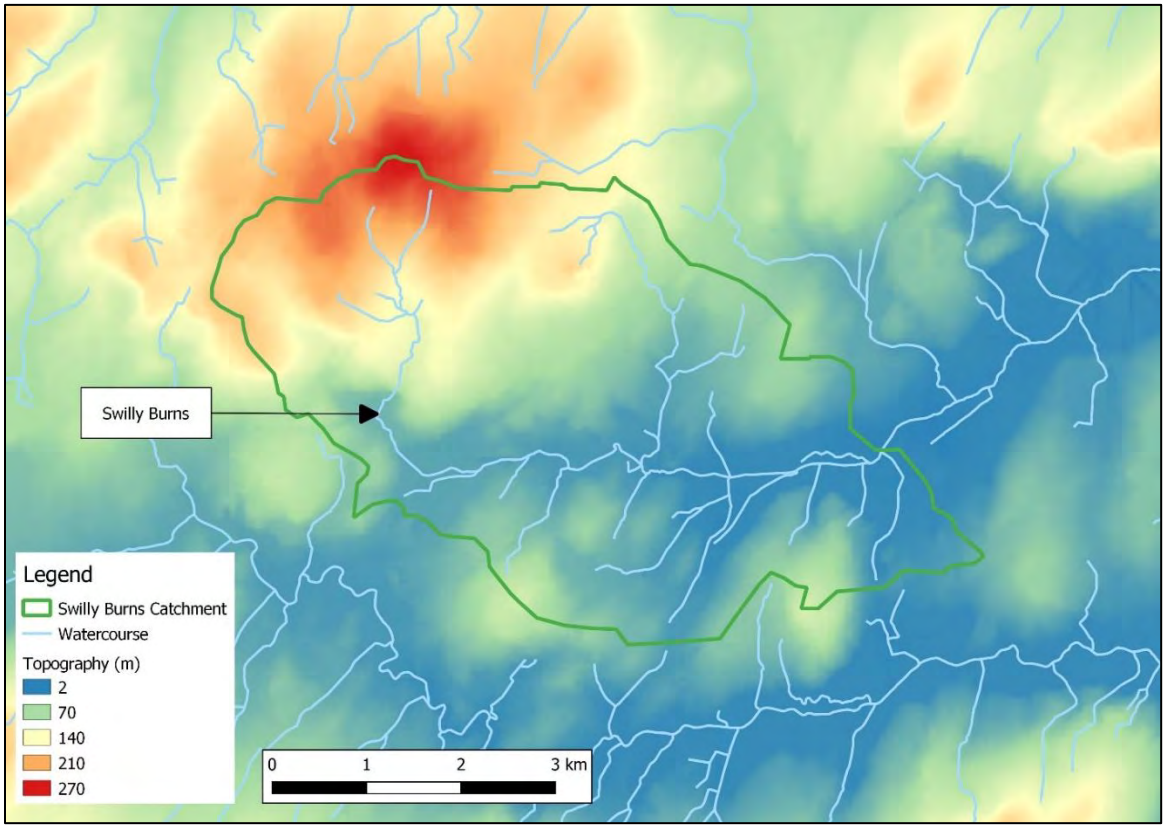


Figure 4-2 Topographical map of the catchment

4.1.2 Design peak flows

Table 4-2 compares a range of AEP flow estimates using the FSU method and the FSU Small Catchments (SC) method. Both methods were assessed as the catchment size is on the limit of the FSU minimum size. It is noted that the FSU SC does not account for the Arterial Drainage in the catchment.

From the table below it is recommended that the FSU flows be applied, as even though the catchment is slightly below the recommended size for the FSU method, it is the most conservative approach while it also accounts for the arterial drainage works carried out on the watercourse.

Table 4-2 Peak flow estimates

Annual Exceedance Probability (%)	FSU (m^3/s)	FSU SC (adjusted) (m^3/s)
50%	**7.43**	6.69
20%	**9.22**	8.29
10%	**10.41**	9.36
5%	**12.12**	10.90
2%	**13.46**	12.11
1%	**15.02**	13.51
0.1%	**21.34**	19.19

4.1.3 Section 50 flows

According to the Section 50 requirements the design flows are based on the 1% AEP event but take into account a factorial standard of error (FSE) and a factor for climate change (1.2). As the FSU method includes the arterial drainage works within the catchment descriptors, the additional factor of 1.6 to account for these works does not need to be included. The FSE values appropriate for the FSU method is either 1.36 for a 68% confidence interval (if no properties are identified as being at risk) or 1.85 for a 95% confidence interval (if properties are identified as being at risk). These values are shown in Table 4-3. There are no properties in the area of the site meaning a 68% confidence interval is appropriate.

Table 4-3 Section 50 design flows

Method	Peak Flow (m^3/s)
FSU 1% AEP Event	15.02
1% AEP + Climate Change	18.02
1% AEP + 68% confidence interval (1.2*1.36)	**24.51**
1% AEP + 95% confidence interval (1.2*1.85)	33.34

4.2 Hydraulics

Detailed hydraulic modelling was performed to assess the pre and post development flood risk and to ensure that the proposed bridge designs are compliant with Section 50 of the Arterial Drainage Act 1945. The Section 50 flows considered in the modelling process are based on the 1% AEP event but take into account a factor for climate change (1.2) and an FSE (1.36) as presented in the previous section.

4.2.1 Proposed structures

The proposed structure for this Section 50 assessment is a bridge having a flat deck and two abutments (one on each bank). The width between the abutments is 23.5m and the deck soffit is set at 4.5mOD.

4.2.2 Modelling approach

The hydraulic performance of the proposed structure was assessed by building a 1D model using HEC-RAS modelling package. The hydraulic model built in the current project allows the estimation of water levels for a range of scenarios. HEC-RAS is designed to perform one-dimensional steady flow and one and two-dimensional unsteady flow calculations for a full network of natural and constructed channels overbank/floodplain areas, banks to protected areas etc. The software is internationally recognised and allows the efficient setup of multiple scenarios and analysis of outputs. HEC-RAS has a user-friendly interface with GIS compatibilities, numerous data entry capabilities, hydraulic analysis components, data storage and management capabilities.

Two different scenarios were undertaken to appraise the hydraulic capabilities of the river system and the efficiency of the proposed structure:

- **Scenario 1 -** Open channel without the structure in place. This scenario assesses the river channel conveyance based on the 1D model built using survey data.

- **Scenario 2 -** Proposed bridge included (Post-development). This scenario assesses the impact generated by the proposed structure. The representation of the proposed new bridge is added into the model to test design criteria.

4.2.3 Hydraulic Modelling Results

The hydraulic modelling results for both scenarios are presented below as cross-sectional view of the bridge and as longitudinal profile.

The simulations reveal that when comparing Scenario 1 (completely open channel scenario) with Scenario 2 (new culvert in place), the proposed bridge is not generating any significant afflux on the upstream face of the structure. The new bridge will convey the design flows with 330 mm freeboard (open air gap within the culvert).

Figure 4-3 presents the cross-sectional view of the proposed culvert and the water level marks for Scenario 2.

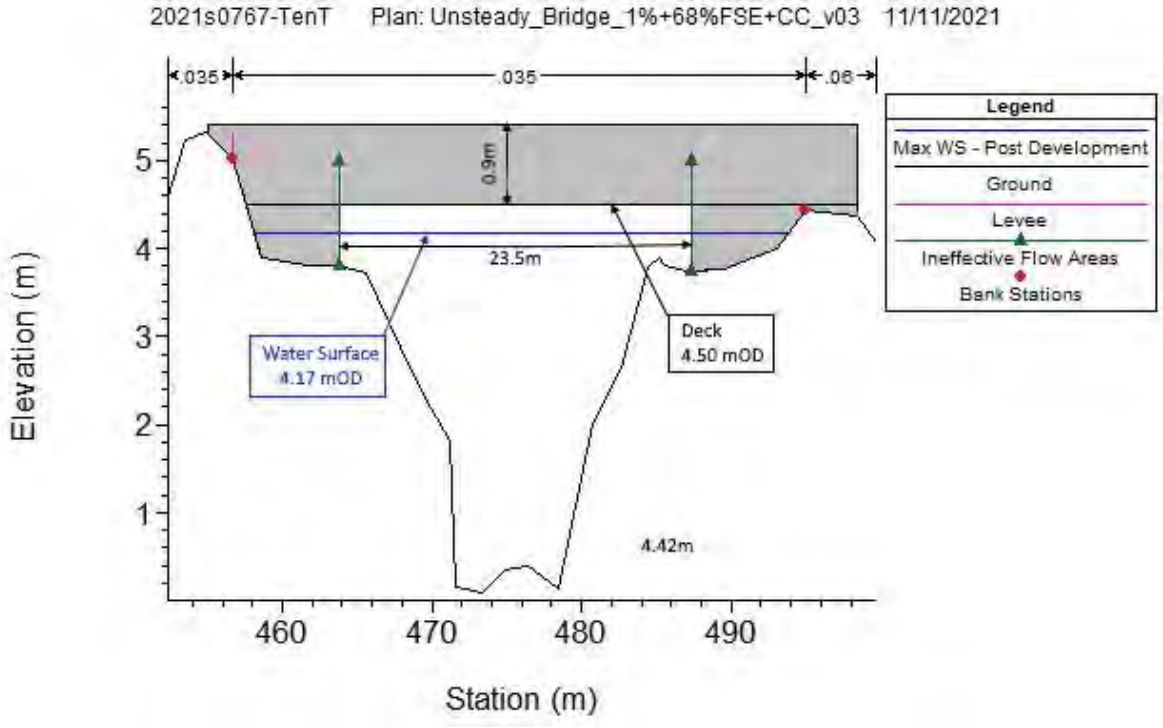


Figure 4-3 Cross section of the proposed bridge

The comparison of the water surface elevation between Scenario 1 and Scenario 2 is also presented on the longitudinal profile in Figure 4-4, which clearly shows no significant impact on the water level.

It is noted that the bridge construction does result in small changes to the velocity through the structure, but velocity is generally low at 0.42m/s at the upstream cross section, in the post-development Scenario 2 this increases to 0.45m/s as the available cross-sectional area drops from 54m^2 to 50.6m^2. There is actually a 0.01m localised drop in water surface elevation upstream in the post development condition as a result of the increase in velocity. This is not considered significant.

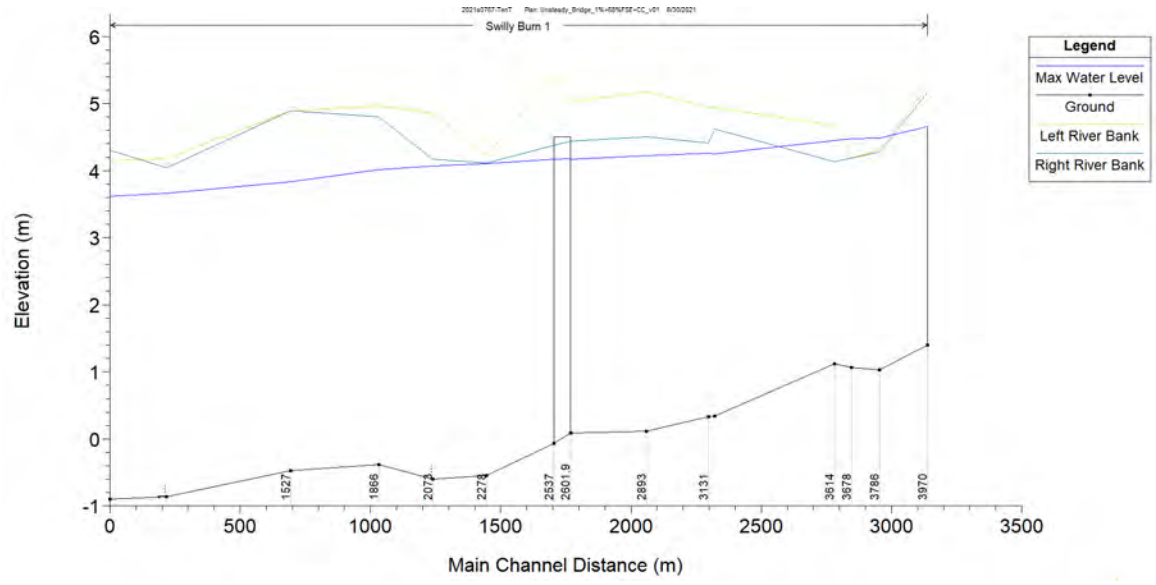


Figure 4-4 Longitudinal profile comparing water surface elevation

A flood extent map was generated using the results of the 1D model showing that there is no flooding in the vicinity of the proposed bridge, but a flooded area can be observed about 600m upstream of the proposed site.



Figure 4-5 Inundation boundary

4.2.4 Sensitivity Analysis

As there are no gauges along the watercourse near the site, no model calibration can be carried out. There are also no recorded flood extents or wrack marks available that can be used to calibrate or validate the model.

4.2.5 Increase/Decrease in friction slope boundary condition

The sensitivity of the model to the downstream boundary condition (normal depth as friction slope) was tested. The friction slope was increased and decreased by 20%. The water level along the reach long section changed with the friction slope, but near the assessed bridge levels remained the same. Therefore, the model is not sensitive to the downstream boundary condition.

4.2.6 Increase/Decrease in Manning's Roughness

To represent the current land use and associated roughness in the model, the Manning`s N values assigned to the river channel range from 0.030-0.04. This represents a channel which is generally clean, straight with some stones and weeds. In the floodplain values ranging from 0.035-0.05 were assigned.

To test the sensitivity of the model to the Manning's N parameter, model scenarios were run with the roughness factor increased by 20%. Increasing the roughness by 20% within the 1D model domain generates an increase of the in-channel water levels by a maximum of 5cm. This 50mm sensitivity to the Manning's N value is contained within the bridge freeboard.

5 Conclusion

The aim of this technical report was to investigate whether the proposed bridge over the Swilly Burn River adheres to the requirements of Section 50 of the Arterial Drainage Act (1945). Table 5-1 shows how the requirements outlined have been addressed.

Table 5-1 Summary of the hydraulic model results in relation to the Section requirements

Section 50 requirement	Response
A bridge or culvert must be capable of passing a fluvial flood flow with a 1% annual exceedance probability (AEP) or 1 in 100-year flow without significantly changing the hydraulic characteristics of the watercourse.	The proposed bridge has been shown to convey the design flows which is 1% AEP flow with 20% allowance for climate change and multiplied with FSE without altering the current hydraulic characteristics of the watercourse. The modelling results reveal that in Scenario 2 which includes the bridge in place, the head loss is not significant, in fact the water level drops very slightly (0.01m) as a result of an increase in velocity upstream of the bridge.
A bridge must be capable of operating under the above design conditions while maintaining a freeboard of at least 300 mm.	The bridge allows 330mm freeboard within the structure. This is in good agreement with the Section 50 provisions which recommends minimum 300mm. The new bridge can easily convey the design flows
If the land potentially affected includes dwellings and infrastructure, it must be demonstrated that those dwellings and/or infrastructure are not adversely affected by constructing the bridge or culvert.	There is no increase in flood risk, the peak flow is contained by the bridge. There is no significant change of the current hydraulic characteristics and dynamics of the river system.

Overall, this document highlights how the proposed designs of the bridge crossing the Swilly Burn River satisfies the requirements of Section 50, as it can safely convey the peak design flows and not increase flood risk.

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Flood estimation report: Ten-T Swilly Burn

Introduction

This report template is based on a supporting document to the Environment Agency's flood estimation guidelines. It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

Approval

	Name and qualifications	Date
Method statement prepared by:	Orla Hannon	13/11/2020
Method statement reviewed by:	Tom Sampson	18/11/2020
Calculations prepared by:	Orla Hannon	13/11/2020
Calculations reviewed by:	Tom Sampson	18/11/2020

Revision History

Revision Ref/Date	Amendments	Issued to
S0-P01.01 / 13/11/2020	Initial Issue	Tom Sampson
S0-P01.02 / 27/11/2020	Update Pivotal site	Tom Sampson
S3-P01 / 20/12/2021	Issue to client	JB Barry

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2	**Locations where flood estimates required**	6
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4	**FSU Small Catchments**	16
5	**Discussion of flow estimations**	17
6	**Hydrograph Shapes**	17
7	**Discussion and summary of results**	19

Abbreviations

AM	Annual Maximum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FSR	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

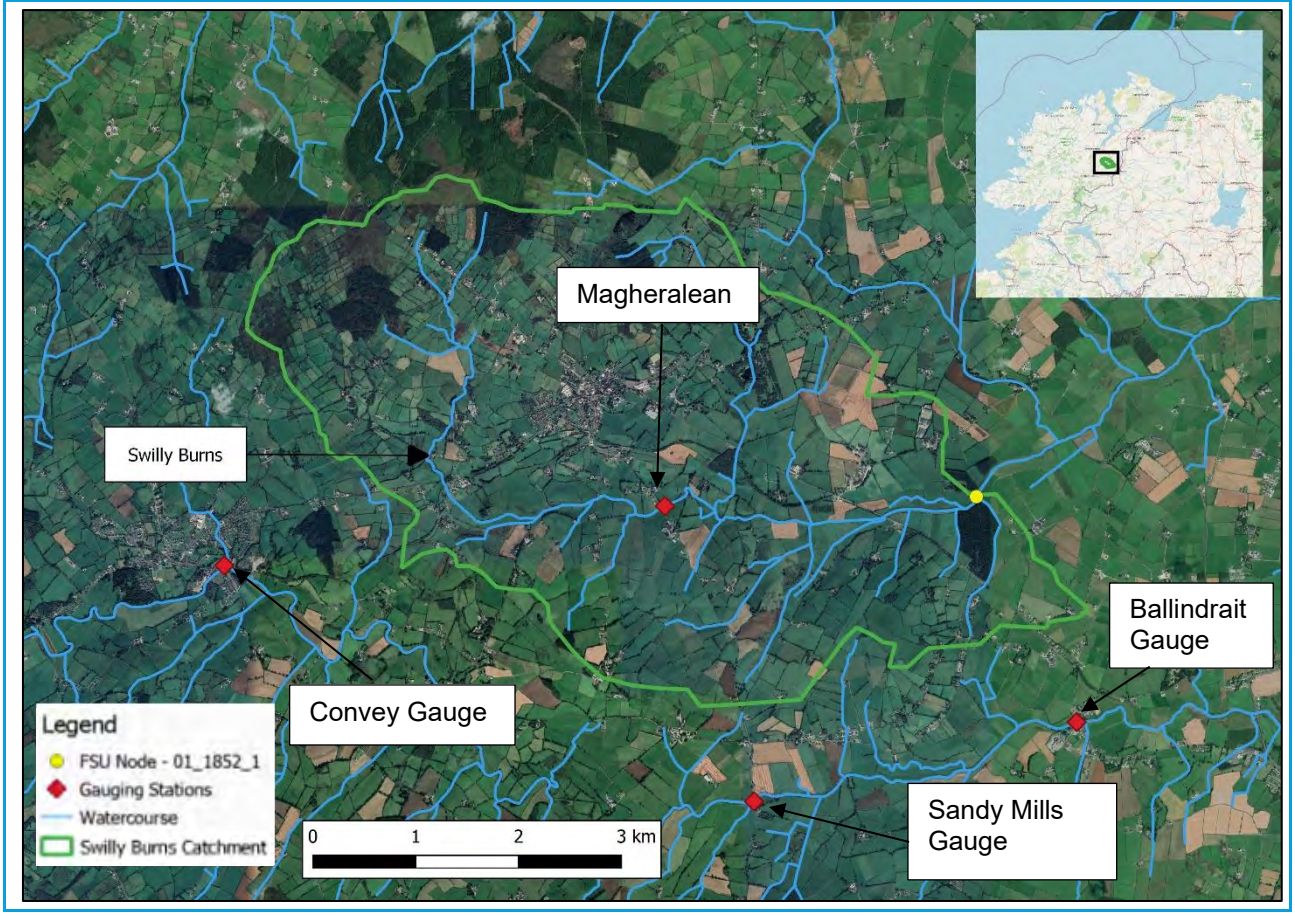
1 Method statement

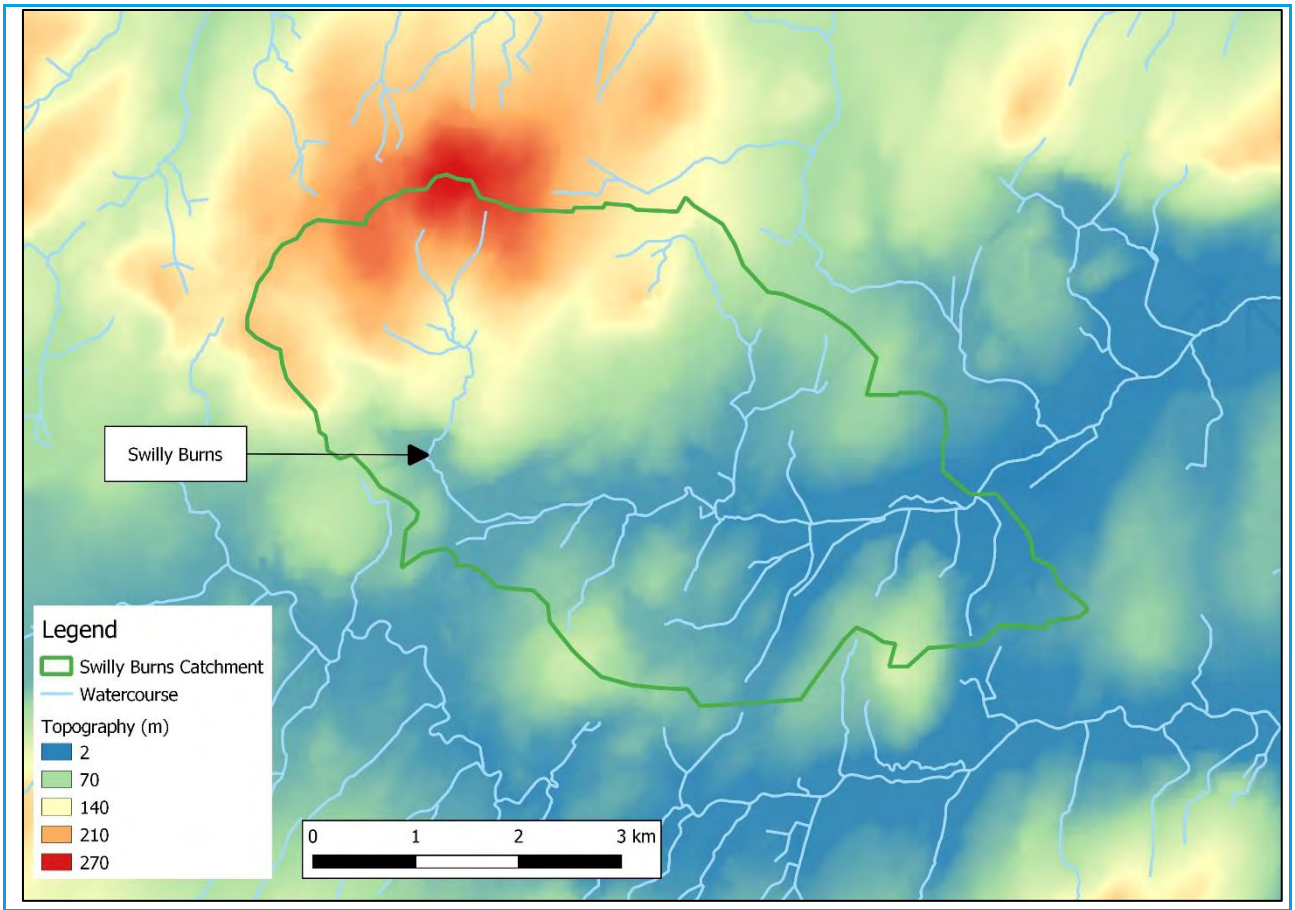
1.1 Requirements for flood estimates

Overview	Proposed road alignment crosses the Swilly Burn near Lifford, Donegal. Detailed hydraulic modelling and hydrological analysis will be required to assess the pre and post development flood risk and ensure that the proposed bridge designs are compliant with Section 50 of the Arterial Drainage Act 1945. The Section 50 flows will be based on the 1% AEP event but take into account a factor for climate change (1.2) and a factorial standard of error (FSE).

1.2 The catchment

Map (Include river network, catchment boundary and gauging stations)





Description	Catchment relatively steep in the north western section where is drops from 270m to 30m while flowing in a southernly direction. Catchment relatively flat once the watercourse flows east, 30m – 7m (DTM). Bedrock is Aghyaran & Killygordon Limestones (marble, quartzite, psammite; graphitic) in the eastern section of the catchment, and Termon Formation (banded semi-pelitic & psammitic schist) and Killeter Quartzite Formation (Slightly impure quartzite). Soils are a mix across the entire catchment of Alluvium Minerals, Till derived from non-calcareous metamorphic rocks, non-calcareous bedrock at surface Land use of the catchment is mainly agricultural with some urban development at a town in the upper section and dispersed across the catchment. A drainage scheme was carried out from 1957-1961.

1.3 Gauging stations (flow or level)

(at or very near to the sites of flood estimates)

Water-course	Station name	Gauging authority number	Gauging Authority	Catchment area (km²)	Type (rated / ultrasonic / level…)	Start of record and end if station closed
Swilly Burn	Magheralean	01049	EPA	10.9	Staff Gauge	1990 - 1998
Deele	Convoy	01046	EPA	85.1	Staff Gauge	1979-1996
Deele	Sandy Mills	01041	OPW	116.2	Recorder	1973 - Active
Deele	Ballindrait	01048	EPA	125.5	Staff Gauge	1990 - 2002

1.4 Data available at each flow gauging station in Table 0

Station name	Start and end of FSU portal flood peak record	Update for this study? (CFRAM or latest data)	OK for QMED?	OK for pooling?	Other comments on station and flow data quality
Magherale an	NA	NA	No	No	Only 8 years of data ending in 1998
Convoy	NA	NA	NA	NA	Only 17 years of data ending in 1996
Sandy Mills	1973 - 2005	Yes	Yes	Yes	Still active, Additional AMAX data available
Ballindrait	NA	NA	NA	NA	Only 12 years of data ending in 2002

1.5 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Historic flood data Include chronology and interpretation of flood history in Annex or separate report.	Yes	Yes	Floodmaps.ie	OPW minutes of Meeting (Mar06); Areas prone to flooding: Mullnaveagh - River Swilly Burn overflows its banks every year after heavy rain. Flood Id = 4050
Rainfall data for events	Yes	Yes	Met.ie	Daily rainfall data at Raphoe station c500m south of the catchment. Oct 2002 – Aug 2019
CFRAM study method & outputs	No	No	NA	NA
Results from other previous studies	Yes	Yes	Old PFRA	Flood Outlines

1.6 Hydrological understanding of catchment

Outline the conceptual model.	Main site of interest is directly upstream and downstream of the proposed road bridge. Peak flows most likely to cause flooding due to flat topography, volumes possibly an issue so this is also to be assessed in sensitivity runs of the hydrograph shape.
Any unusual catchment features to take into account?	Arterial Drainage Scheme carried out from 1957-1961.

1.7 Initial choice of approach

Is FSU appropriate? (it may not be for extremely heavily urbanised or complex catchments) If not, describe other methods to be used.	Yes, the catchment is below the recommended area (24.2km² / 25km²) but only just so will still use. FSU small catchments will also be assessed.
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	FSU Method – CDs and Pooling - JFes most up to date, will still also consider FSU Portal. Hydrograph shape to be derived using FSU. Catchment does not need to be split into sub-catchment as small model with small area difference between the upstream and downstream boundary (<1km2).
Software to be used (with version numbers)	FSU Portal / JBA's Flood Estimation Software (JFes) v.8 / JSpeed

2 Locations where flood estimates required

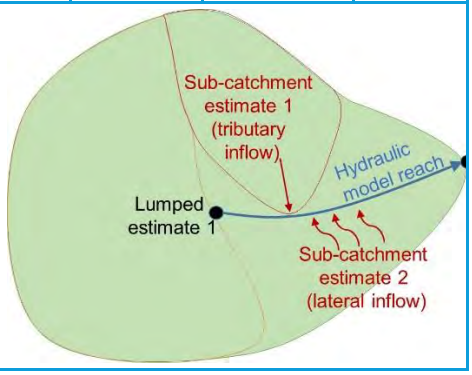
2.1 Summary of subject sites

Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA (km^2)
01_1852_1	L	Swilly Burn	Directly US of proposed bridge	229468	401996	24.224

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required.

Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.



2.2 Important catchment descriptors at each subject site

Descriptor	01_1852_1
Centroid X	226630
Centroid Y	402520
Area	24.224
SAAR	1065.55
FARL	1
BFI Soil	0.601
URBEXT	0.027
MSL	9.206
S1085	17.32897
Stream Frequency	49
DrainD	1.327
ArtDrain2	0.3469
Soil (number)	0.308
SMDBAR	3
M5-2day	58
M5-1day	56.65
r	35

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (add maps if needed)	FSU catchment boundary checked against Ireland_Aligned DTM and Google terrain contours. No changes were made to catchment after review.
Record how other catchment descriptors were checked and describe any changes. Include before/after table if necessary.	Catchment descriptors sourced from FSU database
Source of URBEXT	FSU descriptors
Method for updating of URBEXT	No change

3 FSU Method

3.1 Overview of estimation of QMED at subject site

	Site A
Number	01_1852_1
Catchment area (km2)	24.224
Qmed (rural) m^3/s	7.4338
Urban Adjustment Factor	1.482
Qmed (urban) m^3/s	7.7332

3.2 Data transfer for QMED estimation

Table 3-1. Pivotal gauge options

	Roscrea	Sandy Mills	Ballyhaunis
Number	25040	01041	30020
FSU gauge quality ranking	A2	B	B
Years of suitable data	36yrs 1979 – 2019 Missing 1999-2003	43yrs 1973-2018 Missing 2000-2001	32yrs 1988-2019
Catchment area (km2)	27.93	116.18	21.41
Qmed gauged m3/s	4.13	87.51	4.38
Qmed(rural) m3/s	6.00	51.55	5.91
On same watercourse as subject site (Y/N)	N	N	N
In same catchment as subject site (Y/N)	N	N	N
Distance between catchment centroids	358.86	15.98	245.71
Hydrological similarity to ungauged location	0.5319	2.7047	0.629
URBEXT	0.0618	0.0086	0.0099
Any other catchment features (e.g. Arterial Drainage)	NA	ArtDrain2 = 0.0086 (same drainage scheme as Swilly Burn)	ArtDrain2 = 0.6783
Gauge type	Level and Flow	Level and Flow	Level and Flow
Operator	EPA	OPW	EPA
Status	Active	Active	Active
Reasons for choosing or dismissing	Most hydrologically similar and similar size. Although no arterial drainage. Very far from site.	Directly adjacent to site with similar artdrain2. Catchment much larger than site.	Hydrologically similar. Similar size and not as far from catchment as Roscrea. Has arterial drainage.

3.2.1 Discussion on gauge data, data transfer and pivotal sites



Figure 3-1: Gauge Locations

Of the three gauges reviewed 30020 Ballyhaunis is shortlisted for use as a pivotal gauge as it has a sufficient gauge record length, is hydrological similar and is also impacted by arterial drainage works unlike the Roscrea gauge. It is also very similar in size to the subject catchment. While it is some distance from the site, it is not as far as the Roscrea gauge. The second option is the Sandy Mills gauge. Despite being significantly larger it is directly adjacent to the subject catchment. Both of these gauges are looked at in further detail below.

3.2.1.1.1 Ballyhaunis Gauge

The Ballyhaunis gauge has a record length of over 30 years. It is a B ranked gauge indicating that it is of suitable quality to estimate Qmed values. Although the high flows of 2015 could update this rating. Figure 3-2 shows the Gauge AMAX series and the seasonality plot. Review of the seasonality plot shows that higher flows are generally recorded during the Winter months rather than the Summer months.

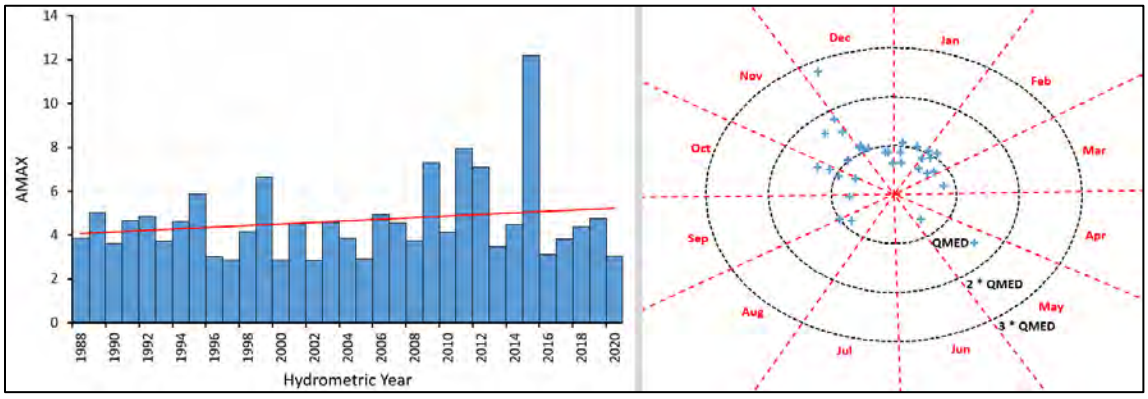


Figure 3-2: AMAX and seasonality plot

Table 3-2. Pivotal sites chosen and QMED adjustment factors

Descriptor	01_1503_1	Pivotal site (30020)
Area	22.224	21.388
SAAR	1065.55	1190.71
FARL	1	1
BFI Soil	0.601	0.68189
URBEXT	0.027	0.009
MSL	9.206	8.828
S1085	17.32897	2.946
DrainD	1.327	1.781
ArtDrain2	0.3469	0.6661
FSU Gauge ranking	-	B
Hydrological similarity		0.629
FSU record	-	32yrs
Qmed(rural) m3/s	7.4338	5.91
Qmed(gauged) m3/s	-	4.38
Adjustment factor	0.7411	0.7411
Adjusted Qmed m3/s	5.509	-
FINAL SELECTED QMED m3/s	7.4338	
Comments	Choosing not to adopt adjusted flows as the adjustment factor is less than 1. Despite this pivotal site being hydrologically similar, the distance between the two leaves slight uncertainty when it comes to reducing the Qmed in the FSU method	

3.2.1.1.2 Sandy Mills Gauge

The Sandy Mills gauge has a record length of over 40 years. It is a B ranked gauge indicating that it is of suitable quality to estimate Qmed values. Although the high flows of 2015 could update this rating. Figure 3-2 shows the Gauge AMAX series and the seasonality plot. Review of the seasonality plot shows that higher flows are generally recorded during the Winter months rather than the Summer months.

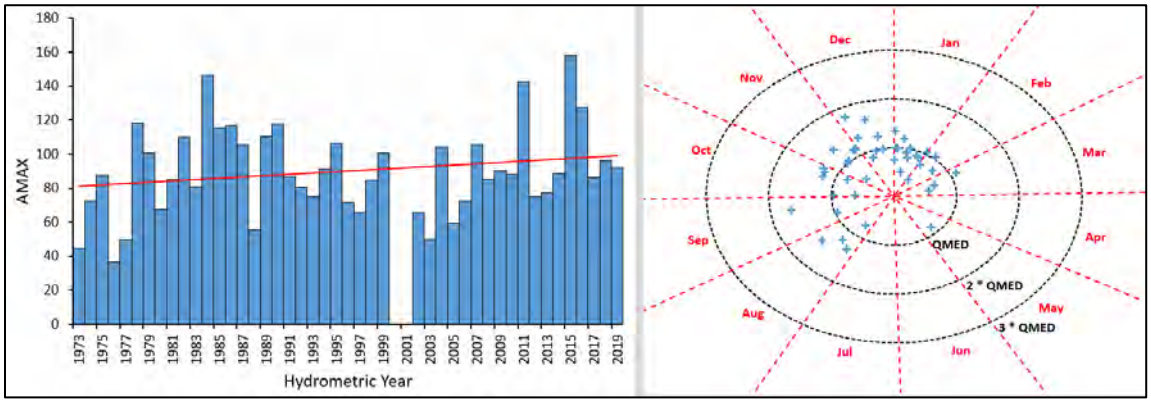


Figure 3-3: AMAX and seasonality plot

Table 3-3. Pivotal sites chosen and QMED adjustment factors

Descriptor	01_1503_1	Pivotal site (01041)
Area	22.224	116.18
SAAR	1065.55	1329.37
FARL	1	1
BFI Soil	0.601	0.3848
URBEXT	0.027	0.0086
MSL	9.206	32.582
S1085	17.32897	70.227
DrainD	1.327	1.469
ArtDrain2	0.3469	0.0447
FSU Gauge ranking	-	B
Hydrological similarity		0.1815
FSU record	-	43yrs
Qmed(rural) m3/s	7.4338	51.55
Qmed (URBEXT) m3/s		52.21
Qmed(gauged) m3/s	-	88.21
Adjustment factor		1.6895
Adjusted Qmed m3/s	12.56	
FINAL SELECTED QMED m3/s	7.4338	
Comments	Not adopting the adjusted Qmed. Favouring the Ballyhaunis gauge over Sandy Mills as this one is considerably larger.	

3.3 Growth Curves

3.3.1 Derivation of flood growth curves at subject sites

Table 3-4. Selection of growth curve approach

Site code	Method (SS, P, ESS, J)	If P, ESS or J, name of pooling group	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Growth factor for 100-year return period
01_1852_1	P	Swilly Burn	GLO – most conservative	NA	2.02
01_1541_1	SS	Sandy Mills Gauge	GLO – fits best with 1st, 2nd and 4th AMAX values	NA	1.89

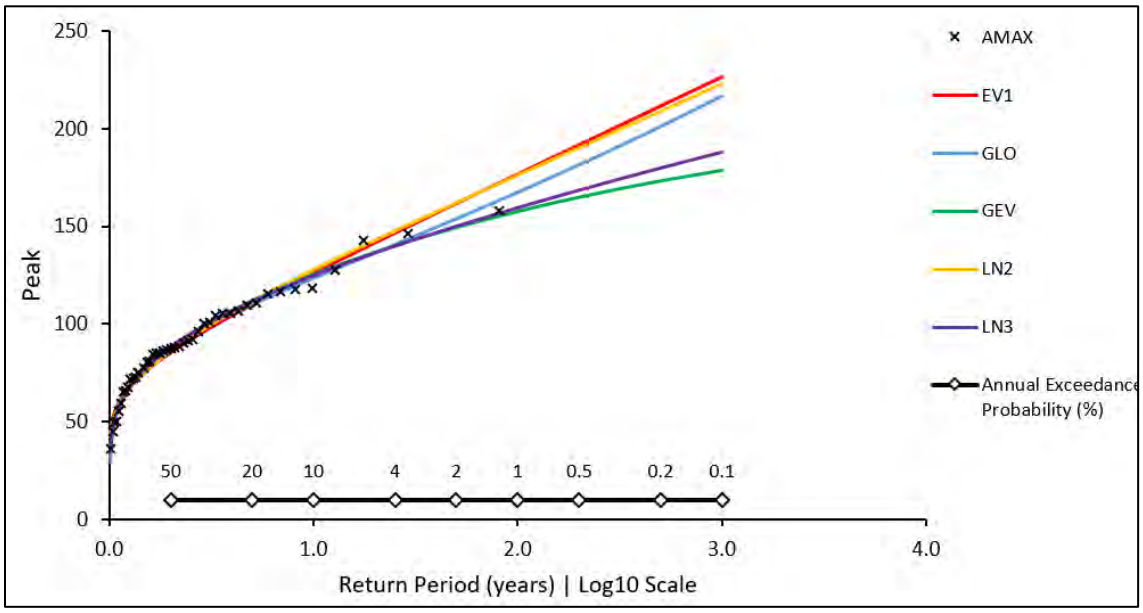


Figure 3-4: Sandy Mills Frequency Distribution

3.3.2 Derivation of pooling groups

Table 3-5. Pooling group details

Name of group	Site code from whose descriptors group was derived	No. of pooled years	No. of stations	Changes made to default pooling group, with reasons	Shape	Distribution	Scale
Swilly Burn	01_1852_1	509	11	None	-0.1511	GL	0.1534
	Note: Pooling groups were derived using the procedures from JFes V8						

3.3.3 Discussion on growth curves

A single pooling group was derived to establish a site-specific growth curve for the catchment. Table 3-6 and Figure 3-5 show the growth curve and the flood frequency curve derived. For more information on the pooling group used refer to Appendix A.3.1. The growth curve for the SSA was also analysed and is shown in Table 3-6. The pooled growth curve is much steeper than the SSA. The pooled growth curve is the most favourable approach to use over the SSA so it will be used going forward.

Table 3-6: Growth curve

AEP (%)	Pooled	SSA
50	1.00	1.00
20	1.24	1.24
10	1.40	1.40
5	1.63	1.54
2	1.81	1.74
1	2.02	1.89
0.1	2.87	2.45

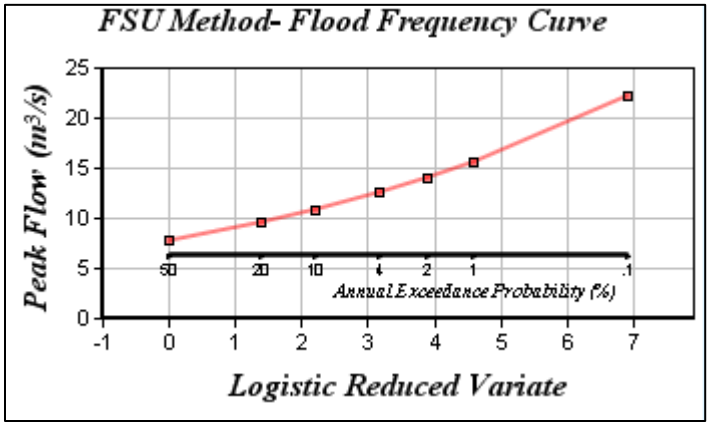


Figure 3-5: FSU flood frequency curve

3.4 Summary of FSU flood estimates

Three Qmed values were derived for the subject site using the catchment descriptors, the Ballyhaunis gauge as a pivotal site and the Sandy Mills as a pivotal site. The flow estimates from these three estimates are shown in the table below after applying the pooled growth curve. The Ballyhaunis gauge was favoured over the Sandy Mills gauge as it was hydraulically similar and similar in size. The only negative was the distance from the site (with the Sandy Mills being directly adjacent). Due to this reason it was decided not to adopt the adjustment factor for the Ballyhaunis gauge as it is less than one. The flow estimates are therefore based on the CDs.

Table 3-7: FSU Flow Estimates

AEP (%)	Peak Flow (m3/s)		
	CDs	Ballyhaunis	Sandy Mills
50	7.43	5.73	12.56
20	9.22	7.09	15.57
10	10.41	8.02	17.58
5	12.12	9.32	20.47
2	13.46	10.39	22.73
1	15.02	11.56	25.37
0.1	21.34	16.43	36.05

4 FSU Small Catchments

The FSU SC method is used to estimate the Qmed value for the catchment. Both an unadjusted and adjusted Qmed was calculated based on the pivotal site. The site-specific growth curve derived for the FSU method has then been used to generate flows for higher return periods.

The adjusted FSU flows are the most representative of the site as the have been adjusted based on the FSU pivotal site.

Note the FSU SC does not account for the Arterial Drainage in this catchment.

Table 4-1: FSU SC peak flow estimates (m3/s)

Annual Exceedance Probability (%)	Unadjusted flow (m^3/s)	Adjusted flow (m^3/s)	Growth Factor
50%	9.02	6.69	1.00
20%	11.19	8.29	1.24
10%	12.63	9.36	1.40
5%	14.71	10.90	1.63
2%	16.33	12.11	1.81
1%	18.23	13.51	2.02
0.1%	25.90	19.19	2.87

5 Discussion of flow estimations

5.1 Choice of Peak Flow

Table 5-1 compares a range of AEP flow estimates using the FSU CDs and FSU SC methods. Both methods were assessed as the catchment size was on the limit of the FSU to FSU SC. The FSU SC does not account for the Arterial Drainage in the catchment and therefore it is recommended that the FSU flows be applied.

Table 5-1: Flow Estimates

Annual Exceedance Probability (%)	FSU (m^3/s)	FSU SC (adjusted) (m^3/s)
50%	7.43	6.69
20%	9.22	8.29
10%	10.41	9.36
5%	12.12	10.90
2%	13.46	12.11
1%	15.02	13.51
0.1%	21.34	19.19

5.2 Section 50 flows

The Section 50 flows will be based on the 1% AEP event but take into account a factorial standard of error (FSE) and a factor for climate change (1.2). The FSE value appropriate for the FSU method is 1.36 for a 68% confidence interval or 1.85 for a 95% confidence interval. These values are shown in Table 5-2. There are no properties in the area of the site meaning a 68% CI is appropriate. Therefore, this will be used in initial testing of the model.

Table 5-2: Section 50 flows

Method	Peak Flow (m^3/s)
FSU 1% AEP Event	15.02
1% AEP + Climate Change	18.02
1% AEP + 68% (1.36 + 1.2)	24.51
1% AEP + 95% (1.85 + 1.2)	33.34

6 Hydrograph Shapes

As the catchment is classed as 'small' (<25kms) two hydrograph generation methods are reviewed to ensure the flows are applied appropriately for the catchments:

- FSR RR hydrograph generally suited to smaller catchments (replicates faster response expected for smaller catchments)
- FSU hydrograph generally suited for larger catchments (replicates longer responses expected for large flatter catchments)

The FSU hydrograph does not give any significant time length in the hydrograph. The FSR RR hydrograph will be used in this study to represent the faster response times. Figure 6-1 shows the hydrograph shape and durations for the FSR RR method.

To test whether the system is sensitive to peak volume rather than flow it is recommended that the hydrograph widths be increased and decreased by 20% and run as a sensitivity test with the hydraulic model.

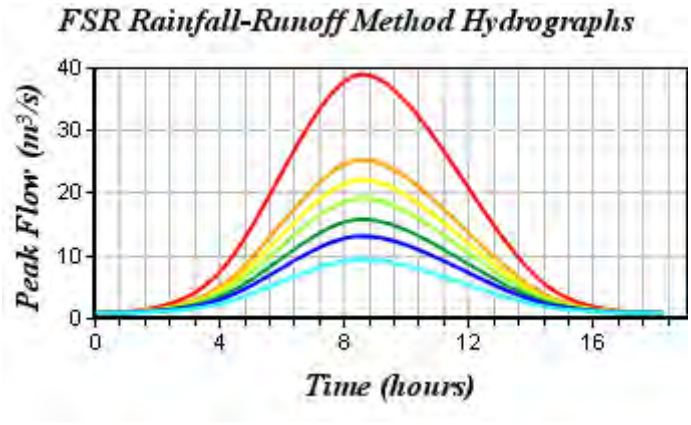


Figure 6-1: FSR RR Hydrograph

7 Discussion and summary of results

7.1 Final choice of method

Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	FSU used for estimating flows. Method is most up to date in Ireland and provides conservative yet representative flows for the watercourses considered. Qmed calculated from CDs used as the Ballyhaunis gauge adjustment factor is less than 1 and as the AOI is located far from the gauge there is an associated uncertainty.
Climate change allowance	+20% flow under OPW MRFS scenario
Section 50	1% AEP Event + Climate Change (1.2) + FSE (1.36)
How will the flows be applied to a hydraulic model? If relevant. Will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	One single inflow point.
Recommended sensitivity tests for hydraulic model e.g. peak flow, volume, hydrograph shape, downstream boundary, bankfull	Sensitivity test on the hydrograph length and downstream boundary.

7.2 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	Ballyhaunis gauge as a suitable pivotal site. Despite the catchment being just below 25km² still using the FSU method rather than the FSU SC. No properties will be impacted by the proposed bridge, so it is sufficient to factor up the design flow estimate to a 68% confidence level (TBC during modelling process)
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.	No pivotal gauges along watercourse therefore unable to validate flows. Pivotal gauge used is some distance away from site.
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	Relevant for use in further FRA work in the area however should be reviewed prior to use.

7.3 Checks

Have adjustments to catchment descriptor methods or gauge data been applied?	Yes
Is storm duration important?	Not likely but hydrograph sensitivity will be carried out to determine
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	1:1.43
Location of calculation sheets, data and records.	Project folder and Jfes online (search project number 2020s1405).

7.4 Final results

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, hydraulic model, or reference to table below)	"N:\2020\Projects\2020s1405 - J B Barry - Ten T Hydraulic Modelling Supp\1_WIP\HO\Non_Graphical\EMQ-JBAI-XX-01-CA-HO-0008-S0-P01.01-Swilly_Burn_Hydrology_Calculations.xlsx"

Appendices

A Methods

A.1 The FSU method

The Flood Studies Update (FSU) method to estimate Qmed as described in research reports produced from FSU work packages 2.2 and 2.3, has been used. Qmed can be estimated using a regression equation based on seven different physical catchment descriptors, in conjunction with an urban adjustment, developed in FSU work package 2.3.

The multivariate regression equation was developed on the basis of data from 199 gauged catchments, linking Qmed to a set of catchment descriptors.

$$QMED = 1.237 \times 10^{-5} AREA^{0.937} BFI_{soil}^{-0.922} SAAR^{1.306} FARL^{2.217} DRAIND^{0.341} S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$

Where:

- AREA is the catchment area (km2).
- BFIsoils is the base flow index derived from soils data
- SAAR is long-term mean annual rainfall amount in mm
- FARL is the flood attenuation by reservoir and lake
- DRAIND is the drainage density
- S1085 is the slope of the main channel between 10% and 85% of its length measured from the catchment outlet (m/km).
- ARTDRAIN2 is the percentage of the catchment river network included in the Drainage

The urban extent can be taken into account using the following equation:

$$Q_{MEDfinal} = Qmed\,(1 + URBEXT)^{1.482}$$

Where URBEXT is the percentage of the catchment covered by urban land use.

Following the calculation of QMED the calculated adjustment factor and a growth curve are applied to generate the peak flows for AEP events. In this case the growth curve produced by the FSU pooling group for the ungauged catchment has been applied.

The catchment descriptors can be used to determine Qmed. In order to improve on this initial estimate of QMED, the data transfer process can be used. In the terminology of the FSU research reports, the gauging station where the adjustment factor is calculated is referred to as a donor site. An adjustment factor for QMED is calculated as the ratio of the gauged to the ungauged estimate of QMED at the gauging station. This factor is then used to adjust the initial estimate of QMED at the hydrological estimation point.

The growth factors for this site are also calculated from the FSU using pooling groups.

For pooled analysis within the FSU, gauges are chosen on the basis of their similarity with the subject catchment according to three catchment descriptors, i.e. AREA, SAAR and BFIsoil. The report on FSU WP 2.2 presents two alternative equations for calculating the similarity of catchments according to these three descriptors. For this study, equal weight was given to each of these variables, applying the similarity distance formula given as Equation 10.2 in the report on FSU WP 2.2.

Not all gauges in Ireland were considered for use in pooling, because the analysis required to fit a flood growth curve makes use of the magnitude of each annual maximum flow, and thus it is

necessary that even the highest flows are reliably measured. This excludes gauges where there is significant uncertainty in the high flow rating.

Although there is some evidence from research on UK data that flood growth curves are affected by additional catchment descriptors such as FARL, the FSU research found that FARL was not a useful variable for selection of pooling groups (uncertainty was greater when FARL was included than when it was excluded) and therefore no attempt was made to allow for the presence of lakes in the composition of pooling groups. Similarly, no allowance was made for arterial drainage in selecting pooling groups.

For pooled growth curves, WP 2.2 recommends considering 3-parameter distributions, because the extra data provided by the pooling group ensures that the standard error is lower than it would be for single-site analysis. The report states that either the generalised extreme value (GEV) or generalised logistic (GL) distributions are worth considering. For this study, GEV has been fitted for the pooled analysis.

A.2 The FSU Small Catchments Method

The FSU small catchments method was created as part of FSU working package 4 and is discussed in 'Work Package 4.2 - Flood Estimation in Small and Urbanised Catchments'.

The FSU small catchment equation is a 5 variable regression equation that was developed after the examination of multiple small catchments equations and regression analysis of multiple catchment descriptors. The FSU small catchment equation for QMED is: 9.02m³/s. When the adjustment factor from the FSU pivotal site is applied the QMED is: 6.69m³/s.

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

Where:

- AREA is the catchment area (km2)
- SAAR is long-term mean annual rainfall amount in mm
- BFISoil is the base flow within the catchment soil
- FARL is the percentage of the catchment covered by lakes or reservoirs
- S1085 is the slope of the main channel between 10% and 85% of its length measured from the catchment outlet (m/km)

The urban extent can be taken into account using the same method as above for the FSU standard method.

A.3 Workings and tables

A.3.1 Pooling group details.

Table 7-1. Pooling Group Details

Station No.	Name	Watercourse	Years	Cumulative years
25040	Roscrea	Bunow	35	35
16006	Ballinaclogh	Multeen	46	81
24022	Hospital	Mahore	35	116
26010	Riverstown	Cloone	48	164
16005	Aughnagross	Multeen	43	207
19020	Ballyedmond	Owennacurra	40	247
25044	Coole	Kilmastulla	51	298
26009	Bellantra Bridge	Black	48	346
29001	Rathgorgin	Raford	53	399
19001	Ballea	Owenboy	59	458
25027	Gourdeen Bridge	Ollatrim	51	509

B Historic Flooding

B.1 Floodmaps.ie



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SECTION 3 FLOOD RISK ASSESSMENT REPORT

APPENDIX C:

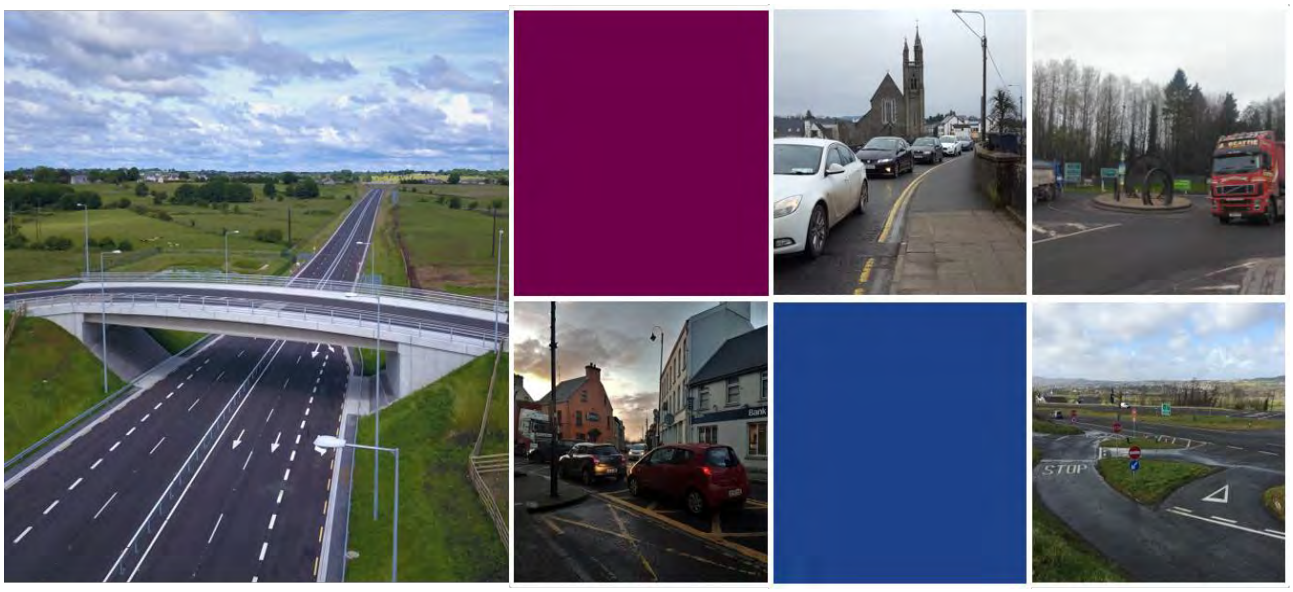
A5 LINK / RIVER FINN SECTION 50 ASSESSMENT

Co-financed by the Connecting Europe Facility of the European Union

TECHNICAL REPORT FOR OPW SECTION 50 APPLICATIONS

TEN-T Priority Route Improvement Project, Donegal

Section 1 – N15/N13 Ballybofey / Stranorlar Urban Region



00501
Technical Report for OPW Section 50 Applications
S3
P01
June 2022

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1 INTRODUCTION

The Trans-European Transport Network (TENT-T) is a selection of strategic transport corridors throughout the European Union (EU) that have been identified to play a key role in the mobility of goods and passengers through the EU.

In November 2016, Donegal County Council appointed joint venture RPS/Barry Transportation as design consultants for the Trans-European Network - Transportation Priority Route Improvement Project, Donegal. Six sections of the TEN-T network were identified and ranked in order of intervention priority due to deficiencies in the existing infrastructure provision. Three sections requiring the most immediate intervention (see Figure 1-1) form part of the TEN-T Priority Route Improvement Project:

- Section 1 – N15/N13 Ballybofey / Stranorlar Urban Region
- Section 2 – N56/N13 Letterkenny to Manorcunningham
- Section 3 – N14 Manorcunningham to Lifford / Strabane / A5 Link.

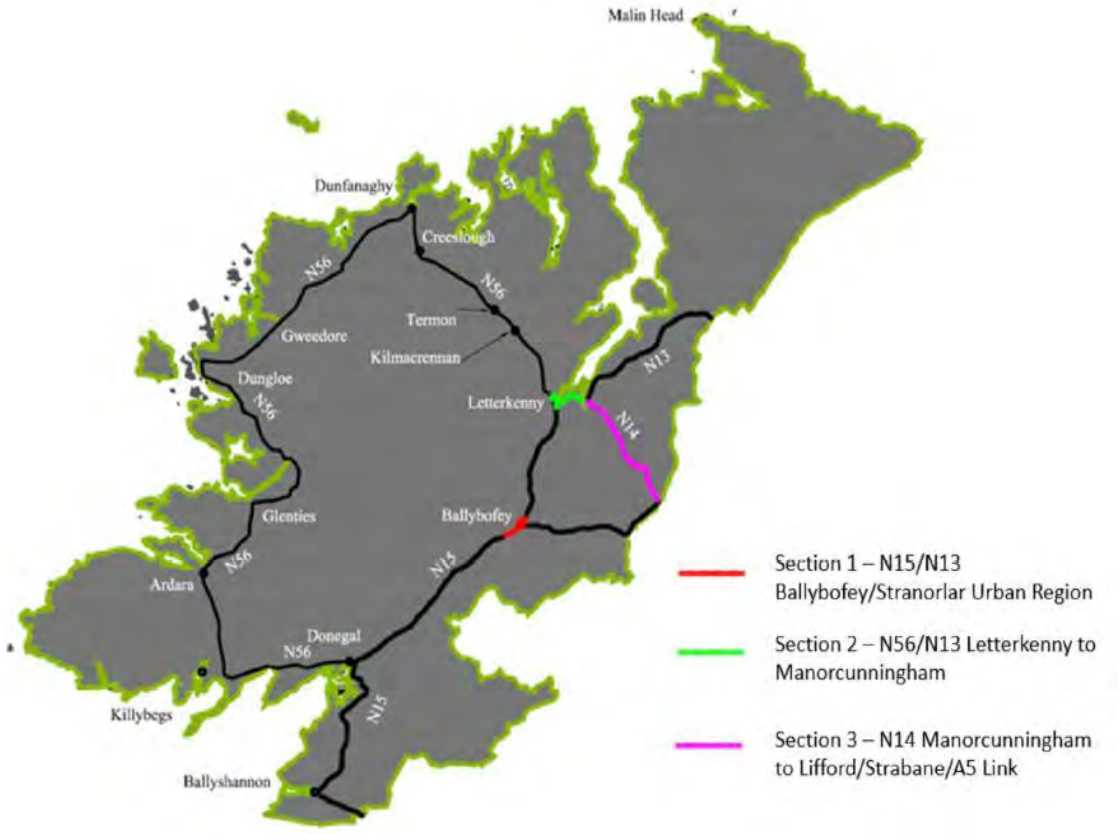


Figure 1-1: Donegal National Roads and Proposed Schemes

This report details the preliminary design location, size and associated hydrological calculations for the proposed River Finn Crossings required to construct the works as part of the Section 3 N14 Mannorcunningham to Lifford/Strabane/A5 Link.

This report details the hydraulic, hydrological and environmental analyses that were carried out in determining the arrangement for the proposed A5 Link Bridge which will connect the A14/15 to the A5.

1.1 Proposed Development

The proposed multi-span bridge N14/15 to A5 Link will be located to the southwest of the Lifford town, Co. Donegal. See Figure 1-2. The proposed bridge constitutes an important key element for relieving road congestion at the border crossing between Lifford and Strabane. The proposal is an important link between the proposed A5WTC in Northern Ireland and the N15 Lifford-Stranorlor-Ballybofey and N14 Letterkenny-Lifford road schemes in the Republic of Ireland.



Figure 1-2: Site Location

The proposed bridge is approx. 290m long and connects a proposed roundabout on the A5 Western Transport Corridor in Co. Tyrone with a proposed roundabout connecting the N14/N15 in Co. Donegal. The Finn Valley is a broad valley overlooked by residential development on the rising slopes of the N15 at Coneyburrow / Curraghalane. The Link Road is Type 2 Dual Carriageway and includes an Active Travel path. See Figure 1-3.

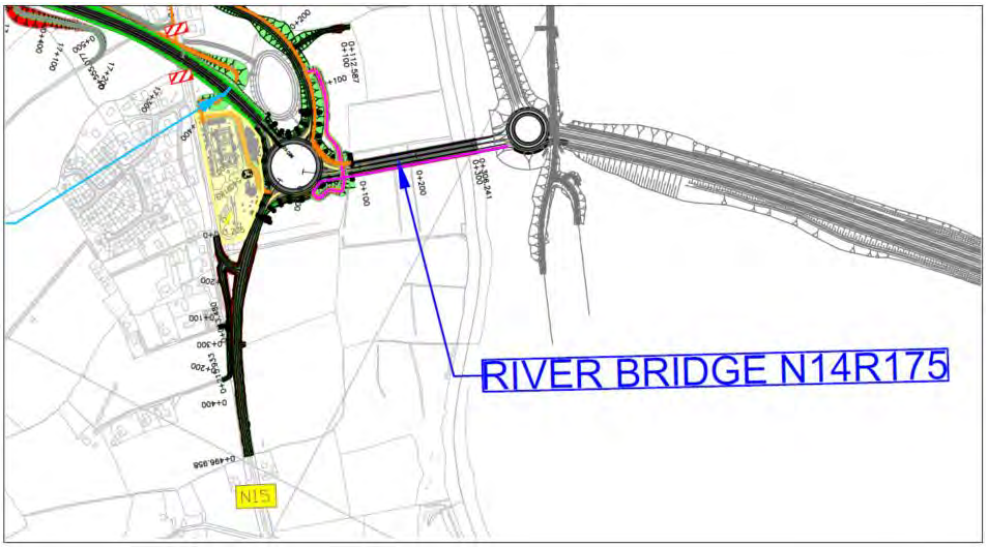


Figure 1-3: Proposed Bridge

1.2 Existing Watercourse

On the north-west side of the River Finn at the proposed crossing location (Co. Donegal), there is a wide flood plain extending up to the existing N15 carriageway, which runs parallel to the river offset by 400-500m. This floodplain area consists of agricultural grassland and hedgerows with a few trees. The proposed roundabout is located on the south-east side of the existing N15 carriageway.

On the south-east side of the River Finn (Co. Tyrone) at the proposed crossing location,the floodplain extends to the location of the proposed roundabout. This floodplain area consists of agricultural grassland, hedgerows, and a few trees. Urney Rd runs parallel to the river offset by 200m.

The floodplain is wide and flat. It has an altitude of approx. 3m AOD and is prone to flooding. The 100-yr design flood level is 7.1m AOD. See the Figure 1-4 and 1-5.



Figure 1-4: River Finn and Floodplain.



Figure 1-5: CFRAM River Flood Extents – Annual Exceedance Probability 1%
(red "x" indicates the bridge site)

The Section 50 application form for the proposed bridge are enclosed in Appendix G.

2 CATCHMENT & DESIGN FLOWS

2.1 Hydrological Analysis

The corresponding hydrological analysis (catchment analysis and design flows) has been developed in the Flood Risk Assessment (FRA) report "Appendix 16" by Williams Sales Partnership (WSP). This was done as part of the A5 WTC project. This report calculated the design fluvial flows based on the Flood Estimation Handbook (FEH) methods for the modelled watercourse, flows have been calculated using both the Statistical and the Revitalised Flood Hydrograph 2 (ReFH2) methods for the watercourse.

The design event used in the FRA report as the Annual Exceedance Probability (AEP) and the associated return period, correspond to the values shown in the Table 2-1.

Annual Exceedance Probability (AEP)	Return Period
50%	1 in 2 year
20%	1 in 5 year
10%	1 in 10 year
4%	1 in 25 year
2%	1 in 50 year
1%	1 in 100 year
0.5%	1 in 200 year
0.2%	1 in 500 year
0.1%	1 in 1000 year

Table 2-1: Hydrological Design Events

In terms of the climate change allowances, as discussed in FRA Volume 1 report the "Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland" published by DfI Water and Drainage Policy Division in February 20197 (hereafter referred to as 'NI climate change guidance') has been applied. The hydraulic model has been run for both the 1% AEP + 20% climate change allowance and 1% AEP + 35% climate change allowance events. The process used to then decide on which event to use as the design event for each model is described in Section 7 of the FRA report.

As mentioned before, the methodology used in the FRA report to obtain the design flows corresponds to Revitalised Flood Hydrograph 2 (ReFH2), which converts design rainfall hyetographs into a flow hydrograph using a model of catchment response. Design rainfall is converted into a flow hydrograph using a loss model, routing model, baseflow model and the catchment descriptors for a given catchment.

A full hydrograph was required for the hydraulic model inflows, therefore a hybrid FEH method has been used. This is where the hydrograph generated using the ReFH2 method is scaled to fit the peak flow derived from the Statistical method, i.e. a combination of FEH statistical and ReFH2 methods has been utilised for each model inflow:

- The ReFH2 method has been used to produce flow hydrographs for a range of return periods.
- The FEH Statistical method was used to determine the peak flow estimates for a range of return periods.

- The ReFH2 hydrograph was then scaled to match the peak flow obtained through the FEH Statistical method.

The inflow hydrology obtained for the River Finn is summarised in the below Table 2-2.

River Catchment	Size (km^2)	100 year + 35% CC peak flow (m^3/s) - 2021 Analysis
River Finn	495	940.3

Table 2-2: Peak flow estimate for design return period

All the hydrological calculations related to the River Finn can be found in the Volume 2, appendix E "Hydrological Calculation Records" of the FRA report.

3 DETAILED ANALYSIS

3.1 Environmental Requirements

An Environmental Impact Statement (EIAR) has been prepared for the Ten-T Project. The EIAR considers the preferred routes at this bridge location and its impact on the environment and local communities. The structure is located on primarily agricultural land, and it will have only a minor impact on the surrounding environment.

The river and floodplain (County Donegal) is a Special Area of Conservation (SAC). As a result, the project requires the completion of an Appropriate Assessment in accordance with Article 6.3 of the Habitats Directive.

Both otter and salmon are Annex 1 species and are selection features of the SAC. It is considered that by clear spanning the river, timing construction adjacent to the river to avoid main salmon migratory periods and by adherence to strict water pollution prevention measures impact on these species can be avoided.

The setback of the works should be sufficient to ensure there is no modification within a 5m riparian zone of the riverbanks during construction. The construction methodology will include a suite of specific measures to mitigate the risk of any untreated surface water run-off into the river.

To minimise the impacts on the River Finn channel and the flood plains, the Environmental Risk Assessment proposed a clear span bridge. The bridge has been designed in accordance with the recommendations of the Lough's Agency and the IFI. Both bodies were consulted with in relation to the bridge design.

3.2 Hydraulic Analysis

The FRA report create a single hydraulic model for the Foyle River System, which comprise the seven key rivers of the mentioned system:

- River Mourne
- River Finn
- River Ballymagorry
- River Dennet
- River Deele
- River Swilly Burn

A fully dynamic and linked 1D / 2D hydraulic model was therefore required to accurately assess the complex flooding patterns within the Foyle River System. The hydraulic model was modelled in the software INFOWORKS ICM (Version 10 64 bit).

Due to tidal influences, a number of model boundary permutations have been applied. This is where combinations of tide levels and river flows with a given chance of occurrence are assessed (joint probability). Tables 3-1 below illustrate the typical model boundary conditions for a 1% AEP event fluvially dominant scenario. A detailed technical note describing the modelling undertaken of the Foyle River System is provided in Volume 2, Appendix B of the FRA report. The inflow locations of model boundaries are shown in Drawings 718736-WSP-0500-00017 and 718736-WSP-0500-00018 in Volume 2, Appendix A of the FRA report.

Watercourse Feature	Manning's n Value	Description
Main Channel	0.030	Clean, straight, some pools and shoals. Mud, stones and gravel
Left Over-bank	0.050	Scattered brush, heavy weeds
Right Over-bank	0.050	Scattered brush, heavy weeds

Table 3-1: Manning's n Values.

The appropriate fluvial design event has been concluded based on the 1% AEP event plus either 20% climate change or plus 35% climate change allowances based on the cliff-edge assessment discussed in FRA Volume 1 report. The design event used for model is shown in Table 3-2.

Section	Watercourse	Design Event
1	M.1 M.2 M.3 River Foyle, River Finn, Mourne River, Deele River, Swilly Burn, Glenmornan and Burn Dennet Rivers	1% AEP + 35CC

Table 3-2: Design Events Used in Models.

Water levels along the watercourses were calculated for a range of return periods up to and including the 1% AEP plus climate change (20% or 35% allowance as appropriate) for the existing scenario. For the 1D only hydraulic models, an estimation of the floodplain extent for various return periods is determined by comparing projected water levels against the prevailing site topography. For the 1D-2D hydraulic models, the floodplain extents are extracted directly from the hydraulic models.

Hydraulic modelling also allowed an assessment of the likely effects resulting from the crossing of the watercourses, and floodplains with the Proposed Scheme. This information was then used for developing possible flood mitigation measures, and ensuring the design complies with the recommendations set out in the DMRB. Further information on this aspect can be seen in FRA volume 3 report.

In order to ensure the hydraulic model provides accurate results, a calibration process was developed using as a reference the recorded water levels form knows peak flows. The hydraulic model coefficients were adjusted to obtain a reasonable fit with the recorded data. The calibration for the hydraulic model of the River Finn is discussed in Appendix B, Volume 2 of the FRA.

In addition to the hydraulic model calibration, and particularly in the absence of reliable calibration data, a sensitivity testing was undertaken. The sensitivity testing for the hydraulic model of the River Finn is discussed in Appendix B, Volume 2 of the FRA.

In term of the model extend, in the below Figure 3-1 can be observe the length of the River Finn modelled.

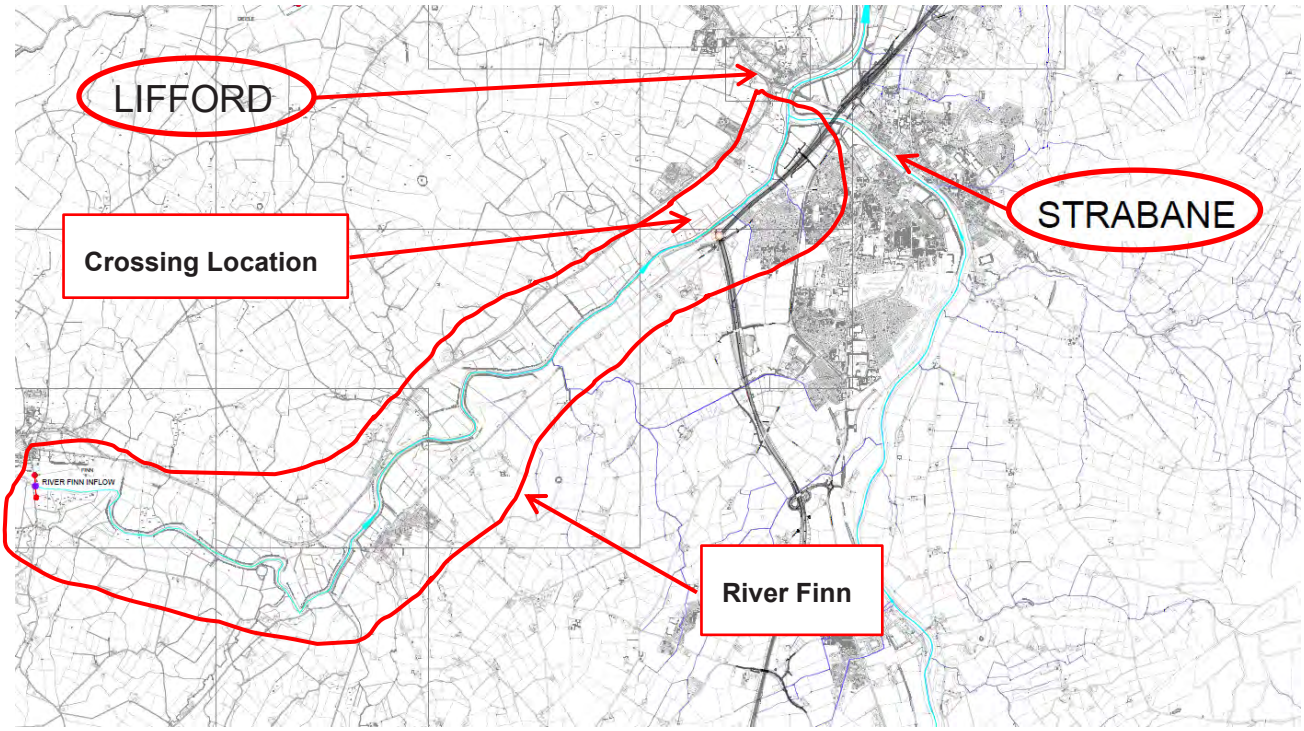


Figure 3-1: Model Extend River Finn

Appendix C shows photographs of the location of existing watercourses where the proposed structure will be located.

4 SUMMARY

Whilst this Section 50 Application was prepared by Barry Transportation, the hydrological and hydraulic modelling as detailed above and provided in the Appendices was done by WSP as part of the A5 WTC project. During the preparation of this Section 50 Application, details of the proposed bridge structure and the Ten-T earthworks extents were provided to WSP, so they could model the effect the A5 Link Bridge and the Ten-T project would have on the River Finn. Below a table details the results of this analysis. The table descriptions have been provided below;

Baseline(No Ten-T): This is the modelling of the River Finn/Foyle, which does not include the proposed changes to the topography and landscape due to the A5 WTC and Ten-T projects. This was only modelled for the 35% climate change scenario.

A5 Spec Des(No Ten-T): This is the modelling of the River Finn/Foyle which includes the landscape and topography changes due to the proposed A5 WTC project. Only the 35% climate change scenario was modelled in this instance.

Baseline with Ten-T: This is the modelling of the River Finn/Foyle which includes the landscape and topography changes due to the proposed A5 Link Bridge(N14R175) and the Ten-T project only. The 35% climate change scenario and the 20% climate change was modelled in this was modelled in this instance.

A5 Spec Design with Ten-T: This is the modelling of the River Finn/Foyle which includes the landscape and topography changes due to the proposed A5 Link Bridge(N14R175) and the Ten-T project. The 35% climate change scenario and the 20% climate change was modelled in this was modelled in this instance. As this is the most onerous of all the scenarios, it has been chosen as the design flood.

Scenario	Model version	Q100+35%CC Max Water Level on floodplain near TEN-T (mAOD)	Q100+20%CC Max Water Level at TEN-T (mAOD)
Baseline (no TEN-T)	V13	7.204	Not available
A5 Spec Des (no TEN-T)	V13	7.205	Not available
Baseline with TEN-T	V20	7.22	6.958
A5 Spec Des with TEN-T	V20	7.222	6.958

Table 4-1: Projected Flooding Levels.

As the flood level of 7.222mAOD is the most onerous and includes the potential development incorporating both the A5 WTC project and the Ten-T project, this is the adopted design flood level.

APPENDIX A: BRIDGE LOCATION

KEY PLAN

OVERBRIDGE - N14O051
OVERBRIDGE - N14O062
OVERBRIDGE - N14O076
UNDERBRIDGE - N14U094
UNDERPASS-N14P045
CULVERT S3-CUL.15
CULVERT S3-CUL.16
CULVERT S3-CUL.13
CULVERT S3-CUL.9
UNDERPASS-N14A027
CULVERT S3-CUL.17
CULVERT S3-CUL.20
GANTRY G303
CULVERT S3-CUL.21
CULVERT S3-CUL.22
CULVERT S3-CUL.08
UNDERBRIDGE-N14U026
GANTRY G301
CULVERT S3-CUL.07
UNDERBRIDGE - N14U018
CULVERT S3-CUL.06
CULVERT S3-CUL.04
CULVERT S3-CUL.01
CULVERT S3-CUL.02
CULVERT S3-CUL.14
UNDERBRIDGE-N14U044
CULVERT S3-CUL.18
CULVERT S3-CUL.19
NOISE BARRIER
S3-NB001
CULVERT S3-CUL.23
CULVERT S3-CUL.24
GANTRY G304
CULVERT S3-CUL.12
GANTRY G302
CULVERT S3-CUL.10
CULVERT S3-CUL.11
UNDERBRIDGE-N14U034
UNDERPASS-N14P021
CULVERT S3-CUL.05
CULVERT S3-CUL.03
OVERBRIDGE - N14O003

LEGEND:
- OVERBRIDGE
- UNDERBRIDGE
- RIVERBRIDGE
- UNDERPASS
- CULVERT
- GANTRY
- NOISE BARRIER
- ACTIVE TRAVEL OVERBRIDGE

0.00km 0.5km 1km 1.5km 2km 2.5km
Scale Bar

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Tionscadal Éireann Project Ireland 2040
Donegal NRO
Oifig Deichtre Raisiunta Dhún na nGall
Comhairle Contae Dhún na nGall Donegal County Council
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Notes

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P01	09.12.25	MG	ISSUE FOR PLANNING	JMM	ED

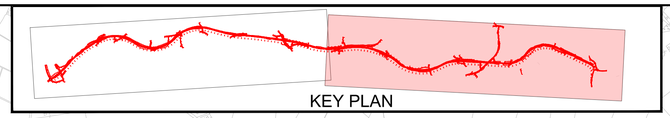
Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: SECTION 3 - BRIDGE LOCATIONS

Status: A3

Designed: JMM	Date: NOV 2025	EIAR Drawing Identifier: EIAR Drawing 4.25	Rev: P01
Drawn: MG	Scale @ A1: 1:12500 @ A3: 1:25000		
Approved: ED		File Identifier: TT_Y16112-BT-1A-SGN-S3-DR-Z-00001	
Checked: JMM	Sheet: 1 OF 2		

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NOISE BARRIER S3-NB002b
NOISE BARRIER S3-NB002a
CULVERT S3-CUL.33
OVERBRIDGE-N14O161
UNDERPASS - N14A143
UNDERPASS-N14A167
NOISE BARRIER S3-NB005
S3-FRC.01
S3-FRC.02
S3-FRC.03
S3-FRC.04
ACTIVE TRAVEL UNDERPASS - N14P142
NOISE BARRIER S3-NB003
CULVERT S3-CUL.25
OVERBRIDGE - N14O108
GANTRY G305
OVERBRIDGE - N14O132
RIVER DEELE
CULVERT S3-CUL.32
SWILLY BURN
RIVER BRIDGE - N14R114
CULVERT S3-CUL.31
UNDERPASS-N14A170
RIVER BRIDGE N14R175
NOISE BARRIER S3-NB004
UNDERBRIDGE-N14U146
RIVER BRIDGE-N14R144
ACTIVE TRAVEL OVERBRIDGE-N14F174
CULVERT S3-CUL.26
GANTRY G306
UNDERBRIDGE - N14U122
UNDERBRIDGE-N14U140
CULVERT S3-CUL.28
CULVERT S3-CUL.29

LEGEND:
- OVERBRIDGE
- UNDERBRIDGE
- RIVERBRIDGE
- UNDERPASS
- CULVERT
- GANTRY
- NOISE BARRIER
- ACTIVE TRAVEL OVERBRIDGE

0.00km 0.5km 1km 1.5km 2km 2.5km
Scale Bar

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P01	09.12.25	MG	ISSUE FOR PLANNING	JMM	ED

Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

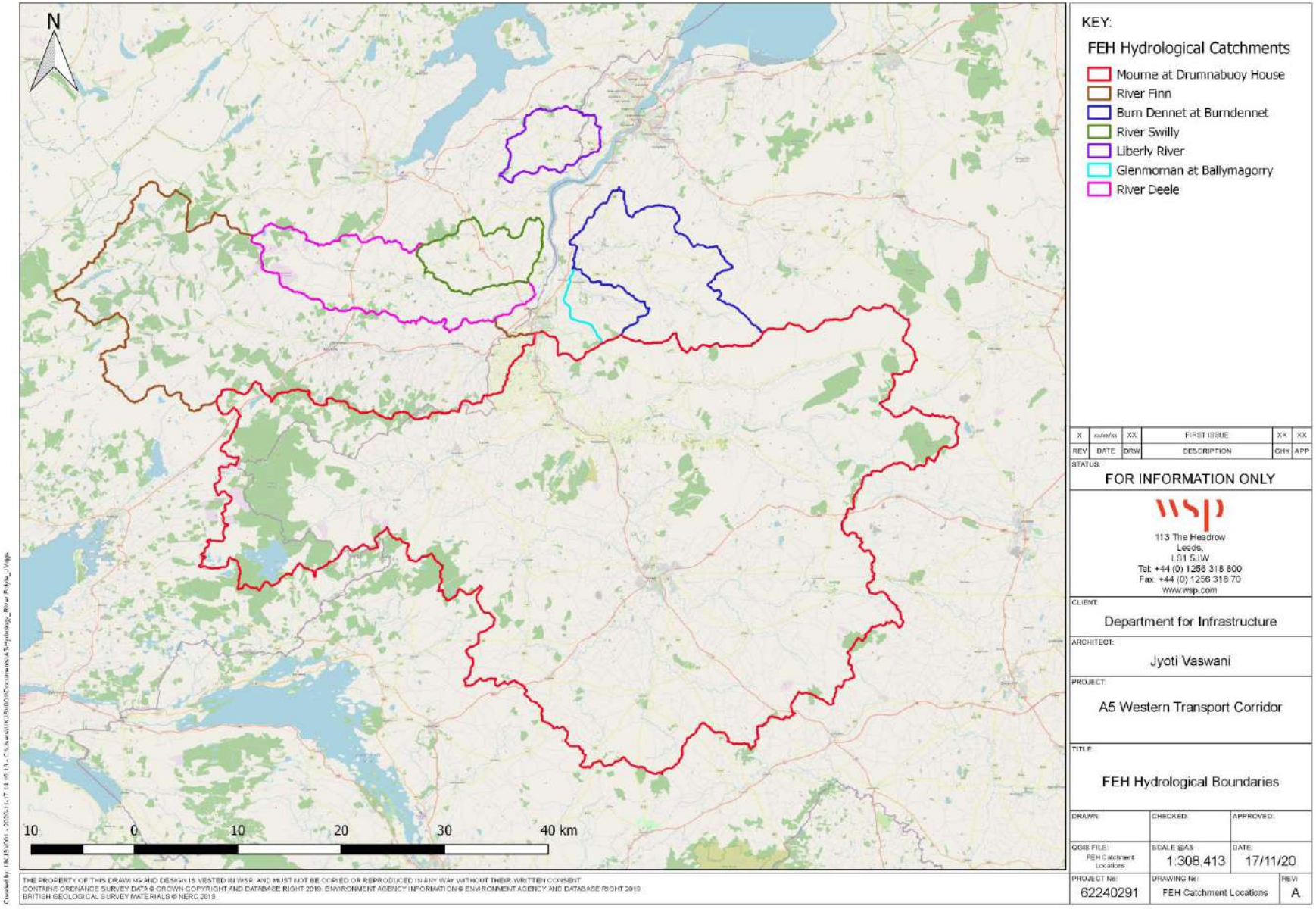
Drawing Title: SECTION 3 - BRIDGE LOCATIONS

Status: A3

Designed: JMM	Date: NOV 2025	EIAR Drawing Identifier:	Rev:
Drawn: MG	Scale @ A1: 1:12500	EIAR Drawing 4.25	P01
Approved: ED	@ A3: 1:25000	File Identifier:	
Checked: JMM	Sheet: 2 OF 2	TT_Y16112-BT-1A-SGN-S3-DR-Z-00001	

APPENDIX B: CATCHMENT LOCATION

Figure 2.1: FEH Hydrological Catchments



APPENDIX C: RIVER FINN PHOTOS

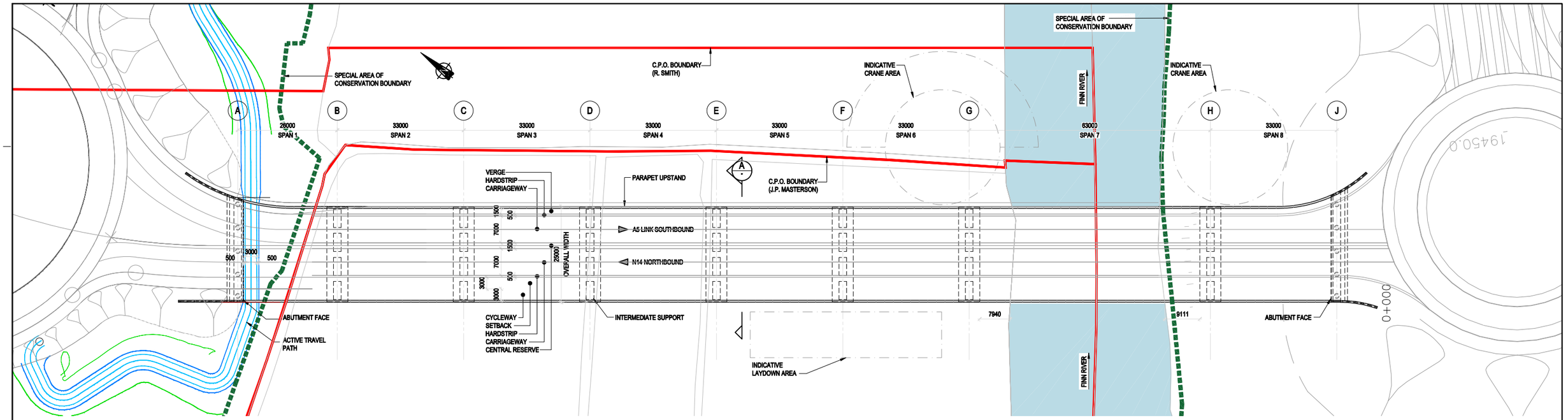
View of River Finn at crossing point



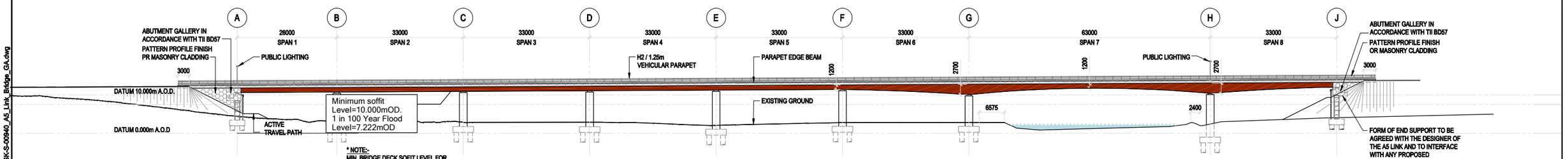
View downstream along the proposed crossing of the River Finn from northern bank



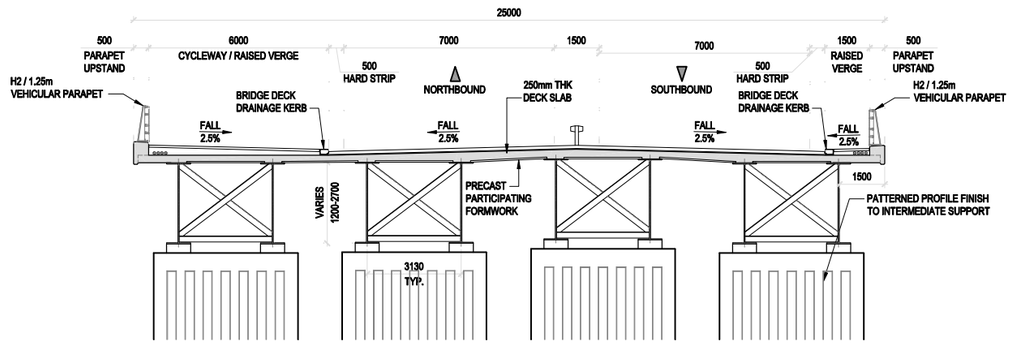
APPENDIX D: STRUCTURE PLAN AND PROFILE DRAWING



PLAN
RIVER FINN CROSSING
SCALE 1:500



SOUTH ELEVATION
RIVER FINN CROSSING
SCALE 1:500



SECTION A-A
RIVER FINN CROSSING
SCALE 1:100

NOTES:

1. LEVELS IN METERS TO MALIN HEAD
2. CO-ORDINATES TO IRISH TRANSVERSE MERCATOR (ITM)
3. WEATHERING STEEL TO BE CONSIDERED AND AGREED WITH AUTHORITY

LEGEND:

C.P.O. BOUNDAY

SPECIAL AREA OR CONSERVATION BOUNDARY (S.A.C.)

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	10/11/2021	DG	FOR REVIEW	MC	WL

Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: N14-N15 TO A5 LINK - RIVER FINN CROSSING (REF N14R175) GENERAL ARRANGEMENT

Status: S3

Designed:	MC	Date: OCTOBER 2021	Model File Identifier: TT_Y16112-BT-1A-SBR-S3-SK-S-00940_Finn River Crossing GA.dwg
Drawn:	DG	Scale @ A1 AS SHOWN	Rev: P01
Approved:	WL	@ A3 AS SHOWN	File Identifier: TT_Y16112-BT-1A-SBR-S3-SK-S-00940
Checked:	MC	Sheet:	

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APPENDIX E: HYDROLOGIC ANALYSIS

CALCULATION CONTROL SHEET
PROJECT: A5 Western Transport Corridor
PART OF PROJECT: River Foyle Model Hydrology
CALCULATION TITLE: River Foyle Hydrological Calculation Record
FILE LOCATION: \\uk.wspgroup.com\central data\Projects\62240xxx\62240291 - A5 WTC\02 WIP\DR Drainge_Flooding\05 Analysis\03 Hydrology data analysis\M.1 M.2 M.3 River Foyle

CALCULATION SUMMARY
This report provides a record of the calculations and decisions made during design flood estimation using the techniques of the Flood Estimation Handbook (Institute of Hydrology, 1999).
Purpose of Calculations To re-generate design hydrographs and peak flows for the River Foyle, in order to update an existing Integrated Catchment Model (ICM) Model. This work is to update existing hydrology undertaken in 2014.

CHECKING AND REVIEW STATUS					
Rev	**Purpose**	**Author**	**Reviewed**	**Authorised**	**Date**
1	Hydrology Update for the River Foyle	JV	AN/HH	TJ	10/02/2021

REVISION HISTORY			
Revision Ref./ Date Issued	**Date**	**Purpose and description of Amendments**	**Issued to**
1	01/12/2021	Submission to DfI Rivers	DfI Rivers

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Abbreviations

AM ..... Annual Maximum

AREA ..... Catchment area (km^2)

BFI ..... Base Flow Index

BFIHOST ..... Base Flow Index derived using the HOST soil classification

CD ..... Catchment Descriptors

CFMP ..... Catchment Flood Management Plan

CPRE ..... Council for the Protection of Rural England

FARL ..... FEH index of flood attenuation due to reservoirs and lakes

FEH ..... Flood Estimation Handbook

FSR ..... Flood Studies Report

HOST ..... Hydrology of Soil Types

NRFA ..... National River Flow Archive

POT ..... Peaks Over a Threshold

QMED ..... Median Annual Flood (with return period 2 years)

RaDAR ..... Radio Detection and Ranging

ReFH ..... Revitalised Flood Hydrograph method

SAAR ..... Standard Average Annual Rainfall (mm)

SPR ..... Standard percentage runoff

SPRHOST ..... Standard percentage runoff derived using the HOST soil classification

Tp(0) ..... Time to peak of the instantaneous unit hydrograph

UAF ..... Urban Adjustment Factor

URBAN ..... Flood Studies Report index of fractional urban extent

URBEXT1990 ..... FEH index of fractional urban extent

URBEXT2000 ..... Revised index of urban extent, measured differently from URBEXT1990

WINFAP-FEH ..... Windows Frequency Analysis Package – used for FEH statistical method

Introduction

This calculation record document provides a record of the calculations and decisions made during flow estimation. The information given here should enable the work to be reproduced in the future. This version of the record is for studies where flow estimates are needed at multiple locations.

1 Method Statement

Table 1.1: Overview of study

Item	Comments
Purpose of study Give an overview which includes: • Purpose of study • Approx. no. of flood estimates required • Peak flows or hydrographs?	The purpose of this study is to update existing hydrology (derived in 2014), in order to update inflows for an existing River Foyle ICM model. This ICM model will be run in the latest version to establish if software updates and updated hydrology significantly impacts the hydraulic model results. The model will be initially run for the 1% Annual Exceedance Probability (AEP) event and the 1% AEP event plus 20% climate change allowance in order to compare updated results to the 2014 results, in terms of water depths and levels. There is a total of seven catchments exported from the FEH Web Service, with sensitivity undertaken to ensure parameters including area, URBEXT, FARL, SPRHOST and DPSBAR are representative of each respective catchment. This was achieved through the use of the FEH Web Service, Ordnance Survey mapping, available contouring and LIDAR, as well as the Soil W.R.A.P map and Greenfield Runoff Rate Estimation Tool (HR Wallingford). Post sensitivity where there was deemed a significant increase in urban area compared to that stated in the FEH catchment descriptors, this has been manually updated in ReFH2 and WINFAP. This approach is conservative and provides the most representative evaluation of the catchments.

Table 1.1: Overview of study

<table>
<tr><th>Item</th><th>Comments</th></tr>
<tr><td>Description of catchment

Brief description of catchment, or reference to section in accompanying report</td><td>River Foyle is located in Northern Ireland and is 32.1km approximately in length, flowing in a northerly direction, from the confluence of the River Mourne and the River Finn to the mouth of the river at Londonderry. The width of the river varies from 90m to 550m. The catchments are deemed rural with minimal development.

The seven catchments that contribute to the River Foyle and their respective catchment sizes are listed in Table 1 below.

<table>
<tr><th>Watercourse</th><th>Catchment Size (km^2)</th></tr>
<tr><td>River Mourne</td><td>1844.20</td></tr>
<tr><td>River Finn</td><td>494.72</td></tr>
<tr><td>Glenmornan River</td><td>31.37</td></tr>
<tr><td>Burn Dennet River</td><td>147.14</td></tr>
<tr><td>Deele River</td><td>133.15</td></tr>
<tr><td>River Swilly</td><td>58.19</td></tr>
<tr><td>Liberly River</td><td>43.75</td></tr>
</table>
Table 1 – River Foyle catchments and sizes

Across the seven catchments the superficial geology is predominately comprised of the following combination; alluvium, till, peat, as well as glacial sand and gravel. The bedrock geology is predominately compromised of the following combination; sandstone, mudstone, siltstone, limestone, granite, psammite and quartzite. This has been sourced from OpenData NI.

It should be noted that the superficial geology extent only covers Northern Ireland and not the Republic of Ireland, within which the River Finn, Swilly River, Liberly River and Deele River catchments are located.</td></tr>
<tr><td>Flood estimates required</td><td>The ICM model will be run with the following flood estimates, requested by Department for Infrastructure (DFI): 1% AEP, 1% AEP +20% CC and 1% AEP +35% CC.</td></tr>
</table>

Table 1.2: Source of flood peak data

Was the HiFlows-UK dataset used? If so, which version? If not, why not? Record any changes made	HiFlows-UK Dataset Used – v9 (September 2020) for Statistical Analysis

Table 1.3: Gauging Stations (flow or level data available at sites or nearby donor catchments)

Watercourse	Station Name	Gauging authority number	NWA number (used in FEH)	Grid reference	Catchment Area (km^2)	Rating?	Period of available data
Bern Dennet River	Burn Dennet at Burndennet	N/A	201007	IC372047	148.3	Q = 14.027 * (h -2.550) ^ 1.732 Q = 16.722 * (h -2.510) ^ 1.722 Q = 16.965 * (h -2.535) ^ 1.439 Q = 16.722 * (h -2.510) ^ 1.722	1975 – 2019
River Mourne	Mourne at Drumnabuoy House	N/A	201010	IH347959	1843.8	Q = 54.893 * (h -0.4240) ^ 1.695	1982 – 2019
River Derg	Derg at Castlederg	N/A	201008	IH265842	335.4	Q = 39.302 * (h + 0.05500) ^ 2.469 Q = 31.944 * (h + 0.000) ^ 1.590	1975 - 2019
Fairywater	Fairywater at Dudgeon Bridge	N/A	201002	IH405758	158.4	Q = 16.610 * (h -0.03000) ^ 1.650	1971 - 2019

Table 1.4: Data available at each Gauging Station

Station Name	Start and end of data in HiFlows-UK	Update from EA for this study? Dates?	Suitable for QMED?	Suitable for pooling?	Data Quality Check needed?
Burn Dennet at Burndennet	1975 – 2013	N/A	Yes	Yes	No
Mourne at Drumnabuoy House	1982 – 2019	N/A	Yes	No	No
Derg at Castlederg	1975 - 2019	N/A	Yes	No	No
Fairywater at Dudgeon Bridge	1971 - 2019	N/A	Yes	No	No

Table 1.4: Data available at each Gauging Station

Station Name	Start and end of data in HiFlows-UK	Update from EA for this study? Dates?	Suitable for QMED?	Suitable for pooling?	Data Quality Check needed?
Comments on data quality (inc. rating) and any checks made	201007 Burn Dennet @ Burndennet - Daily flows from October 2013 are not available as a result of a shifting bed effecting gauging at low flows. Peak flows unaffected. Some query at low flows as difficult to gauge as channel is wide and shallow. Bank works carried out in the winter of 1999 after a breach appeared to have had no impact on the rating. Adequate gauging up to QMED, more high flow measurements would be advantageous as simple extrapolation of the rating curve is used beyond 65m3/s. No water abstractions or significant returns. Discharge through the underlying gravels may be significant. 201010 Mourne @ Drumnabuoy House - Floor of station raised up following major inundation during 1987 flood event. No gaps in record. Daily flows for full period of record reprocessed in 2002. POT threshold revised in 2017 using entire period of record data up to 2015 water year. *Full period of record peak flow data reviewed and released in October 2018 (WINFAP Files v7). This review was done post-2014.* Station location selected to be outside tidal influence of Foyle. Electric cableway historically used for high flow gauging however this was destroyed during high flows in winter 2015. Last high flow gauging undertaken in 2002. Rating derived from current meter gaugings. Simple extrapolation used beyond maximum gauged level of 4.27m. There is a slight effect of water abstractions. 201008 Derg @ Castlederg - The two highest flows on record took place within three weeks of each other in November/December 2015 both surpassing the previous long-held Peak Flow record from 1985. Daily flows from 1975 onwards reprocessed in 2002. POT threshold revised in 2017 using entire period of record data up to 2015 water year. Full period of record peak flow data reviewed and released in October 2018 (WINFAP Files v7). 201002 Fairywater @ Dudgeon Bridge - Daily flows from 1977 reprocessed in 2002. Late December 2010 daily flows considered suspect due to likely freezing in stilling well. Rating derived from current meter gaugings.				

Table 1.5: Rating Equations

Station Name	Type of rating e.g. theoretical, empirical; degree of extrapolation	Rating review needed?	Reasons e.g. availability of recent flow gaugings, amount of scatter in the rating.
Burn Dennet at Burndennet	Empirical	No	High number of flow gaugings available. High flows believed to give reliable flows. Please note from 2004-2005 to present rating 6b used and largely extrapolated since 2014. Rating also shows a degree of scatter at high gaugings. This should be taken into consideration when using data from this station.
Mourne at Drumnabuoy House	Empirical	No	All Amax since 2014 were derived by extrapolation using rating C1a which has been active since 17 June 1982. There are no additional high flows to justify a rating review. Rating curve shows good fit so no basis for a review. High number of flow gaugings available. High flows believed to give reliable flows.
Derg at Castlederg	Empirical	No	High number of flow gaugings available. High flows believed to give reliable flows.
Fairywater at Dudgeon Bridge	Empirical	No	High number of flow gaugings available. High flows believed to give reliable flows.

Table 1.6: Other data available

Item	Comments
Flow / levels gaugings	Based on NRFA gauging station dataset we understand there are no flow or level gauging stations on the River Foyle.
Historic flood data	No historic flood data has been made available by DFI, including but not limited to Section 19s and/or 38s for any historic flood events.
Extra data for other sites in pooling groups	All pooling group data taken from HiFlows-UK v9 and NRFA, no additional data collated.
Flow data for events	15-minute runoff data has been received from Dfi Rivers.
Rainfall data for events	Rainfall data was received for Ballymagrory, at 15-minute intervals. Rainfall data was also received from the Met Office for fifteen rainfall gauges, within the 2014 hydrology study.
Potential evaporation data / MORECS data	N/A
Results from previous studies / models	The 2014 hydrology study, including the associated model and results, are available. In addition to this, the Lifford FRA study data (shared via OPW/RPS) and Strabane feasibility study (RPS via Dfi Rivers) are also available.
Other data (e.g. Groundwater, tidal	N/A

Table 1.7: Initial choice of approach

Item	Comments
Outline the conceptual model, addressing questions such as: • Where are the main sites of interest? • What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) • Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? • Is there a need to consider temporary debris dams that could collapse?	The overall site of interest is the reach of the A5 WTC feasability works. For the River Foyle, located around the Londonderry and Strabane region, there are seven main hydrological catchments that contribute to the River Foyle as shown in Figure 2.1. All of these catchments have been derived from the FEH Web Service. For the seven catchments for which hydrological analysis has been undertaken for, the hydrographs will be derived and included as inflows along the River Foyle. The potential causes of flooding within the study site may include peak flows within the River Foyle or one of the seven associated watercourses, as well as rainfall over a prolonged period of time. Increased urbanisation and runoff in upstream catchments may lead to increased flood risk. There are no large reservoirs therefore partial catchments not a consideration.
Any unusual catchment features to take into account? e.g. • highly permeable – avoid ReFH if	None of the seven catchments are deemed highly permeable (BFIHOST >0.75 or BFIHOST19 >0.65, SPRHOST <20%) or highly urbanised (URBEXT1990 > 0.125). However, for Liberly River and River Mourne the FARL values were at 0.969 and 0.977 respectively, indicating potential major reservoir influence. These FARL values were acceptable as per WINFAP requirements and review concluded they were representative; no further action was needed.

Table 1.7: Initial choice of approach

Item	Comments
BFIHOST >0.75 (or BFIHOST19 >0.65), consider permeable catchment adjustment for statistical method if SPRHOST <20% • highly urbanised – avoid standard ReFH if URBEXT2000>0.150; consider FEH Statistical or other alternatives; consider method that can account for differing sewer and topographic catchments • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence (FARL<0.90) – consider flood routing, extensive floodplain storage – consider choice of method carefully	All seven catchments fall within the urbanisation category of 'Essentially Rural'. URBEXT2000 was adjusted to year and all seven catchments remained within the 'Essentially Rural' category. Further catchment checks were carried out on each of the seven catchments, including checks and adjustments made to URBEXT based on visual inspection of Ordnance Survey maps.
Is FEH appropriate? (it may not be for very small, heavily urbanised or complex catchments) **Outline the choices available and whether appropriate for the sites of interest:** • FEH Statistical (single site or pooled?) • FEH rainfall-runoff • Revitalised rainfall runoff • IoH124 • Rational Method • Hybrid approach?	ReFH2 has been used to derive hydrographs for all seven catchments. ReFH2 is the most up to date method, superseding ReFH1. The FEH Statistical method, single site, enhanced single site analysis (gauged sites) and pooled analysis (ungauged sites), is deemed appropriate for calculating peak flows. The hydrograph shape was based on the hybrid approach adopted in 2014 whereby the FEH rainfall-runoff method was calibrated for the Mourne and Burn Dennet catchments using recorded catchment rainfall and flows for the event in October 1987 and a lesser event in September 2008. In 2020, for catchments with gauging stations (Burn Dennet and River Mourne), 15-min gauge data was provided by DfI Rivers and this was used to compare against hydrograph shapes previously derived for the 2014 hydraulic model. The hydrograph shapes were deemed still representational of the events captured at the gauges and hence were not altered. The hydrograph shapes were then fitted to the revised peak flows (Table 6.1). For the other five ungauged catchments the shape of the hydrographs derived from the FEH rainfall runoff method were also fitted to the revised peak flows (Table 6.1).

Table 1.7: Initial choice of approach

Item	Comments
Initial choice of method(s) and reasons • Will the catchment be split into sub-catchments? If so, how?	The seven catchments have been established within the 2014 hydrology study and the same seven catchments have been used in this study. Catchment descriptors have been abstracted from the FEH Web Service for all seven catchments. Catchment descriptors were reviewed, with sensitivity undertaken to on area, URBEXT, FARL, SPRHOST and DPSBAR. ReFH2 and FEH Statistical was undertaken for all seven catchments.
Software to be used (with version numbers)	WINFAP 4 (v4.2.7282) and ReFH 2 (v3.2.7591)

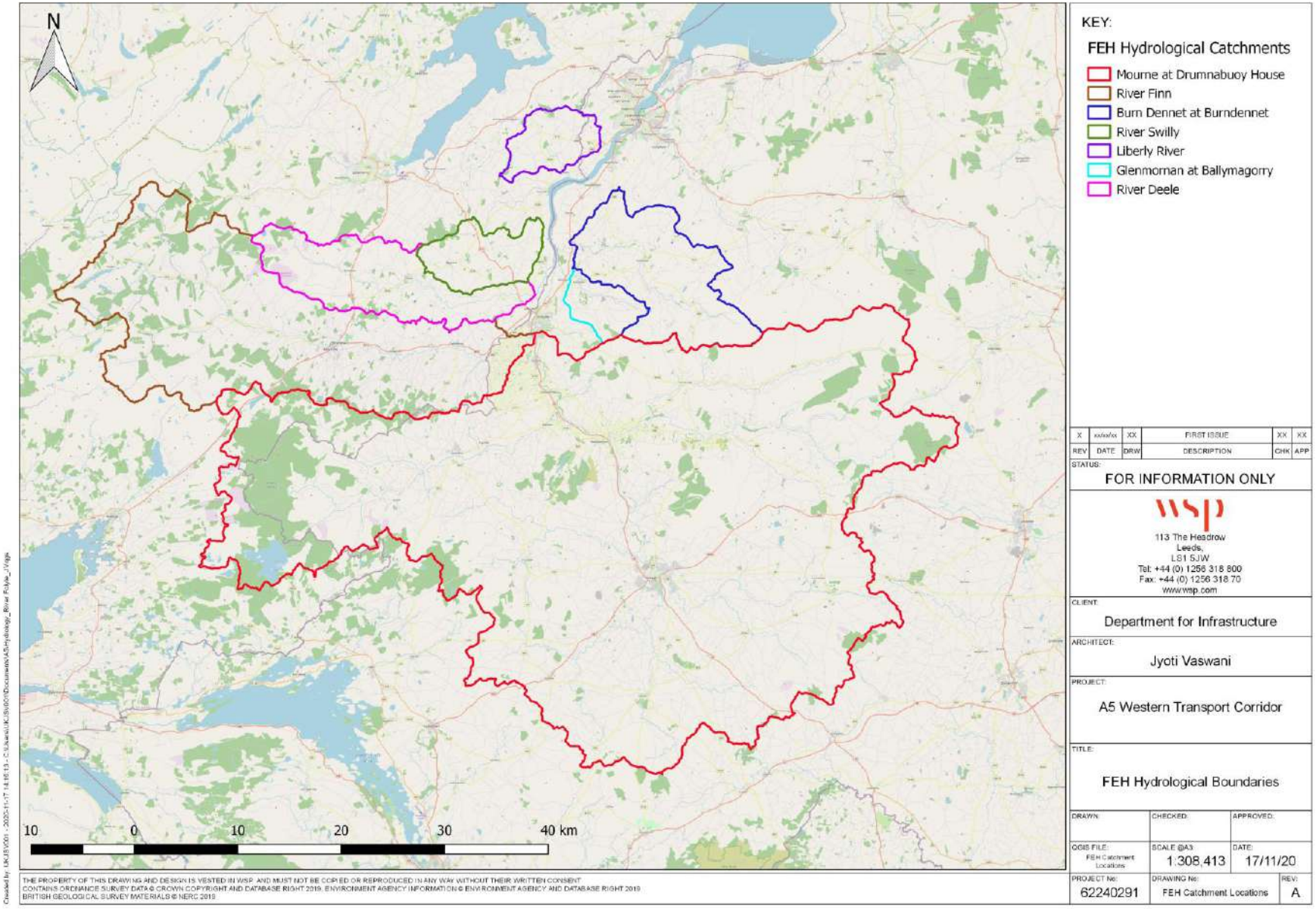
2 Locations where flood estimates are required

The table below lists the locations of hydrological points of interest (for all subject sites). The site codes listed in Table 2.1 below will be used in all subsequent tables. A map showing the hydrological boundaries and points of interest for all seven catchments is shown in Figure 2.1.

Table 2.1: Summary of hydrological points of interest (all subject sites)

Site code	Watercourse	Site Reference	Grid Reference		Catchment area from FEH WEB (km^2)	Revised area if required (km^2)
1	River Mourne	Mourne at Drumnabuoy House	234800	396150	1844.20	N/A
2	Burn Dennet River	Burn Dennet at Burndennet	237250	404750	147.14	N/A
3	River Finn	River Finn	231250	395850	494.72	N/A
4	Glenmornan River	Glenmornan at Ballymagorry	237200	401400	31.37	N/A
5	Deele River	Deele River	233850	399850	133.15	N/A
6	River Swilly	River Swilly	234400	404100	58.19	N/A
7	Liberly River	Liberly River	236450	411750	43.75	N/A
Reasons for choosing hydrological points of interest (subject sites)		The seven catchments of interest are the main hydrological catchments contributing to the River Foyle. In 2014, apart from the Burndennet and Glenmornan rivers, all flow estimates are associated with the most downstream point of the river prior to discharge to the Foyle. Flow estimates for the Burndennet and Glenmornan rivers are associated with the locations of the Rivers Agency gauging stations. It was not considered necessary to recalculate these peak flows for locations further downstream as extensive embankments largely prevent any significant additional flows entering these rivers prior to discharge into the Foyle. This was replicated in 2020 with hydrological analysis for the downstream extents of both the Burndennet and Glenmornan rivers not considered necessary for modelling purposes to assess impacts of the new A5 WTC. As the focus of these studies is associated with the floodplains in the vicinity of the Foyle, for simplicity and robustness, hydrographs would be conservatively applied to the most upstream cross section of the corresponding modelled reach as a hydrological inflow boundary condition.			
How catchment descriptors were checked		Catchment descriptors, in particular area, URBEXT, FARL, SPRHOST and DPSBAR were checked against background mapping, LIDAR, contours, as well as the Soil W.R.A.P map and Greenfield Runoff Rate Estimation Tool (HR Wallingford).				

Figure 2.1: FEH Hydrological Catchments



3 Data used in analysis

Catchment Descriptors from FEH Web Service for five ungauged catchments have been extracted for use on this study. For 201007 Burn Dennet at Burndennet and 201010 Mourne at Drumnabuoy House, the catchment descriptors were taken from the HiFlows-UK dataset (v9).

For the design runs, the URBEXT 2000 values were updated to 2020 for each catchment. The method used to adjust QMED for urbanisation, is that published in Kjeldsen (2010)[1] in which PRUAF (percentage runoff urban adjustment factor) is calculated from BFIHOST.

$$PRUAF = 1 + 0.47 * URBEXT_{2000} (BFIHOST/(1-BFIHOST))$$

N.B. The FEH Web Service provides URBEXT values for the year 2000 ($URBEXT_{2000}$). $URBEXT_{2000}$ is not simply an update of $URBEXT_{1990}$ but it is based on new data produced using different mapping techniques.

Table 3.1 shows the re-statement of the categories of urbanisation distinguished in the FEH according to their URBEXT 1990 values, together with 'equivalent' URBEXT 2000 values.

Table 3.1: Categories of catchment urbanisation related to FEH

Category	URBEXT1990	URBEXT2000
Essentially rural	0.000 <_ $URBEXT_{1990}$ < 0.025	0.000 <_ $URBEXT_{2000}$ < 0.030
Slightly urbanised	0.025 _ $URBEXT_{1990}$ < 0.050	0.030 _ $URBEXT_{2000}$ < 0.060
Moderately urbanised	0.050 _ $URBEXT_{1990}$ < 0.125	0.060 _ $URBEXT_{2000}$ < 0.150
Heavily urbanised	0.125 _ $URBEXT_{1990}$ < 0.250	0.150 _ $URBEXT_{2000}$ < 0.300
Very heavily urbanised	0.250 _ $URBEXT_{1990}$ < 0.500	0.300 _ $URBEXT_{2000}$ < 0.600
Extremely heavily urbanised	0.500 _ $URBEXT_{1990}$ _ 1.000	0.600 _ $URBEXT_{2000}$ _ 1.000

In addition to updating URBEXT to 2020 values, URBEXT values were checked and adjustments were made based on visual inspection of Ordnance Survey maps. The original catchment descriptors (extracted from the FEH Web Service) and the final catchments descriptors (with adjusted URBEXT) used in the analysis are provided in Tables 3.2 and 3.3, respectively.

[1] Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. 41. 391-405.

Table 3.2 shows the original catchment descriptors for each point of interest.

Table 3.2: Catchment descriptors (extracted from the FEH Web Service)

CD	Mourne at Drumnabuoy House	Burn Dennet at Burndennet	River Finn	Glenmornan at Ballymagorry	Deele River	River Swilly	Liberly River
Grid Ref	234800, 396150	237250, 404750	231250, 395850	237200, 401400	233850, 399850	234400, 404100	236450, 411750
AREA	1844.195	147.1375	494.72	31.3725	133.145	58.1875	43.75
ALTBAR	168	167	170	162	127	64	68
ASPBAR	167	307	43	335	91	128	150
ASPVAR	0.03	0.13	0.08	0.31	0.2	0.28	0.12
BFIHOST	0.448	0.455	0.317	0.472	0.325	0.357	0.37
DPLBAR	47.64	16.43	35.19	6.89	22.53	8.59	5.98
DPSBAR	79.6	98.3	97.8	92.7	71.7	63.1	71.1
FARL	0.977	0.994	0.997	1	1	1	0.969
FPEXT	0.0787	0.046	0.0759	0.0332	0.0921	0.147	0.079
FPDBAR	0.891	0.515	1.235	0.342	1.002	1.03	0.604
FPLOC	0.994	0.752	0.913	0.862	0.798	0.715	0.811
LDP	78.34	31.7	60.83	12.53	39.18	16.83	12.84
PROPWET	0.62	0.61	0.61	0.62	0.61	0.61	0.61
RMED-1H	8.7	8.2	9.6	8.1	8.7	7.9	8
RMED-1D	35	35.5	45.1	32.9	37.1	32.4	33.4
RMED-2D	47	48.7	61.8	46.1	51.2	44.1	44.4
SAAR	1288	1186	1346	1147	1222	1035	1033
SAAR4170	1261	1156	1526	1088	1249	1047	1050
SPRHOST	38.84	40.72	47.66	40.1	42.91	38.8	39.29
URBCONC1990	-999999	-999999	-999999	-999999	-999999	-999999	-999999
URBEXT1990	0.0121	0.0044	0.0045	0.0104	0.0052	0.0086	0
URBLOC1990	0.817	-999999	-999999	0.227	0.749	1.389	-999999
URBCONC2000	-999999	-999999	-999999	0.657	-999999	-999999	-999999
URBEXT2000	0.003	0.0004	0.0007	0.0052	0.0005	0.0017	0
URBLOC2000	-999999	-999999	-999999	0.252	-999999	-999999	-999999
C	-0.02472	-0.02906	-0.02481	-0.02999	-0.03091	-0.03118	-0.03012
D1	0.43573	0.45211	0.49721	0.43236	0.46023	0.44307	0.44899
D2	0.45171	0.45993	0.5054	0.46724	0.4966	0.46616	0.4407
D3	0.35345	0.31982	0.36505	0.31666	0.34536	0.34189	0.33461
E	0.27388	0.28928	0.26902	0.29067	0.29035	0.29184	0.29252
F	2.23773	2.22277	2.29606	2.19509	2.2093	2.13882	2.16033
C(1km)	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
D1(1km)	0.42	0.423	0.42	0.436	0.418	0.438	0.452
D2(1km)	0.467	0.448	0.464	0.451	0.463	0.456	0.442
D3(1km)	0.316	0.314	0.319	0.289	0.297	0.325	0.329
E(1km)	0.289	0.292	0.29	0.291	0.291	0.294	0.292
F(1km)	2.16	2.137	2.142	2.158	2.13	2.089	2.155
Adjusted URBEXT1990 to URBEXT2020	0.013	0.005	0.005	0.011	0.006	0.009	0
Adjusted URBEXT2000 to URBEXT2020	0.003	0.00042	0.001	0.005	0.001	0.002	0
Notes on changes made:	URBEXT1990 factor used = 1.079 URBEXT2000 factor used = 1.036						

URBEXT$_{2000}$ values were updated in Table 3.3 to reflect the updated URBEXT values following inspection. These catchments descriptors are used for each point of interest.

Table 3.3: Catchment descriptors

CD	Mourne at Drumnabuoy House	Burn Dennet at Burndennet	River Finn	Glenmornan at Ballymagorry	Deele River	River Swilly	Liberly River
Grid Ref	234800, 396150	237250, 404750	231250, 395850	237200, 401400	233850, 399850	234400, 404100	236450, 411750
AREA	1844.195	147.1375	494.72	31.3725	133.145	58.1875	43.75
ALTBAR	168	167	170	162	127	64	68
ASPBAR	167	307	43	335	91	128	150
ASPVAR	0.03	0.13	0.08	0.31	0.2	0.28	0.12
BFIHOST	0.448	0.455	0.317	0.472	0.325	0.357	0.37
DPLBAR	47.64	16.43	35.19	6.89	22.53	8.59	5.98
DPSBAR	79.6	98.3	97.8	92.7	71.7	63.1	71.1
FARL	0.977	0.994	0.997	1	1	1	0.969
FPEXT	0.0787	0.046	0.0759	0.0332	0.0921	0.147	0.079
FPDBAR	0.891	0.515	1.235	0.342	1.002	1.03	0.604
FPLOC	0.994	0.752	0.913	0.862	0.798	0.715	0.811
LDP	78.34	31.7	60.83	12.53	39.18	16.83	12.84
PROPWET	0.62	0.61	0.61	0.62	0.61	0.61	0.61
RMED-1H	8.7	8.2	9.6	8.1	8.7	7.9	8
RMED-1D	35	35.5	45.1	32.9	37.1	32.4	33.4
RMED-2D	47	48.7	61.8	46.1	51.2	44.1	44.4
SAAR	1288	1186	1346	1147	1222	1035	1033
SAAR4170	1261	1156	1526	1088	1249	1047	1050
SPRHOST	38.84	40.72	47.66	40.1	42.91	38.8	39.29
URBCONC$_{1990}$	-999999	-999999	-999999	-999999	-999999	-999999	-999999
URBEXT$_{1990}$	0.0121	0.0044	0.0045	0.0104	0.0052	0.0086	0
URBLOC$_{1990}$	0.817	-999999	-999999	0.227	0.749	1.389	-999999
URBCONC$_{2000}$	-999999	-999999	-999999	0.657	-999999	-999999	-999999
URBEXT$_{2000}$ (adjusted after visual inspection of OS maps)	0.0095	0.0021	0.0077	0.016	0.0050	0.0059	0.0048
URBLOC$_{2000}$	-999999	-999999	-999999	0.252	-999999	-999999	-999999
C	-0.02472	-0.02906	-0.02481	-0.02999	-0.03091	-0.03118	-0.03012
D1	0.43573	0.45211	0.49721	0.43236	0.46023	0.44307	0.44899
D2	0.45171	0.45993	0.5054	0.46724	0.4966	0.46616	0.4407
D3	0.35345	0.31982	0.36505	0.31666	0.34536	0.34189	0.33461
E	0.27388	0.28928	0.26902	0.29067	0.29035	0.29184	0.29252
F	2.23773	2.22277	2.29606	2.19509	2.2093	2.13882	2.16033
C(1km)	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
D1(1km)	0.42	0.423	0.42	0.436	0.418	0.438	0.452
D2(1km)	0.467	0.448	0.464	0.451	0.463	0.456	0.442
D3(1km)	0.316	0.314	0.319	0.289	0.297	0.325	0.329
E(1km)	0.289	0.292	0.29	0.291	0.291	0.294	0.292
F(1km)	2.16	2.137	2.142	2.158	2.13	2.089	2.155

4 Statistical Method

The FEH statistical method constructs a flood frequency curve based on the estimation of QMED, which is then used to calculate peak flow estimates for each return period. FEH methods should not normally be applied on heavily urbanised catchments (with an URBEXT value greater than 0.5) or catchments smaller than 0.5km².

Table 4.1: Search for Donor Sites (if applicable)

Comment on potential donor sites: • Number of potential donor sites available • Distances from subject site • Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors • Quality of flood peak data • Include a map if necessary. Note that donor catchments should usually be rural.	It should be noted that for the two gauged sites (201007 Burn Dennet at Burndennet and 201010 Mourne at Drumnabuoy House) donor sites were not required, as the record lengths exceed 13 years so QMED can be taken from the AMAX series. Statistical analysis and donor selection for each of the five ungauged catchments (River Finn, Glenmornan at Ballymagorry, Deele River, River Swilly and Liberly River) was undertaken within WINFAP. By default, WINFAP derives 10 potential donor sites and orders these in terms of distance from the subject site. In order to check the suitability of the closest donor sites, a set of criteria was applied to the catchment descriptors and compared with that of the subject site. The donor site/s were chosen based on the following criteria, with the greatest importance given to the centroid distance of the donor site to the subject site; • SAAR: Factor of less than 1.1 • AREA: Factor of less than 5 • BFIHOST: Difference of less than 0.18 • FARL: Difference of less than 0.05 **3 River Finn –** The River Finn is an ungauged site and used a two-donor joint donor; 201008 (Derg @ Catlederg) and 201002 (Fairywater @ Dudgeon Bridge). These stations were 16.15km and 32.30km centroid distant from the subject site respectively, the closest in terms of centroid distance. Other potential donor stations were located 38.39km to 63.80km centroid distant from the subject site. The areas of the two donor stations were 335.520km^2 and 158.240km^2, respectively. The subject site had an area of 494.72km^2 so the area for both donor sites meets the above criteria of a factor less than 5. 201008 (Derg @ Catlederg) was the closest in terms of area with 201002 (Fairywater @ Dudgeon Bridge) the second closest. The SAAR values at the two chosen donor stations is 1558mm (201008) and 1285mm (201002), only 201002 meeting the above criteria of a factor less than 1.1 when compared to the subject site, with a SAAR of 1346mm. The FARL values at the donor stations is 0.914 (201008) and 0.992 (201002), again with only 201002 meeting the above criteria of a difference less than 0.05 when compared to the subject site, with a FARL of 0.997. The BFIHOST values at the donor sites are 0.504 (201008) and 0.419 (201002), again with only 201002 meeting the above criteria of a difference less than 0.18 when compared to the subject site, with a BFIHOST of 0.317. Although 201008 does not meet the criteria in terms of SAAR, FARL and BFIHOST, the other potential stations also do not meet the criteria and were located further away from the subject site, subsequently having less of an influence on the QMED donor adjusted and less representative of the subject site. Stations which were not used for the River Finn catchment included; • 201007 (Burn Dennet @ Burndennet) • 201010 (Mourne @ Drumnabuoy House) • 202002 (Faughan @ Drumahoe) • 236007 (Sillees @ Drumrainey Bridge) • 201009 (Owenkillew @ Crosh) • 201005 (Camowen @ Camowen Terrace)

Table 4.1: Search for Donor Sites (if applicable)

	• 236005 (Colebrooke @ Ballindarragh Bridge) • 203022 (Blackwater @ Derrymeen Bridge) **4 Glenmornan at Ballymagorry -** The Glenmornan at Ballymagorry is an ungauged site and used 201007 (Burn Dennet @ Burndennet) as a donor site. This station was 6.34km centroid distant from the subject site, which was the closest in terms of centroid distance. Other potential donor stations were located from 16.68km to 43.44km centroid distant from the subject site. The area of the donor station was 147.14km$^{2.}$ The subject site had an area 31.37km^2 so the area of 201007 meets the above criteria of a factor less than 5. The SAAR values at the chosen donor station is 1186mm which meets the above criteria of a factor less than 1.1 when compared to the subject site, with a SAAR of 1147mm. The FARL value at the donor station is 0.994 which meets the above criteria of a difference less than 0.05 when compared to the subject site, with a FARL of 1. The BFIHOST value at the donor site is 0.455 which meets the above criteria of a difference less than 0.18 when compared to the subject site, with a BFIHOST of 0.472. Stations which were not used for the Glenmornan at Ballymagorry catchment included; • 202002 (Faughan @ Drumahoe) • 201009 (Owenkillew @ Crosh) • 201010 (Mourne @ Drumnabuoy House) • 201002 (Fairywater @ Dudgeon Bridge) • 201008 (Derg @ Castlederg) • 201005 (Camowen @ Camowen Terrace) • 202001 (Roe @ Ardnargle) • 203020 (Moyola @ Moyola New Bridge) • 203012 (Ballinderry @ Ballinderry Bridge) **5 Deele River -** The Deele River is an ungauged site and used 201007 (Burn Dennet @ Burndennet) as a donor site. This station was 27.27km centroid distant from the subject site, which was the second closest in terms of centroid distance. Other potential donor stations were located from 29.15km to 60.17km centroid distant from the subject site. 201008 (Derg @ Castlederg) was the closest donor site at 20.19km, however the catchment descriptors were less similar to the subject site than 201007. The area of the donor station was 147.14km$^{2.}$ The subject site had an area 133.15 km^2 so the area of 201007 meets the above criteria of a factor less than 5. The SAAR values at the chosen donor station is 1186mm which meets the above criteria of a factor less than 1.1 when compared to the subject site, with a SAAR of 1222mm. The FARL value at the donor station is 0.994 which meets the above criteria of a difference less than 0.05 when compared to the subject site, with a FARL of 1. The BFIHOST value at the donor site is 0.455 which meets the above criteria of a difference less than 0.18 when compared to the subject site, with a BFIHOST of 0.325. Stations which were not used for the Deele River catchment included; • 201008 (Derg @ Castlederg) • 201002 (Fairywater @ Dudgeon Bridge) • 201010 (Mourne @ Drumnabuoy House) • 202002 (Faughan @ Drumahoe) • 201009 (Owenkillew @ Crosh) • 201005 (Camowen @ Camowen Terrace) • 202001 (Roe @ Ardnargle) • 236007 (Sillees @ Drumrainey Bridge)

Table 4.1: Search for Donor Sites (if applicable)

	• 203022 (Blackwater @ Derrymeen Bridge) **6 River Swilly -** The River Swilly is an ungauged site and used 201007 (Burn Dennet @ Burndennet) as a donor site. This station was 17.31km centroid distant from the subject site, which was the closest in terms of centroid distance. Other potential donor stations were located from 26.06km to 53.00km centroid distant from the subject site. The area of the donor station was 147.14km$^{2.}$ The subject site had an area 58.19 km^2 so the area of 201007 meets the above criteria of a factor less than 5. The SAAR values at the chosen donor station is 1186mm which does not meet the above criteria of a factor less than 1.1 when compared to the subject site, with a SAAR of 1035mm. The FARL value at the donor station is 0.994 which meets the above criteria of a difference less than 0.05 when compared to the subject site, with a FARL of 1. The BFIHOST value at the donor site is 0.455 which meets the above criteria of a difference less than 0.18 when compared to the subject site, with a BFIHOST of 0.357. Although 201007 does not meet the criteria in terms of SAAR the other potential stations also do not meet the criteria for SAAR and were located further away from the subject site. Stations which were not used for the River Swilly catchment included; • 202002 (Faughan @ Drumahoe) • 201008 (Derg @ Castlederg) • 201002 (Fairywater @ Dudgeon Bridge) • 201010 (Mourne @ Drumnabuoy House) • 201009 (Owenkillew @ Crosh) • 202001 (Roe @ Ardnargle) • 201005 (Camowen @ Camowen Terrace) • 203020 (Moyola @ Moyola New Bridge) • 203028 (Agivey @ Whitehill) **7 Liberly River -** The Liberly River is an ungauged site and used 201007 (Burn Dennet @ Burndennet) as a donor site. This station was 16.72km centroid distant from the subject site, which was the closest in terms of centroid distance. Other potential donor stations were located from 20.38km to 49.79km centroid distant from the subject site. The area of the donor station was 147.14km$^{2.}$ The subject site had an area 43.75 km^2 so the area of 201007 meets the above criteria of a factor less than 5. The SAAR values at the chosen donor station is 1186mm which does not meet the above criteria of a factor less than 1.1 when compared to the subject site, with a SAAR of 1033mm. The FARL value at the donor station is 0.994 which meets the above criteria of a difference less than 0.05 when compared to the subject site, with a FARL of 0.969. The BFIHOST value at the donor site is 0.455 which meets the above criteria of a difference less than 0.18 when compared to the subject site, with a BFIHOST of 0.403. Although 201007 does not meet the criteria in terms of SAAR the other potential stations also do not meet the criteria for SAAR and were located further away from the subject site. Stations which were not used for the Liberly River catchment included; • 202002 (Faughan @ Drumahoe) • 202001 (Roe @ Ardnargle) • 201009 (Owenkillew @ Crosh) • 201010 (Mourne @ Drumnabuoy House) • 201002 (Fairywater @ Dudgeon Bridge) • 201008 (Derg @ Castlederg) • 203028 (Agivey @ Whitehill) • 201005 (Camowen @ Camowen Terrace)

Table 4.1: Search for Donor Sites (if applicable)

	• 203020 (Moyola @ Moyola New Bridge)

Methods:
AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer; CD – Catchment descriptors alone.
When QMED is estimated from POT data, it should also be adjusted for climatic variation.

Table 4.2: Donor sites chosen and QMED adjustment factors

NWA number	Watercourse	Station	Reason	AM or POT	QMED from flow data (A)	QMED from CDs (B)	Adj ratio (A/B)
201002	Fairy Water	Fairywater @ Dudgeon Bridge	Most similar catchment descriptors	AM	65.646	81.485	0.806
201008	River Derg	Derg @ Catlederg	Most similar catchment descriptors and closest donor station	AM	194.202	118.127	1.644
201007	Burn Dennet	Burn Dennet @ Burndennet	Most similar catchment descriptors and closest donor station	AM	84.166	61.985	1.358

The data transfer procedure is the revised one from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in Table 4.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

$$a = 0.4598*\exp(-0.020*d_{ij})+(1-0.4598)*\exp(-0.4785*d_{ij})$$

If more than one donor has been used, use multiple rows for the site. Record the weighted average adjustment factor in the penultimate column.

Table 4.3: Estimation of QMED at subject sites

Site Code	Method	Initial QMED from CDs (m^3/s)	Initial QMED from CDs (m^3/s)					Final estimate of QMED (m^3/s)
			NRFA no. used	Distance between centroids d_{ij}	Power term, a	Moderated QMED adjustment factor, $(A/B)^a$	If more than one donor: Weighted ave. adjustment	
3	DT	294.418	201008	16.15	0.333	1.180	1.115	328.395
			201002	32.30	0.241	0.949		
4	DT	15.335	201007	6.34	0.431	1.141	N/A	17.496
5	DT	83.209	201007	27.27	0.267	1.085	N/A	90.277
6	DT	29.158	201007	17.31	0.325	1.105	N/A	32.210
7	DT	19.864	201007	16.72	0.329	1.106	N/A	21.970

Are the values of QMED consistent, for example at successive points along the watercourse and at confluence?	Each catchment associated with this study is an independent tributary, therefore there are no successive points or confluences on the River Foyle where results can be compared.

Pooling groups were derived using the revised procedures from Science Report SC050050 (2008). Several subject sites may use the same pooling group. Table 4.4 outlines the pooling group process for each of the catchments.

Table 4.4: Derivation of pooling groups

Name of Group	Site code for which group initially derived	Subject site treated as gauged? (enhanced single site analysis)	Changes made to default pooling group with reasons. Note also any sites that were investigated but retained in the group.	Weighted average L-moments, L-CV and L-skew (before urban adjustment)
Mourne at Drumnabuoy House	**1**	Yes	The initial pooling group had 544 years of records from 10 stations with a H_2 value of 3.07. The following stations were removed from the initial pooling group; • 8010 (Spey @ Grantown) • 76017 (Eden @ Great Corby) 8010 (Spey @ Grantown) was removed due to a low FARL value of 0.938 and the station information states 'Loch Insh and Insh Marshes: at high flows floodplain becomes part of loch, significant storage controlling about 50% of catchment. 22% of catchment developed for hydro-power with diversions and storage, significant net export, water use also for aluminium industry. Reservoirs for hydropower: Spey Dam (1944), Loch and T-Seilich (1941) and Cuaich (1961)'. 76017 (Eden @ Great Corby) was removed due to a very steep growth curve and the station information states 'Ullswater has a significant effect on Eamont flows'. To increase the data record years to 500 or greater 12001 (Dee @ Woodend) was added to the pooling group, creating a pooling group with 540 years. The SPRHOST (40.27%) and BFIHOST (0.506) were acceptable for this added site, along with a review of the overall characteristics. No further stations were removed or added to the pooling group at this stage. The H_2 value for this final pooling group was 2.42. The heterogeneity remained within the review is desirable category.	$L\text{-}CV_{initial} = 0.141$ $L\text{-}Skew_{initial} = 0.202$ $L\text{-}CV_{final} = 0.139$ $L\text{-}Skew_{final} = 0.192$
Burn Dennet at Burndennet	**2**	Yes	The initial pooling group had 513 years of records from 11 stations with a H_2 value of 1.09. The following stations were removed from the initial pooling group; • 28023 (Wye @ Ashford) 28023 (Wye @ Ashford) was removed due to a low SPRHOST value of 14.32%. To increase the data record years to 500 or greater 15013 (Almond @ Almondbank) and 63001 (Ystwyth @ Pont Llolwyn) was added to the pooling group, creating a pooling group with 552 years. The SPRHOST (42.65% and 39.17% respectively) and BFIHOST (0.466 and 0.489 respectively) were acceptable for	$L\text{-}CV_{initial} = 0.187$ $L\text{-}Skew_{initial} = 0.220$ $L\text{-}CV_{final} = 0.186$ $L\text{-}Skew_{final} = 0.208$

			these added sites, along with a review of the overall characteristics. No further stations were removed or added to the pooling group at this stage. The H_2 value for this final pooling group was 0.52. The heterogeneity improved to a review is not required category.	
River Finn	**3**	No	The initial pooling group had 526 years of records from 12 stations with a H_2 value of 2.20. The following stations were removed from the initial pooling group; • 76005 (Eden @ Temple Sowerby) • 202001 (Roe @ Ardnargle) 76005 (Eden @ Temple Sowerby) was removed due to a very steep growth curve, due to it being a steep catchment with short drainage path lengths. 202001 (Roe @ Ardnargle) was removed due to a very flat growth curve and the station information states, 'reservoir in the headlands', 'Headwaters contain Altnaheglish reservoir yielding 32Ml/d' and 'High spring tides intrude up to the station'. To increase the data record years to 500 or greater 27090 (Swale @ Catterick Bridge) and 50002 (Torridge @ Torrington) was added to the pooling group, creating a pooling group with 512 years. The SPRHOST (46.29% and 40.52% respectively) and BFIHOST (0.381 and 0.425 respectively) were acceptable for these added sites, along with a review of the overall characteristics. No further stations were removed or added to the pooling group at this stage. The H_2 value for this final pooling group was 0.23. The heterogeneity improved to a review is not required category.	$L\text{-}CV_{initial} = 0.158$ $L\text{-}Skew_{initial} = 0.182$ $L\text{-}CV_{final} = 0.161$ $L\text{-}Skew_{final} = 0.172$
Glenmornan at Ballymagorry	**4**	No	The initial pooling group had 513 years of records from 14 stations with a H_2 value of 0.84. The following stations were removed from the initial pooling group; • 44013 (Piddle @ Little Puddle) • 28058 (Henmore Brook @ Ashbourne) 44013 (Piddle @ Little Puddle) was flagged as discordant. It was removed due to a low SPRHOST of 11.77% and a high BFIHOST of 0.893. It also had and a very steep growth curve. 28058 (Henmore Brook @ Ashbourne) was removed due to was removed due to a very flat growth curve and the station parameters showed the AM and POT data from 1992 to 2018 was rejected and station information states 'Responsive catchment affected by Carsington pump storage reservoir'.	$L\text{-}CV_{initial} = 0.233$ $L\text{-}Skew_{initial} = 0.193$ $L\text{-}CV_{final} = 0.212$ $L\text{-}Skew_{final} = 0.203$

			To increase the data record years to 500 or greater 27032 (Hebden Beck @ Hebden) was added to the pooling group, creating a pooling group with 526 years. The SPRHOST (57.36%) and BFIHOST (0.252) were acceptable for this added site, along with a review of the overall characteristics. No further stations were removed or added to the pooling group at this stage. The H_2 value for this final pooling group was -0.94. The heterogeneity improved to a review is not required category.	
Deele River	**5**	No	The initial pooling group had 511 years of records from 12 stations with a H_2 value of 1.70. The initial pooling group was deemed suitable, therefore no sites were removed or added. The H_2 value for this final pooling group was 1.70. The heterogeneity was within the review is optional category.	L-CV $_{initial}$ = 0.169 L-Skew $_{initial}$ = 0.219 L-CV $_{final}$ = 0.169 L-Skew $_{final}$ = 0.219
River Swilly	**6**	No	The initial pooling group had 501 years of records from 13 stations with a H_2 value of 5.80. The following stations were removed from the initial pooling group; • 205005 (Ravernet @ Ravernet) – removed due to was removed due to low FARL value of 0.934, which is notable lower than the subject catchment FARL of 1. • 33032 (Heacham @ Heacham) – removed due to a low SPRHOST value of 6.01% and a high BFIHOST value of 0.968. • 26003 (Foston Beck @ Foston Mill) – removed due to a low SPRHOST value of 10.43% and a high BFIHOST value of 0.878. • 42003 (Lymington @ Brockenhurst) – removed due to a very steep growth curve and the station information states 'Water goes out of bank during highest flows most years' and 'Historic lack of homogeneity at high flows (bypassing occurs above 7 cumecs and most pre-1980 flows truncated at ~10 cumecs) but high flow rating now in place and performs well'. • 33054 (Babingley @ Castle Rising) - removed due to a low SPRHOST value of 9.74% and a high BFIHOST value of 0.906. • 26013 (Driffield Trout Stream @ Driffield) - removed due to a low SPRHOST value of 17.61% and a high BFIHOST value of 0.807. • 205008 (Lagan @ Drumiller) - was removed due to a very flat growth curve, the station information states, 'Minor floodplain flow on left bank at	L-CV $_{initial}$ = 0.225 L-Skew $_{initial}$ = 0.170 L-CV $_{final}$ = 0.205 L-Skew $_{final}$ = 0.191

			very high flows' and the Pooling Suitability stated 'Station gets out of bank on the left bank during high flows but at the highest recorded level the estimated floodplain flow is less than 10%'. It should be noted that a sensitivity was undertaken keeping 42003 (Lymington @ Brockenhurst) and 205008 (Lagan @ Drumiller) in the final pooling group, however the growth curve fittings were lower and the H2 was higher (above 3.0). Removing these two sites dropped the H_2 to approximately 2.2 and the growth curve fittings were higher and therefore more conservative. To increase the data record years to 500 or greater 203028 (Agivey @ Whitehill), 41022 (Lod @ Halfway Bridge), 41020 (Bevern Stream @ Clappers Bridge), 203019 (Claudy @ Glenone Bridge), 48003 (Fal @ Tregony) and 53017 (Boyd @ Bitton) were added to the pooling group, creating a pooling group with 524 years. The SPRHOST (41.8%, 38.72%, 43.25%, 35.11%, 34.6%, 37.6% respectively) and BFIHOST (0.404, 0.48, 0.355, 0.463, 0.546, 0.496 respectively) were acceptable for these added sites, along with a review of the overall characteristics. No further stations were removed or added to the pooling group at this stage. The H_2 value for this final pooling group was 2.29. The heterogeneity improved to a review desirable category.	
Liberly River	**7**	No	The initial pooling group had 504 years of records from 15 stations with a H_2 value of 1.03. The following stations were removed from the initial pooling group; • 43029 (Wylye @ Brixton Deverill) • 47023 (Tamar @ Tamarstone Bridge) • 28058 (Henmore Brook @ Ashbourne) 47023 (Tamar @ Tamarstone Bridge) was flagged as discordant. It was removed due to only 6 years of data and the station information states, 'The Upper Lake is a water supply reservoir whilst the Lower Lake is no longer used as a reservoir and so acts as an online pond' and 'As site is subject to backwatering from downstream'. Also, the growth curve is very steep. 3029 (Wylye @ Brixton Deverill) was flagged as discordant. It was removed due to a low SPRHOST value (8.34%) and high BFIHOST value (0.931), as well as a very steep growth curve. 28058 (Henmore Brook @ Ashbourne) was removed due to a very flat growth curve and the station parameters showed the AM and POT data from 1992 to 2018 was rejected and states 'Responsive catchment affected by Carsington pump storage reservoir'.	$L\text{-}CV_{initial} = 0.235$ $L\text{-}Skew_{initial} = 0.201$ $L\text{-}CV_{final} = 0.217$ $L\text{-}Skew_{final} = 0.189$

			To increase the data record years to 500 or greater 76023 (Dacre Beck @ Dacre Bridge), 6012 (Enrick @ White Bridge) and 24006 (Rookhope Burn @ Eastgate) was added to the pooling group, creating a pooling group with 500 years. The SPRHOST (36.34%, 52.02% and 46.36% respectively) and BFIHOST (0.457, 0.293 and 0.392 respectively) were acceptable for these added sites, along with a review of the overall characteristics. No further stations were removed or added to the pooling group at this stage. The H_2 value for this final pooling group was -0.32. The heterogeneity improved to a review is not required category.	
Notes: The weighted average L-moments, before urban adjustment, can be found at the bottom of the Pooling-group details window in WINFAP-FEH.				

Table 4.5: Derivation of flood growth curves

Site code	Method:	Distribution(s) chosen and reason, include goodness of fit parameters	Any urban adjustment or permeable adjustment?	Parameters of chosen distribution(s)
1	ESS	Generalised Logistic (GL) value is 0.6205. The GL method provided the best fit and is the preferred method for UK catchments.	N/A	Location: 1.000 Scale: 0.137 Shape: -0.192 Bound: 0.288
2	ESS	Generalised Logistic (GL) value is 1.1537. The GL and GEV distributions both provided an acceptable fit to the data. The GL method provided the best fit and is the preferred method for UK catchments.	N/A	Location: 1.000 Scale: 0.185 Shape: -0.208 Bound: 0.110
3	P	Generalised Logistic (GL) value is 1.3019. The GL and GEV distributions both provided an acceptable fit to the data. The GL method provided the best fit and is the preferred method for UK catchments.	N/A	Location: 1.000 Scale: 0.160 Shape: -0.172 Bound: 0.068
4	P	Generalised Logistic (GL) value is 0.8094. The GL and GEV distributions both provided an acceptable fit to the data. The GL method provided the best fit and is the preferred method for UK catchments.	N/A	Location: 1.000 Scale: 0.213 Shape: -0.203 Bound: -0.050
5	P	Generalised Logistic (GL) value is 1.3935. The GL and GEV distributions both provided an acceptable fit to the data. The GL method provided the best fit and is the preferred method for UK catchments.	N/A	Location: 1.000 Scale: 0.166 Shape: -0.219 Bound: 0.243
6	P	Generalised Logistic (GL) value is 0.7438. The GEV and Pearson Type III distributions both provided an acceptable fit to the data. The GEV method provided the best fit.	N/A	Location: 0.887 Scale: 0.308 Shape: -0.033 Bound: -8.363

Site code	Method:	Distribution(s) chosen and reason, include goodness of fit parameters	Any urban adjustment or permeable adjustment?	Parameters of chosen distribution(s)
7	P	Generalised Logistic (GL) value is 0.5822. The GEV and Pearson Type III distributions both provided an acceptable fit to the data. The GEV method provided the best fit.	N/A	Location: 0879 Scale: 0.328 Shape: -0.029 Bound: -10.369

Notes:
Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis
A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters.
Urban adjustments are all carried out using the v3 method: Kjeldsen (2010).
Growth curves were derived using the revised procedures from Science Report SC050050 (2008).

Table 4.6: Growth Curves

Site Code	Growth Curve Factor for the following return periods in years								
	2	5	10	25	50	100	200	500	1000
1	1.000	1.217	1.374	1.600	1.793	2.011	2.258	2.639	2.975
2	1.000	1.297	1.515	1.833	2.108	2.423	2.784	3.346	3.849
3	1.000	1.251	1.428	1.677	1.887	2.121	2.383	2.779	3.122
4	1.000	1.341	1.590	1.951	2.263	2.618	3.024	3.654	4.215
5	1.000	1.268	1.467	1.761	2.017	2.313	2.655	3.192	3.676
6	1.000	1.360	1.606	1.925	2.169	2.416	2.669	3.011	3.276
7	1.000	1.382	1.642	1.979	2.235	2.494	2.758	3.114	3.389

Table 4.7 provides the final peak flow estimates calculated using the statistical method with an urban adjustment factor (UAF) of 1.036 applied to the $QMED_{rural}$ and urban adjustment applied to the growth curves utilising Kjeldsen, Version 3 (2010).

Table 4.7: Statistical Method Estimate of Peak Flows

Site code	Flood peak (m^3/s) for the following return periods in years								
	2	5	10	25	50	100	200	500	1000
1	602.28	732.98	827.54	963.65	1079.89	1211.19	1359.95	1589.42	1791.79
2	84.17	109.16	127.51	154.28	177.42	203.93	234.32	281.62	323.95
3	328.40	410.82	468.95	550.72	619.68	696.53	782.57	912.61	1025.25
4	17.50	23.46	27.82	34.13	39.59	45.80	52.91	63.93	73.75
5	90.28	114.47	132.44	158.98	182.09	208.81	239.69	288.16	331.86
6	32.21	43.81	51.73	62.00	69.86	77.82	85.97	96.98	105.52
7	21.97	30.36	36.07	43.48	49.10	54.79	60.59	68.41	74.46

5 Revitalised FSR/FEH rainfall runoff method

The Revitalised Flood Hydrograph (ReFH) method was developed by CEH to provide a more realistic representation of flood hydrology. This method is generally believed to perform reasonably well on most catchments. However, this method is not currently appropriate for either 'heavily urbanised' or 'very heavily urbanised' based on the values of URBEXT2000 extracted from FEH Web Service because its summer design event was only calibrated on seven urban catchments, and further research to improve the ReFH method has been recommended.

Parameters used to derive the ReFH method hydrographs are provided in tables 5.1 and 5.2. For this study, the critical storm duration of each catchment has been calculated (based on the 1 in 100 event) in order to generate

the maximum peak flow estimate produced by each catchment. This may change following optimisation of the hydraulic model inflows.

In addition to updating URBEXT to 2020 values, URBEXT values were checked and adjustments were made based on visual inspection of Ordnance Survey maps. The final catchments descriptors (with adjusted URBEXT) were used in the ReFH2 analysis.

Table 5.1: Parameters for ReFH2

Site Code	Method OPT: Optimisation BR: Baseflow Recession Fitting CD: Catchment Descriptors DT: Data Transfer	T_p (hours)	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow Recharge
1	Catchment Descriptors	7.52	254.091	48.8	0.882
2	Catchment Descriptors	3.896	302.645	43.097	1.527
3	Catchment Descriptors	6.034	214.794	40.792	0.436
4	Catchment Descriptors	2.37	325.208	36.816	1.883
5	Catchment Descriptors	5.159	227.426	38.634	0.622
6	Catchment Descriptors	3.095	34.003	256.958	1.03
7	Catchment Descriptors	2.422	249.072	30.797	0.973
Brief description of any flood event analysis carried out (further details should be or in a project report)		N/A			

Table 5.2: Design events for ReFH2 method

Site Code	Urban or Rural	Season of design (summer or winter)	Storm Duration (hours)	Storm area for ARF (if not catchment area)
1	Rural	Winter	17 hours	0.861
2	Rural	Winter	8 hours 30 minutes	0.905
3	Rural	Winter	15 hours	0.895
4	Rural	Winter	5 hours 30 minutes	0.932
5	Rural	Winter	11 hours	0.917
6	Rural	Winter	6 hours 30 minutes	0.921
7	Rural	Winter	4 hours 30 minutes	0.917
Are the storm durations likely to be changed in the next stage of the study? (e.g. by optimisation within a hydraulic model?)	The default storm duration and timestep has been chosen, in line with the requirements for this study. This is unlikely to be changes in the subsequent stages of the study.			

Table 5.3: Peak flow estimates from the ReFH2 model (rural flows)

Site code	Flood peak (m^3/s) for the following return periods in years								
	2	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1000**
1	535.78	675.54	781.85	938.28	1079.03	1247.27	1444.33	1752.71	2019.32
2	44.65	59.13	69.98	85.91	100.28	117.76	139.44	175.36	207.16
3	242.33	306.19	352.25	417.13	473.07	539.83	622.08	760.73	887.19
4	10.83	14.74	17.74	22.17	26.15	30.98	37.02	47.02	55.88
5	55.85	71.83	83.34	100.22	114.95	133.10	155.32	192.36	225.75
6	22.52	30.16	36.05	44.64	52.33	61.81	73.53	92.82	109.84
7	18.43	25.59	31.02	38.91	46.10	55.05	66.25	84.88	101.29

6 Summary of results

Peak discharges were calculated for each of the seven catchments for the following events: 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP. The following methods were investigated: FEH Statistical and ReFH2. Table 6.1 summarises the 1% AEP peak flows for both methods for all seven catchments.

Table 6.1: Summary of 1 in 100 year return period peak flow estimates for the different methods

Site code	Site name	Peak flow for 100 year return period (m^3/s)	
		FEH Statistical	ReFH2
1	Mourne at Drumnabuoy House	1211.19	1247.27
2	Bern Dennet at Berndennet	203.93	117.76
3	River Finn	696.53	539.83
4	Glenmornan at Ballymagorry	45.80	30.98
5	Deele River	208.81	133.10
6	River Swilly	77.82	61.81
7	Liberly River	54.79	55.05

Table 6.2: Choice of method

Item	Comments
Final choice of method and reasons Include: • Reference to type of study • Nature of catchment • Type of data available	The final choice of method is the FEH Statistical. The catchments are all 'essentially rural', donors are representative and WINFAP uses most up to date AMAX data. The required hydrographs will be generated in ReFH2 and scaled to the FEH Statistical peak for each respective catchment.

Table 6.3: Assumptions, limitations and uncertainty

Item	Comments
List the main assumptions made (specific to this study)	There is known urban expansion within the study area. In addition to updating URBEXT to 2020 values, URBEXT values were checked and adjustments were made based on visual inspection of Ordnance Survey maps. The final catchments descriptors (with adjusted URBEXT) were used in both the FEH Statistical analysis and the ReFH2 analysis. Assumed 201007, 201010, 201008 and 201002 AMAX data reliable. Assumed appropriate to use 201007, 201010, 201008 and 201002 AMAX data during QMED transfer for the ungauged sites in the points of interest. Assumed that the rating curve of 201007 represents the missing data after 2013 correctly.

Item	Comments
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed	N/A
Give what information you can on uncertainty in the results – e.g. confidence limits for the QMED estimates using FEH 3 12.5 or the factorial standard error from Science Report SC050050 (2008).	Uncertainty in the URBEXT values has been minimised where possible by comparing against Ordnance Survey mapping to ensure realistic values for urban area have been used. For the catchment used in this study, the standard methods have been applied and appropriate guidance followed. Donors for QMED were available for this catchment, reducing the uncertainty in QMED values.
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	The calculations were carried out for the A5 WTC project.
Give any other comments on the study, for example suggestions for additional work.	None.

Table 6.4: Checks

Item	Comments
Are the results consistent, for example at confluences?	Each catchment associated with this study is an independent tributary, therefore there are no successive points or confluences on the River Foyle where results can be compared. FEH flows are generally higher than ReFH2 flows, however due to availability of good donor catchments and catchments >5km^2 statistical peaks are accepted.
What do the results imply regarding the return periods of floods during the period of record?	N/A
What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 to 4.0)	Growth factors for the seven catchments are as follows from site code 1 to 7; 2.011, 2.423, 2.121, 2.618, 2.313, 2.416 and 2.494. These are mostly in range and are considered realistic.
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	From site code 1 to 7 the ratios are as follows; 1.48, 1.59, 1.47, 1.61, 1.59, 1.36 and 1.36.
What range of specific runoffs (l/s/ha) do the results equate to? Are there any inconsistencies?	From site code 1 to 7 the specific runoffs (for the 1% AEP event) are as follows; 6.57, 13.86, 14.08, 14.60, 15.68, 13.37 and 12.52 l/s/ha.

Item	Comments
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	The difference in 1% AEP flows from 2014 to 2020, for site codes 1 to 7 are as follows; 5.93%, 12.15%, 12.41%, 11.76%, 16.48%, 7.86% and 7.18%. The differences in flows have occurred due to additional flow data records and change in distribution for some sites. The 1% AEP flows derived for 2020 have been taken forward for modelling purposes.
Are the results compatible with the longer-term flood history? **Are there any amendments to parameters after verification / Calibration?**	N/A
Describe any other checks on the results	None.

Appendix – Supporting Information

Additional spreadsheets with details and screenshots can be found in the location: \\uk.wspgroup.com\central data\Projects\62240xxx\62240291 - A5 WTC\02 WIP\DR Drainge_Flooding\05 Analysis\03 Hydrology data analysis\M.1 M.2 M.3 River Foyle

APPENDIX F: HYDRAULIC ANALYSIS

Appendix B

FOYLE MODEL BUILD TECHNICAL NOTE

PUBLIC

FLOOD RISK ASSESSMENT - APPENDIX B TECHNICAL NOTE

DATE	01 March 2022	**CONFIDENTIALITY**	Confidential
SUBJECT	River Foyle Hydraulic Model Build		

1 INTRODUCTION

This technical note details the updates made to the River Foyle hydraulic model for use in the Flood Risk Assessment (FRA) for the A5WTC project. The hydrological and hydraulic assessments use the latest available data, current guidance and best practice which inevitably apply conservative, but appropriate, methods. This technical note covers software updates, model edits and updates to hydrology.

2 MODEL UPDATES IN 2018

The existing River Foyle model was built using MIKE software and obtained from DfI Rivers for use on A5WTC project. It was later converted to Infoworks ICM v8.0 software in 2018 by WSP and an assessment was undertaken that compared results between the ICM and MIKE models to confirm the validity of using the ICM model in assessing the impacts of the A5WTC. The change from using MIKE software to ICM software caused changes to the model results. These were mainly attributed to the differences in the model representation of linkages between the watercourse and floodplain, representation of the floodplain itself and different meshing mechanisms[1]. The conclusion was that the ICM hydraulic model provided a robust predictive tool capable of adaption as the project progresses to inform the scheme design and associated FRA.

3 MODEL UPDATES 2021

The following items were considered essential updates as a result of recommendations made by the Planning Appeals Commission (PAC)[2] and have been further implemented in the model:

- Use the latest version of ICM software. The River Foyle hydraulic model has been updated from Infoworks ICM v8.0 software to v10.0, the latest version at time of writing. When trying to run the models in the latest software there were some stability issues and both the baseline and proposed Foyle models crashed. The models were packaged up and sent to the software supplier (Innovyze) to help resolve these stability issues. The following parameters were updated as a result:
    - Weir and bank crest levels updated at confluence (FOYLE_25548*.1) by using the channel section data from tributary upstream (at FOYL_25441 as the bank profile). This change is located on the River Foyle where it joins together again after the split at Corkan Island. This is in the tidal reach of the river so would not have a significant effect on water levels.
    - Unstable due to lateral exchanges across right bank (at FOYL_4833.1) with upstream reach (Gransha.1). Dropped the modular limit further to 0.4 and changed the value of the drowned bank linearisation threshold from 0.01 to 0.1. This is just

[1] Meshing is the method used by ICM to represent the ground elevation using a network of triangles

[2] Planning Appeals Commission, Public Inquiry Report, A5 Western Transport Corridor Road Scheme NewBuildings to Aughnacloy, May 2017

north of Londonderry (Derry) and is in the tidal reach of the River Foyle so would not have a significant effect on water levels.

- Roughness has been reviewed and updated on all cross-sections where necessary – refer to main report for detail. All panel markers have been updated to ensure top of banks and changes of roughness are identified.
- Roughness zones for roads have been added in the 2D Zone which apply a smoother Mannings 'n' value of 0.02 representative of tarmac or concrete. This has been done on both the Northern Ireland side of the Foyle and the Republic of Ireland side.
- Roughness zones for buildings have been added in the 2D Zone which apply a high Mannings 'n' value of 0.1 representative of the flow slowing as it enters / passes through a building. This has been done on both the Northern Ireland side of the Foyle and the Republic of Ireland side.
- Mesh zones for roads (from Mastermap) have been added in the 2D Zone and lowered by 0.125m (kerb height) to ensure flow paths / flooding routes are realistic. This has been done on both the Northern Ireland side of the Foyle and the Republic of Ireland side.
- Mesh Zones have been added for Buildings and raised by 0.3m (as "stubby" buildings) to direct flows around buildings up to the point where it may enter the building at the threshold (assumed 0.3m). This has been done on both the Northern Ireland side of the Foyle and the Republic of Ireland side
- No new LiDAR data has been identified as available for the Foyle catchment, so the original LiDAR used in the 2014 model updates (flown in 2009) is still being used.
- A comparison of the flood defences on the River Foyle and River Mourne, as identified in the North Western Flood Risk Management Plan[3] and on the Flood Maps (NI) website[4], against what was included in the baseline ICM hydraulic model was undertaken.
    - Defences on the River Mourne are included to the 1 in 100 year (1%AEP) standard of protection (SOP).
    - However, the River Foyle right bank (set back flood defence adjacent to existing A5 Barnhill Road) that has a 1 in 100 year SOP, was not included in the baseline model and hence this area was not shown to be defended in the baseline results. A topographic survey of Barnhill Road was available, and the flood defence has now been added to the model. This was an important finding as it affects the impacts of the A5WTC and the number of receptors flooded from the baseline 1 in 100 year (and above) model flood extents.
- There are flood defences also on the Republic of Ireland (RoI) side of the River Mourne that tie-in to Lifford Road bridge but details of the crest levels along the full length were not available at the time of writing this technical note. Topographic survey data of the defences was subsequently received from Office of Public Works (OPW) in August 2021. Comparisons between topographic surveys were undertaken to ensure that the model remained representational for watercourse capacity and bank top levels however these have not been incorporated in the baseline model presented in this note. It is understood that the RoI defences have a 1 in 100 year SOP along the River Mourne but that they breach at lower return periods along the River Swilly and therefore flooding occurs behind.

[3] Rivers Agency, North Western Flood Risk Management Plan, December 2015

[4] https://www.infrastructure-ni.gov.uk/topics/rivers-and-flooding/flood-maps-ni

4 MODEL BOUNDARIES

The following assumptions and parameters have been used for the 1D and 2D model boundaries:

- Hydrology was updated to the present day (refer also to Section 6 and 7), the previous hydrology update was undertaken in 2014. For the River Foyle catchment this included:
    - Update of the tidal boundary to use the latest Coastal Flood Boundary Extreme Sea Levels (2018)[5] data and latest tidal gauge data. Uplift the climate change (CC) allowance to project to the end of the design life (120 years) to year 2140 using coastal flood map provided by DfI Rivers[6]. Tidal Boundary has been updated for the Higher Emissions scenario 95th percentile climate change allowance.
    - Update the fluvial boundaries to include 35% climate change (CC) allowance[7] to the estimated 'Present Day' 1 in 100 year peak flow.
    - Update of the Flood Estimation Handbook (FEH) statistical analysis for the peak catchment inflows (7No.) to include the latest annual maxima gauges flows in the latest UK high flows data (National River Flow Archive peak flow dataset v9).
    - Review and update where required, the inflow hydrograph shapes for each catchment (FEH Rainfall Runoff method and latest ReFH2 methods were assessed).
    - Critical storm duration for each of the main watercourses has been used and the timing of the tide with the peak on the River Foyle along the key reaches of interest have been aligned to ensure a worst-case combination of fluvial and tidal flood risk has been assessed (refer also to Section 8 for sensitivity testing).
- The 2D Zone has been extended on all watercourses to account for the larger floodplains for the design 1 in 100 year + 35% climate change return period. It was widened where DTM is available. There remain some locations where glass wall cuts off a tiny and insignificant part of the floodplain as DTM is unavailable.
- It is noted that the upstream river reaches of Finn, Deele and Mourne are modelled in 1D only (simplified for reduced run times) as they are not close to proposed A5WTC alignment.
- The edge of the 2D Zone (2D boundary) cuts across a large floodplain on the River Finn which is not an ideal location but remains the best place for a boundary as further upstream there is no DTM available and downstream the floodplain remains wide (and close to the A5WTC alignment) all the way to the River Foyle confluence. Sensitivity tests (refer to Section 8) have shown that using a "Vertical Wall" at all 2D boundaries is most appropriate for all 2D Zones as this ensures no re-circulations and hence no loss of flows from the model.
- There are two known areas of land-raising in the River Foyle system floodplain that have been flagged during consultation with DfI Rivers as influencing flood extents and levels. One is the public tip area on the right bank of River Finn: the DTM in the area has been reviewed, is considered representational of the land-raising and is included in the 2D model. The other is a field adjacent to Park Road that was raised by illegal dumping reported near Nancy Burn and Tarry Drain, the area is very small in comparison to the extensive nature of the River Foyle floodplain being modelled that it would have negligible impact on fluvial water levels assessed in the area.

[5] https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

[6] DfI Rivers publish sea level climate change uplifts base on UKCP09 data

[7] Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland, DfI Water & Drainage Policy Division, February 2019

5 OTHER SCHEMES IN THE AREA

WSP are aware of other schemes being undertaken in the Foyle catchment:

- A5 TEN-T Road Bridge;
- N14/15 to A5 Link 'Proposed New Lifford Bridge'; and
- Lifford Flood Relief Scheme;
- Strabane Feasibility Study;
- Riverine Park Project; and
- Castlefinn Flood Relief Scheme.

The above six schemes are not as advanced as the A5WTC and information is limited at present. Where information has been made available, we have used it as far as is practicable to determine the cumulative effects of the schemes.

The N14/N15 to A5 Link project has gone through the oral hearing process in the Republic of Ireland and is awaiting approval by An Bord Pleanala to coincide with the approval of the A5WTC. The proposed 8 span steel composite bridge (A5 TEN-T Road Bridge) crossing as detailed in the Report on the Environmental Impact Statement[8] has also been incorporated into the A5WTC Foyle model. Plan drawings of the N14/N15 road embankments have also been provided so have been included in the 2D Zone on the RoI side.

The Lifford FRS[9] is in Stage I (Scheme Development and Design) and as such a preferred option has not been established nor has it been confirmed if the scheme will proceed beyond this stage. Therefore, the scheme has not been incorporated into the FRA for the Proposed Scheme.

The North Western River Basin Flood Risk Management Plan shows Strabane as being a "significant flood risk area" and meetings with DfI indicate there are plans for a Strabane Feasibility Study on Nancy Burn but no details are available to date.

Some high-level layout images of the Riverine Project are available. Land use is mainly green space and car parking therefore it is anticipated that there are minimal changes in the area in terms of roughness and ground levels (and hence flood risk). There is a Visitor Centre proposed on the Republic of Ireland side which will be assessed for any increases in water level. There is a footbridge proposed across the River Foyle but no details are yet available.

Castlefinn FRS is a Proposed Scheme on the River Finn in the RoI. Castlefinn is approximately 4km upstream of the upstream boundary of the Foyle River System hydraulic model and beyond the intertidal reach of the River Finn, which is our area of interest (adjacent to the Proposed Scheme). Therefore, it was not considered necessary to include representation of the Castlefinn FRS in the Foyle River System hydraulic model.

6 FLUVIAL HYDROLOGICAL UPDATES 2021

The 2019 DfI guidance on climate change[4] is a significant update compared to when the hydraulic modelling was undertaken in 2014, and recommends for the fluvial (river) context throughout Northern Ireland (NI), that a single climate change allowance of +20% additional flow is applied to the estimated 'Present Day' 100-year peak flow. It advises that the allowance for climate change should be made separately from any additional allowance for freeboard / uncertainty in design. This is a change from previous guidance which recommended 'testing' for climate change within

[8] N14/N15 to A5 Link, Environmental Impact Statement / Environmental Statement, Volume 1, Roughan & O'Donovan Consulting Engineers on behalf of Donegal County Council, July 2011

[9] http://liffordfrs.ie/

the freeboard envelope. A 'sensitivity test' is also recommended to be undertaken based on a higher 90% probability level to determine whether there are any 'cliff-edge' effects where the flooding consequences may suddenly become extremely severe.

Subsequent discussions between DfI Roads and DfI Water & Drainage Policy Division established that the A5WTC should be regarded as a strategically important development and that a +35% additional flow should be adopted for the higher 90% probability level

The River Foyle system is a complex area hydraulically, being at the confluence of Rivers Mourne, Finn and Foyle as well as a number of minor watercourses. The Foyle is tidally influenced such that flood levels are influenced by the combined effect of river flows and tidal surge.

Initial results were for a fluvial climate change allowance of +20%. The model results indicated significant impacts at five locations on the right bank of the River Foyle in excess of 100mm.

Since then, the model inflows have been increased using the +35% climate change allowance due to the number of properties potentially at risk of flooding in the Strabane, and the presence of existing flood defences.

The change to upstream hydrological boundaries is driven by:

- The need to include 35% climate change (CC) allowance in design (plus freeboard over and above);
- New gauge data becoming available (further 6 years of data);
- Changes to pooling group selection; and
- Updates to WINFAP software.

The inflow hydrology for the River Foyle model are summarised in Table 1.

River Catchment	Size (km^2)	100 year + 35% CC peak flow (m^3/s) - 2021 Analysis
River Mourne	1861	1635.1
Burn Dennet River	147	275.3
River Finn	495	940.3
Glenmornan River	31	61.8
Deele River	133	281.9
River Swilly	58	105.1
Liberly River	44	74.0

Table 1: Peak flow estimates for design return period

The increase in peak design flows since the 2014 assessment inevitably results in increased flood extents for the baseline scenario and hence potentially greater impacts caused by the A5WTC.

For catchments with gauging stations (Burn Dennet and River Mourne), 15-min gauge data was provided by DfI Rivers and this was used to compare against hydrograph shapes previously derived for the 2014 hydraulic model. The hydrograph shapes were deemed still representational of the events captured at the gauges and were not altered. The hydrograph shapes were then fitted to the revised peak flows in Table 1. For the other five ungauged catchments, the shape of the hydrographs derived from the FEH rainfall runoff method were fitted to the revised peak flows in Table 1, this is the same method as used in 2014 and is still appropriate.

7 TIDAL HYDROLOGICAL UPDATES 2021

The change to the tidal boundary is driven by:

- Availability of gauge data;

- Updates to Coastal Boundary Dataset (latest is 2018);
- Updates to latest climate change (CC) allowances for extreme tides and use of high emissions scenario (95th percentile estimate); and
- The design year pushing to 2140 (120 year design life from the present year).

The tidal boundary is summarised in Table 2.

Return Period (1 in x years)	Peak Tide Levels (m AOD) – Updated 2021		
	Extreme tide levels including surge	Climate change (m) – high emissions	Extreme tide levels including CC
2 year	2.45	0.736	3.19
200 year	3.1	0.736	3.84

Table 2: Peak tide levels for 2 & 200 year return periods

The latest tide level derivation applies a high emissions scenario for climate change at 95th percentile probability extrapolated to year 2140, as recommended by DfI Water & Drainage Policy Division document *'Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland'* published in February 2019[7] where A5WTC is regarded as a strategically important development and the Foyle area has 'cliff-edge' effects.

8 SENSITIVITY TESTS

The following sensitivity tests were undertaken to determine the sensitivity of the updated hydraulic model to changes in key parameters and to determine worst case design boundary conditions.

8.1 Joint Probability

Sensitivity tests show that the fluvial dominant joint probability scenario is the worst case for the majority of the length of the Burn Dennet and all other incoming watercourses in the Foyle catchment. Therefore, the fluvial Q100+35%CC with tidal T2+95th%ile CC has been used as the design return period along the majority of the length of the proposed A5WTC within the River Foyle system.

A tidal dominant joint probability return period was run (T200+95th%ile CC with Q2+35%CC) and this is the worst case scenario for Foyle from cross-section FOYL_23263 downstream (which is north of the Burn Dennet confluence but there is little or no interaction between the flood extents and the proposed A5WTC from the location downstream).

A medium joint probability scenario was also checked (Q25+35%CC with T10+95th%ile CC) to ensure water levels are not greater for Burn Dennet and Glenmornan watercourses that are in the tidal zone. Results show fluvial dominant is worst case and therefore is used in design.

8.2 Downstream Boundary

Further sensitivity was undertaken to check phasing of tidal peaks with fluvial peaks. The baseline model has been run such that the greatest tidal surge peaks at the same time as the peak of the hydrograph on the Mourne River. A -9 hour phasing scenario was run which aimed to coincide the tidal peak (with surge) with the peak of the Burn Dennet watercourse. Results show that water levels are not higher for this scenario for any of the 7 watercourses. Therefore, the original phasing which coincides the tidal peak with the peak of the River Mourne has been taken as the worst case design scenario for phasing.

8.3 Roughness

A global increase in Manning's value (+20%) in both the 1D and 2D domains resulted in water depths increasing by up to 10.4%. A global decrease in Manning's value (-15%) in both the 1D and 2D domains resulted in water depths decreasing by up to -8.7%. This shows that the model is only moderately sensitive to typical changes in roughness parameter. The range of manning's values used in the model (as provided in main report) are typical for the materials represented.

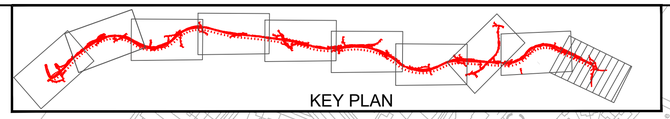
8.4 2D Boundary Condition

Sensitivity tests show that Vertical Wall 2D boundaries are most appropriate for the edge of all 2D Zones as this ensures no re-circulations or loss of flows from the model. Applying a normal depth boundary at the edge of the 2D domain results in loss of water from the upstream ends of the model and considerably lower water levels through the areas of interest which is not representative.

8.5 Conclusions to Sensitivity Tests

The sensitivity tests have confirmed the worst-case design scenario for the various watercourse crossings of the proposed A5WTC and given confidence that the boundaries used are appropriate and conservative. This has further proved that the model is a robust predictive tool to inform the scheme design and associated FRA.

APPENDIX G: FLOOD EXTEND



MATCHLINE SHEET 9

MATCHLINE SHEET 10

0+586.433

0+400

0+300

0+200

0+100

0+000

0+496.958

0+200

0+100

0+000

0+300.241

0+200

0+100

0+000

0+253.305

0+200

0+100

0+000

0+200

0+100

0+000

0+400

0+500

0+496.958

CARRICKNASLATE

Carricknaslate

Leggandorragh

Rosnakill

Reservoir (County Council)

Cooldrain Ridge

Finn Side Canal

Donaghan Middle

Donaghan Middle

Donaghan Middle

APPENDIX H: SECTION 50 APPLICATION

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**A5 Link**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Pablo Delgado**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ pdelgado@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**River Finn**			Catchment:	**River Finn Catchment**
Address (Townland – County):		**Curraghalane Townland, Co. Donegal**			
Grid Reference	X:	**632549.605**	Y:	**897082.772**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:		**495** Km^2		Road Reference:	**A5 Link**
Design Flood Flow:	**940.3** m^3/s			Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**13/07/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☐
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☐
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS [*1]	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☐	
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☒	**940.3**
FSR ☐	FSU ☐	Other ☒
Comments: Refer to the report for the different methods applied.		

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.35**
Irish Growth Curve	
Factor for Standard Error	
Other	**Varies. Refer to Appendix A**
OPW Arterial Drainage Scheme	
FSU Adjustment Factor	
Tidal ☐	
Comments	

Hydraulic/Structure Details

Description of Structure*3	**Multi-span bridge 287m long.**
Effective Conveyance Area *4	**1179.3 m2 (Upstream), 1179.8 m^2 (Downstream)**
Upstream Invert Level **0.07 mOD (Stream Level)**	Downstream Invert Level **0 mOD (Stream Level)**
Upstream Soffit Level **Varies 10.000mOD Minimum**	Downstream Soffit Level **Varies 10.000mOD Minimum**
Upstream Design Flood Level **7.222** mOD	Downstream Design Flood Level **7.222** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

EIAR APPENDIX C11.03

SECTION 3 FLOOD RISK ASSESSMENT REPORT

APPENDIX D:

MANORCUNNINGHAM SECTION 50 ASSESSMENT

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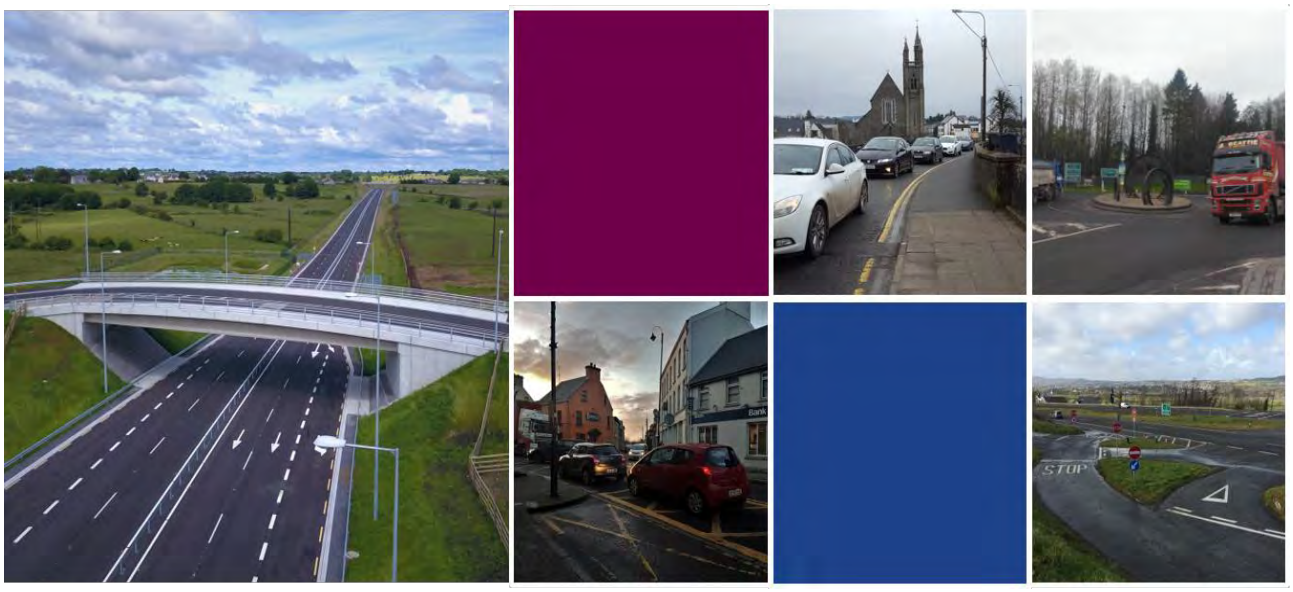
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TECHNICAL REPORT FOR OPW SECTION 50 APPLICATIONS MANORCUNNINGHAM

TEN-T Priority Route Improvement Project, Donegal

Section 3-N14 Manorcunningham to Lifford/Strabane/ A5 Link



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BARRY TRANSPORTATION

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1 INTRODUCTION

This report details the preliminary design location, size and associated hydrological calculations for the proposed watercourse crossings required in Manorcunningham to construct the works as part of the Section 3 – N14 Manorcunningham to Lifford/Strabane/ A5 Link section of the TENT-T Priority Route Improvement Project, Donegal.

1.1 Proposed Development

The proposed route is approximately 17.6km long and it commences at the N13/N14 junction. It then runs along a similar alignment as the existing N14 for approximately 800m. From here, the option continues in a similar westerly direction offline towards Drumoghill before turning south through Drumcairn. At this point, the proposed route continues towards the existing N14 at Sheskinapoll. It then aligns in a southeasterly direction for approximately 4km to Feddyglass running close to the existing N14. At this point, the option crosses the existing N14 continuing to the townland of Tamnawood. From here, it continues in a south easterly direction to Murlough; it curves then around to the east side of Croaghan Hill and subsequently in a southerly direction between Coneyburrow and Beechwood Park. Here, the termination point occurs next to the existing N15 on greenfield land.

1.2 Existing Watercourses

The proposed alignments of the mainline, side roads and access roads cross existing watercourses in numerous locations. Where these streams cross the proposed road , the consent of the OPW in accordance with Section 50 of the Arterial Drainage Act, 1945 is required.

This report is in support of an application for 6 such culverts under Section 50 of the Arterial Drainage Act, 1945; it forms the basis for Section 50 approval of these culverts located along this section of road in Co. Donegal. The Section 50 application forms for all culverts are enclosed in Appendix D. The location of all culverts, any required stream diversions and typical construction details are provided in Appendix B.

2 HYDROLOGICAL ESTIMATION

2.1 Calculation Methods

Most streams are ungauged and so the design flows have been estimated using several methods that take into account different parameters and the catchment size. These parameters were taken from the OPW website (Rainfall and Flood Estimation Applications) from ungauged locations.

The catchment size for the watercourses upstream of the proposed culverts were derived using a mixture of topographical surveying, discovery mapping and the information from a Lidar survey.

Table 2-1 below outlines the various methods applied.

Table 2-1: Design Flow Calculation Methods

Catchment size (Km^2)	Calculation Method	Method Reference
<0.4	ADAS	DN-DNG-03064 (TII)
0.4 to 25.0	IH 124	DN-DNG-03064 (TII)
0.4 to 25.0	FSSR 6, 3- Variable Method	FSU Web portal
0.4 to 25.0	FSU 3- Variable Method	FSU Web portal
0.4 to 25.0	FSU 4.2A Regression Model	FSU Web portal
>25	FSU 7-Variable Equation	FSU Web portal

The design flow was based on what was considered the most appropriate calculation method taking into consideration the topography and the catchment parameters.

There are several factors applied to the various methods. Below there is a description of them, but more details can be found in **Appendix A** “Hydraulic Calculations”.

- **Factorial Standard Error**: depending on whether the 68% or 95% confidence interval is required. The section below describes how this factor was applied.

- **OPW Adjustment Factor**: to consider the OPW maintenance of the stream. These are outlined in the section below.

- **Growth Factor**: to convert QBAR to Q100. For IoH 124 and FSSR 6, 3- Variable methods, a factor of 1.96 was used. For the FSU methods’ a factor of 2.14 was applied. This factor was derived from using the OPW’s FSU portal when determining the flow rate for the FSU-7 Variable method, but has been applied to FSU 4.2A and FSU 3- Variable Method as a conservative measure.

- **FSU Adjustment Factor**: determined when using the FSU-7 Variable Method as it is the only flow method where a pivotal site was used.

- **Climate Change Factor**: 1.20

For convenience the FSU flows have been converted from QMED to QBAR for the calculating procedure, as the IoH 124 and FSSR 6, 3 -Variable Method are based on QBAR. The conversion factor is QBAR= 0.96 QMED. As a result of this conversion, the flows using the FSU formulas’ are overestimated by approximately 5 %.

2.2 Catchments Methodology

Further to a review of the flow regimes in the vicinity of the proposed culverts, it was decided to divide the study area into five separate catchments. Below there is a description of each of the catchments, parameters used and the methodology applied.

2.2.1 Catchment A

FSU Method (7 Variable Equation as described in OPW Works package 2.3)

Whilst this catchment is less than 25 square kilometres it was decided to include the OPW's 7 variable method (as described in OPW Work Package 2.3) as part of the analysis, meaning a pivotal site was used. Location Node 39_431_3 was chosen and the following PCD's(Physical Catchment Descriptors) were provided(Refer to Figure 1 below and **Appendix A**). This is an ungauged catchment. The physical catchment descriptors for the catchment area and S1085 were adjusted following an analysis of the available topographical survey data, lidar data, Ordnance Survey mapping and Discovery Mapping.

The gauged station, 22009 White Bridge was chosen as the pivotal site, because following an analysis it was determined to be the most suitable. The calculations using the OPW FSU Web Portal provided the following Factors:

- QMED Adjustment Factor: 1.17(Refer to Figure 2 below).
- Growth Factor from QMED to Q100: 2.14.(Refer to Figure 3 below).
- OPW Adjustment Factor (Arterial Drainage Scheme): 1.

The FSU 7 Variable Method does not require an OPW adjustment factor to be used as the arterial drainage is accounted for as part of the Physical Catchment Descriptors. The flow derived using the FSU 7 Variable method was smaller than the chosen design flow which is based on the FSU 4.2 Regression Method.

The resulting flow from this method was 34.51 m3/s.

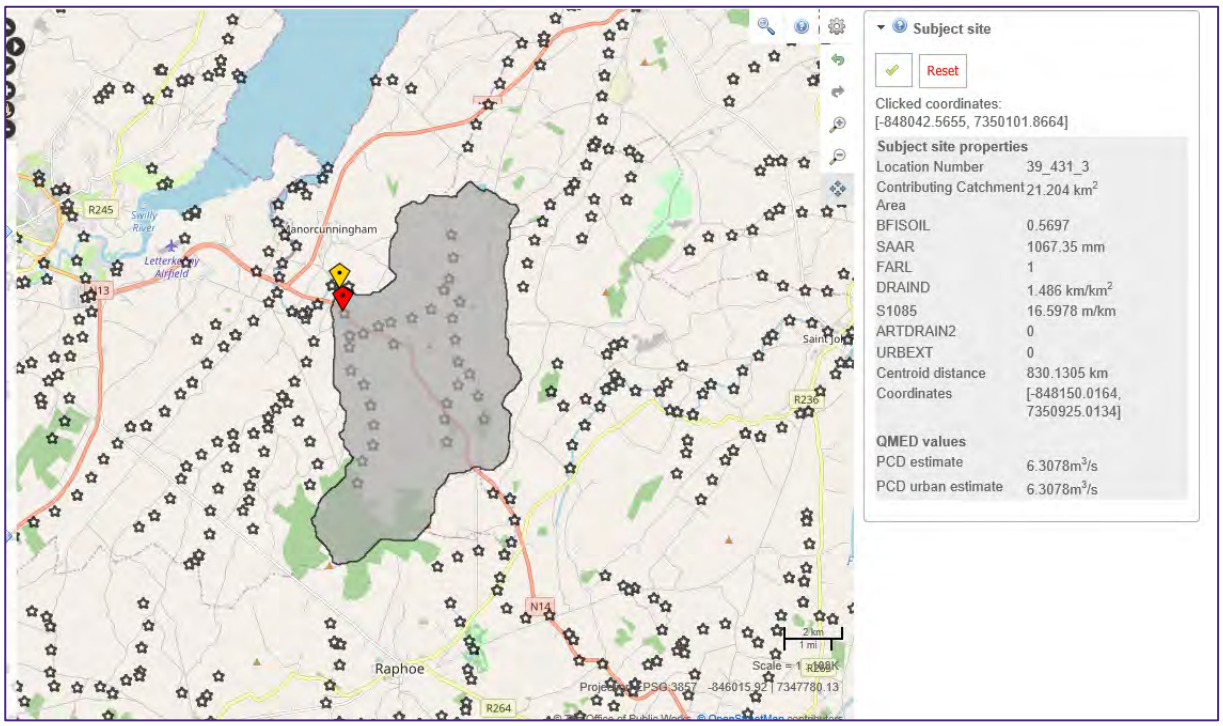


Figure 1 Catchment A PCD's

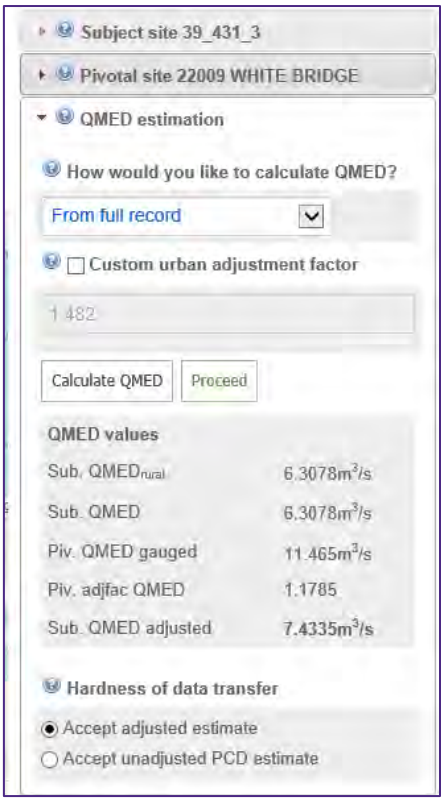


Figure 2 QMED Adjustment Factor

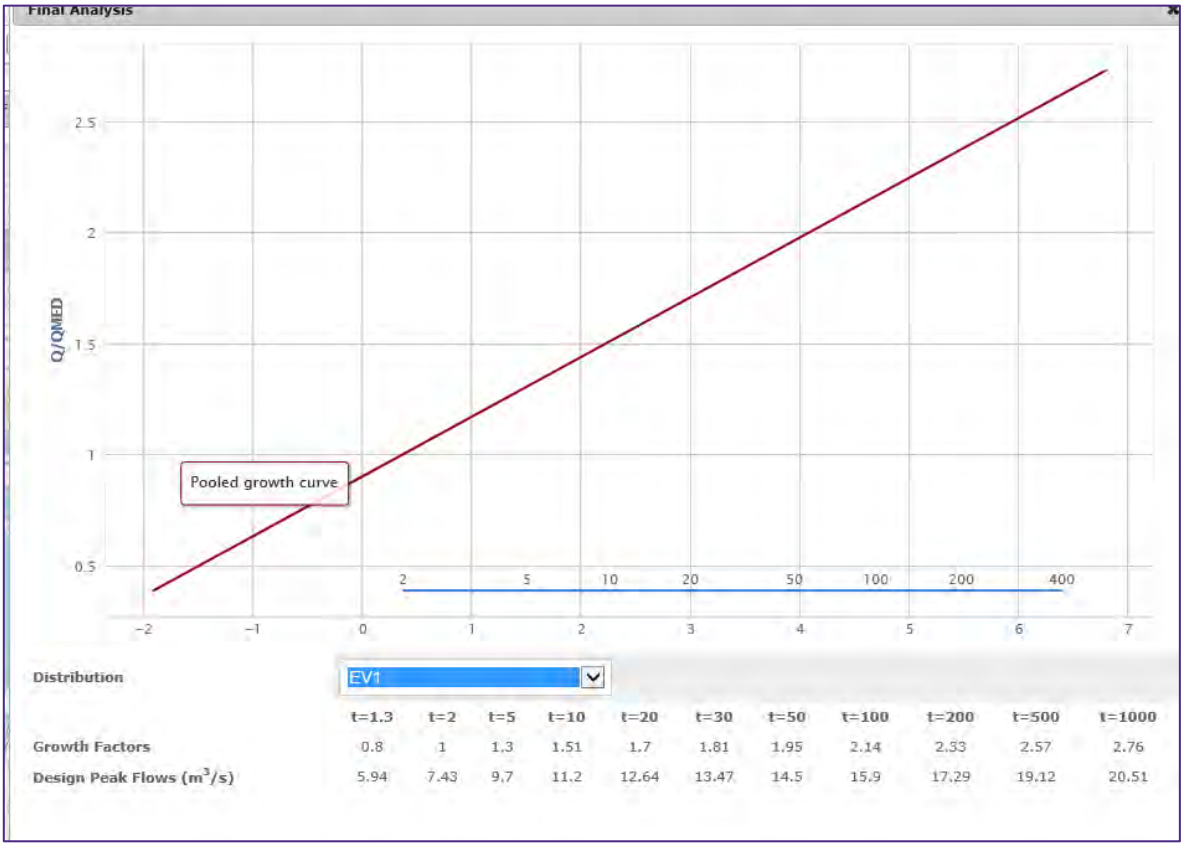


Figure 3 Growth Factor

Other Methods

The flows derived from the remaining four formula's have been provided in **Appendix A**. The FSU 4.2A Small Catchments Equation derived a flow of 41.60 m3/s and this was chosen as the design flow. This is a little bit higher than the one determined using the FSU 7 Variable Equation Method.

In relation to the OPW Adjustment Factor, it was estimated that approximately 700m of the main channel(at it's lower end within Catchment A) is maintained by the OPW. Refer to Figure 5 below. For this catchment, the main stream length is 7.7 kilometers and it is made up of a number of significant tributary streams which are not maintained. Due to the small portion of the catchment watercourse been maintained, an adjustment Factor of 1.1(as opposed to 1.6) was applied.

The flow rates derived for catchment A are already quite significant and are based on the 95% Confidence Interval as it was identified that there was a risk to properties in the vicinity. The decision to use a factor of 1.1 to take account of OPW maintenance, was based on the results from the FSU method, the small part of the channel maintained by the OPW, and the fact that the 95% confidence interval is been used, which is yielding significant flows.

2.2.2 Catchments B and C

The calculations for these catchments are provided in **Appendix A**. The FSU-7 Variable method was not used for none of these catchments as they are much smaller than the 25 km2 minimum requirement. In both cases, the FSU 4.2A equation was found to yield the highest result which was taken as the design flow. For both catchments B and C, the same Location Node 39_674_1 was chosen from the OPW's FSU website and the following PCD's(Physical Catchment Descriptors) were provided.(Refer to Figure 4). The physical catchment descriptors for the Catchments B and C's area and S1085 were adjusted following an analysis of the available topographical survey data, lidar data, Ordnance Survey mapping and Discovery Mapping.

There are sections of the main streams of these catchments that are part of the OPW Arterial Drainage Scheme so a factor of 1.6 was applied to the design flows. This is a conservative measure as the entire length of these streams are not maintained.

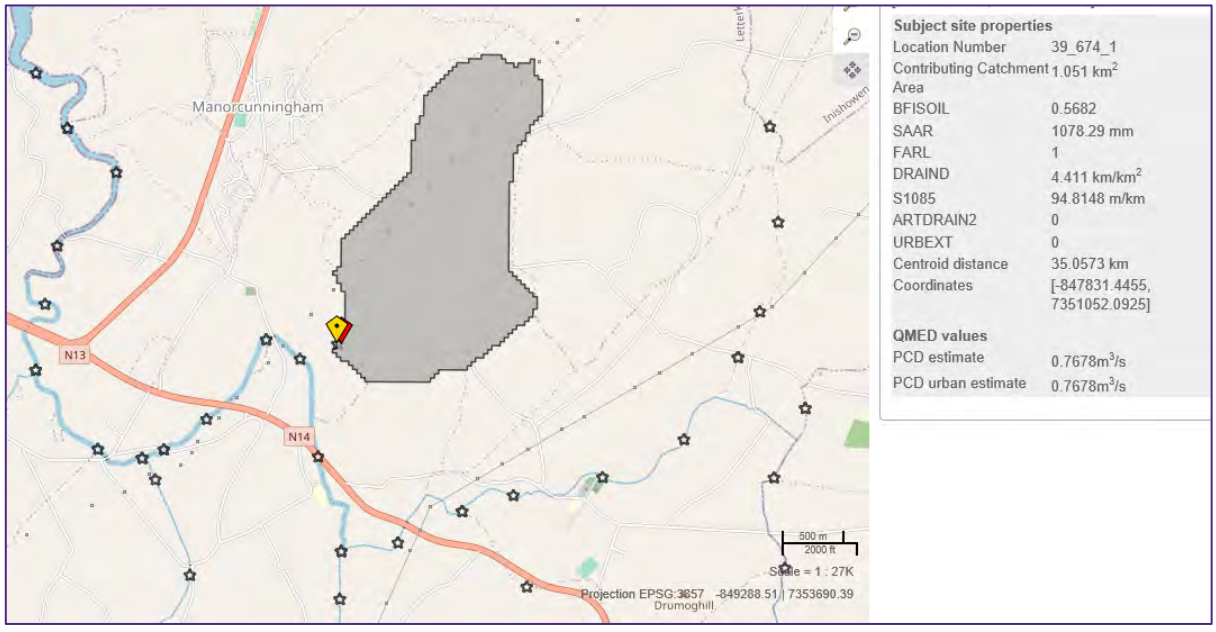


Figure 4 Catchments B and C PCD

2.2.3 Catchments D and E

These are small catchments downstream of the culverts whose areas are smaller than 0.4 km2. The only method applied here was the ADAS method.

As these streams form part of the OPW Arterial Drainage Scheme, a factor of 1.6 was applied to the calculations.

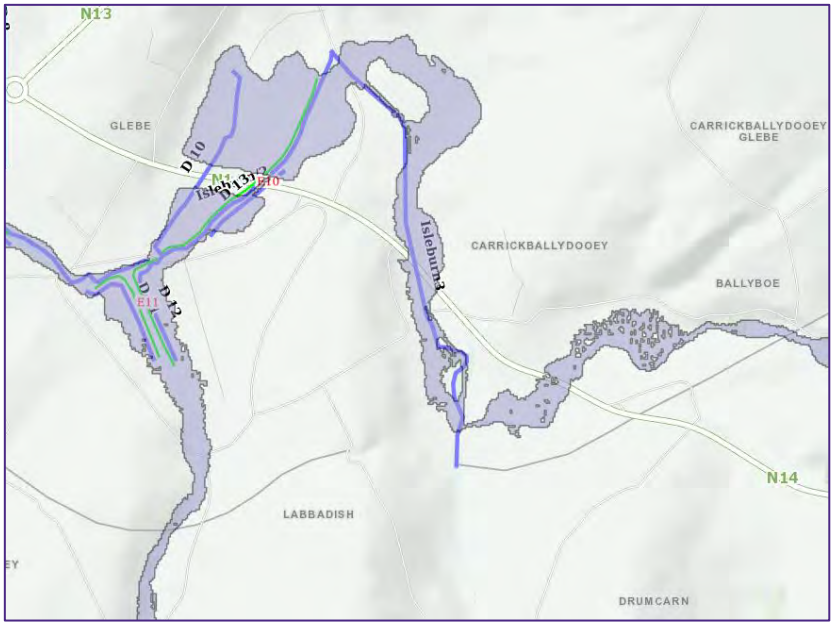


Figure 5 OPW Arterial Drainage Scheme

Table 2-2 Catchment Design Flows

Catchment Reference	Total Catchment Area (km2)	Q_{100}						Q_{100} + 20%
		ADAS	IoH 124	FSSR 6, 3 Variable Method	FSU 3 Variable Method	FSU 4.2A Regression	FSU 7 Variable Equation	(CC) (m3/s)
A	20.94	-	24.32	25.98	21.53	**34.67**	28.76	**41.60**
B	1.73	-	3.89	3.86	4.00	**7.91**	-	**9.50**
C	0.77	-	1.90	1.84	2.05	**3.11**	-	**3.73**
D	0.14	**0.43**	-	-	-	-	-	**0.52**
E	0.06	**0.23**	-	-	-	-	-	**0.28**

*Values in bold indicate the adopted Q_{100} (excl CC allowance). This Q_{100} includes all the OPW factors.

2.3 Recorded Flooding events

As part of the catchment analysis, a check was done on recorded flooding events in the region. The OPW's Flooding website identified two locations where historical flooding has occurred. Refer to Figure 6 below for the locations of these historical flood events. Both of these flooding events occur in Catchment C. From reference to the flooding report (as provided in Figure 7), it would appear that this flooding is due to the runoff from the elevated ground to the South East of the recorded flood event. This description is consistent with the

topography in the region. As the recorded flood event is outside the influence of this Section 50 Application, no alteration to the design has been carried out. However, it is considered that the provision of the proposed road and culverts will not worsen the existing situation.

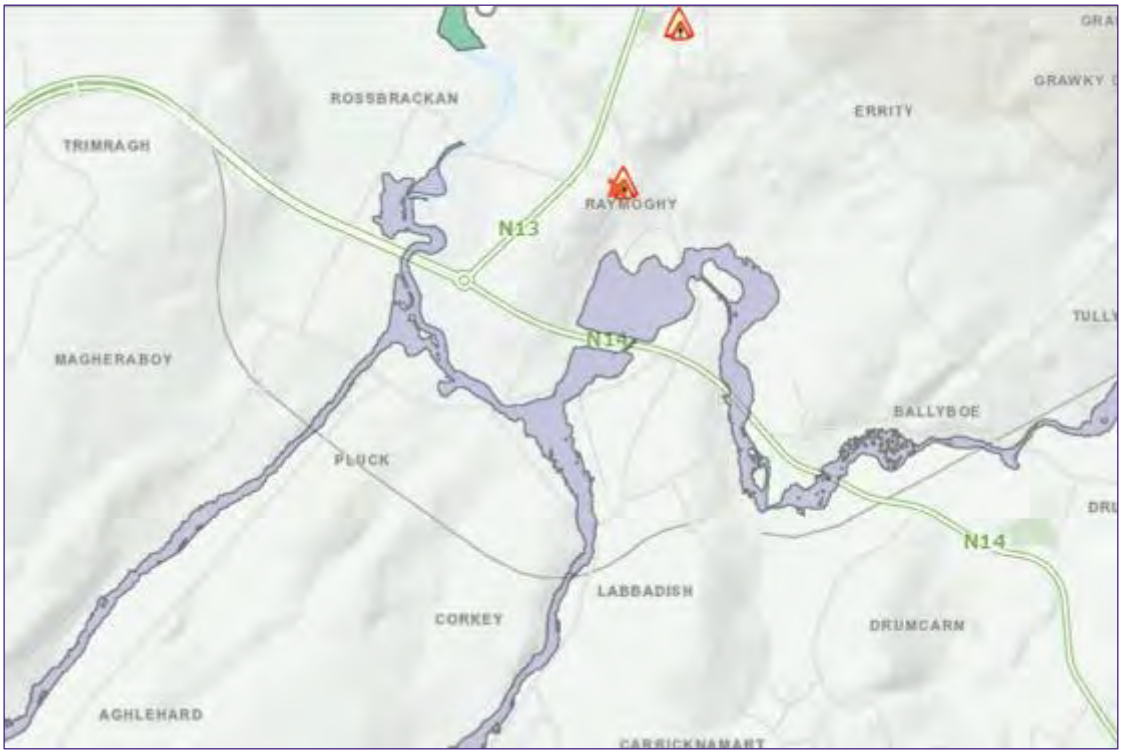


Figure 6 Historical Flood Events

L21. Manorcunningham 1 - Runoff from high ground causes flooding every 5 years approximately after very heavy rain. The road is liable to flood and properties are affected.
Flood Id = 4056

L22. Big Isle – Tidal flooding due to overtopping of and breaching of embankments due to exceptional high tide.
Flood Id = 343

L23. Manorcunningham 2 - Runoff from high ground causes flooding every 10 years approximately after very heavy rain. The road is liable to flood and properties are affected.
Flood Id = 4057

Figure 7 Extract from flooding report relating to historical flood events

3 HYDRAULIC MODELLING

A steady 1D hydraulic model was developed using HEC-RAS 5.0.3 software to calculate design water levels throughout the reach.

Topographical river sections were developed through the reach and flooding area's using. information from a variety of sources, e.g., lidar surveys, topographical surveys etc. The extents of the proposed embankments were taken from the modelled alignment which was in Civil CAD format.

Two separate models were developed with two scenarios for each one. Both models are on the same river, but relate to different locations; the extents of both models are indicated below. They are modelled at least 200-250 m upstream and downstream of the proposed road and they were developed for two scenarios: existing or pre-development scenario and post-development. Refer to Figure 8 below. The figure below shows the existing flooding in the area taken from the National Indicative Fluvial Mapping with AEP of 1%.

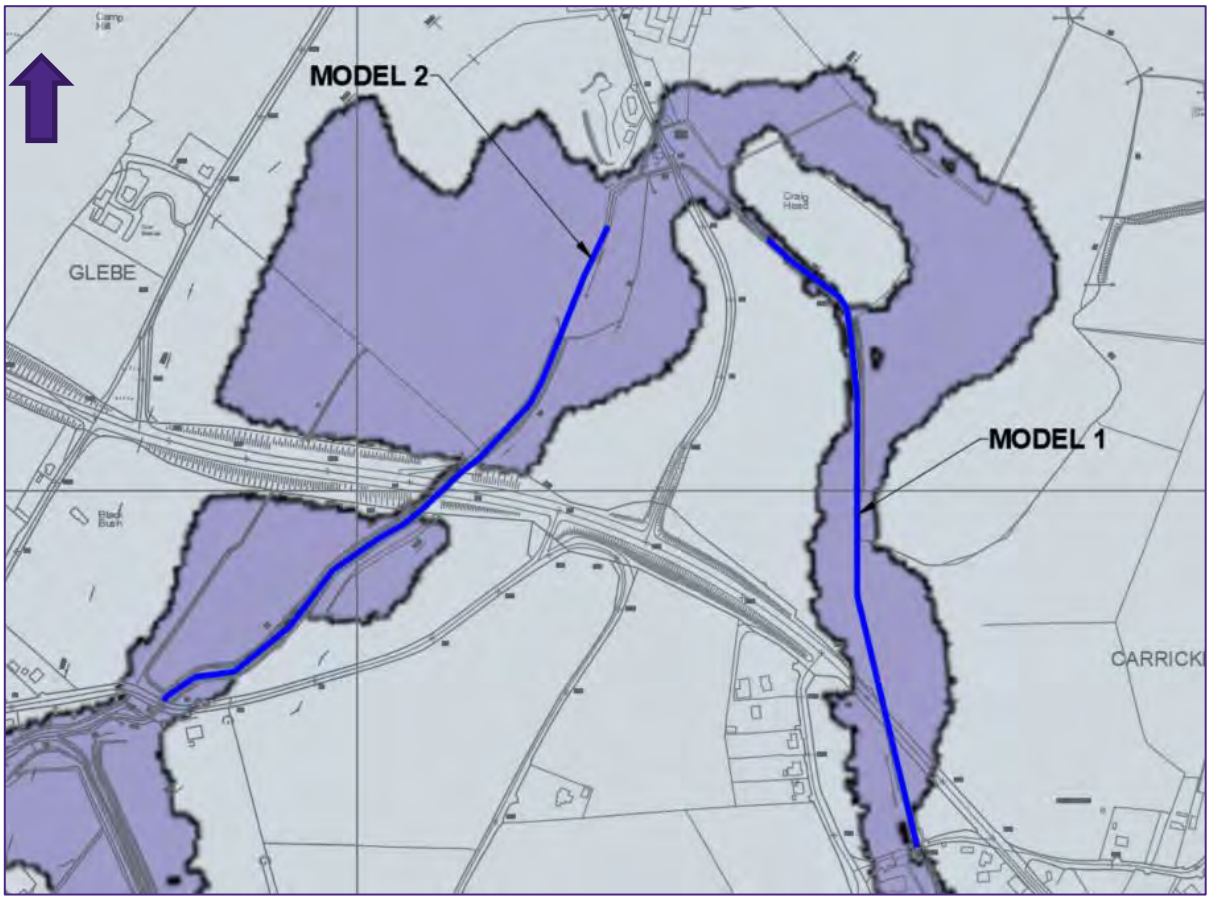


Figure 8 Models developed in HEC-RAS

The first model (Model 1) contains 17 cross sections and one existing culvert and the second model (Model 2) contains 16 sections, two existing culverts and one existing bridge. These two existing culverts in Model 2 will be replaced in the post-development scenario for new culverts.

3.1 Model 1

A schematic of the model is presented in Figure 9 below.

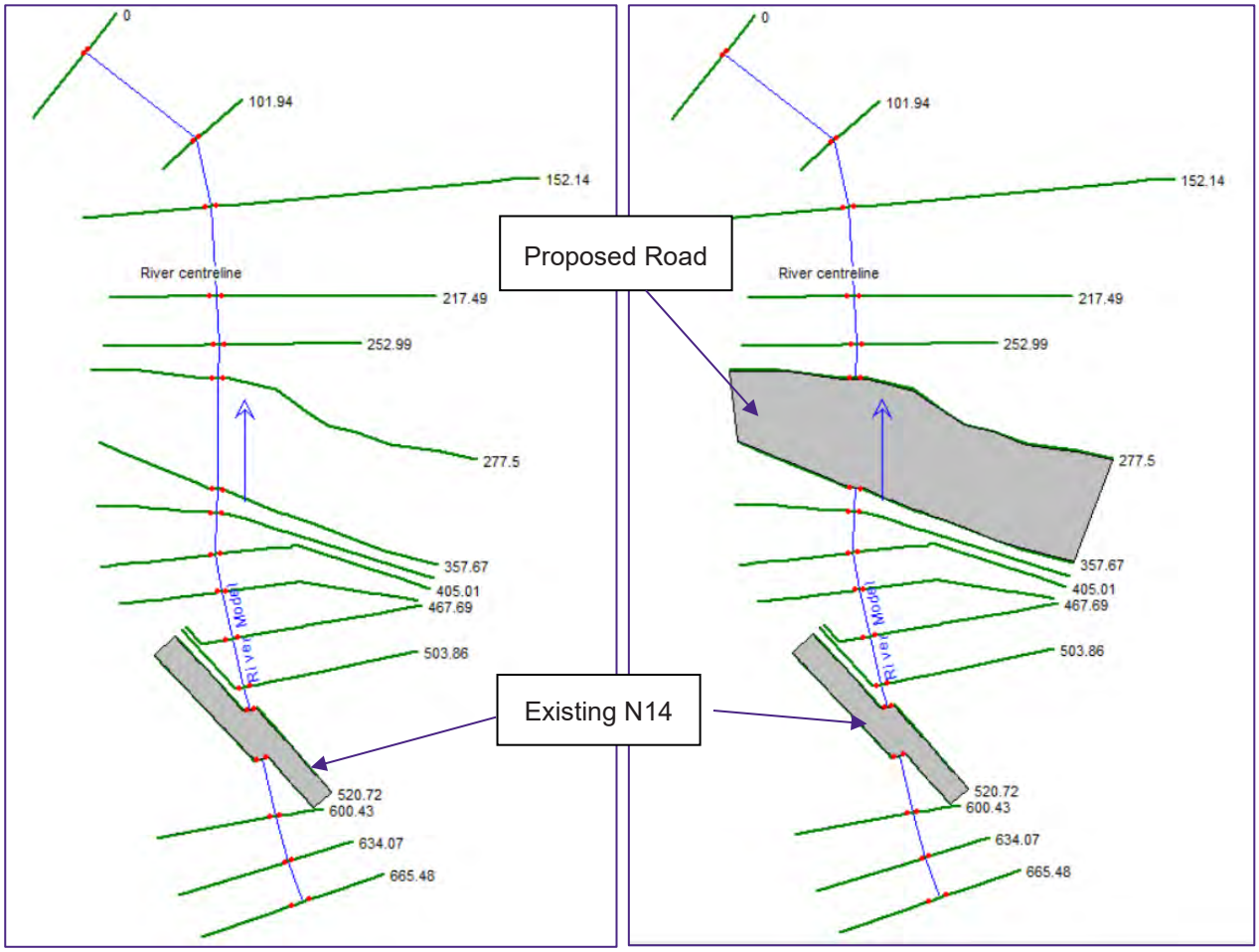


Figure 9 Model 1- Hydraulic models- Existing and Proposed scenarios

The design flow was applied as a single point inflow boundary at the first section (Station 665.48) with a flow of 41.60 m3/s and the normal depth was used as downstream boundary condition.

A manning's roughness coefficient of 0.04 was applied to the channel and the over banks based on Table 3-1 of the HEC-RAS Hydraulic Reference Manual considering the existing conditions of the river and the flood plain.

There is an existing culvert under the N14 that is currently flooded when there is a storm event for the 100 year return period. As the modelling indicates that flooding in the vicinity of this culvert will not be made worse by the development so it is not proposed to replace this culvert. Refer to drawing TT_Y16112-BT-1A-HDR-S3-DR-CD-05520_Flooding in Appendix B for locations of existing and proposed culverts. Also refer to Table 3-2 which indicates that the water levels do not change for the existing culvert (the culvert at station 539.07)

The modelling indicates that there will be a change in water level of approximately 110mm on the existing stream once culvert S3-Cul.06 is installed. Refer to Table 3-2 below ,stations 357.67 and 277.This is deemed acceptable since there are no properties at immediate flood risk and land impact is confined to the existing floodplain with negligible increase in floodplain area.

Figure 10 and Figure 11 below present a long section view of the existing and proposed scenarios with their respective culverts. The existing culvert floods in both scenarios but it hasn't been made worse.

The existing culvert has an estimated size of 5 x 3 m and the new culvert (S3-Cul.06) 12 x 3.2 m (width x height). Refer to Table 3-1 below for more information about this culvert. Culvert sizes and hydraulic outputs are specified in the next section.

Table 3-1 Culvert and stream details

Culvert Reference	Watercourse Ref.	Stream name	Mainline Chainage	Road Reference
S3-CUL.06	W3-03	Leslie Hill Stream_020	1+100	Mainline

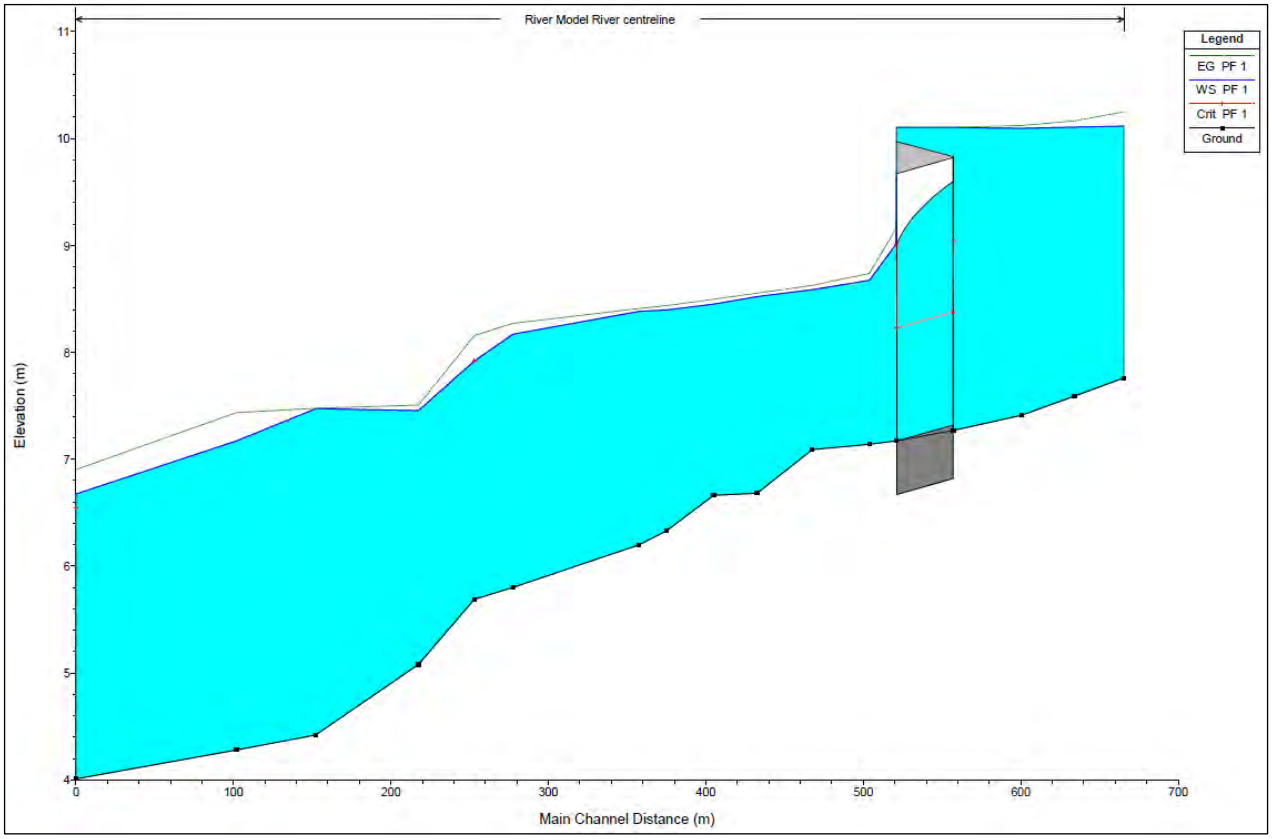


Figure 10 Surface Water Profile Plot - Existing Scenario

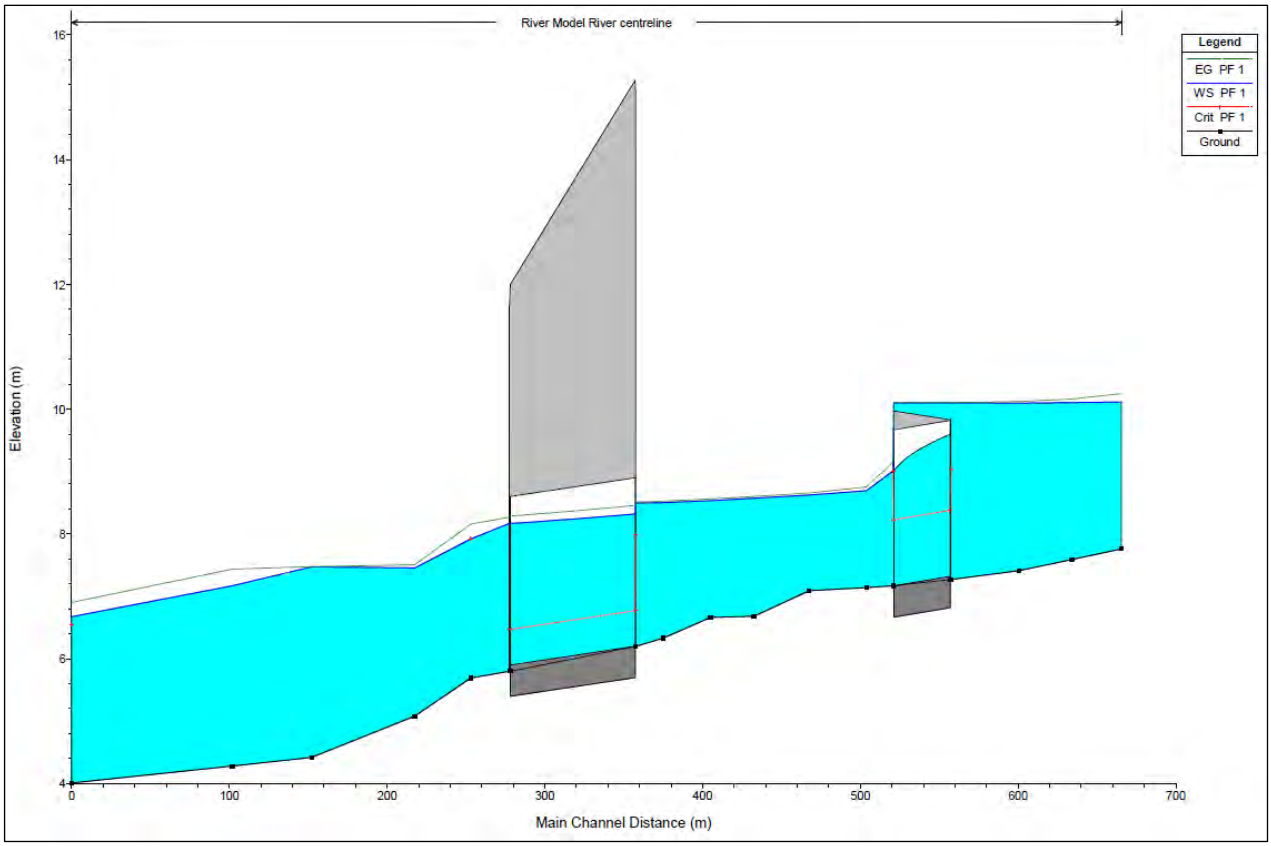


Figure 11 Surface Water Profile Plot - Proposed Scenario

It should also be noted that the potential impact is estimated for a very conservative 100-year flow including the 95 % confidence limit and the climate change condition. A summary of the critical hydraulic results are presented in Table 3-2 below.

Table 3-2 Summary hydraulic outputs for both scenarios

		Existing scenario		Proposed scenario	
River Station	**Q Total (m3/s)**	**W.S. Elev (m)**	**Vel. Chnl (m/s)**	**W.S. Elev (m)**	**Vel. Chnl (m/s)**
665.48	41.6	10.12	1.65	10.12	1.65
634.07	41.6	10.11	1.43	10.11	1.43
600.43	41.6	10.1	0.99	10.1	0.99
557.41	41.6	10.1	0.36	10.1	0.36
539.07		Culvert			
520.72	41.6	9.01	2.36	9.01	2.36
503.86	41.6	8.67	1.56	8.69	1.48

		Existing scenario		Proposed scenario	
River Station	**Q Total (m3/s)**	**W.S. Elev (m)**	**Vel. Chnl (m/s)**	**W.S. Elev (m)**	**Vel. Chnl (m/s)**
467.69	41.6	8.59	1.24	8.62	1.14
432.53	41.6	8.52	1.2	8.57	1.06
405.01	41.6	8.45	1.38	8.53	1.12
375.06	41.6	8.4	1.26	8.5	1
357.67	41.6	8.38	1.04	8.49	0.85
317.58		-	-	S3-CUL.06	
277.5	41.6	8.17	1.74	8.17	1.74
252.99	41.6	7.92	2.44	7.92	2.44
217.49	41.6	7.46	1.27	7.46	1.27
152.14	41.6	7.47	0.42	7.47	0.42
101.94	41.6	7.17	2.53	7.17	2.53
0	41.6	6.67	2.53	6.67	2.53

The flood extent downstream of the proposed road hasn't changed in the post-development scenario

The modelling indicates that the flood levels upstream of the existing culvert at Station 539.07 have not changed in the pre and post development scenario. Whilst there is some impact on the flood levels upstream of the new culvert S3-CUL.06, these are within the acceptable range and the maximum value is 110mm. There are no properties located in the region which is subject to water level variations. Whilst a pre and post development hydrographs would show some slight variation due the pre and post development scenarios, it is considered these changes are negligible.

3.2 Model 2

A schematic of the model is presented in Figure 12 below.

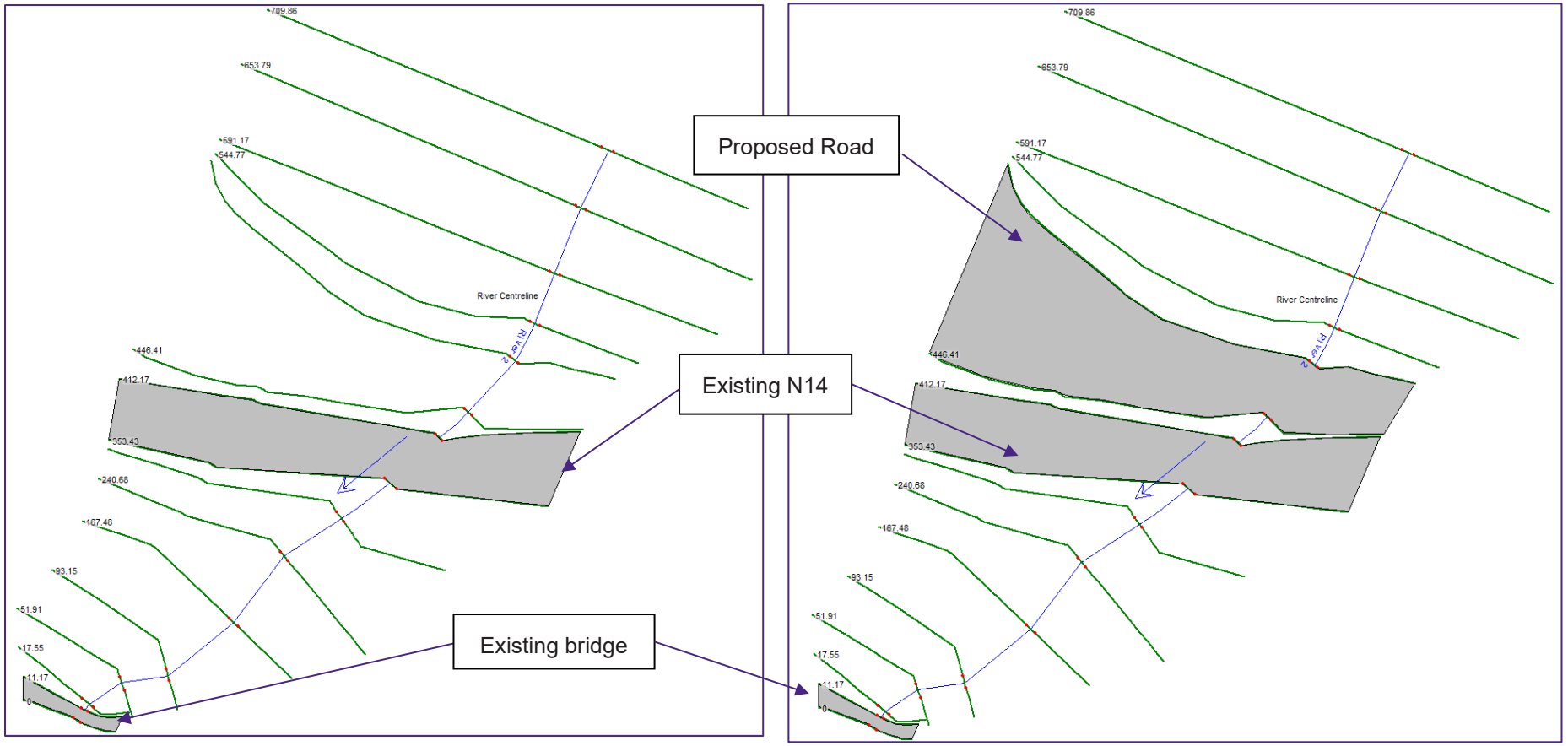


Figure 12 Model 2- Hydraulic models- Existing and Proposed scenario

There are five proposed culverts in this model for the post-development scenario. Two are along the main river/channel (Culverts S3-CUL.04 and S3-CUL.05) but there is also a small stream/ditch on the left hand side of the model that has been taken into account in the cross sections. The other proposed culverts S3-CUL.01, 02 and 03, are along this stream/ditch. Refer to Figure 13 below for the locations of the proposed culverts.

Figure 13 Proposed Culverts Locations



There are currently two culverts under the existing N14, the largest one being a single round corrugated steel structure of approx. 5 m diameter in the main river and the small one a box culvert of approximately 2.5 x 1.5 m in the small stream/ditch. These existing culverts are at the same location as the proposed culverts S3-CUL.05 and S3-CUL.03, respectively. They will be replaced in the post-development scenario.

The approach to modelling in the proposed scenario has been to model the main river channel along with Culverts S3-CUL.04 and S3-CUL.05 being provided. The three culverts on the minor stream (S3-Cul.01, S3-Cul.02 and S3-Cul.03) have been modelled as a single opening in the embankment, meaning, that, from a modelling perspective this will function as a flood alleviation culvert when there is a 1 in 100 Year Storm event in the main river channel. During the 1 in 100 year flood event, all culverts will have a minimum of 300mm freeboard. To consider the scenario when there was a 100 year storm event in the minor stream, but which did not occur in the main river channel, the minor culverts (S3-Cul,01, S3-Cul.02 and S3-Cul.03) were checked in Culvert Master to ensure they functioned adequately in isolation.

Refer to the Table 3-3 below for more information about these culverts. Culvert sizes and hydraulic outputs are specified in the next section.

Table 3-3 Culverts References

Culvert Reference	Watercourse Code	Stream name	Mainline Chainage	Road Ref.
S3-CUL.01	W3-01	Drainage ditch tributary to W3-02	0+574	Access Road
S3-CUL.02	W3-01	Drainage ditch tributary to W3-02	0+535	Mainline
S3-CUL.03	W3-01	Drainage ditch tributary to W3-02	0+500	Link South-Existing N14
S3-CUL.04	W3-02	Leslie Hill Stream_020	0+722	Mainline and Access Road
S3-CUL.05	W3-02	Leslie Hill Stream_020	0+670	Existing N14

In accordance with the different catchments outlined in the previous section, their flows were analysed and applied to different river stations:

Table 3-4 Design Flows

River Station	Flow (m3/s)
709.86	54.83
300.77	55.35
17.55	55.63

The normal depth was used as a downstream boundary condition. A manning's roughness coefficient of 0.04 was applied to the channel and the over banks based on Table 3-1 of the HEC-RAS Hydraulic Reference Manual considering the existing conditions of the river and the flood plain.

The existing flooding is held upstream of the N14 as their current culverts are probably undersized for the storm event in the 100 year return period and the road performs as a barrier.

The proposed scenario ensures that the new culverts provide a better conveyance than the existing conditions and won't block or worsen the flooding upstream. This is validated by the modelling results, which indicate a significant drop in pre and post development water levels due to the replacement of the culverts beneath the existing N14. Downstream of the Existing Bridge 2, the channel widens and there would appear to be significant conveyance capacity between Existing Bridge 2 and the open sea. The hydraulic modelling ends at the downstream end of Existing Bridge 1. The slope of the channel downstream of Existing Bridge 1 was set as the boundary condition in the hydraulic modelling. Whilst there may be a tidal influence during extreme flood events, it was found that during the 1 in 5 Year tidal event, water levels will not be impacted in the vicinity of Existing Bridge 1. The loss in flood plain storage is a consequence to applying the Section 50 criteria when replacing existing culverts; it is considered this could be prevented by providing weirs and hence preserving

the flood plain storage; however, it is considered this would not be appropriate in this instance, as the flood plain is not ecologically sensitive. The modelling has indicated that the water levels in the vicinity of Existing Bridge 1 will not change in the pre and post development scenario. Whilst a pre and post development hydrographs would show some variation due to the pre and post development scenarios, it is considered this is inevitable as part of the replacement of the undersized culverts beneath the existing N14; more importantly it is found that the water levels downstream have not changed.

Figure 14 Downstream Constraints of Model 2

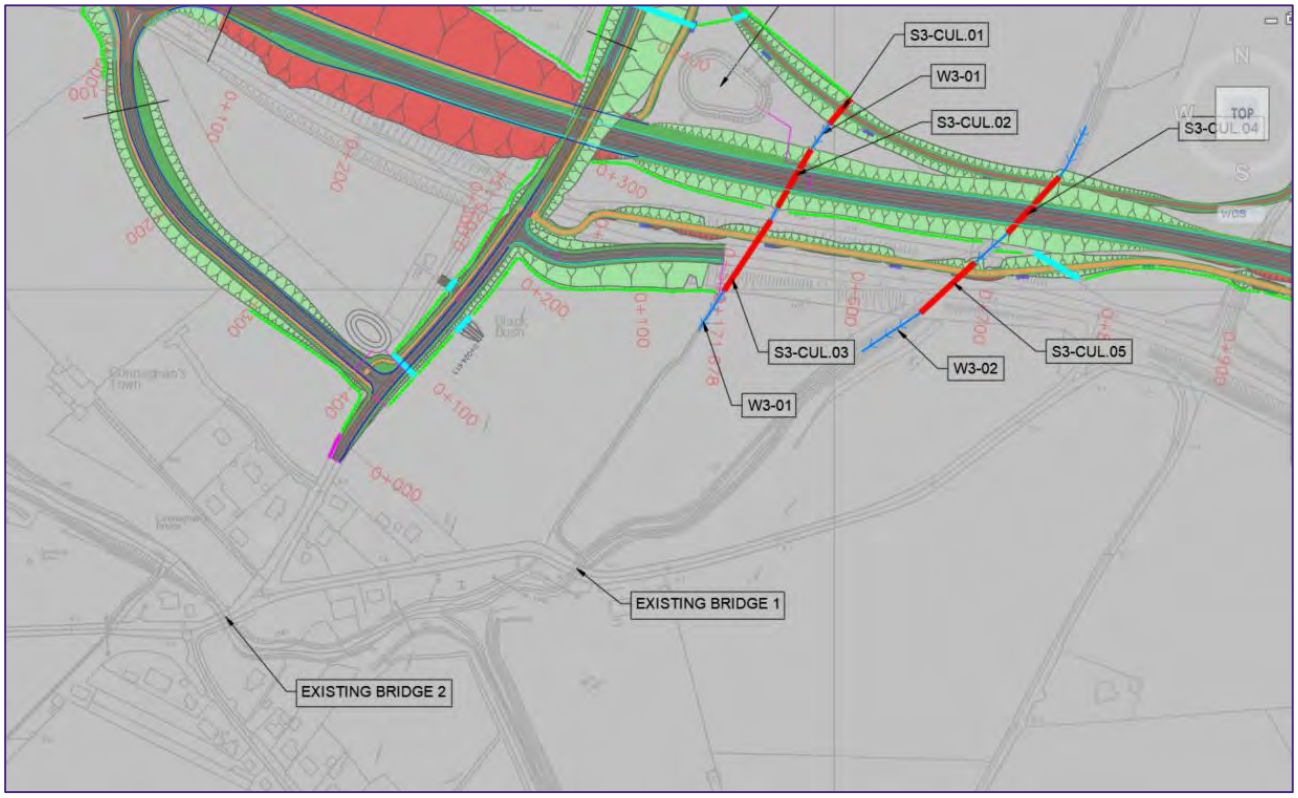


Figure 15 and Figure 16 below present a long section view of the existing and proposed scenarios with their respective culverts.

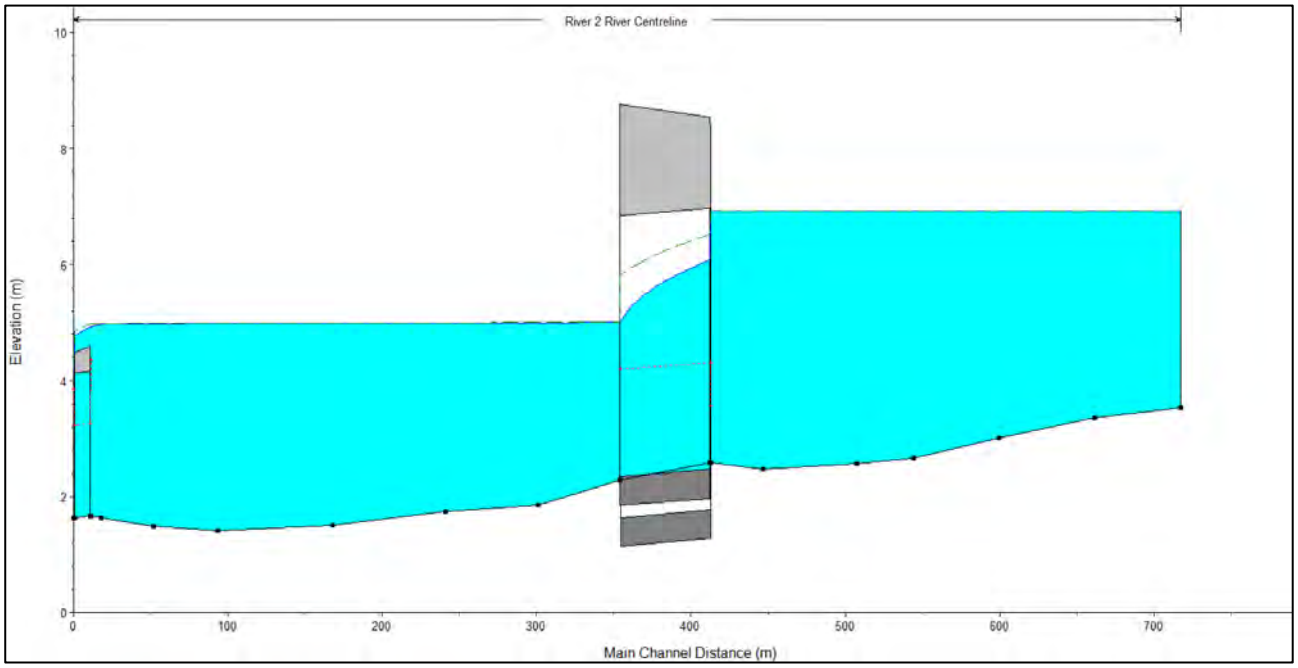


Figure 15 Surface Water Profile Plot - Existing Scenario

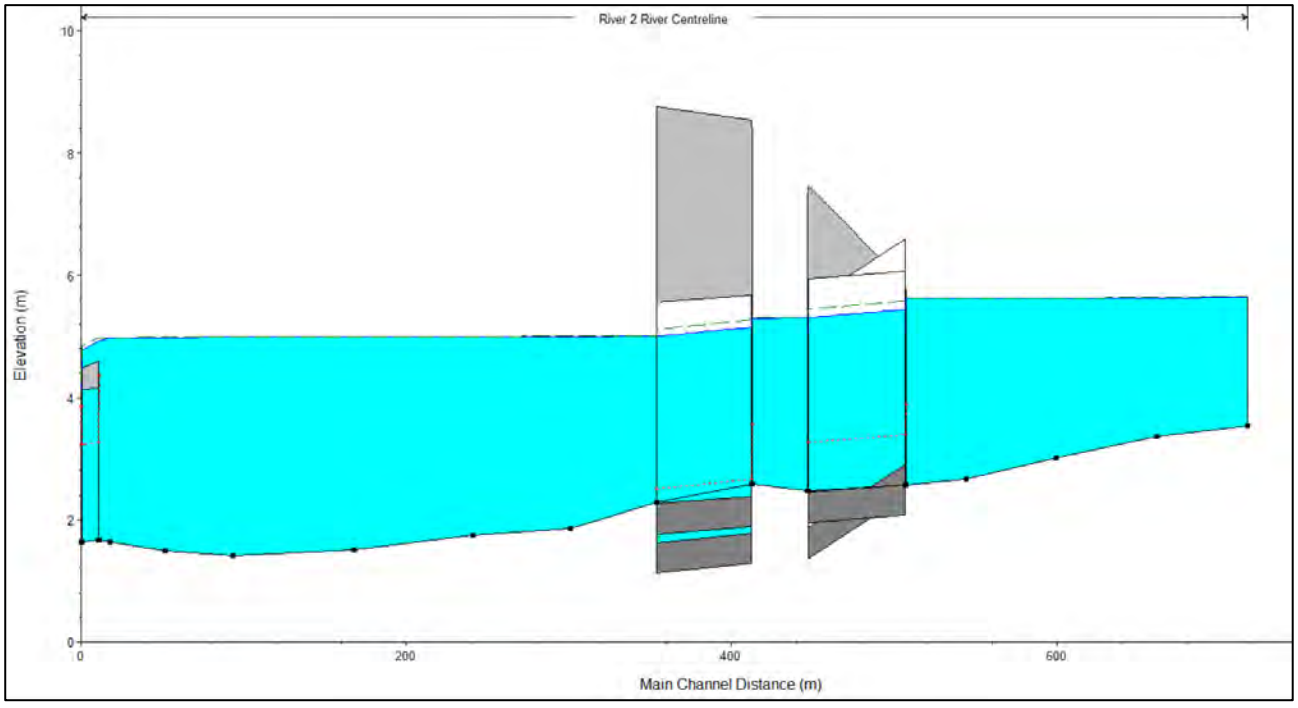


Figure 16 Surface Water Profile Plot - Proposed Scenario

As per Model 1, it should be noted that the potential impact is estimated for a very conservative 100-year flow including the 95 % confidence limit and the climate change condition. A summary of the critical hydraulic results are presented in Table 3-5 below.

Table 3-5 Summary hydraulic outputs for both scenarios

		Existing scenario		Proposed scenario	
River Station	**Q Total (m3/s)**	**W.S. Elev (m)**	**Vel. Chnl (m/s)**	**W.S. Elev (m)**	**Vel. Chnl (m/s)**
709.86	54.83	6.93	0.13	5.64	1.09
653.79	54.83	6.93	0.09	5.63	0.41
591.17	54.83	6.93	0.08	5.63	0.24
544.77	54.83	6.93	0.08	5.63	0.21
507.43	54.83	6.93	0.08	5.63	0.19
476.92				S3-CUL.01, S3-CUL.02, S3-CUL.04	
446.41	54.83	6.93	0.07	5.3	0.19
412.17	54.83	6.92	0.1	5.3	0.31
382.8		Existing Culverts		S3-CUL.03, S3-CUL.05	
353.43	54.83	5	0.28	5	0.28
300.77	55.35	5	0.19	5	0.19
240.68	55.35	5	0.21	5	0.21
167.48	55.35	4.99	0.26	4.99	0.26
93.15	55.35	4.99	0.31	4.99	0.31
51.91	55.35	4.98	0.5	4.98	0.5
17.55	55.63	4.97	0.54	4.97	0.54
11.17	55.63	4.93	1.24	4.93	1.24
5.585		Existing Bridge 1			
0	55.63	4.14	1.8	4.14	1.8

4 PROPOSED CULVERT DETAILS

4.1 Environmental Requirements

The watercourses affected by the construction works in this application are named in the drawings as W3-01, W3-02 and W3-03. The first one is a drainage ditch tributary to W3-02 with a lower value in terms of biodiversity, while the other two are part of the same watercourse Leslie Hill Stream_020.

When site surveys were carried out there was no evidence of fish observed in these watercourses and there was very little cover. Also, the water quality was unlikely to support some habitats but if improved it could have the potential to have fish. In addition, in terms of biodiversity, W3-02 and W3-03 were rated with a higher value for local importance.

The culverts have been designed in accordance with the recommendations of the IFI and the Guidelines for the crossing of watercourses during the construction of national roads scheme NRA.

Where mammal crossings have to be provided in the vicinity of watercourses, they will be provided as a separate pipe.

4.2 Culvert sizing calculations

The hydraulic analysis for the box culverts was undertaken in HEC-RAS and Culvert Master and in accordance with the CIRIA C689 Culvert Design and Operation Guide.

Manning's Roughness Coefficients of 0.04 and 0.013 were used for the bottom and top of the culverts respectively. They were based on the HEC-RAS Hydraulic Reference Manual.

For the culverts that were designed in Culvert Master a Manning's Roughness Coefficient of 0.04 was assumed based on CIRIA 689 Appendix A1 Table A1.1 for the tailwater conditions and the compound coefficient through the culvert was calculated to be 0.03.

Appendix C shows photographs of the location of existing watercourses where the proposed culverts will be located.

A summary of the resulting calculation outputs and proposed culvert details are given in Table 4-1 below. The dimensions are sufficient to incorporate a minimum freeboard of 0.3m and an embedment into the streambed of 0.5 m.

Table 4-1: Proposed Culvert Sizes & Hydrological Calculation Outputs

Culvert name	Type	Length	Size			Depth of embedment	USIL*	DSIL *	Culvert gradient	Freeboard Achieved Upstream (Min. 0.3 m)	Freeboard Achieved Downstream (Min. 0.3 m)
			Diameter	Width	Height (incl. embedment)						
		(m)		(m)	(m)	(m)	(mOD)	(mOD)	(1:x)	(m)	(m)
S3-CUL.01	Box	25.80	-	4.0	3.0	0.5	2.90	2.77	200.0	0.37	1.28
S3-CUL.02	Box	52.70	-	4.0	3.2	0.5	1.98	1.87	479.0	0.37	0.92
S3-CUL.03	Box	66.80	-	4.0	4.0	0.5	1.78	1.62	417.0	0.53	0.86
S3-CUL.04	Box	60.00	-	8.0	4.0	0.5	2.57	2.45	500.0	0.44	0.65
S3-CUL.05	Box	58.00	-	8.0	3.8	0.5	2.38	2.26	500.0	0.38	0.56
S3-CUL.06	Box	60.00	-	12.0	3.2	0.5	6.20	5.90	200.0	0.41	0.43

* Top of 500 mm embedment

APPENDIX A: HYDRAULIC CALCULATIONS

CATCHMENT A

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	12.09	m/km

1.2 Spatial PCD's

AREA - Catchment Area	20.94	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.486	km/km^2
ARTDRAIN2	0	

1.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ 4.144 m^3/s

2.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR 4.824 m^3/s

3.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED 4.678 m^3/s

QBAR 4.873 m^3/s

4.0 FSU 7 VARIABLE EQUATION(FSU WORK PACKAGE 2.3)

$$Qmed = 1.237X10^{-5}\,AREA^{0.937}\,BFIsoils^{-0.922}\,SAAR^{1.306}\,FARL^{2.217}\,DRAIND^{0.341}\,S1085^{0.185}\,(1+ARTDRAIN2)^{0.408}$$

QMED 5.874 m^3/s

QBAR 6.119 m^3/s

4.0 FSU 4.2 REGRESSION EQUATION

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

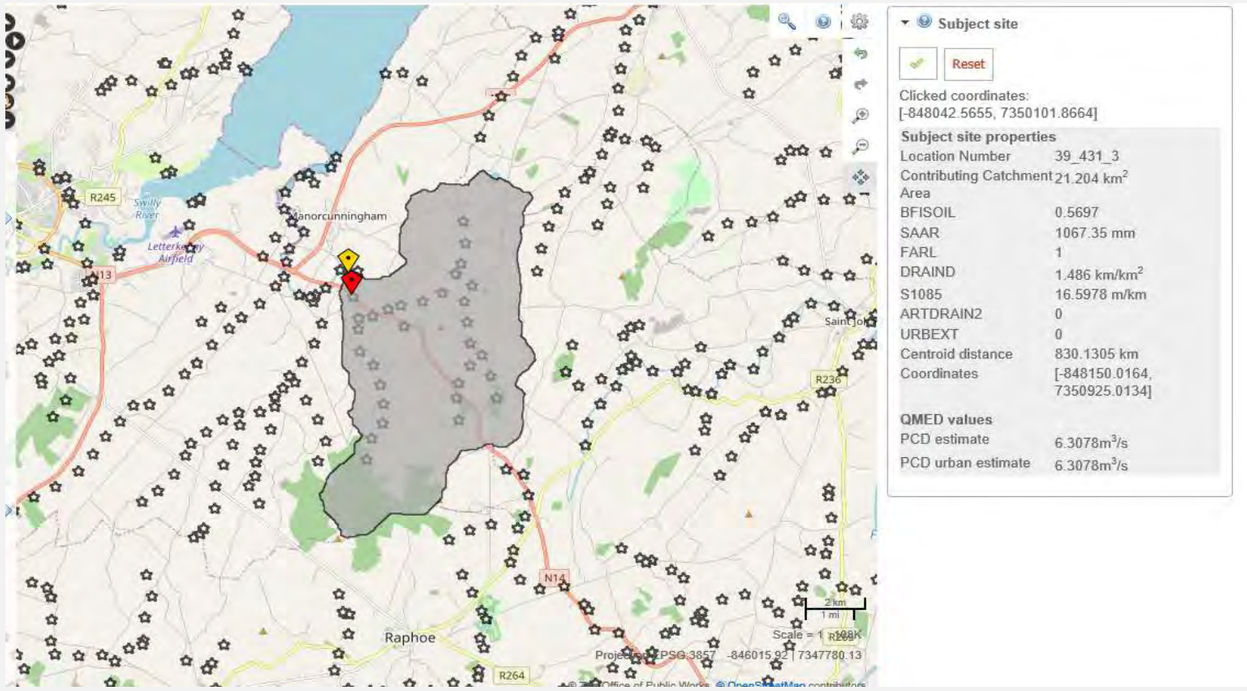
QMED 7.533323017

QBAR 7.847

Method	QBAR	FSE (68% C.I)	FSE 95% C.I	QBAR factored for 95% Coinfidence Interval	Factor to Q100 Growth Factor	100 Year Flow	OPW Factor	Flow including OPW Factor	FSU Adjustment Factor	Flow including FSU adjustment Factor	Climate Change Factor (20%)	Flow including Climate Change
IoH 124	4.14 m3/s	1.65	1.65	11.28 m3/s	1.96	22.11 m3/s	1.10	24.32 m3/s	1.000	24.32 m3/s	1.2	29.19 m3/s
FSSR 6, 3-Variable Method	4.82 m3/s	1.58	1.58	12.05 m3/s	1.96	23.62 m3/s	1.10	25.98 m3/s	1.000	25.98 m3/s	1.2	31.18 m3/s
FSU 3-Variable Method	4.87 m3/s	1.37	1.37	9.15 m3/s	2.14	19.57 m3/s	1.10	21.53 m3/s	1.000	21.53 m3/s	1.2	25.84 m3/s
FSU 2.3 Work Package(FSU 7 Variable equation)	6.12 m3/s	1.37	1.37	11.48 m3/s	2.14	24.58 m3/s	1.00	24.58 m3/s	1.170	28.76 m3/s	1.2	34.51 m3/s
FSU Regresion 4.2	7.85 m3/s	1.37	1.37	14.73 m3/s	2.14	31.52 m3/s	1.10	34.67 m3/s	1.000	34.67 m3/s	1.2	41.60 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT B

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	69.40	m/km

1.2 Spatial PCD's

AREA - Catchment Area	1.73	km^2
SAAR - Standard Annual Average Rainfall	1078	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	4.411	km/km^2
ARTDRAIN2	0	

1.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.456** **m^3/s**

2.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.493** **m^3/s**

3.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.598*	m^3/s
QBAR	**0.622**	**m^3/s**

4.0 FSU 7 VARIABLE EQUATION(FSU WORK PACKAGE 2.3)

$$Qmed = 1.237X10^{-5}\,AREA^{0.937}\,BFIsoils^{-0.923}\,SAAR^{1.806}\,FARL^{2.717}\,DRAIND^{0.344}\,S1085^{0.185}\,(1+ARTDRAIN2)^{0.408}$$

QMED		m^3/s
QBAR		**m^3/s**

4.0 FSU 4.2 REGRESSION EQUATION

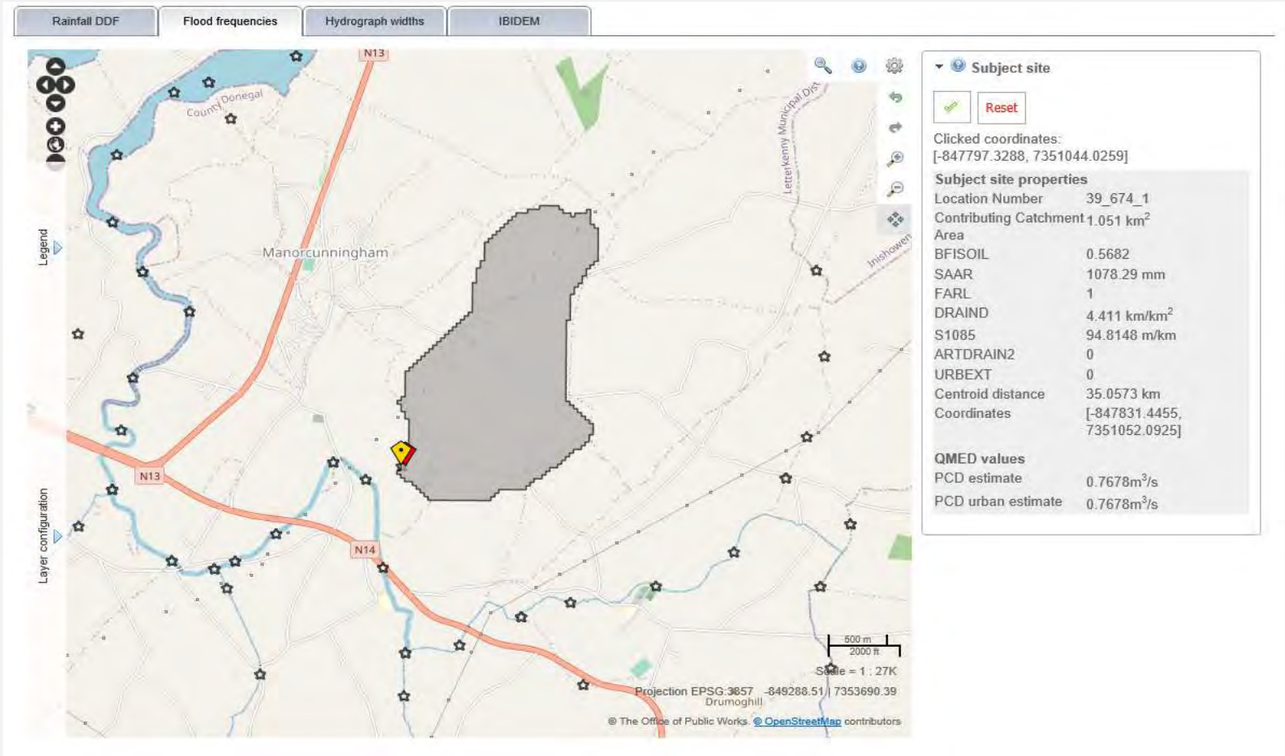
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFT^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	1.182309567
QBAR	*1.232*

Method	QBAR	FSE (68% C.I)	FSE 95% C.I	QBAR factored for 95% Coinfidence Interval	Factor to Q100 Growth Factor	100 Year Flow	OPW Factor	Flow including OPW Adjustment Factor	FSU Adjustment Factor	Flow including FSU adjustment Factor	Climate Change Factor (20%)	Flow including Climate Change
IoH 124	0.46 m3/s	1.65	1.65	1.24 m3/s	1.96	2.43 m3/s	1.60	3.89 m3/s	1.000	3.89 m3/s	1.2	4.67 m3/s
FSSR 6, 3-Variable Method	0.49 m3/s	1.58	1.58	1.23 m3/s	1.96	2.41 m3/s	1.60	3.86 m3/s	1.000	3.86 m3/s	1.2	4.63 m3/s
FSU 3-Variable Method	0.62 m3/s	1.37	1.37	1.17 m3/s	2.14	2.50 m3/s	1.60	4.00 m3/s	1.000	4.00 m3/s	1.2	4.80 m3/s
FSU 2.3 Work Package(FSU 7 Variable equation)	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A.	N.A.	N.A.	N.A	N.A
FSU Regresion 4.2	1.23 m3/s	1.37	1.37	2.31 m3/s	2.14	4.95 m3/s	1.60	7.91 m3/s	1.000	7.91 m3/s	1.2	9.50 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT C

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	32.30	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.774	km^2
SAAR - Standard Annual Average Rainfall	1078	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.486	km/km^2
ARTDRAIN2	0	

1.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\ AREA^{0.89}\ SAAR^{1.17}\ SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.223** **m^3/s**

2.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\ AREA^{0.92}\ SAAR^{1.22}\ SOIL^{2.0}$$

QBAR **0.235** **m^3/s**

3.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.307*	m^3/s
QBAR	**0.320**	**m^3/s**

4.0 FSU 7 VARIABLE EQUATION(FSU WORK PACKAGE 2.3)

$$Qmed = 1.237X10^{-5}\ AREA^{0.937}\ BFIsoils^{-0.922}\ SAAR^{1.306}\ FARL^{2.217}\ DRAIND^{0.344}\ S1085^{0.185}(1+ARTDRAIN2)^{0.408}$$

QMED	*0.325*	m^3/s
QBAR	**0.338**	**m^3/s**

4.0 FSU 4.2 REGRESSION EQUATION

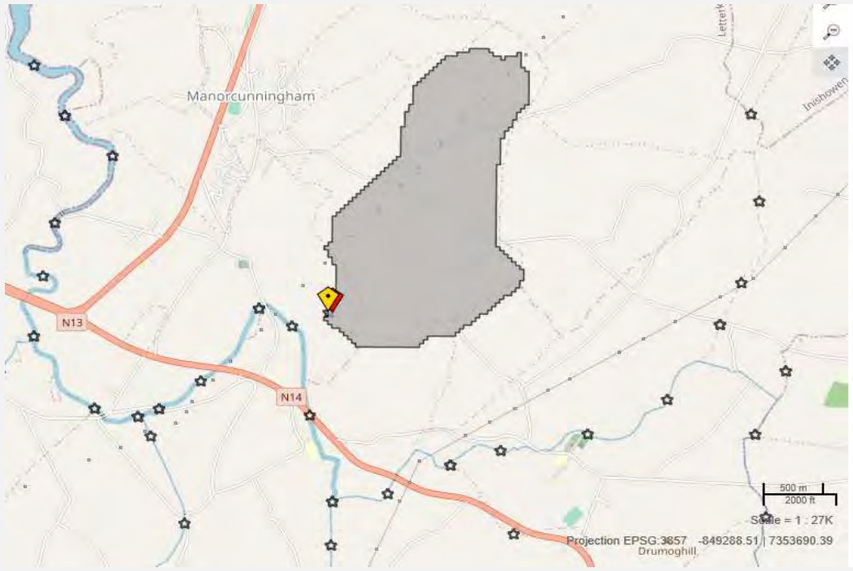
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	0.463983152
QBAR	*0.483*

Method	QBAR	FSE (68% C.I)	FSE 95% C.I	QBAR factored for 95% Coinfidence Interval	Factor to Q100	100 Year Flow	OPW Factor	Flow including OPW Adjustment Factor	FSU Adjustment Factor	Flow including FSU adjustment Factor	Climate Change Factor (20%)	Flow including Climate Change
IoH 124	0.22 m3/s	1.65	1.65	0.61 m3/s	1.96	1.19 m3/s	1.60	1.90 m3/s	1.000	1.90 m3/s	1.2	2.28 m3/s
FSSR 6, 3-Variable Method	0.24 m3/s	1.58	1.58	0.59 m3/s	1.96 1.96	1.15 m3/s	1.60	1.84 m3/s	1.000	1.84 m3/s	1.2	2.21 m3/s
FSU 3-Variable Method	0.32 m3/s	1.37	1.37	0.60 m3/s	2.14	1.28 m3/s	1.60	2.05 m3/s	1.000	2.05 m3/s	1.2	2.46 m3/s
FSU 2.3 Work Package(FSU 7 Variable equation)	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A.	N.A	N.A	N.A	N.A.
FSU Regresion 4.2	0.48 m3/s	1.37	1.37	0.91 m3/s	2.14	1.94 m3/s	1.60	3.11 m3/s	1.000	3.11 m3/s	1.2	3.73 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



Subject site properties

Location Number	39_674_1
Contributing Catchment Area	1.051 km^2
BFISOIL	0.5682
SAAR	1078.29 mm
FARL	1
DRAIND	4.411 km/km^2
S1085	94.8148 m/km
ARTDRAIN2	0
URBEXT	0
Centroid distance	35.0573 km
Coordinates	[-847831.4455, 7351052.0925]

QMED values

PCD estimate	0.7678m^3/s
PCD urban estimate	0.7678m^3/s

CATCHMENT D

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope		m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.14	km^2
SAAR - Standard Annual Average Rainfall	1067.98	mm
FARL - Flood Attenuation by Rivers and Lakes		

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}		
URBEXT	0	
SOIL	0.3	
DRAIND		km/km^2
ARTDRAIN2		

1.4 Catchment characteristics

Width	400	m
Height	26.3	m
Time of Concentration	5	min

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ m^3/s

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR m^3/s

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED m^3/s

QBAR m^3/s

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED m^3/s

QBAR m^3/s

6.0 ADAS

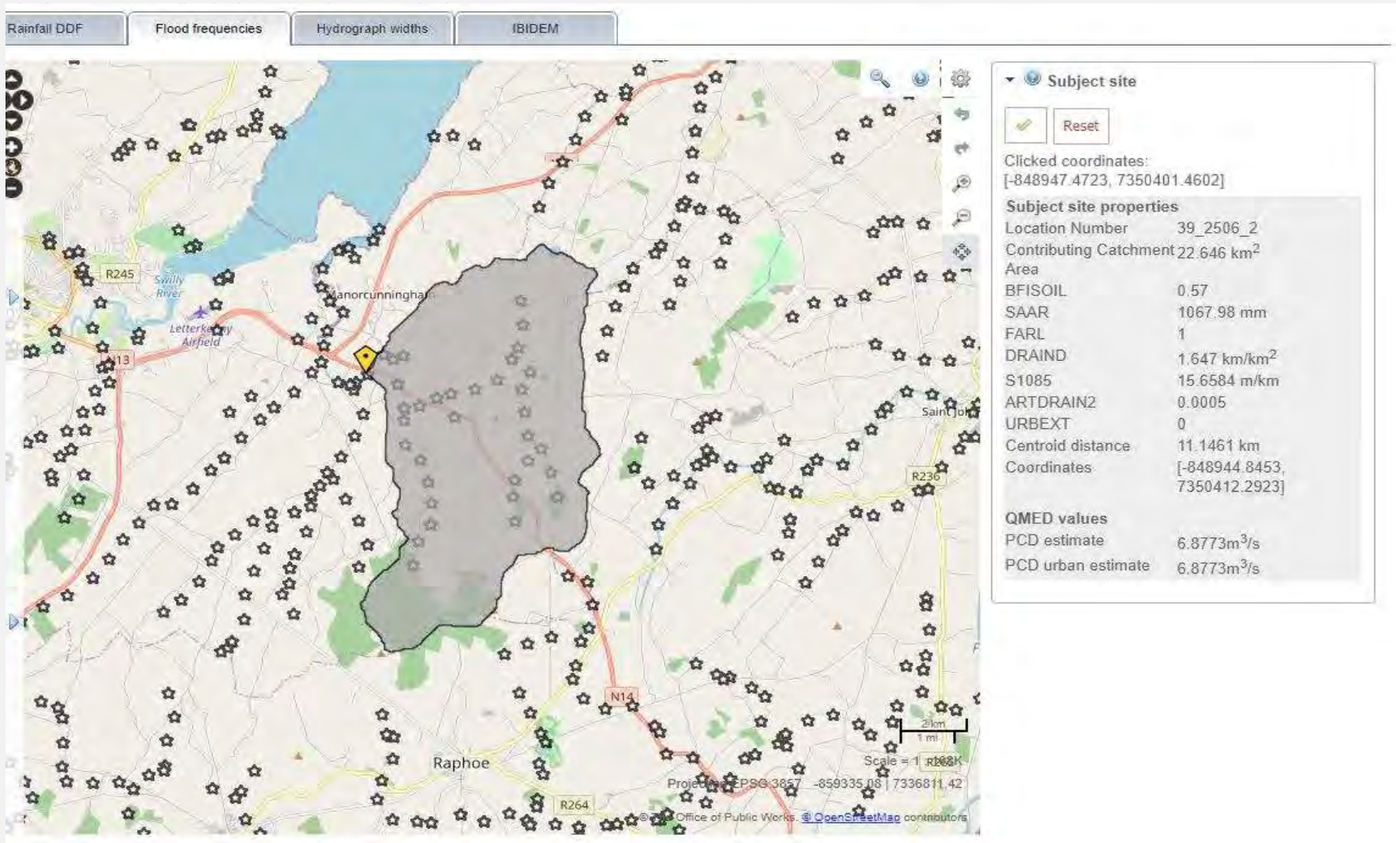
$$Q = AREA(0.0443SAAR - 11.19)SOIL^{2.0}\left[\frac{18.79T^{-0.28} - 1}{10T}\right] \qquad T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$$

Q 75 year *0.259* m^3/s

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124					
FSSR 6, 3-Variable Method					
FSU 3-Variable Method					
FSU 4.2A Regression					

Method	QBAR	Q 75 Year	100 Year Flow	OPW Factor	Climate Change
ADAS	0.138 m3/s	0.26	0.270 m3/s	0.43 m3/s	0.52 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW



CATCHMENT E

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope		m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.059	km^2
SAAR - Standard Annual Average Rainfall	1067.98	mm
FARL - Flood Attenuation by Rivers and Lakes		

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}		
URBEXT	0	
SOIL	0.3	
DRAIND		km/km^2
ARTDRAIN2		

1.4 Catchment characteristics

Width	185	m
Height	14	m
Time of Concentration	3.5	min

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ m^3/s

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR m^3/s

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFT^{1.539})$$

QMED m^3/s

QBAR m^3/s

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFT^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED m^3/s

QBAR m^3/s

6.0 ADAS

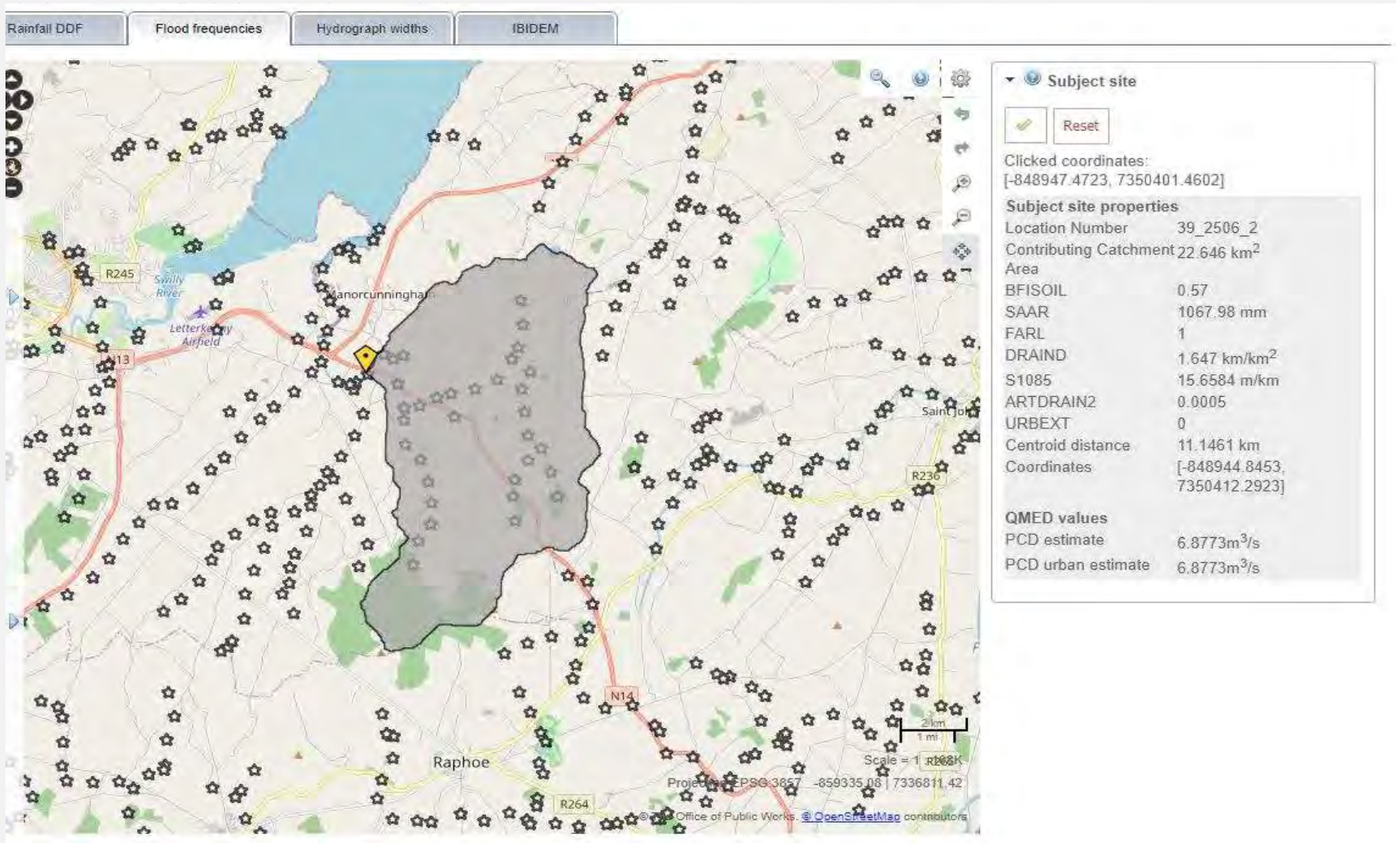
$$Q = AREA(0.0443SAAR - 11.19)SOIL^{2.0}\left[\frac{18.79T^{-0.28} - 1}{10T}\right] \qquad T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$$

Q 75 year *0.141* m^3/s

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124					
FSSR 6, 3-Variable Method					
FSU 3-Variable Method					
FSU 4.2A Regression					

Method	QBAR	Q 75 Year	100 Year Flow	OPW Factor	Climate Change
ADAS	0.075 m3/s	0.14	0.147 m3/s	0.23 m3/s	0.28 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW



Culvert Designer/Analyzer Report
S3-CUL.01

Peak Discharge Method: User-Specified					
Design Discharge	16.9700	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	2.90	m	Invert Downstream	2.77	m
Length	25.80	m	Slope	0.005039	m/m
Drop	0.13	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	16.9700	m³/s	Bottom Elevation	2.77	m
Depth	1.22	m	Velocity	3.73	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-4000 x 2500 Box	16.9700 m³/s	5.03 m	3.47 m/s

Culvert Designer/Analyzer Report
S3-CUL.01

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	5.03	m	Discharge	16.9700	m³/s
Headwater Depth/Height	0.85		Tailwater Elevation	3.99	m
Inlet Control HW Elev.	4.86	m	Control Type	Outlet Control	
Outlet Control HW Elev.	5.03	m			

Grades					
Upstream Invert	2.90	m	Downstream Invert	2.77	m
Length	25.80	m	Constructed Slope	0.005039	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.22	m
Slope Type	Mild		Normal Depth	1.84	m
Flow Regime	Subcritical		Critical Depth	1.22	m
Velocity Downstream	3.47	m/s	Critical Slope	0.015596	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	4.00	m
Section Size	4000 x 2500		Rise	2.50	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	5.03	m	Upstream Velocity Head	0.36	m
Ke	0.50		Entrance Loss	0.18	m

Inlet Control Properties					
Inlet Control HW Elev.	4.86	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	10.0	m²
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
S3-CUL.02

Comments: Channel slope calculated from culvert 2 outlet to culvert 3 outlet taking levels from culverts downstream inverts

Peak Discharge Method: User-Specified					
Design Discharge	16.9700	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	1.98	m	Invert Downstream	1.87	m
Length	52.70	m	Slope	0.002087	m/m
Drop	0.11	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	16.9700	m³/s	Bottom Elevation	1.87	m
Depth	1.78	m	Velocity	2.12	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-4000 x 2700 Box	16.9700 m³/s	4.31 m	2.38 m/s

Culvert Designer/Analyzer Report
S3-CUL.02

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	4.31	m	Discharge	16.9700	m³/s
Headwater Depth/Height	0.86		Tailwater Elevation	3.65	m
Inlet Control HW Elev.	3.94	m	Control Type	Outlet Control	
Outlet Control HW Elev.	4.31	m			

Grades					
Upstream Invert	1.98	m	Downstream Invert	1.87	m
Length	52.70	m	Constructed Slope	0.002087	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.78	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	1.22	m
Velocity Downstream	2.38	m/s	Critical Slope	0.015596	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	4.00	m
Section Size	4000 x 2700		Rise	2.70	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	4.31	m	Upstream Velocity Head	0.23	m
Ke	0.50		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	3.94	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	10.8	m²
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

Culvert Designer/Analyzer Report
S3-CUL.03

Comments: Channel slope calculated as an average from levels downstream as it seems quite irregular (levels going up and down). Measured slope at three different points from culvert outlet to last point of channel in the survey and to two more sections in the middle

Peak Discharge Method: User-Specified					
Design Discharge	20.8100	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	1.78	m	Invert Downstream	1.62	m
Length	66.80	m	Slope	0.002395	m/m
Drop	0.16	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	20.8100	m³/s	Bottom Elevation	1.62	m
Depth	2.64	m	Velocity	1.59	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-4000 x 3500 mm Box	20.8100 m³/s	4.75 m	1.97 m/s

Culvert Designer/Analyzer Report
S3-CUL.03

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	4.75	m	Discharge	20.8100	m³/s
Headwater Depth/Height	0.85		Tailwater Elevation	4.26	m
Inlet Control HW Elev.	4.26	m	Control Type	Outlet Control	
Outlet Control HW Elev.	4.75	m			

Grades					
Upstream Invert	1.78	m	Downstream Invert	1.62	m
Length	66.80	m	Constructed Slope	0.002395	m/m

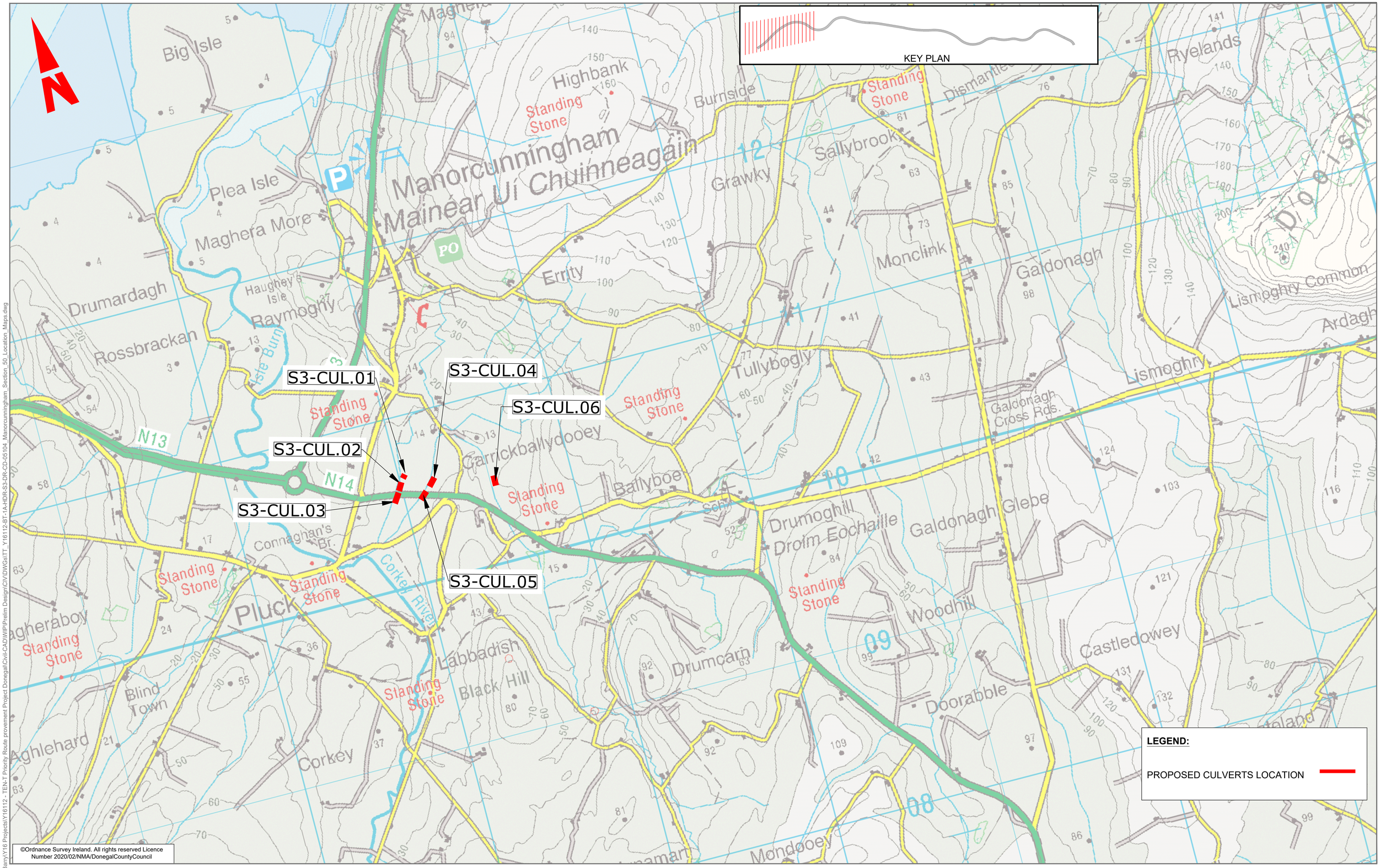
Hydraulic Profile					
Profile	M2		Depth, Downstream	2.64	m
Slope Type	Mild		Normal Depth	2.86	m
Flow Regime	Subcritical		Critical Depth	1.40	m
Velocity Downstream	1.97	m/s	Critical Slope	0.016014	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	4.00	m
Section Size	4000 x 3500 mm		Rise	3.50	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	4.75	m	Upstream Velocity Head	0.19	m
Ke	0.50		Entrance Loss	0.10	m

Inlet Control Properties					
Inlet Control HW Elev.	4.26	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares		Area Full	14.0	m²
K	0.02600		HDS 5 Chart	8	
M	1.00000		HDS 5 Scale	1	
C	0.03470		Equation Form	1	
Y	0.86000				

APPENDIX B: DRAWINGS



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\\IETRAMFS02\projects\Halcrow\Barry\Y16 Projects\Y16112 - TEN-T Priority Route provement Project Donegal\Civil-CAD\WIP\Prelim Design\CIV\DWGs\TT_Y16112-BT-1A-HDR-S3-DR-CD-05104_Manorcunningham_Section_50_Location_Maps.dwg

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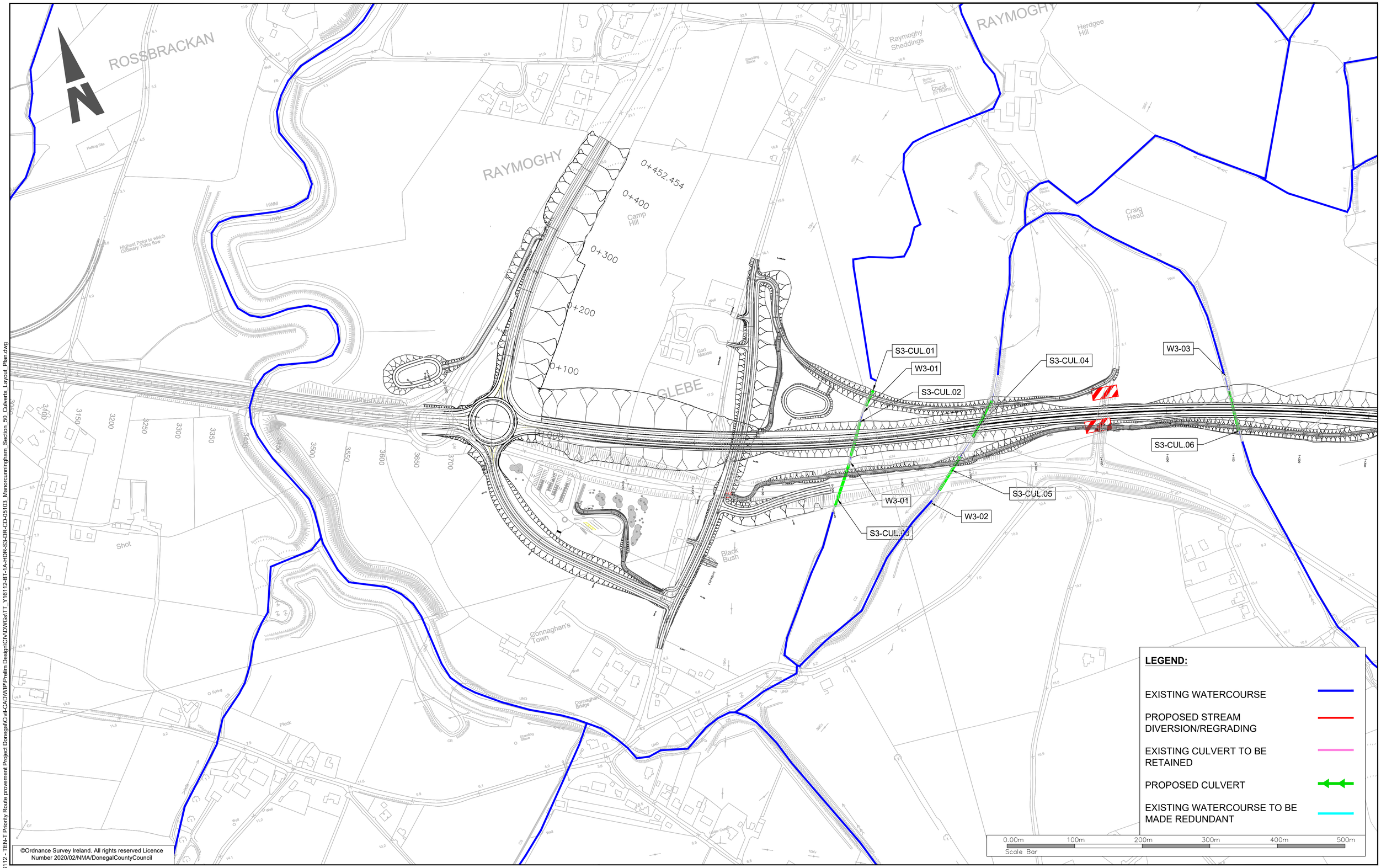
Rev.	Date	Drawn	Description	Chk'd	Appr.
P02	18/10/22	JM	ISSUED FOR SECTION 50 APPROVAL	SHS	RF
P01	03/06/22	JM	REVIEW & COMMENTS	SHS	RF

Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Manorcunningham Section 50 Location Maps

Status: S4

Designed: SHS	Date: JUNE 2022	Model File Identifier:	Rev:
Drawn: JM	Scale @ A1: 1:10000	TT_Y16112-BT-1A-HDR-S3-DR-CD-05104_Manorcunningham_Section_50_Location_Maps	P02
Approved: ED	@ A3: 1:20000	File Identifier:	
Checked: RF	Sheet: 1 OF 1	Y16112-500-532	



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Rev.	Date	Drawn	Description	Chk'd	Appr.
P02	19/10/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED
P01	03/11/21	LRB	FOR REVIEW & COMMENTS	SHS	RF

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts Plan Layout

Status: S4

Designed:	SHS	Date: JUNE 2022	Model File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05020_Section_50_Applications_
Drawn:	LRB	Scale @ A1: 1:2500	
Approved:	ED	@ A3:	File Identifier: Y16112-0500-020
Checked:	RF	Sheet: 1	Rev: P02

CATCHMENT B
Area = 1.73 Km²

CATCHMENT C
Area = 0.77 Km²

CATCHMENT D
Area = 0.14 Km²

CATCHMENT E
Area = 0.06 Km²

CATCHMENT A
Area = 20.94 Km²

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LEGEND:
EXISTING WATERCOURSE

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P01	24/05/22	JMG	REVIEW & COMMENTS	RF	RF

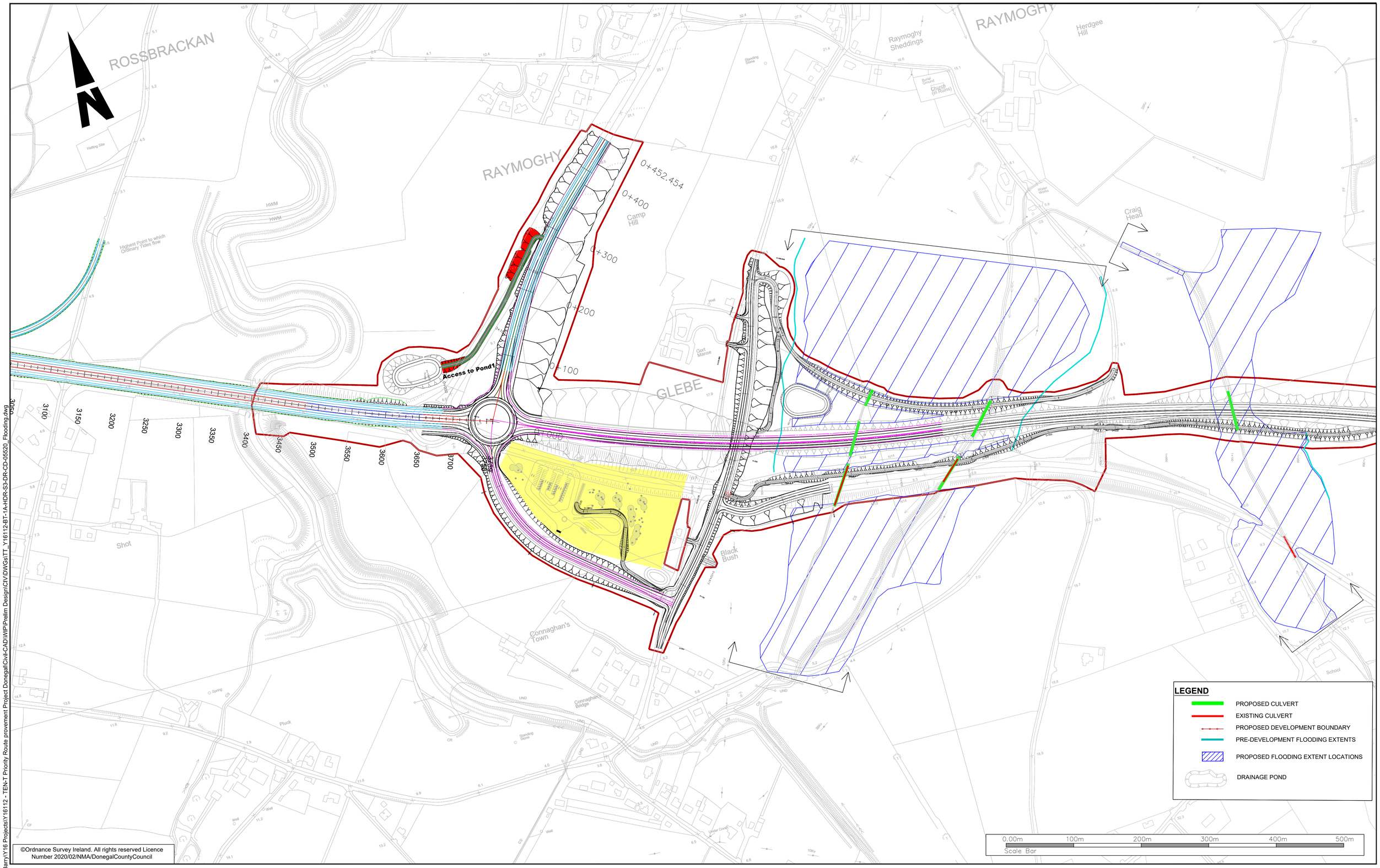
Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: SECTION 50 CULVERTS CATCHMENTS

Status: S4

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Drawn:	JMG	Scale @ A1: 1:10000 @ A3: 1:20000	Rev: P02
Approved:	ED		File Identifier: Y16112-0500-035
Checked:	RF	Sheet: 1	

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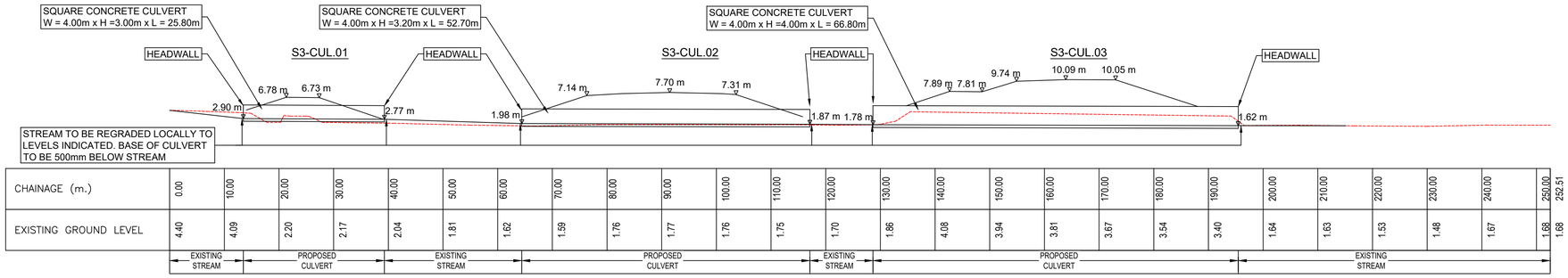
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P01	25/05/2022	JMG	ISSUED FOR REVIEW & COMMENTS	SHS	RF
P01	10/01/22	LRB	ISSUED FOR REVIEW & COMMENTS	SHS	RF

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: FLOODING DRAWINGS

Status: S4

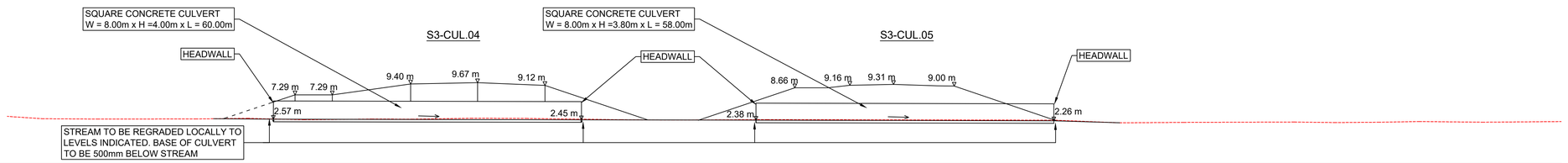
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Drawn:	LRB	Scale @ A1: 1:2500	Rev: P02
Approved:	ED	@ A3: 1:5000	File Identifier: Y16112-0500-521
Checked:	RF	Sheet: 1	



CHAINAGE (m.)	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	252.51
EXISTING GROUND LEVEL	4.40	4.09	2.20	2.17	2.04	1.81	1.62	1.59	1.76	1.77	1.76	1.75	1.70	1.86	4.08	3.94	3.81	3.67	3.54	3.40	1.64	1.63	1.53	1.48	1.67	1.68	1.68
	EXISTING STREAM		PROPOSED CULVERT		EXISTING STREAM			PROPOSED CULVERT					EXISTING STREAM		PROPOSED CULVERT						EXISTING STREAM						

LONG SECTION ALIGNMENT No. 1

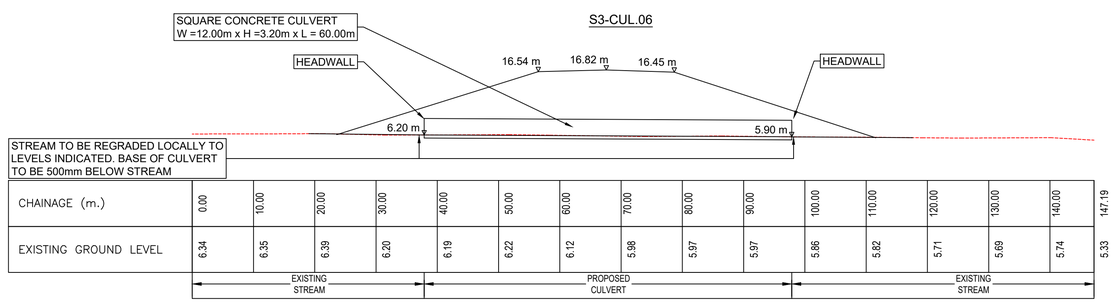
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EXISTING GROUND LEVEL	3.10	2.62	2.58	2.59	2.64	2.64	2.46	2.57	2.58	2.72	2.70	2.58	2.45	2.38	2.43	2.47	2.45	2.43	2.41	2.39	2.37	2.12	1.87	1.93	1.97	2.00	1.91	2.01	2.05	1.99	2.07	2.09
	EXISTING STREAM					PROPOSED CULVERT							EXISTING STREAM			PROPOSED CULVERT						EXISTING STREAM										

LONG SECTION ALIGNMENT No. 2

SCALE 1:500



CHAINAGE (m.)	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	147.19
EXISTING GROUND LEVEL	6.34	6.35	6.39	6.20	6.19	6.22	6.12	5.98	5.97	5.97	5.86	5.82	5.71	5.69	5.74	5.33
	EXISTING STREAM				PROPOSED CULVERT						EXISTING STREAM					

LONG SECTION ALIGNMENT No. 3

SCALE 1:500

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Rev.	Date	Drawn	Description	Chk'd	Appr.
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P01	20/05/22	JMG	ISSUED FOR REVIEW	RF	ED

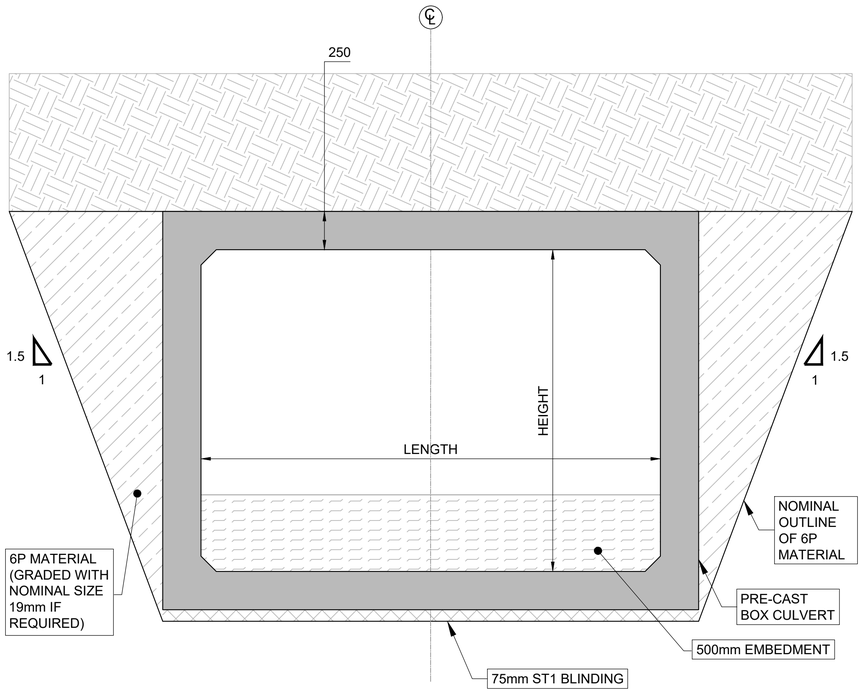
Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Manorcunningham Culvert Long Sections

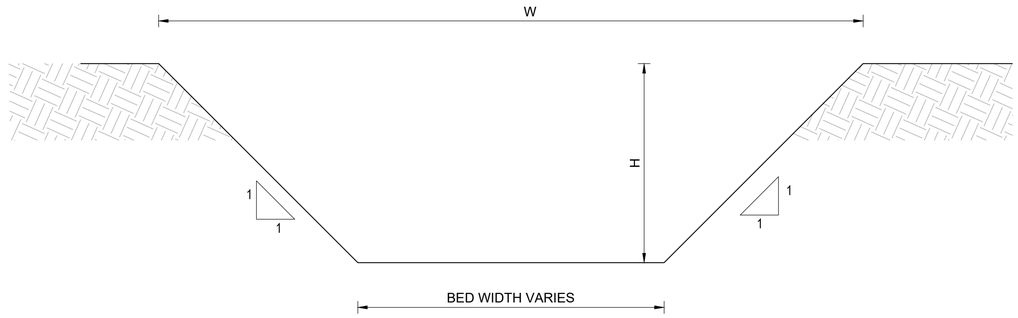
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Approved: ED	@ A3: 1:1000	File Identifier:	
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BOX CULVERT
TYPICAL CROSS SECTION SCALE 1:20 @A1 ; 1:40 @A3



WATERCOURSE
TYPICAL CROSS SECTION SCALE 1:20 @A1 ; 1:40 @A3

\\ETRAMFS02\projects\Halcrow\Barry\Y16 Projects\Y16112 - TEN-T Priority Route provement Project Donegal\Civil-CAD\WIP\Prelim Design\CIVIL\DWGs\TT_Y16112-BT-1A-HDR-S3-DR-CD-05034_Section_50_Culvert_Standard_Details.dwg

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	06/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Culvert Section 50 Standard Details

Status: S4

Designed: SHS	Date: JUNE 2022	Model File Identifier: TT_Y16112-BT-1A-HDR-ZZ -DR-CD-05033_Culvert_Section_50	Rev: P01
Drawn: LRB	Scale @ A1: NTS @ A3:		
Approved: RF			
Checked: ED	Sheet: 1 OF 1	File Identifier: Y16112-0500-035	

APPENDIX C: PHOTOS

W3-01

Drainage ditch





W3-02

Leslie Hill Stream_020



Existing Culvert N14



W3-03

Leslie Hill Stream_020



Existing Culvert N14



APPENDIX D: SECTION 50 APPLICATIONS

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.01**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-01)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	223996.63	Y:	410631.07	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.77** Km^2		Road Reference:	**Access track**	
Design Flood Flow:	**3.73** m^3/s (from above catchment) **16.97** m3/s (from flood plain)		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**24/01/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.28**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**Varies. Refer to report.**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW arterial drainage scheme	**1.6**

Tidal ☐

Comments
This culvert is in a flood plain; it was designed by modelling the flooding area. The actual catchment that would discharge to this culvert without considering the flooding caused by the adjacent river is stated on the first page of this form.

Hydraulic/Structure Details

Description of Structure*3	**4.0 m wide by 3.0 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 25.80 m.**
Effective Conveyance Area *4	**8.52 m2 (Upstream), 4.88 m^2 (Downstream)**
Upstream Invert Level **2.40** ….. mOD Bed level **2.90** mOD	Downstream Invert Level **2.27** mOD Bed level **2.77** mOD
Upstream Soffit Level **5.40** mOD	Downstream Soffit Level **5.27** mOD
Upstream Design Flood Level **5.03** mOD	Downstream Design Flood Level **3.99** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.02**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-01)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**223983.52**	Y:	**410613.39**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.77** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**3.73** m^3/s (from catchment above) **16.97** m3/s (from flood plain)		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**24/01/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.28**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**Varies. Refer to report.**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**1.6**

Tidal ☐

Comments
This culvert is in a flood plain; it was designed by modelling the flooding area. The actual catchment that would discharge to this culvert without considering the flooding caused by the adjacent river is stated on the first page of this form.

Hydraulic/Structure Details

Description of Structure*3	**4.0 m wide by 3.2 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 52.70 m.**
Effective Conveyance Area *4	**9.32 m2 (Upstream), 7.12 m^2 (Downstream)**
Upstream Invert Level **1.48** mOD Bed level **1.98** mOD	Downstream Invert Level **1.37** mOD Bed level **1.87** mOD
Upstream Soffit Level **4.68** mOD	Downstream Soffit Level **4.57** mOD
Upstream Design Flood Level **4.31** mOD	Downstream Design Flood Level **3.65** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.03**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-01)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**223950.37**	Y:	**410554.77**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.77** Km^2		Road Reference:	**Existing N14**	
Design Flood Flow:	**3.73** m^3/s (from catchment above) **20.81** m3/s (from flood plain)		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**24/01/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.28**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**Varies. Refer to report.**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**1.6**

Tidal ☐

Comments
This culvert is in a flood plain; it was designed by modelling the flooding area. The actual catchment that would discharge to this culvert without considering the flooding caused by the adjacent river is stated on the first page of this form.

Hydraulic/Structure Details

Description of Structure*3	**4.0 m wide by 4.0 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 66.80 m.**
Effective Conveyance Area *4	**11.88 m2 (Upstream), 10.56 m^2 (Downstream)**
Upstream Invert Level **1.28** mOD Bed level **1.78** mOD	Downstream Invert Level **1.12** mOD Bed level **1.62** mOD
Upstream Soffit Level **5.28** mOD	Downstream Soffit Level **5.12** mOD
Upstream Design Flood Level **4.75** mOD	Downstream Design Flood Level **4.26** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.04**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-02)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**224176.82**	Y:	**410587.49**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**22.67** Km^2		Road Reference:	**N14 Mainline and Access Track**	
Design Flood Flow:	**51.10** m^3/s (from catchment above) **37.94** m3/s (from flood plain)		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**24/01/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**33.86**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**Varies. Refer to report.**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**Varies. Refer to report.**
FSU Adjustment Factor	**Varies. Refer to report.**

Tidal ☐

Comments
This culvert is in a flood plain so it was designed by modelling the flooding area. The flow from the contributing catchment is 51.10 m3/s but this flow is distributed between this culvert and S3-Cul.01. The actual flow going through this culvert is 37.94 m3/s

Hydraulic/Structure Details

Description of Structure*3	**8.0 m wide by 4.0 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 60.00 m.**
Effective Conveyance Area *4	**23.36 m2 (Upstream), 21.36 m^2 (Downstream)**
Upstream Invert Level **2.07** mOD Bed level **2.57** mOD	Downstream Invert Level **1.95** mOD Bed level **2.45** mOD
Upstream Soffit Level **5.87** mOD	Downstream Soffit Level **5.75** mOD
Upstream Design Flood Level **5.49** mOD	Downstream Design Flood Level **5.12** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.05**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-02)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**224068.24**	Y:	**410481.62**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**22.67** Km^2		Road Reference:	**Existing N14 and cycle track**	
Design Flood Flow:	**51.10** m^3/s (from catchment above) **34.33** m3/s (from flood plain)		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**24/01/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**33.86**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	
FSR ☐	FSU ☒	Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**Varies. Refer to report.**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**Varies. Refer to report.**
FSU Adjustment Factor	**Varies. Refer to report.**

Tidal ☐

Comments
This culvert is in a flood plain so it was designed by modelling the flooding area. The flow from the contributing catchment is 51.10 m3/s. The actual flow going through this culvert is 34.33 m3/s

Hydraulic/Structure Details

Description of Structure*3	**8.0 m wide by 3.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 58.00 m.**
Effective Conveyance Area *4	**21.84 m2 (Upstream), 19.92 m^2 (Downstream)**
Upstream Invert Level **1.88** mOD Bed level **2.38** mOD	Downstream Invert Level **1.76** mOD Bed level **2.26** mOD
Upstream Soffit Level **5.48** mOD	Downstream Soffit Level **5.36** mOD
Upstream Design Flood Level **5.12** mOD	Downstream Design Flood Level **4.75** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.06**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-03)**			Catchment:	**Lough Swilly**
Address (Townland – County):		**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**224520.45**	Y:	**410451.42**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**20.94** Km^2		Road Reference:	**N14 Mainline**	
Design Flood Flow:	**41.60** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**24/01/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**29.19**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	
FSR ☐	FSU ☒	Other ☒
Comments: Refer to the report for the different methods applied.		

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**Varies. Refer to report.**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**Varies. Refer to report.**
FSU Adjustment Factor	**Varies. Refer to report.**
Tidal ☐	
Comments	

Hydraulic/Structure Details

Description of Structure*3	**12.0 m wide by 3.2 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 60.00 m.**		
Effective Conveyance Area *4	**27.48 m2 (Upstream), 27.24 m^2 (Downstream)**		
Upstream Invert Level **5.70** mOD Bed level **6.20** mOD		Downstream Invert Level **5.40** mOD Bed level **5.90** mOD	
Upstream Soffit Level **8.90** mOD		Downstream Soffit Level **8.60** mOD	
Upstream Design Flood Level **8.49** mOD		Downstream Design Flood Level **8.17** mOD	

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

APPENDIX E:

CULVERTS CROSSINGS SECTION 50 ASSESSMENT

Co-financed by the Connecting Europe Facility of the European Union

TECHNICAL REPORT FOR OPW SECTION 50 APPLICATIONS

TEN-T Priority Route Improvement Project, Donegal

Section 3-N14 Manorcunningham to Lifford/Strabane/ A5 Link



00501
Technical Report for OPW Section 50 Applications
S4
P02
October 2022

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Appendix B: DRAWINGS
Appendix C: PHOTOS
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1 INTRODUCTION

This report details the preliminary design location, size and associated hydrological calculations for the proposed watercourse crossings required to construct the works as part of the Section 3 – N14 Manorcunningham to Lifford/Strabane/ A5 Link section of the TENT-T Priority Route Improvement Project, Donegal.

1.1 Proposed Development

The proposed route is approximately 17.6km long and it commences at the N13/N14 junction. It then runs along a similar alignment as the existing N14 for approximately 800m. From here, the option continues in a similar westerly direction offline towards Drumoghill before turning south through Drumcairn. At this point, the proposed route continues towards the existing N14 at Sheskinapoll. It then aligns in a southeasterly direction for approximately 4km to Feddyglass running close to the existing N14. At this point, the option crosses the existing N14 continuing to the townland of Tamnawood. From here, it continues in a south easterly direction to Murlough; it curves then around to the east side of Croaghan Hill and subsequently in a southerly direction between Coneyburrow and Beechwood Park. Here, the termination point occurs next to the existing N15 on greenfield land.

1.2 Existing Watercourses

The proposed alignments of the mainline, side roads and access roads cross existing watercourses in numerous locations. Where these streams cross the proposed road , the consent of the OPW in accordance with Section 50 of the Arterial Drainage Act, 1945 is required.
This report is in support of an application for 27 such culverts under Section 50 of the Arterial Drainage Act, 1945; it forms the basis for Section 50 approval of these culverts located along this section of road in Co. Donegal. The Section 50 application forms for all culverts are enclosed in Appendix D. The location of all culverts, necessary stream diversions and typical construction details are provided in Appendix B.

2 CULVERT CATCHMENTS & DESIGN FLOWS

2.1 Calculation Methods

Most streams are ungauged and so the design flows have been estimated using several methods that take into account different parameters and the catchment size. These parameters were taken from the OPW website (Rainfall and Flood Estimation Applications) from ungauged locations.

The catchment size for the watercourses upstream of the proposed culverts were derived using a mixture of topographical surveying, discovery mapping and the information from a Lidar survey.

Table 1 below outlines the various methods applied.

Table 2-1: Design Flow Calculation Methods

Catchment size	Calculation Method	Method Reference
Km^2	-	-
<0.4	ADAS	DN-DNG-03064 (TII)
0.4 to 25.0	IH 124	DN-DNG-03064 (TII)
0.4 to 25.0	FSSR 6, 3- Variable Method	FSU Web portal
0.4 to 25.0	FSU 3- Variable Method	FSU Web portal
0.4 to 25.0	FSU 4.2A Regression Model	FSU Web portal

The design flow was based on what was considered the most appropriate calculation method taking into consideration the topography and the catchment parameters.

If the watercourse forms part of an OPW arterial drainage scheme, a drainage district factor of 1.6 was applied to all methods as required by the OPW. The following factorial standard errors (FSE) were applied to the different methods:

Table 2-2: FSE Factorial Standard Error

Calculation Method	FSE
ADAS	-
IH 124	1.65
FSSR 6, 3- Variable Method	1.58
FSU 3- Variable Method	2.05
FSU 4.2A Regression Model	1.68

All flow estimates are subject to a 20% climate change allowance.

Table 2-3 Catchment Design Flows

Culvert	Watercourse Reference	Catchment Reference	Total Catchment Area (km2)	Q_{100}					Q_{100} + 20%
				ADAS	IoH 124	FSSR 6, 3 Variable Method	FSU 3 Variable Method	FSU 4.2A Regression	(CC) (m3/s)
S3-CUL.07	W3-04	4+6+7+8	13.850	0.55	10.12	10.87	15.99	**20.07**	**24.04**
S3-CUL.08	W3-05	5A	0.360	**0.77**	0.36	0.36	0.68	0.70	**0.92**
S3-CUL.09	W3-05	5	0.402	-	0.40	0.39	0.74	**0.83**	**1.00**
S3-CUL.10	W3-05	3A+5	0.902	-	0.88	0.87	1.63	**1.78**	**2.15**
S3-CUL.11	W3-05	3A+5	0.902		0.88	0.87	1.63	**1.78**	**2.15**
S3-CUL.12	W3-07	6	0.450	-	0.44	0.44	0.81	**0.90**	**1.07**
S3-CUL.13	W3-07	6	0.450	-	0.44	0.44	0.81	**0.90**	**1.07**
S3-CUL.14	W3-08	7	2.778	-	2.22	2.33	3.67	**5.42**	**6.50**
S3-CUL.15	W3-08	7	2.778	-	2.22	2.33	3.67	**5.42**	**6.50**
S3-CUL.16	W3-08	7	2.778	-	2.22	2.33	3.67	**5.42**	**6.50**
S3-CUL.17	W3-09	8	0.346	**0.55**	0.35	0.34	0.65	0.92	**0.66**
S3-CUL.18	W3-10	9	1.260	-	1.10	1.13	**1.91**	1.54	**2.29**
S3-CUL.19	W3-10	9	1.260	-	1.10	1.13	**1.91**	1.54	**2.29**
S3-CUL.20	W3-11	9+10	2.260	-	1.98	2.03	**3.47**	**3.25**	**4.34***
S3-CUL.21	W3-12A	11	0.576	-	0.54	0.54	0.93	**1.31**	**1.58**
S3-CUL.22	W3-12A	11	0.576	-	0.54	0.54	0.93	**1.31**	**1.58**
S3-CUL.23	W3-12A	11	0.576	-	0.54	0.54	0.93	**1.31**	**1.58**
S3-CUL.24	W3-12	9+10+11+12	7.610	-	6.06	6.35	9.80	**12.55**	**15.06**
S3-CUL.25	W3-13	13	1.140	-	0.99	1.01	1.64	**2.15**	**2.59**
S3-CUL.26	W3-13	13	1.140	-	0.99	1.01	1.64	**2.15**	**2.59**
S3-CUL.27	W3-13	9+10+11+12+13+14	9.366		7.62	7.94	12.43	**15.77**	**18.95**
S3-CUL.28	W3-16	15	0.720	-	1.04	1.05	**1.74**	1.54	**2.09**
S3-CUL.29	W3-15	15+16	1.645	-	2.35	2.38	**3.88**	3.55	**4.66**

Culvert	Watercourse Reference	Catchment Reference	Total Catchment Area (km2)	Q_{100}					Q_{100} + 20%
				ADAS	IoH 124	FSSR 6, 3 Variable Method	FSU 3 Variable Method	FSU 4.2A Regression	(CC) (m3/s)
S3-CUL.30	W3-17A	17	0.710	-	1.02	1.03	1.85	**2.18**	**2.62**
S3-CUL.31	W3-18	18	0.710	-	0.64	0.64	1.15	**1.76**	**2.11**
S3-CUL.32	W3-19	19	0.200	**0.44**	0.27	0.26	0.87	1.04	**0.52**
S3-CUL.33	W3-20	20	0.226	**0.50**	0.30	0.29	0.96	1.20	**0.60**

- Values in bold indicate the adopted Q_{100} (excl CC allowance)
- *Design flow determined by the combination of two methods (highlighted in bold) from two different catchments. Each method selected had the largest flow for a particular catchment which provides the most conservative design flow.

3 PROPOSED CULVERT DETAILS

3.1 Environmental Requirements

During the Preliminary Environmental Assessment, there was no evidence of fish observed in the majority of the watercourses. However, it was noted that in the majority of cases, the watercourses have the potential to support fish in the future. In addition, in terms of biodiversity, a large number of streams were rated with a higher value for local importance.

The culverts have been designed in accordance with the recommendations of the Lough's Agency and the IFI. Both bodies were consulted with in relation to the culvert design.

Where mammal crossings have to be provided in the vicinity of watercourses, they will be provided as a separate pipe.

3.2 Culvert sizing calculations

The hydraulic analysis for the box culverts was undertaken in Culvert Master and in accordance with the CIRIA C689 Culvert Design and Operation Guide. Pipe culverts were designed using the manning formula.

Manning's Roughness Coefficient of 0.04 was assumed based on CIRIA 689 Appendix A1 Table A1.1 for the tailwater conditions. Also, the compound coefficient through the culvert was calculated to be 0.03.

Appendix C shows photographs of the location of existing watercourses where the proposed culverts will be located.

A summary of the resulting calculation outputs and proposed culvert details are given in Table 4 below. The dimensions are sufficient to incorporate a minimum freeboard of 0.3m and an embedment into the streambed of 0.5/0.3 m.

Table 3-1: Proposed Culvert Sizes & Hydrological Calculation Outputs

Culvert name	Type	Length	Size			Depth of embedment	USIL (Top of embedment)	DSIL (Top of embedment)	Culvert gradient	Freeboard Achieved Upstream (Min. 0.3 m)	Freeboard Achieved Downstream (Min. 0.3 m)
			Diameter	Width	Height (incl. embedment)						
		(m)		(m)	(m)	(m)	(mOD)	(mOD)	(1:x)	(m)	(m)
S3-CUL.07	Box	69.50	-	4.2	3.5	0.5	22.92	22.57	200.0	0.34	1.51
S3-CUL.08	Box	24.50	-	1.8	1.4	0.5	41.20	41.10	245.0	0.31	0.38
S3-CUL.09	Box	79.10	-	1.8	1.4	0.5	41.05	40.67	200.0	0.30	0.36
S3-CUL.10	Box	53.50	-	2.0	1.8	0.5	35.60	35.33	200.0	0.38	0.61
S3-CUL.11	Box	19.00	-	2.0	1.7	0.5	34.90	34.80	190.0	0.31	0.54
S3-CUL.12	Pipe	62.00	1.2	-	-	0.3	84.20	83.60	100.0	0.42	0.42
S3-CUL.13	Pipe	31.80	1.2	-	-	0.3	73.50	73.17	100.0	0.44	0.44
S3-CUL.14	Box	23.23	-	4.2	1.9	0.5	72.26	72.05	111.1	0.31	0.45
S3-CUL.15	Box	60.00	-	3.7	2.2	0.5	71.80	71.60	303.0	0.32	0.43
S3-CUL.16	Box	22.71	-	3.7	2.3	0.5	71.45	71.30	151.5	0.32	0.33
S3-CUL.17	Pipe	49.82	1.2	-	-	0.3	85.60	85.30	166.6	0.52	0.52
S3-CUL.18	Box	48.40	-	2.0	1.8	0.5	82.51	82.27	200.0	0.35	0.79
S3-CUL.19	Box	36.00	-	2.0	1.8	0.5	80.55	80.37	200.0	0.36	0.69
S3-CUL.20	Box	60.00	-	3.2	1.9	0.5	70.03	69.80	263.2	0.31	0.48
S3-CUL.21	Box	16.50	-	2.8	1.4	0.5	66.04	65.90	117.9	0.31	0.31
S3-CUL.22	Box	34.60	-	2.8	1.5	0.5	65.80	65.65	230.7	0.32	0.30
S3-CUL.23	Box	23.66	-	2.2	1.5	0.5	65.22	65.10	197.2	0.32	0.51
S3-CUL.24	Box	17.70	-	6.0	3.0	0.5	34.15	34.11	500.0	0.39	0.49
S3-CUL.25	Box	50.20	-	2.0	1.9	0.5	21.55	21.40	333.0	0.44	0.83
S3-CUL.26	Box	59.00	-	2.0	1.9	0.5	21.30	21.00	200.0	0.36	0.71
S3-CUL.27	Bottomless Culvert	36.20	-	9.5	2.9	0.5	19.03	18.85	200.0	0.60	0.60
S3-CUL.28	Box	60.00	-	2.0	1.8	0.5	1.69	1.39	200.0	0.36	0.40

Culvert name	Type	Length	Size			Depth of embedment	USIL (Top of embedment)	DSIL (Top of embedment)	Culvert gradient	Freeboard Achieved Upstream (Min. 0.3 m)	Freeboard Achieved Downstream (Min. 0.3 m)
			Diameter	Width	Height (incl. embedment)						
		(m)		(m)	(m)	(m)	(mOD)	(mOD)	(1:x)	(m)	(m)
S3-CUL.29	Box	54.50	-	2.8	2.2	0.5	0.63	0.36	202.0	0.51	0.90
S3-CUL.30	Box	66.00	-	2.0	1.8	0.5	4.50	3.50	66.0	0.34	0.39
S3-CUL.31	Box	70.50	-	1.8	1.8	0.5	25.78	19.35	12.0	0.39	0.98
S3-CUL.32	Pipe	44.50	1.2	-	-	0.3	37.30	35.70	27.8	0.77	0.77
S3-CUL.33	Pipe	50.70	1.2	-	-	0.3	49.13	44.69	10.9	0.80	0.80

The following watercourses have been designed based on the catchments' flows estimated above and using Mannings' formula to calculate the dimensions required.

Table 3-2 Watercourses details

Watercourse Reference	Culverts	Base width	Channel Sides slopes	Earthworks Side Slopes	Notes
W3-04	S3-CUL.07	4.2	1/1	1/2	
W3-05	S3-CUL.08 S3-CUL.09	1.0	1/1	1/2	
W3-05	S3-CUL.10 S3-CUL.11	1.0	1/1	1/2	
W3-07	S3-CUL.12 S3-CUL.13	1.0	1/1	1/2	
W3-08	S3-CUL.14 S3-CUL.15 S3-CUL.16	2.0	1/1	1/2	
W3-09	S3-CUL.17	1.0	1/1	1/2	
W3-10	S3-CUL.18 S3-CUL.19	2.0	1/1	1/2	
W3-11	S3-CUL.20	2.0	1/1	1/2	
W3-12A	S3-CUL.21 S3-CUL.22 S3-CUL.23"	1.0 1.0 1.0	1/1 1/1 1/1	1/2 1/1.5 1/2	Ch 0+070 to 0+160
W3-12	S3-CUL.24	3.0	1/1	1/2	
W3-13	S3-CUL.25 S3-CUL.26 S3-CUL.27	2.0 4.0	1/1	1/2 1/2	
W3-16	S3-CUL.28	2.0	1/1	1/1	Watercourse diversion to be subject to geotechnical assessment
W3-15	S3-CUL.29	2.0	1/1	1/1	
W3-17A	S3-CUL.30	1.0	1/1	1/2	
W3-18	S3-CUL.31	N/A	N/A	N/A	Tie into existing stream. No watercourse diversion or realignment required.
W3-19	S3-CUL.32	1.0	1/1	1/2	
W3-20	S3-CUL.33	1.0	1/1	1/2	

APPENDIX A: HYDRAULIC CALCULATIONS

CATCHMENT 3A

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	21.90	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.5	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0.0005	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.149**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.155**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.212*	*m^3/s*
QBAR	**0.220**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

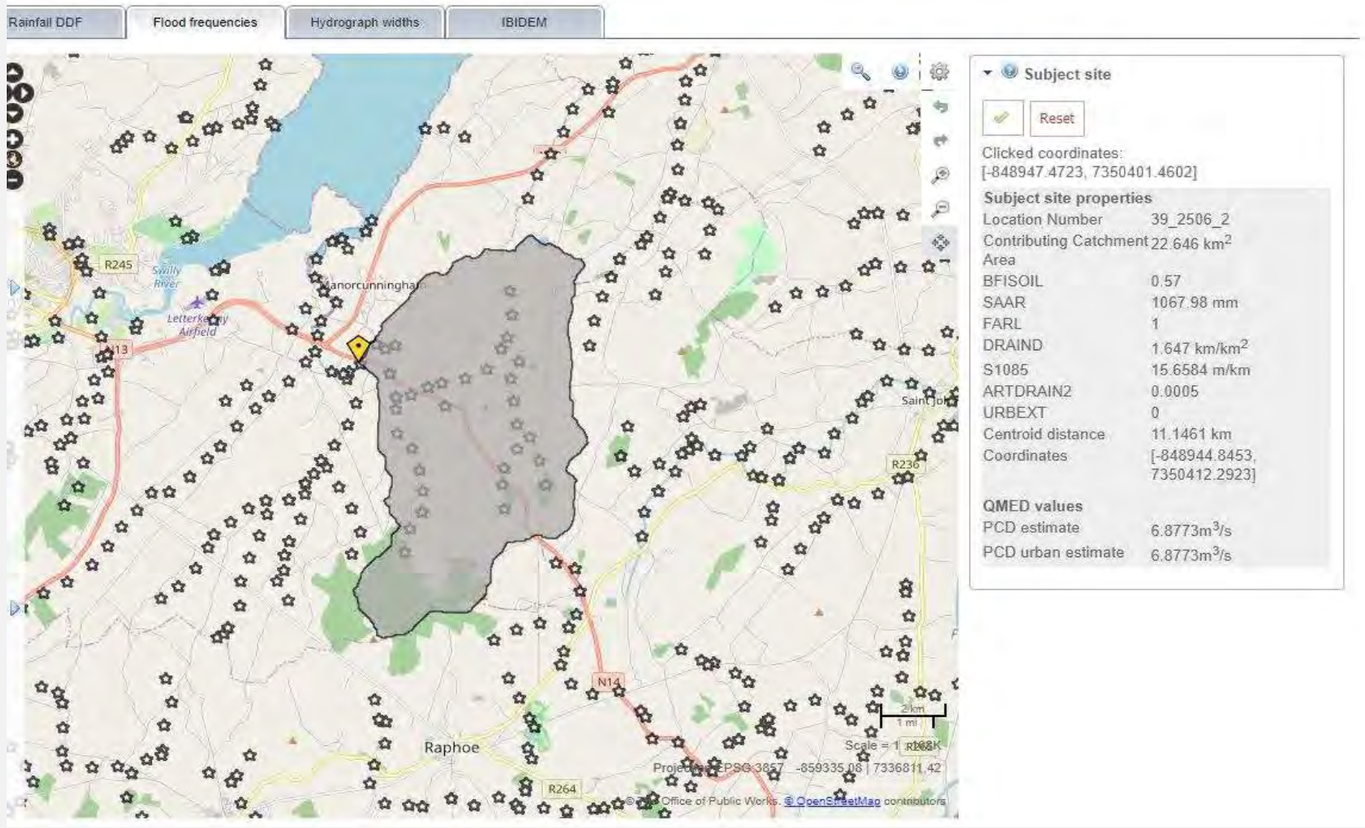
QMED	*0.278*	*m^3/s*
QBAR	**0.290**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.149 m3/s	1.65	0.246 m3/s	0.48 m3/s	**0.58 m3/s**
FSSR 6, 3-Variable Method	0.155 m3/s	1.58	0.246 m3/s	0.48 m3/s	**0.58 m3/s**
FSU 3-Variable Method	0.220 m3/s	2.05	0.452 m3/s	0.89 m3/s	**1.06 m3/s**
FSU 4.2A Regression	0.290 m3/s	1.68	0.487 m3/s	0.95 m3/s	**1.15 m3/s**

Irish Growth Factor
Dublin Growth Factor

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 4

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	10.00	m/km

1.2 Spatial PCD's

AREA - Catchment Area	10.28	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**2.200**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**2.507**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*2.594*	*m^3/s*
QBAR	**2.702**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

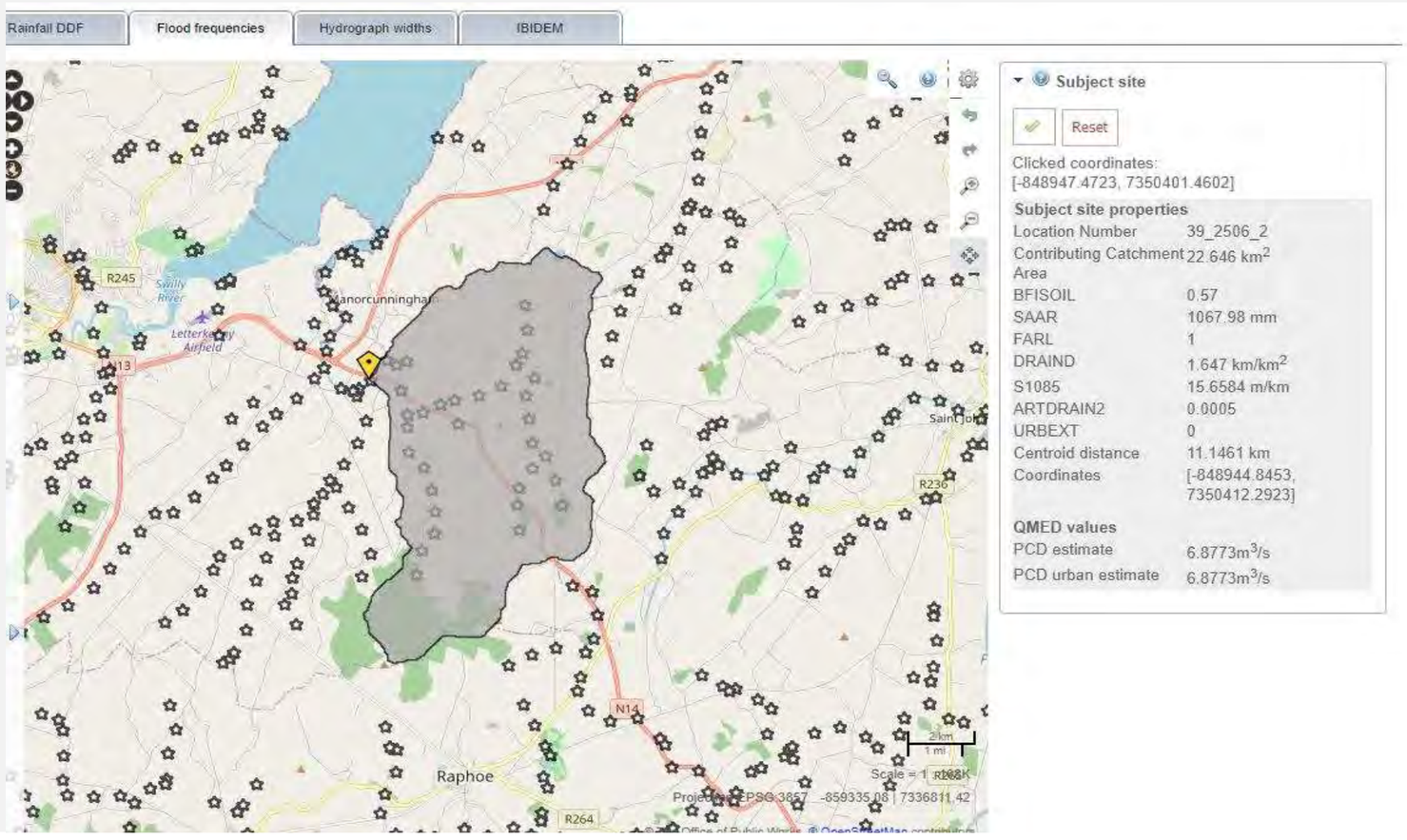
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*3.739*	*m^3/s*
QBAR	**3.895**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	2.200 m3/s	1.65	3.630 m3/s	7.11 m3/s	**8.54 m3/s**
FSSR 6, 3-Variable Method	2.507 m3/s	1.58	3.964 m3/s	7.77 m3/s	**9.32 m3/s**
FSU 3-Variable Method	2.702 m3/s	2.05	5.539 m3/s	10.86 m3/s	**13.03 m3/s**
FSU 4.2A Regression	3.895 m3/s	1.68	6.544 m3/s	12.83 m3/s	**15.39 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 5A

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	21.11	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.363	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0	

1.4 Catchment characteristics

Width	376	m
Height	32	m
Time of Concentration	4.4	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.112** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.116** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.162*	*m^3/s*
QBAR	**0.169**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.205*	*m^3/s*
QBAR	**0.214**	**m^3/s**

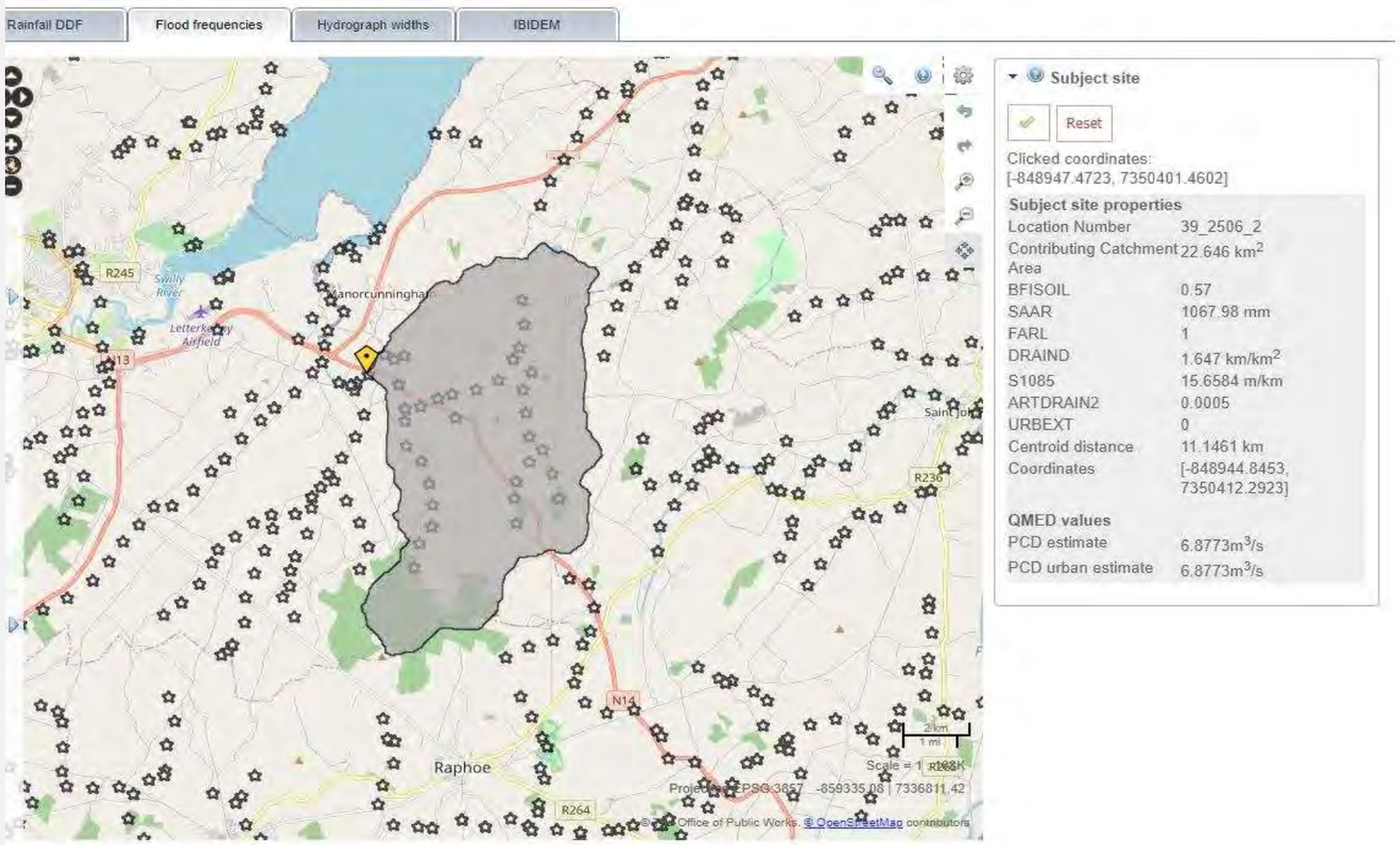
6.0 ADAS

$$Q = AREA(0.0443SAAR - 11.19)SOIL^{2.0}\left[\frac{18.79T^{0.28}-1}{10T}\right] \qquad T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$$

Q 75 year *0.735* *m^3/s*

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.112 m3/s	1.65	0.185 m3/s	0.36 m3/s	**0.44 m3/s**
FSSR 6, 3-Variable Method	0.116 m3/s	1.58	0.183 m3/s	0.36 m3/s	**0.43 m3/s**
FSU 3-Variable Method	0.169 m3/s	2.05	0.346 m3/s	0.68 m3/s	**0.81 m3/s**
FSU 4.2A Regression	0.214 m3/s	1.68	0.359 m3/s	0.70 m3/s	**0.84 m3/s**

Method	QBAR	Q 75 Year	100 Year Flow	Climate Change
ADAS	0.391 m3/s	0.735 m3/s	0.767 m3/s	0.920 m3/s



CATCHMENT 5

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	28.30	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.402	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.123**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.127**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.177*	*m^3/s*
QBAR	**0.184**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

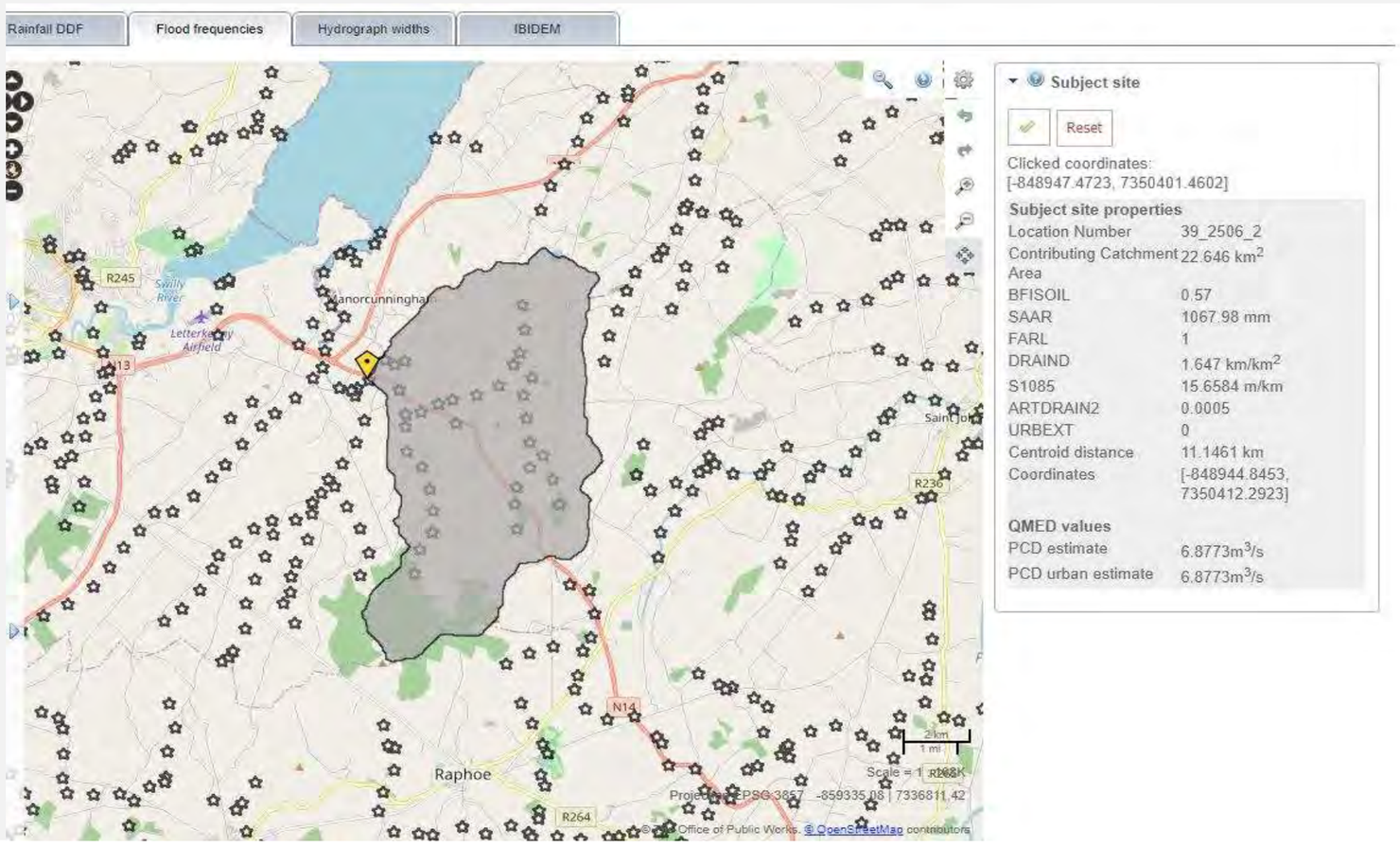
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.243*	*m^3/s*
QBAR	**0.253**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.123 m3/s	1.65	0.203 m3/s	0.40 m3/s	**0.48 m3/s**
FSSR 6, 3-Variable Method	0.127 m3/s	1.58	0.201 m3/s	0.39 m3/s	**0.47 m3/s**
FSU 3-Variable Method	0.184 m3/s	2.05	0.377 m3/s	0.74 m3/s	**0.89 m3/s**
FSU 4.2A Regression	0.253 m3/s	1.68	0.425 m3/s	0.83 m3/s	**1.00 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 6

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	25.00	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.45	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.136**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.141**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.194*	*m^3/s*
QBAR	**0.202**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

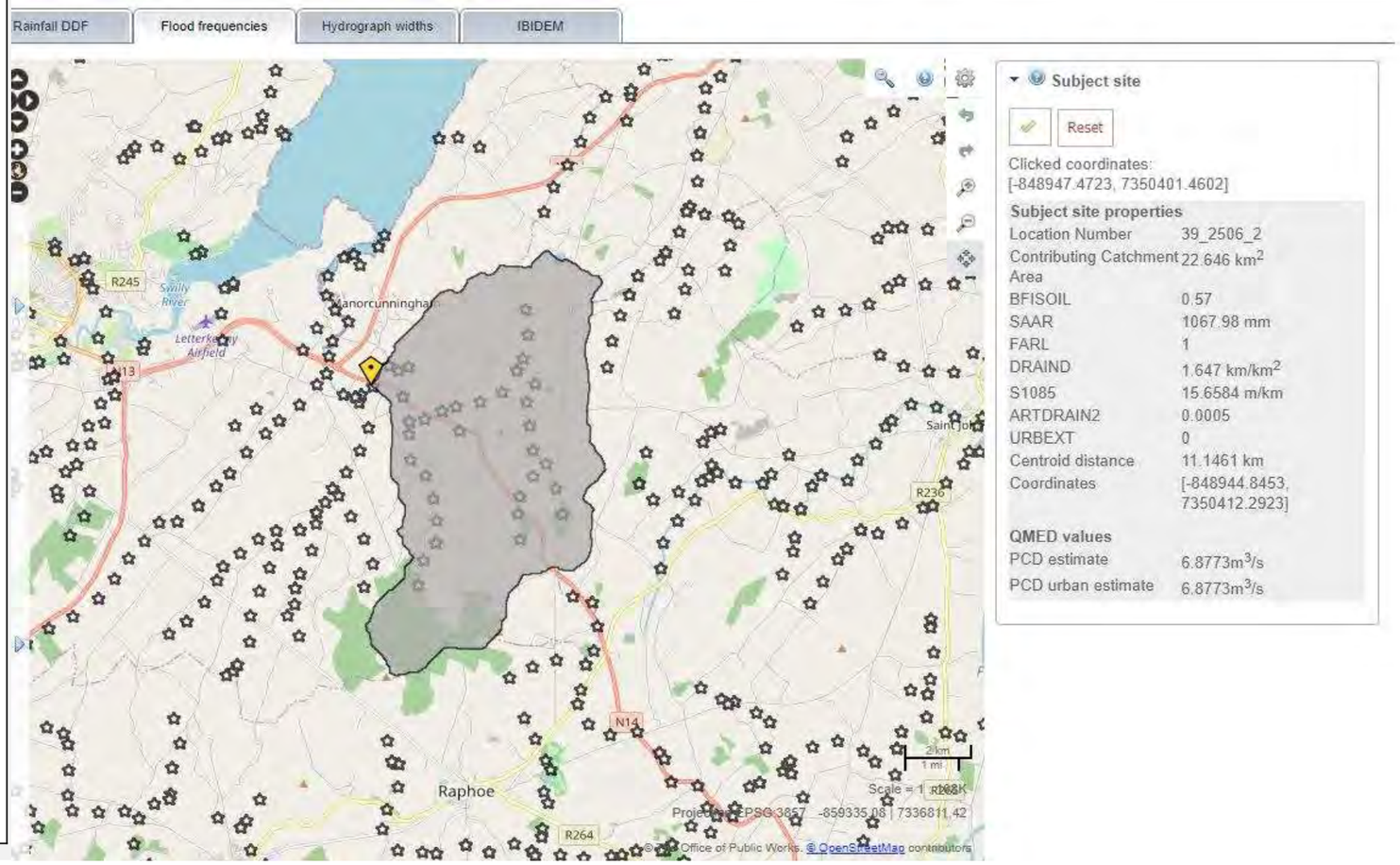
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.261*	*m^3/s*
QBAR	**0.272**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.136 m3/s	1.65	0.224 m3/s	0.44 m3/s	**0.53 m3/s**
FSSR 6, 3-Variable Method	0.141 m3/s	1.58	0.223 m3/s	0.44 m3/s	**0.52 m3/s**
FSU 3-Variable Method	0.202 m3/s	2.05	0.414 m3/s	0.81 m3/s	**0.97 m3/s**
FSU 4.2A Regression	0.272 m3/s	1.68	0.457 m3/s	0.90 m3/s	**1.07 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 7

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	40.00	m/km

1.2 Spatial PCD's

AREA - Catchment Area	2.778	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.687** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.752** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED *0.877* *m^3/s*

QBAR **0.913** **m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

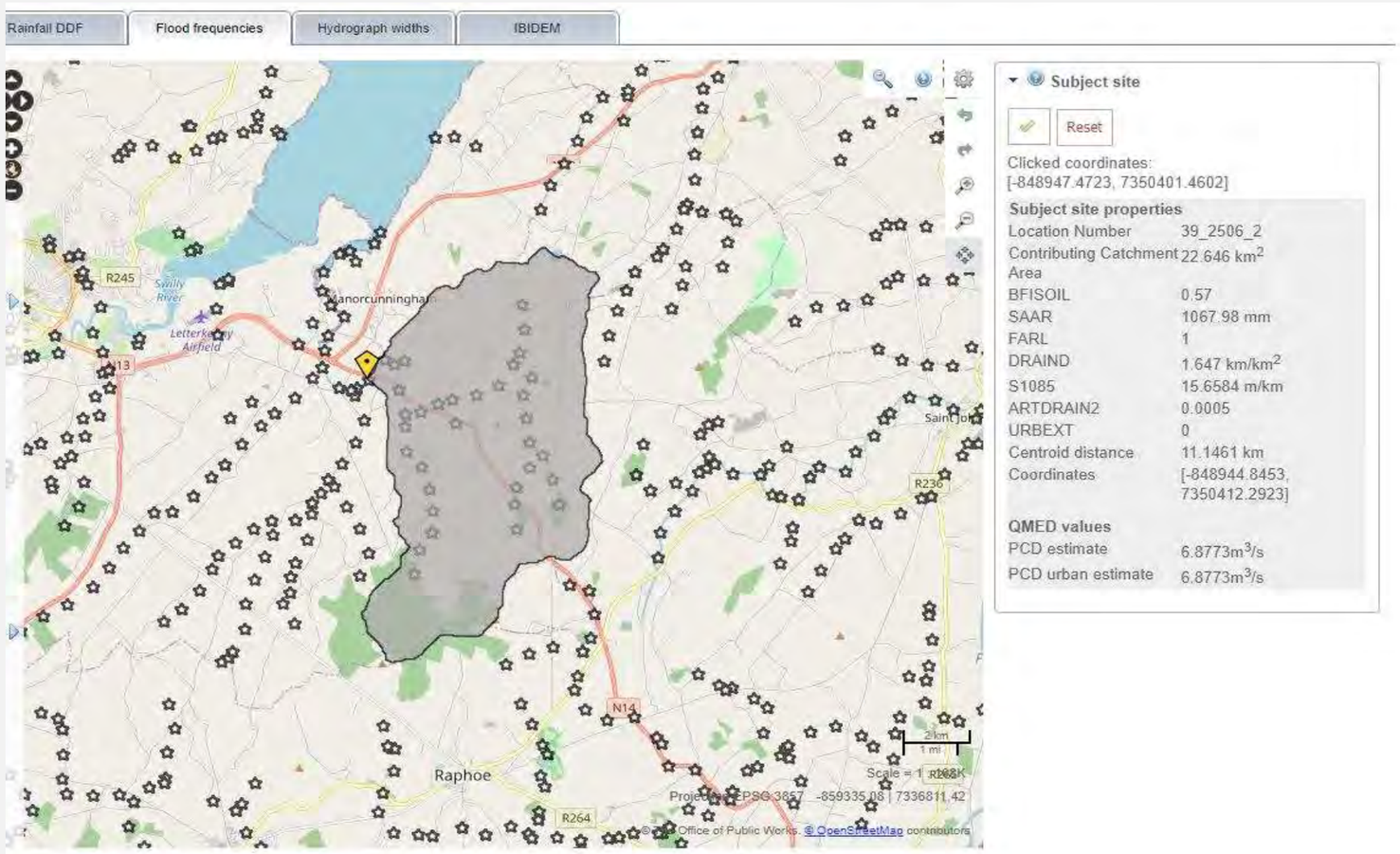
QMED *1.580* *m^3/s*

QBAR **1.646** **m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.687 m3/s	1.65	1.133 m3/s	2.22 m3/s	**2.66 m3/s**
FSSR 6, 3-Variable Method	0.752 m3/s	1.58	1.189 m3/s	2.33 m3/s	**2.80 m3/s**
FSU 3-Variable Method	0.913 m3/s	2.05	1.872 m3/s	3.67 m3/s	**4.40 m3/s**
FSU 4.2A Regression	1.646 m3/s	1.68	2.765 m3/s	5.42 m3/s	**6.50 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 8

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	74.00	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.346	km^2
SAAR - Standard Annual Average Rainfall	1067	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.57	
URBEXT	0	
SOIL	0.3	
DRAIND	1.647	km/km^2
ARTDRAIN2	0	

1.4 Catchment characteristics

Width	750	m
Height	48.5	m
Time of Concentration	6.5	min

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.108**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.111**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.156*	*m^3/s*
QBAR	**0.162**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.269*	*m^3/s*
QBAR	**0.280**	**m^3/s**

6.0 ADAS

$$Q = AREA(0.0443SAAR - 11.19)SOIL^{2.0}\left[\frac{18.79T^{0.28} - 1}{10T}\right] \qquad T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$$

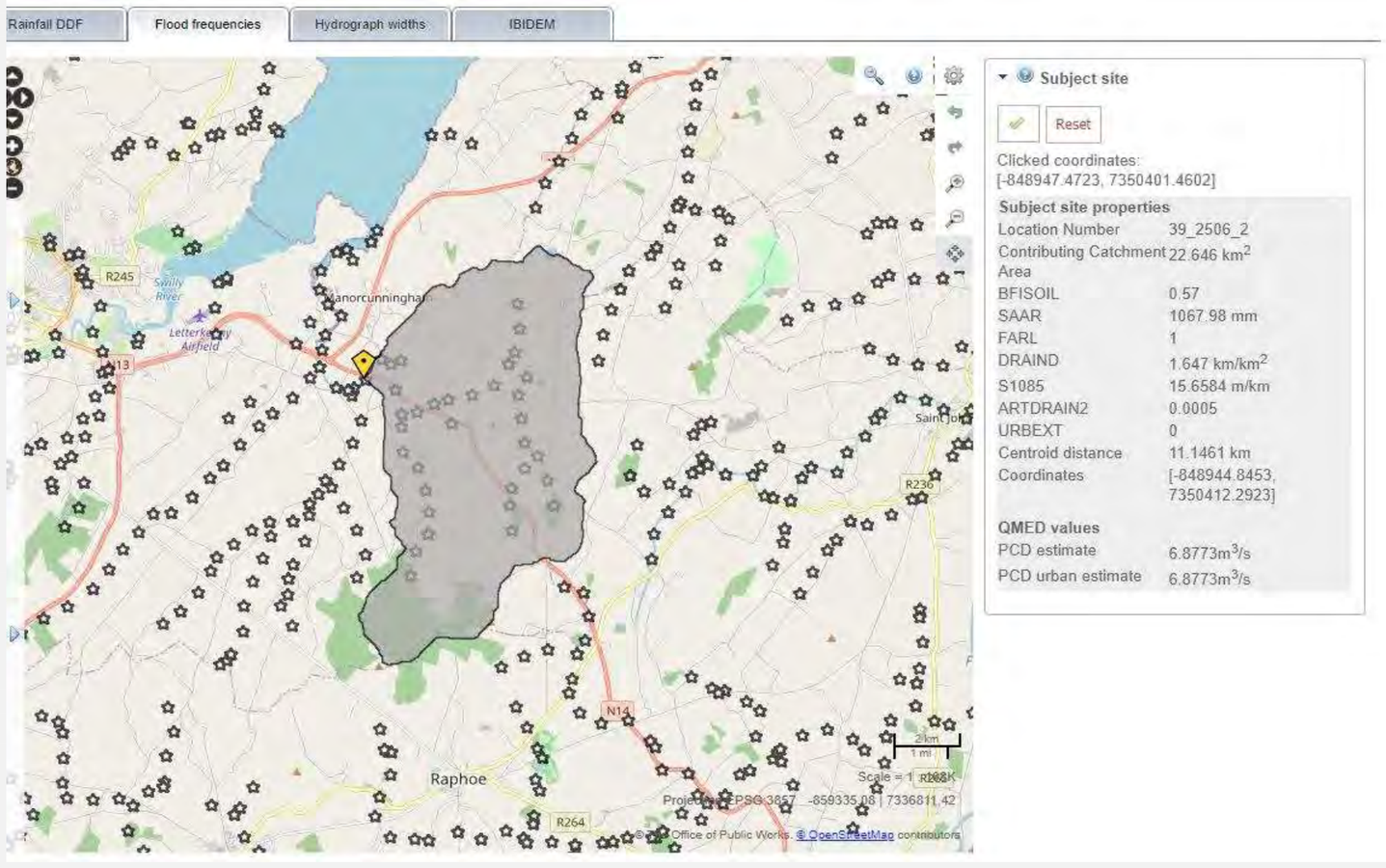
Q 75 year	*0.531*	*m^3/s*

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.108 m3/s	1.65	0.177 m3/s	0.35 m3/s	**0.42 m3/s**
FSSR 6, 3-Variable Method	0.111 m3/s	1.58	0.175 m3/s	0.34 m3/s	**0.41 m3/s**
FSU 3-Variable Method	0.162 m3/s	2.05	0.333 m3/s	0.65 m3/s	**0.78 m3/s**
FSU 4.2A Regression	0.280 m3/s	1.68	0.470 m3/s	0.92 m3/s	**1.11 m3/s**

Method	QBAR	Q 75 Year	100 Year Flow	Climate Change
ADAS	0.283 m3/s	0.53	0.554 m3/s	0.66 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 9

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	4.90	m/km

1.2 Spatial PCD's

AREA - Catchment Area	1.26	km^2
SAAR - Standard Annual Average Rainfall	1068.38	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5693	
URBEXT	0	
SOIL	0.3	
DRAIND	0.63	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.340**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.364**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.457*	*m^3/s*
QBAR	**0.476**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

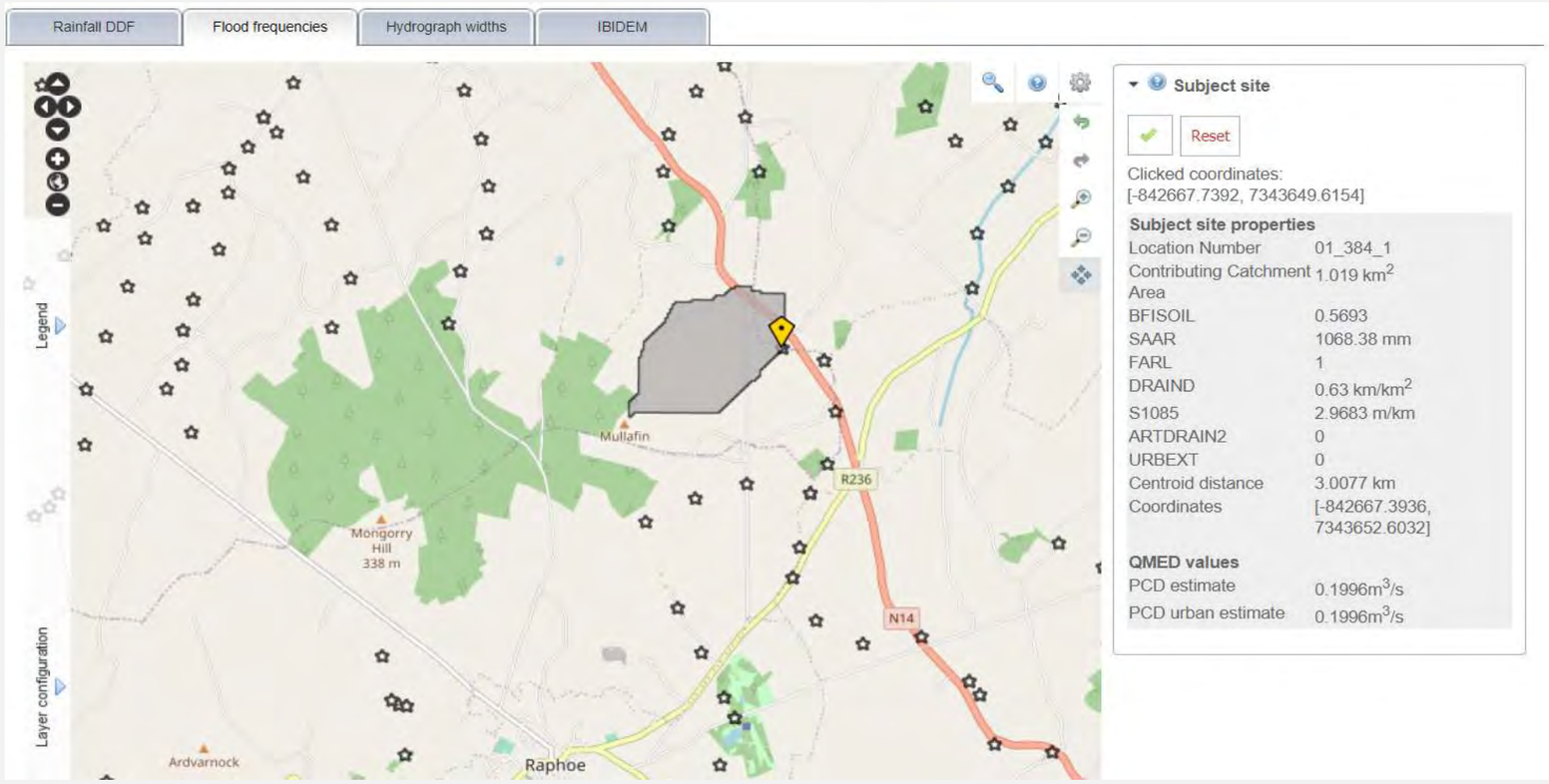
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.450*	*m^3/s*
QBAR	**0.469**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.340 m3/s	1.65	0.561 m3/s	1.10 m3/s	**1.32 m3/s**
FSSR 6, 3-Variable Method	0.364 m3/s	1.58	0.576 m3/s	1.13 m3/s	**1.35 m3/s**
FSU 3-Variable Method	0.476 m3/s	2.05	0.975 m3/s	1.91 m3/s	**2.29 m3/s**
FSU 4.2A Regression	0.469 m3/s	1.68	0.788 m3/s	1.54 m3/s	**1.85 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 10

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	18.40	m/km

1.2 Spatial PCD's

AREA - Catchment Area	1	km^2
SAAR - Standard Annual Average Rainfall	1052.26	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5686	
URBEXT	0	
SOIL	0.3	
DRAIND	0.965	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.272**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.289**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.373*	*m^3/s*
QBAR	**0.388**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

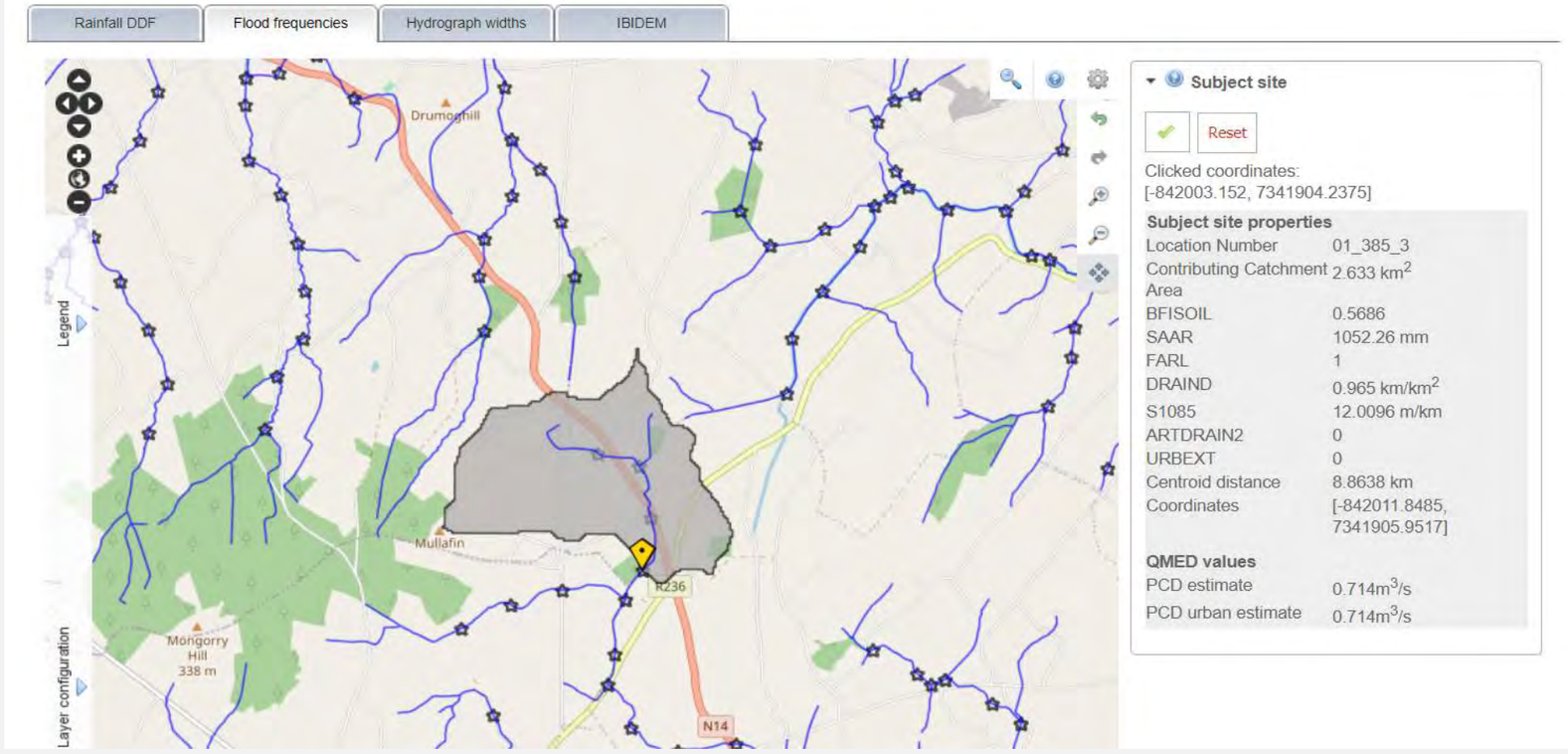
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.498*	*m^3/s*
QBAR	**0.519**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.272 m3/s	1.65	0.449 m3/s	0.88 m3/s	**1.06 m3/s**
FSSR 6, 3-Variable Method	0.289 m3/s	1.58	0.457 m3/s	0.90 m3/s	**1.07 m3/s**
FSU 3-Variable Method	0.388 m3/s	2.05	0.796 m3/s	1.56 m3/s	**1.87 m3/s**
FSU 4.2A Regression	0.519 m3/s	1.68	0.871 m3/s	1.71 m3/s	**2.05 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 11

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	56.00	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.576	km^2
SAAR - Standard Annual Average Rainfall	1052.98	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5894	
URBEXT	0	
SOIL	0.3	
DRAIND	1.091	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.167** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.174** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.223*	m^3/s
QBAR	**0.233**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

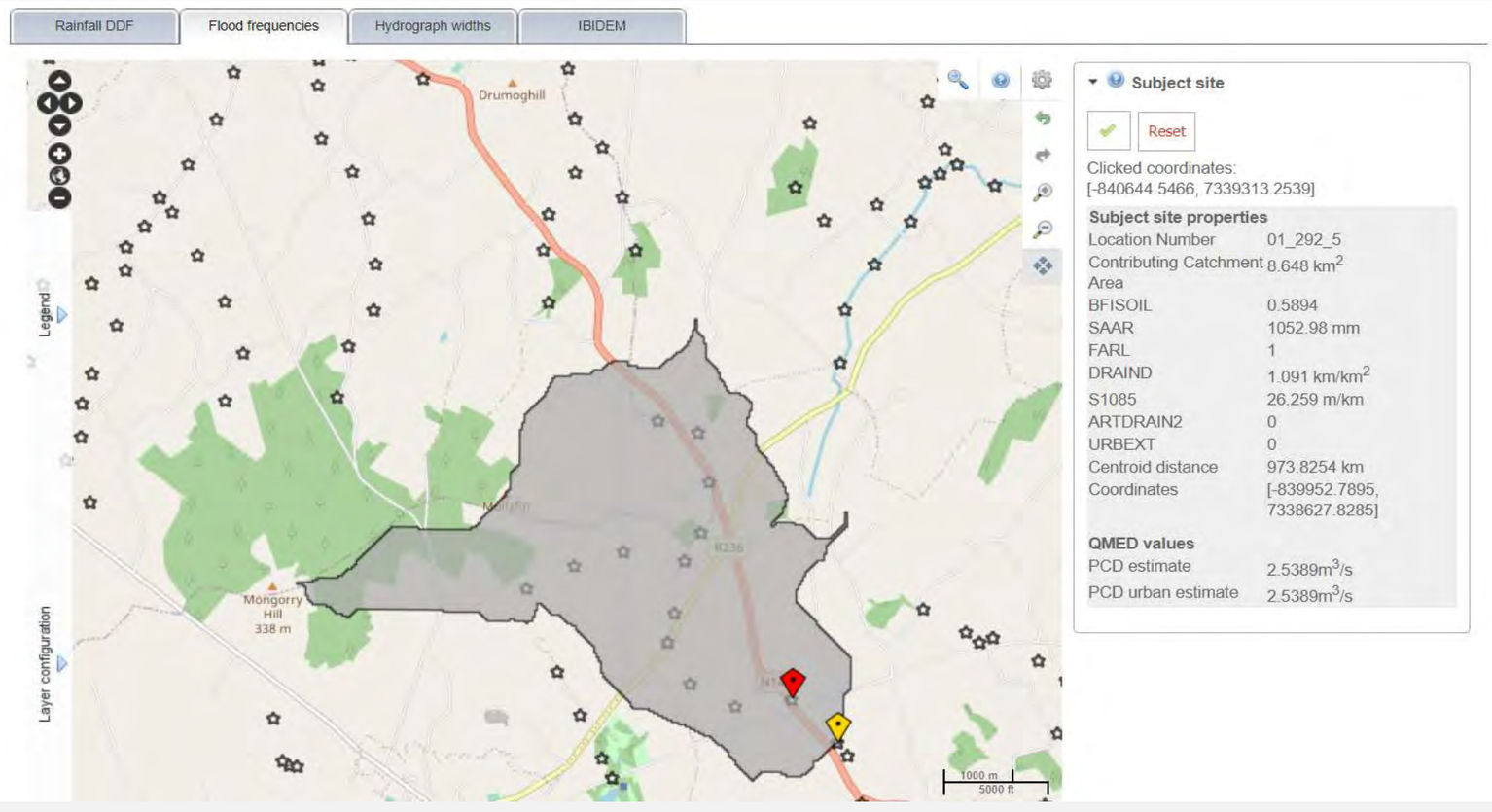
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.383*	m^3/s
QBAR	**0.399**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.167 m3/s	1.65	0.275 m3/s	0.54 m3/s	**0.65 m3/s**
FSSR 6, 3-Variable Method	0.174 m3/s	1.58	0.275 m3/s	0.54 m3/s	**0.65 m3/s**
FSU 3-Variable Method	0.233 m3/s	2.05	0.477 m3/s	0.93 m3/s	**1.12 m3/s**
FSU 4.2A Regression	0.399 m3/s	1.68	0.670 m3/s	1.31 m3/s	**1.58 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 12

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	30.70	m/km

1.2 Spatial PCD's

AREA - Catchment Area	4.77	km^2
SAAR - Standard Annual Average Rainfall	1054.13	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5894	
URBEXT	0	
SOIL	0.3	
DRAIND	1.11	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **1.095** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **1.219** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED *1.289* *m^3/s*

QBAR **1.343** **m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

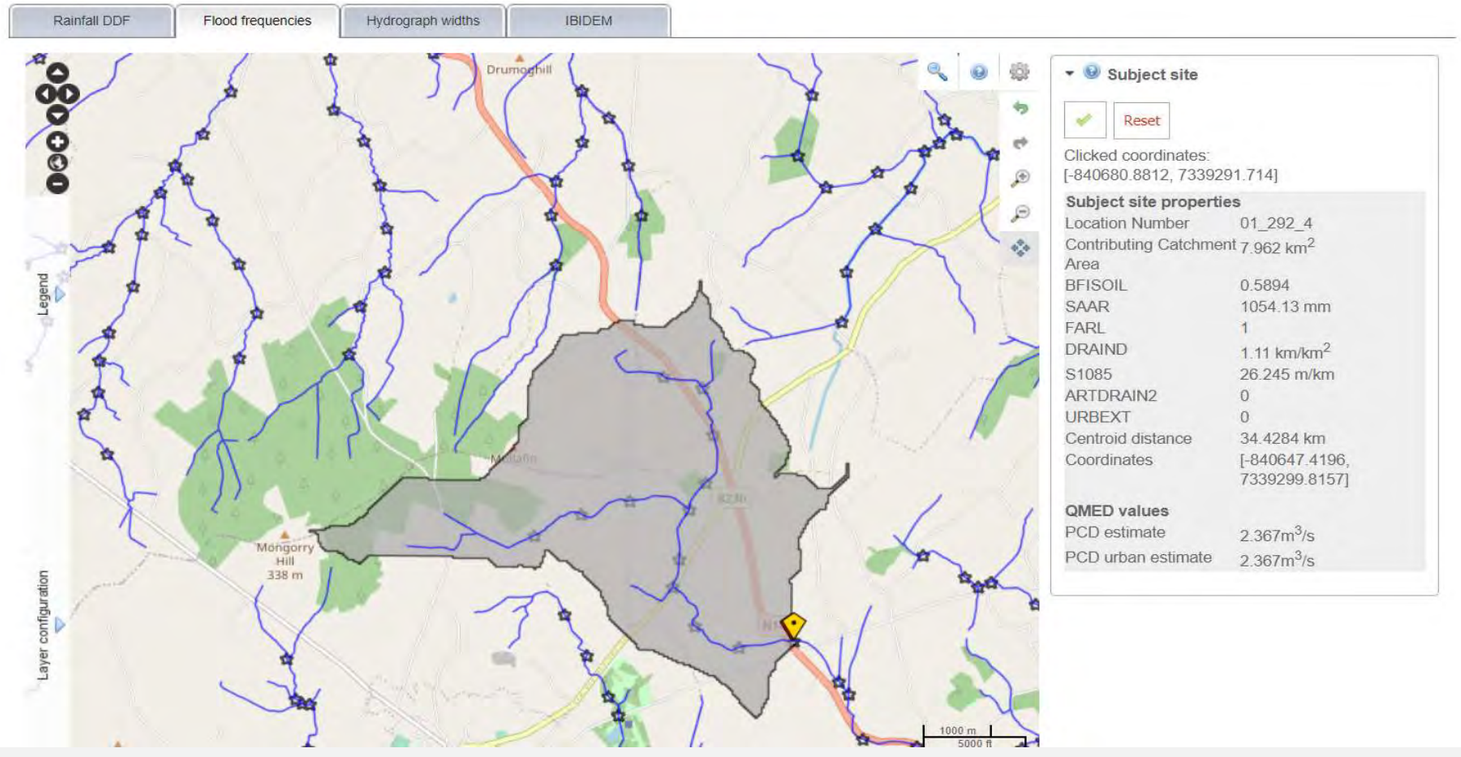
QMED *2.329* *m^3/s*

QBAR **2.426** **m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	1.095 m3/s	1.65	1.807 m3/s	3.54 m3/s	**4.25 m3/s**
FSSR 6, 3-Variable Method	1.219 m3/s	1.58	1.927 m3/s	3.78 m3/s	**4.53 m3/s**
FSU 3-Variable Method	1.343 m3/s	2.05	2.753 m3/s	5.40 m3/s	**6.48 m3/s**
FSU 4.2A Regression	2.426 m3/s	1.68	4.075 m3/s	7.99 m3/s	**9.58 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CACTHMENT 13

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	32.70	m/km

1.2 Spatial PCD's

AREA - Catchment Area	1.14	km^2
SAAR - Standard Annual Average Rainfall	1052.12	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5896
URBEXT	0
SOIL	0.3
DRAIND	1.087 km/km^2
ARTDRAIN2	0

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.306** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.326** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED *0.393* *m^3/s*

QBAR **0.409** **m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

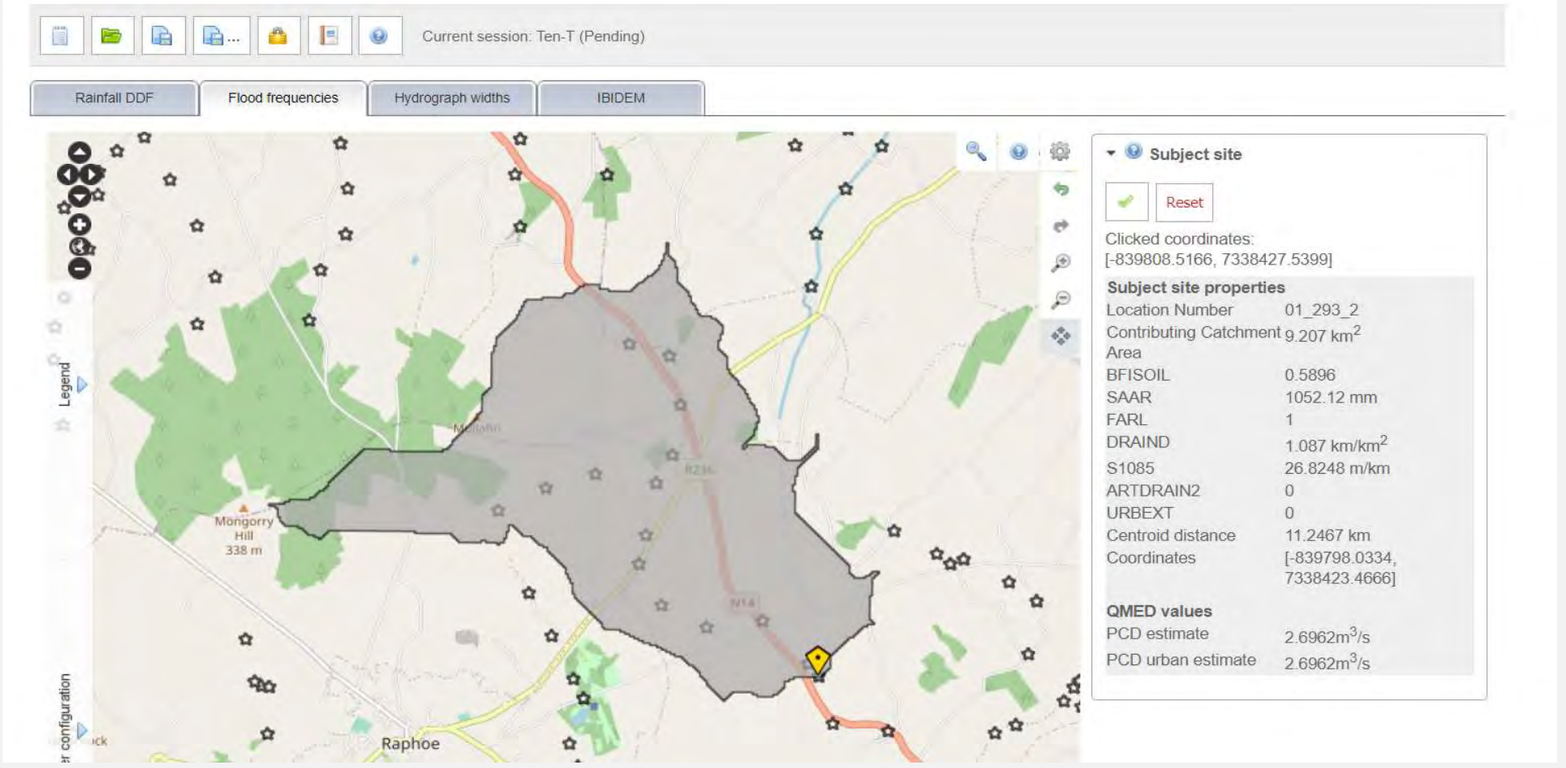
QMED *0.628* *m^3/s*

QBAR **0.654** **m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.306 m3/s	1.65	0.504 m3/s	0.99 m3/s	**1.19 m3/s**
FSSR 6, 3-Variable Method	0.326 m3/s	1.58	0.515 m3/s	1.01 m3/s	**1.21 m3/s**
FSU 3-Variable Method	0.409 m3/s	2.05	0.839 m3/s	1.64 m3/s	**1.97 m3/s**
FSU 4.2A Regression	0.654 m3/s	1.68	1.099 m3/s	2.15 m3/s	**2.59 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 14

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	19.23	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.62	km^2
SAAR - Standard Annual Average Rainfall	1051.67	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5894
URBEXT	0
SOIL	0.3
DRAIND	1.156 km/km^2
ARTDRAIN2	0

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.178** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.186** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED *0.237* *m^3/s*

QBAR **0.247** **m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

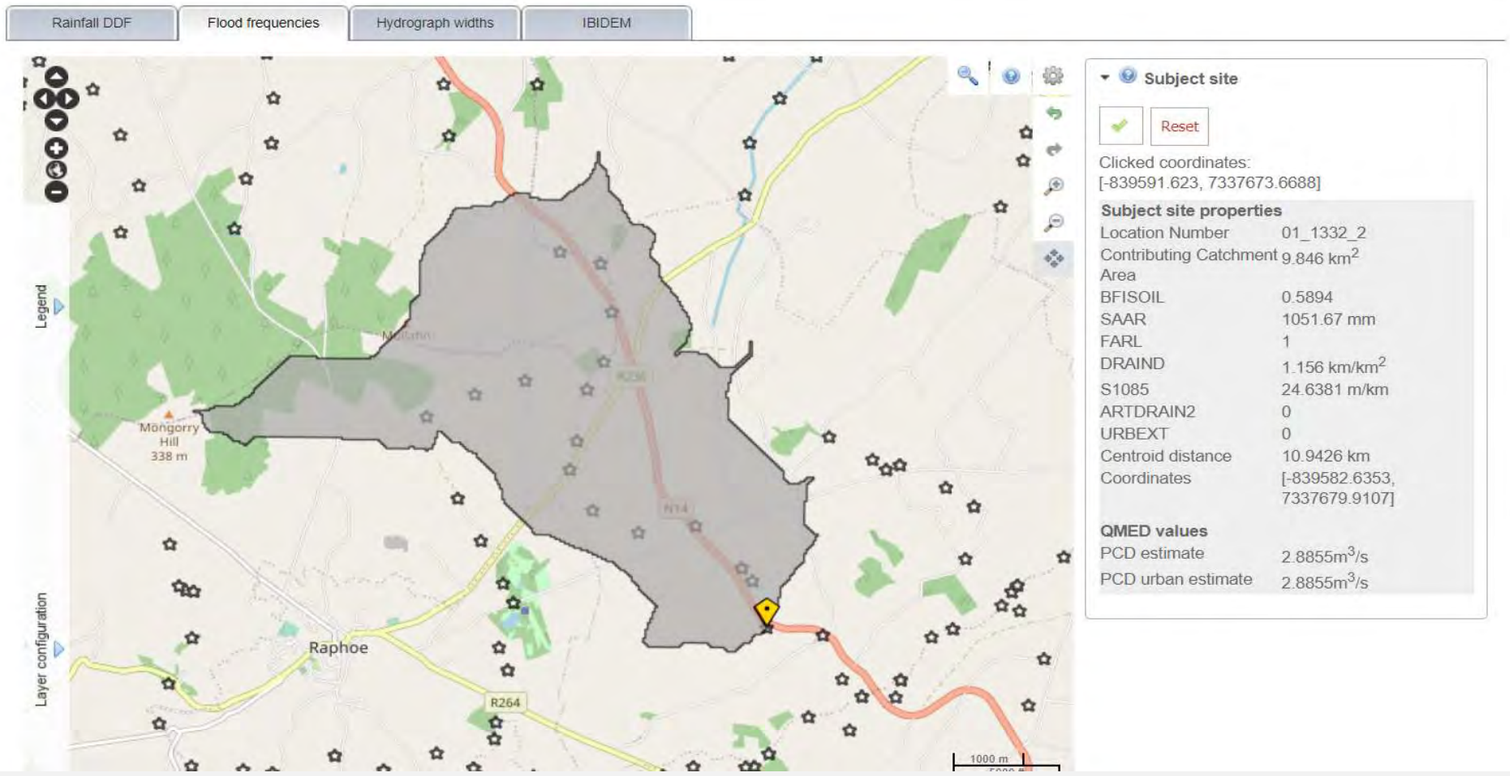
QMED *0.313* *m^3/s*

QBAR **0.326** **m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.178 m3/s	1.65	0.293 m3/s	0.57 m3/s	**0.69 m3/s**
FSSR 6, 3-Variable Method	0.186 m3/s	1.58	0.294 m3/s	0.58 m3/s	**0.69 m3/s**
FSU 3-Variable Method	0.247 m3/s	2.05	0.506 m3/s	0.99 m3/s	**1.19 m3/s**
FSU 4.2A Regression	0.326 m3/s	1.68	0.548 m3/s	1.07 m3/s	**1.29 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 15

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	7.90	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.72	km^2
SAAR - Standard Annual Average Rainfall	1046.8	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.6007	
URBEXT	0	
SOIL	0.3	
DRAIND	1.076	km/km^2
ARTDRAIN2	0.5048	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.202**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.212**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.260*	*m^3/s*
QBAR	**0.270**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

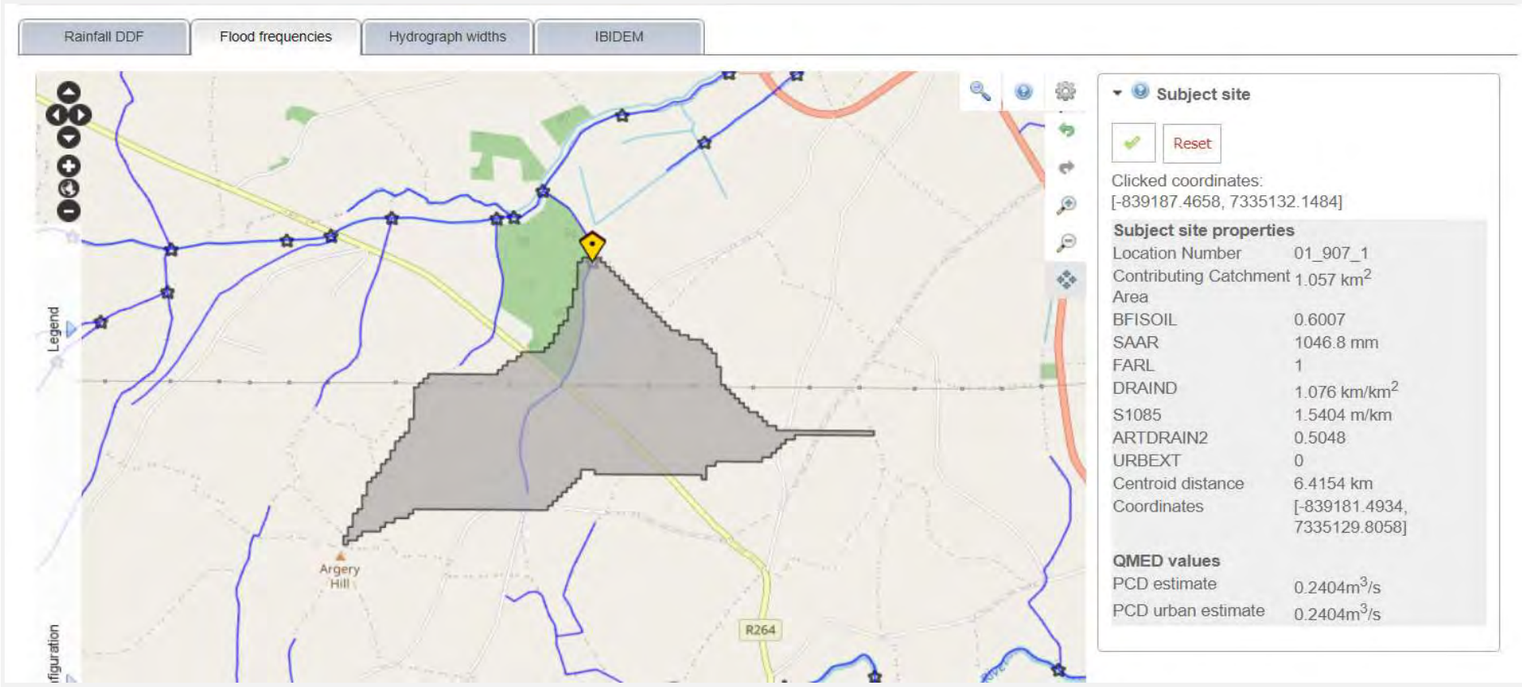
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.281*	*m^3/s*
QBAR	**0.293**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	OPW Factor	Climate Change
IoH 124	0.202 m3/s	1.65	0.333 m3/s	0.65 m3/s	1.04 m3/s	**1.25 m3/s**
FSSR 6, 3-Variable Method	0.212 m3/s	1.58	0.336 m3/s	0.66 m3/s	1.05 m3/s	**1.26 m3/s**
FSU 3-Variable Method	0.270 m3/s	2.05	0.554 m3/s	1.09 m3/s	1.74 m3/s	**2.09 m3/s**
FSU 4.2A Regression	0.293 m3/s	1.68	0.491 m3/s	0.96 m3/s	1.54 m3/s	**1.85 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 16

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	9.00	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.925	km^2
SAAR - Standard Annual Average Rainfall	1046.8	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.6007	
URBEXT	0	
SOIL	0.3	
DRAIND	1.076	km/km^2
ARTDRAIN2	0.5048	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.252**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.267**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.319*	*m^3/s*
QBAR	**0.333**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

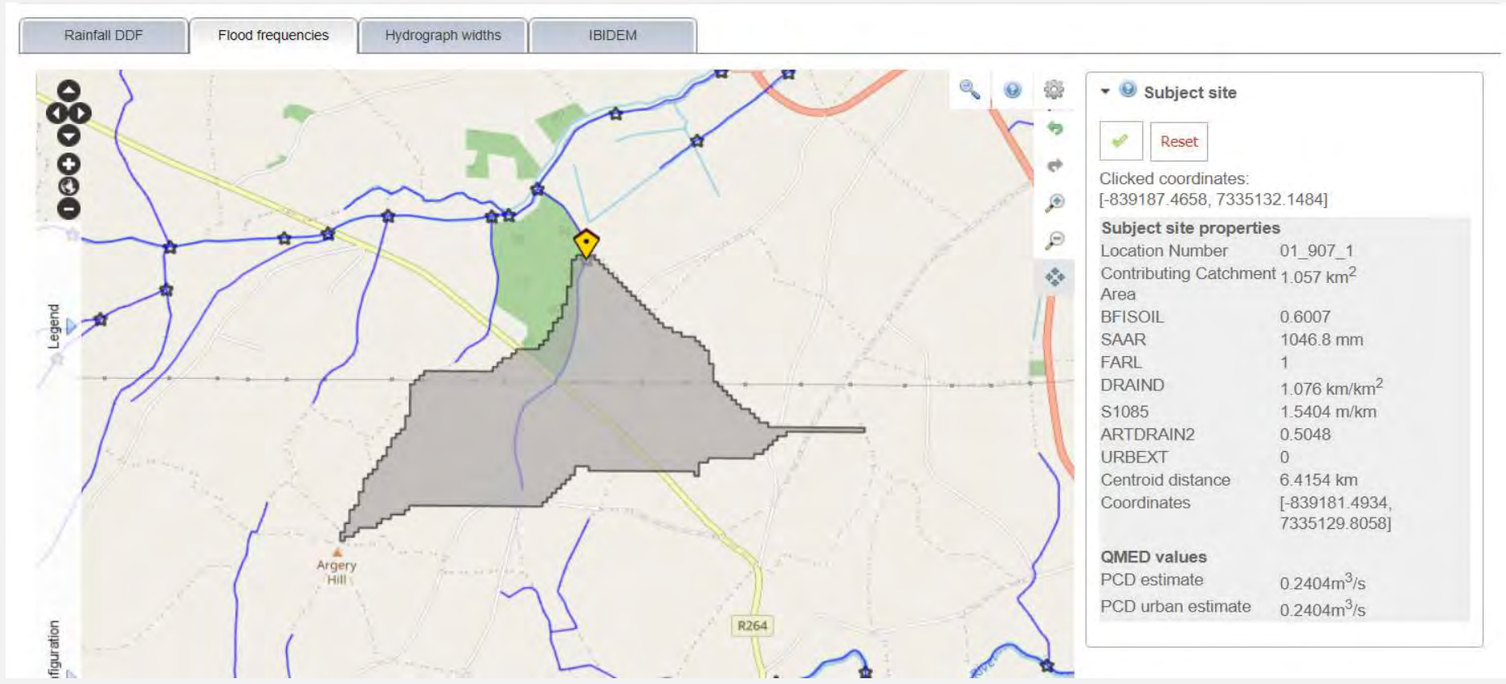
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.366*	*m^3/s*
QBAR	**0.381**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	OPW Factor	Climate Change
IoH 124	0.252 m3/s	1.65	0.416 m3/s	0.82 m3/s	1.31 m3/s	**1.57 m3/s**
FSSR 6, 3-Variable Method	0.267 m3/s	1.58	0.423 m3/s	0.83 m3/s	1.33 m3/s	**1.59 m3/s**
FSU 3-Variable Method	0.333 m3/s	2.05	0.682 m3/s	1.34 m3/s	2.14 m3/s	**2.57 m3/s**
FSU 4.2A Regression	0.381 m3/s	1.68	0.640 m3/s	1.25 m3/s	**2.01 m3/s**	**2.41 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 17

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	28.72	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.71	km^2
SAAR - Standard Annual Average Rainfall	1038.1	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5702	
URBEXT	0	
SOIL	0.3	
DRAIND	1.578	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.197**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.207**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.276*	*m^3/s*
QBAR	**0.287**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

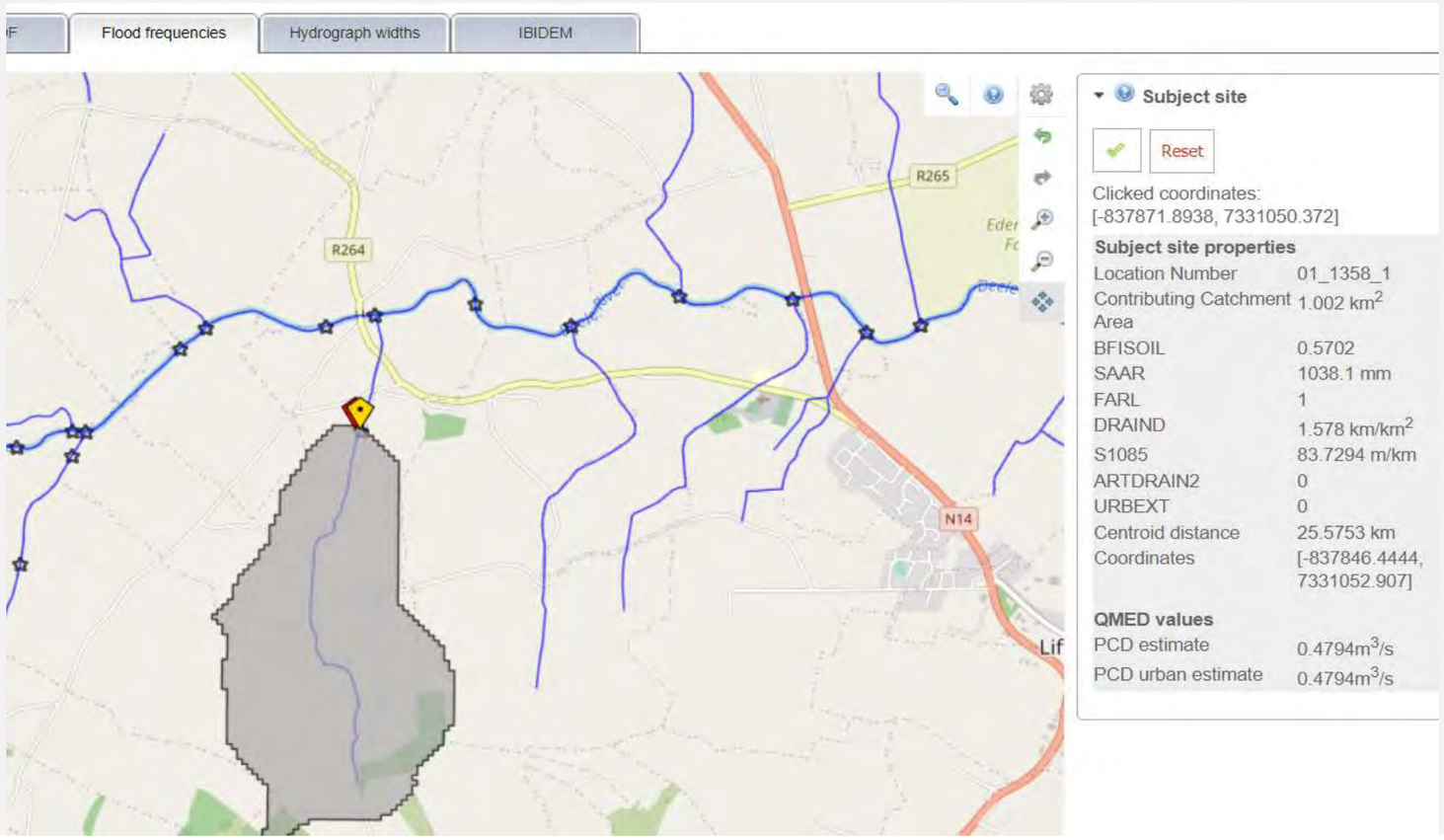
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.398*	*m^3/s*
QBAR	**0.414**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	OPW Factor	Climate Change
IoH 124	0.197 m3/s	1.65	0.326 m3/s	0.64 m3/s	1.02 m3/s	**1.23 m3/s**
FSSR 6, 3-Variable Method	0.207 m3/s	1.58	0.328 m3/s	0.64 m3/s	1.03 m3/s	**1.23 m3/s**
FSU 3-Variable Method	0.287 m3/s	2.05	0.589 m3/s	1.15 m3/s	1.85 m3/s	**2.22 m3/s**
FSU 4.2A Regression	0.414 m3/s	1.68	0.696 m3/s	1.36 m3/s	**2.18 m3/s**	**2.62 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 18

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	78.87	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.71	km^2
SAAR - Standard Annual Average Rainfall	1038.1	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.5702	
URBEXT	0	
SOIL	0.3	
DRAIND	1.578	km/km^2
ARTDRAIN2	0	

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.197**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.207**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.276*	*m^3/s*
QBAR	**0.287**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

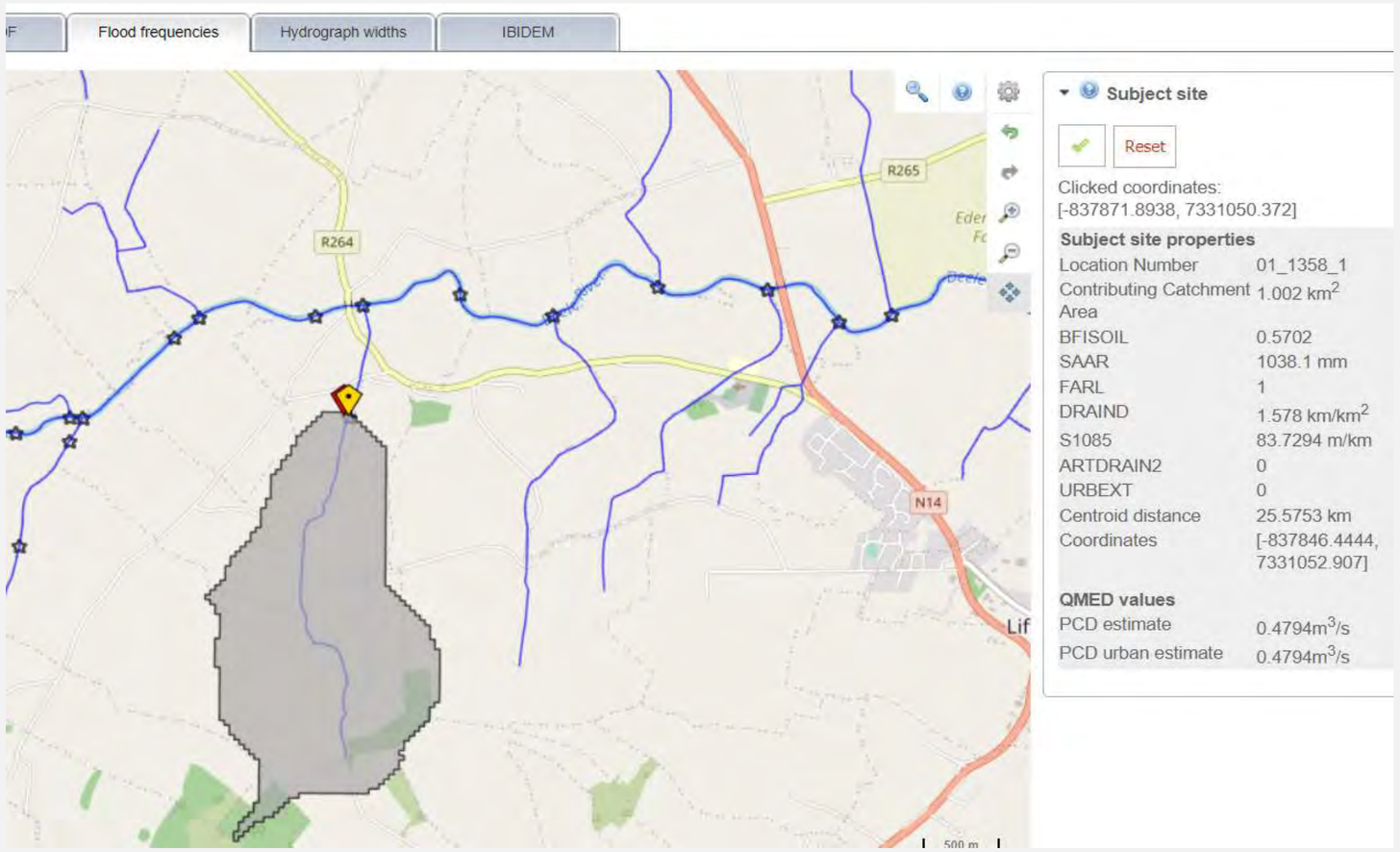
$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.513*	*m^3/s*
QBAR	**0.534**	**m^3/s**

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.197 m3/s	1.65	0.326 m3/s	0.64 m3/s	**0.77 m3/s**
FSSR 6, 3-Variable Method	0.207 m3/s	1.58	0.328 m3/s	0.64 m3/s	**0.77 m3/s**
FSU 3-Variable Method	0.287 m3/s	2.05	0.589 m3/s	1.15 m3/s	**1.39 m3/s**
FSU 4.2A Regression	0.534 m3/s	1.68	0.897 m3/s	1.76 m3/s	**2.11 m3/s**

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW

Flood Estimation in Small and Urbanised Catchments in Ireland



CATCHMENT 19

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	89.15	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.2	km^2
SAAR - Standard Annual Average Rainfall	1298.99	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.3941	
URBEXT	0.0077	
SOIL	0.3	
DRAIND	1.477	km/km^2
ARTDRAIN2	0.0813	

1.4 Catchment characteristics

Width	968	m
Height	96.5	m
Time of Concentration	6	min

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$	**0.083**	**m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR	**0.085**	**m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED	*0.208*	*m^3/s*
QBAR	**0.217**	**m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{-0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED	*0.304*	*m^3/s*
QBAR	**0.317**	**m^3/s**

6.0 ADAS

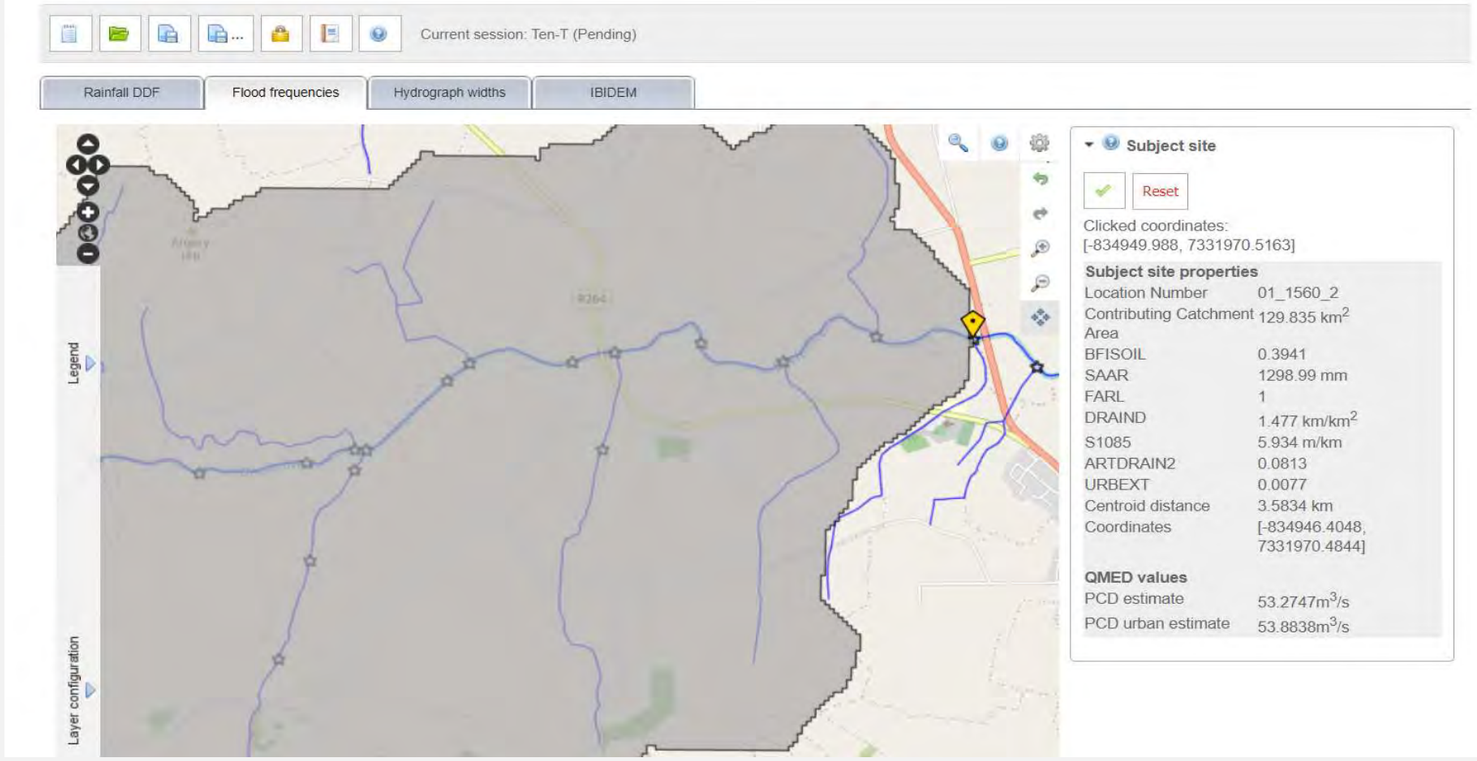
$$Q = AREA(0.0443SAAR - 11.19)SOIL^{2.0}\left[\frac{18.79T^{0.28} - 1}{10T}\right] \qquad T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$$

Q 75 year	*0.418*	*m^3/s*

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.083 m3/s	1.65	0.137 m3/s	0.27 m3/s	**0.32 m3/s**
FSSR 6, 3-Variable Method	0.085 m3/s	1.58	0.134 m3/s	0.26 m3/s	**0.32 m3/s**
FSU 3-Variable Method	0.217 m3/s	2.05	0.445 m3/s	0.87 m3/s	**1.05 m3/s**
FSU 4.2A Regression	0.317 m3/s	1.68	0.532 m3/s	1.04 m3/s	**1.25 m3/s**

Method	QBAR	Q 75 Year	100 Year Flow	Climate Change
ADAS	0.222 m3/s	0.42	0.435 m3/s	0.52 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW



CATCHMENT 20

1.0 PHYSICAL CATCHMENT DESCRIPTORS (PCD'S):

1.1 Hydrological PCD's

S1085 - Mainstream Slope	101.97	m/km

1.2 Spatial PCD's

AREA - Catchment Area	0.226	km^2
SAAR - Standard Annual Average Rainfall	1296.05	mm
FARL - Flood Attenuation by Rivers and Lakes	1.000	

1.3 Spatial PCD's Representing Soil, Subsoil & Aquifer Types

BFI_{SOIL}	0.3946	
URBEXT	0.0076	
SOIL	0.3	
DRAIND	1.476	km/km^2
ARTDRAIN2	0.0825	

1.4 Catchment characteristics

Width	885	m
Height	88.5	m
Time of Concentration	5.8	min

2.0 INSTITUTE OF HYDROLOGY REPORT 124 (IoH 124)

$$QBAR_{Rural} = 0.00108\,AREA^{0.89}\,SAAR^{1.17}\,SOIL^{2.17}$$

$QBAR_{RURAL}$ **0.092** **m^3/s**

3.0 FSSR 6, 3-VARIABLE METHOD

$$QBAR = 0.00066\,AREA^{0.92}\,SAAR^{1.22}\,SOIL^{2.0}$$

QBAR **0.095** **m^3/s**

4.0 FSU - 3 VARIABLES EQUATION

$$Qmed = 0.000302*(AREA^{0.829})*(SAAR^{0.898})*(BFI^{1.539})$$

QMED *0.230* *m^3/s*

QBAR **0.239** **m^3/s**

5.0 FSU 4.2A REGRESSION MODEL

$$Qmed = (2.0951*10^{-5})*(AREA^{0.9245})*(SAAR^{1.2695})*(BFI^{0.9030})*(FARL^{2.3163})*(S1085^{0.2513})$$

QMED *0.351* *m^3/s*

QBAR **0.365** **m^3/s**

6.0 ADAS

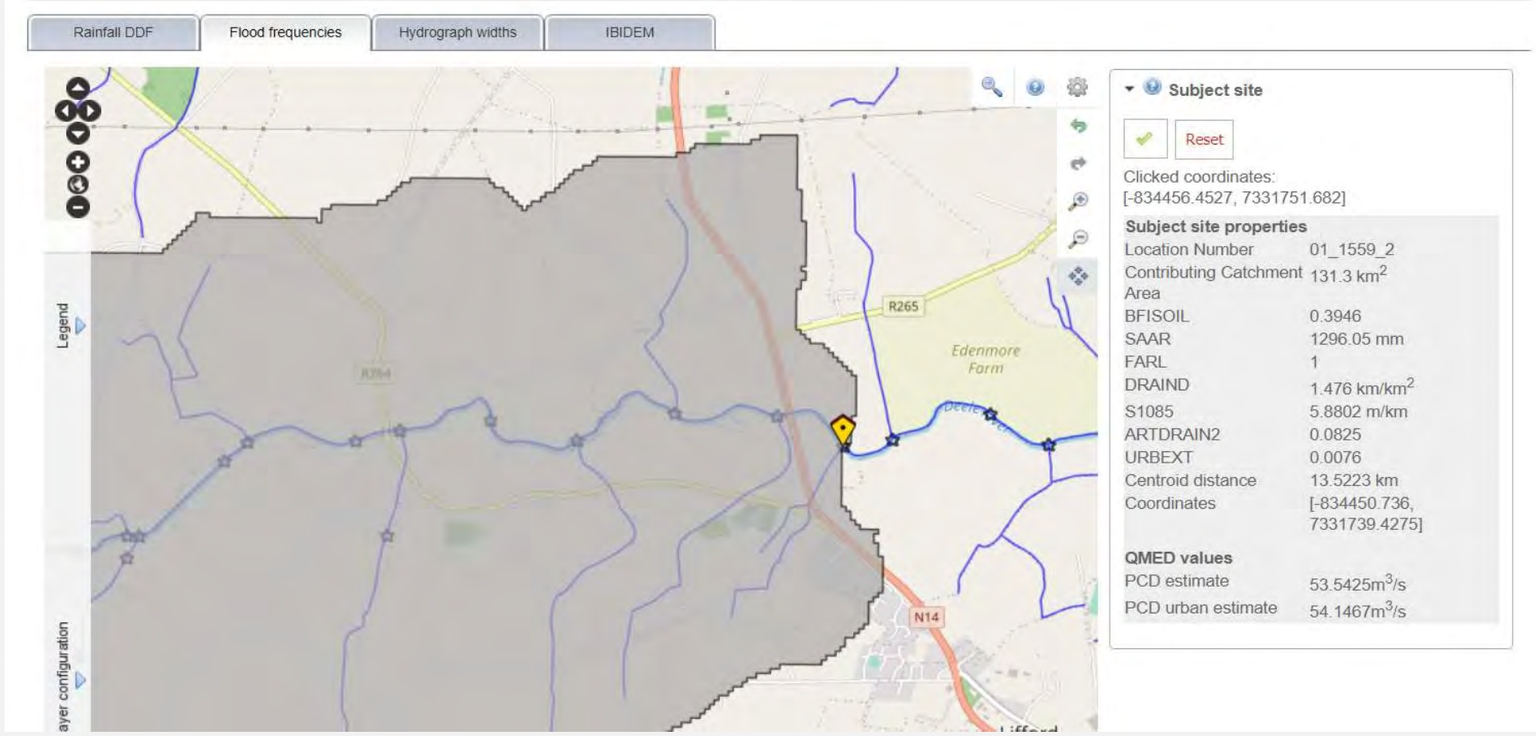
$$Q = AREA(0.0443SAAR - 11.19)SOIL^{2.0}\left[\frac{18.79T^{0.28} - 1}{10T}\right] \qquad T = 0.1677\frac{W^{0.78}}{Z^{0.39}}$$

Q 75 year *0.482* *m^3/s*

Method	QBAR	FSE	$QBAR_{FSE}$	100 Year Flow	Climate Change
IoH 124	0.092 m3/s	1.65	0.152 m3/s	0.30 m3/s	**0.36 m3/s**
FSSR 6, 3-Variable Method	0.095 m3/s	1.58	0.150 m3/s	0.29 m3/s	**0.35 m3/s**
FSU 3-Variable Method	0.239 m3/s	2.05	0.491 m3/s	0.96 m3/s	**1.15 m3/s**
FSU 4.2A Regression	0.365 m3/s	1.68	0.614 m3/s	1.20 m3/s	**1.44 m3/s**

Method	QBAR	Q 75 Year	100 Year Flow	Climate Change
ADAS	0.256 m3/s	0.48	0.503 m3/s	0.60 m3/s

QMED = 0.96QBAR as per "Flood Estimation in Small and Urbanised Catchments in Ireland" by the OPW



Culvert Designer/Analyzer Report
CV07

Peak Discharge Method: User-Specified					
Design Discharge	24.0400	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	22.92	m	Invert Downstream	22.57	m
Length	69.50	m	Slope	0.005036	m/m
Drop	0.35	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	24.0400	m³/s	Bottom Elevation	22.57	m
Depth	1.39	m	Velocity	3.15	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-2	1-4200 x 3000 Box	24.0400 m³/s	25.58 m	3.83 m/s

Culvert Designer/Analyzer Report
CV07

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	25.58	m	Discharge	24.0400	m³/s
Headwater Depth/Height	0.89		Tailwater Elevation	23.96	m
Inlet Control HW Elev.	25.20	m	Control Type	Outlet Control	
Outlet Control HW Elev.	25.58	m			

Grades					
Upstream Invert	22.92	m	Downstream Invert	22.57	m
Length	69.50	m	Constructed Slope	0.005036	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.49	m
Slope Type	Mild		Normal Depth	2.28	m
Flow Regime	Subcritical		Critical Depth	1.49	m
Velocity Downstream	3.83	m/s	Critical Slope	0.015807	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	4.20	m
Section Size	4200 x 3000		Rise	3.00	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	25.58	m	Upstream Velocity Head	0.39	m
Ke	0.50		Entrance Loss	0.19	m

Inlet Control Properties					
Inlet Control HW Elev.	25.20	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	12.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV08

Peak Discharge Method: User-Specified					
Design Discharge	0.9200	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	41.20	m	Invert Downstream	41.10	m
Length	24.50	m	Slope	0.004082	m/m
Drop	0.10	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	0.9200	m³/s	Bottom Elevation	41.10	m
Depth	0.52	m	Velocity	0.87	m/s

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-1800 x 900 Box	0.9200 m³/s	41.79 m	0.99 m/s

Culvert Designer/Analyzer
Report CV08

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	41.79	m	Discharge	0.9200	m³/s
Headwater Depth/Height	0.65		Tailwater Elevation	41.62	m
Inlet Control HW Elev.	41.65	m	Control Type	Outlet Control	
Outlet Control HW Elev.	41.79	m			

Grades					
Upstream Invert	41.20	m	Downstream Invert	41.10	m
Length	24.50	m	Constructed Slope	0.004082	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.52	m
Slope Type	Mild		Normal Depth	0.51	m
Flow Regime	Subcritical		Critical Depth	0.30	m
Velocity Downstream	0.99	m/s	Critical Slope	0.019348	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	1.80	m
Section Size	1800 x 900		Rise	0.90	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	41.79	m	Upstream Velocity Head	0.05	m
Ke	0.50		Entrance Loss	0.03	m

Inlet Control Properties					
Inlet Control HW Elev.	41.65	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	1.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
S3-CV09

Peak Discharge Method: User-Specified					
Design Discharge	1.0000	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	41.05	m	Invert Downstream	40.67	m
Length	79.10	m	Slope	0.004804	m/m
Drop	0.38	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	1.0000	m³/s	Bottom Elevation	40.67	m
Depth	0.54	m	Velocity	0.89	m/s

Name	Description	Discharge	HW Elev.	Velocity
x Trial-1	1-1800 x 900 mm Box	1.0000 m³/s	41.65 m	1.02 m/s

Culvert Designer/Analyzer Report
S3-CV09

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	41.65	m	Discharge	1.0000	m³/s
Headwater Depth/Height	0.67		Tailwater Elevation	41.21	m
Inlet Control HW Elev.	41.52	m	Control Type	Outlet Control	
Outlet Control HW Elev.	41.65	m			

Grades					
Upstream Invert	41.05	m	Downstream Invert	40.67	m
Length	79.10	m	Constructed Slope	0.004804	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.54	m
Slope Type	Mild		Normal Depth	0.51	m
Flow Regime	Subcritical		Critical Depth	0.32	m
Velocity Downstream	1.02	m/s	Critical Slope	0.019355	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	1.80	m
Section Size	1800 x 900 mm		Rise	0.90	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	41.65	m	Upstream Velocity Head	0.06	m
Ke	0.50		Entrance Loss	0.03	m

Inlet Control Properties					
Inlet Control HW Elev.	41.52	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	1.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV10

Comments:

Peak Discharge Method: User-Specified					
Design Discharge	2.1500	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	35.60	m	Invert Downstream	35.33	m
Length	53.50	m	Slope	0.005047	m/m
Drop	0.27	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.1500	m³/s	Bottom Elevation	35.33	m
Depth	0.69	m	Velocity	1.85	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2000 x 1300 mm RCBC	2.1500 m³/s	36.52 m	1.56 m/s

Culvert Designer/Analyzer
Report CV10

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	36.52	m	Discharge	2.1500	m³/s
Headwater Depth/Height	0.70		Tailwater Elevation	36.02	m
Inlet Control HW Elev.	36.34	m	Control Type	Outlet Control	
Outlet Control HW Elev.	36.52	m			

Grades					
Upstream Invert	35.60	m	Downstream Invert	35.33	m
Length	53.50	m	Constructed Slope	0.005047	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.69	m
Slope Type	Mild		Normal Depth	0.79	m
Flow Regime	Subcritical		Critical Depth	0.49	m
Velocity Downstream	1.56	m/s	Critical Slope	0.019053	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1300 mm		Rise	1.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	36.52	m	Upstream Velocity Head	0.10	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	36.34	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV11

Comments:

Peak Discharge Method: User-Specified					
Design Discharge	2.1500	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	34.90	m	Invert Downstream	34.80	m
Length	19.00	m	Slope	0.005263	m/m
Drop	0.10	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.1500	m³/s	Bottom Elevation	34.80	m
Depth	0.66	m	Velocity	1.96	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2000 x 1200 mm RCBC	2.1500 m³/s	35.79 m	1.62 m/s

Culvert Designer/Analyzer
Report CV11

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	35.79	m	Discharge	2.1500	m³/s
Headwater Depth/Height	0.74		Tailwater Elevation	35.46	m
Inlet Control HW Elev.	35.64	m	Control Type	Outlet Control	
Outlet Control HW Elev.	35.79	m			

Grades					
Upstream Invert	34.90	m	Downstream Invert	34.80	m
Length	19.00	m	Constructed Slope	0.005263	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.66	m
Slope Type	Mild		Normal Depth	0.77	m
Flow Regime	Subcritical		Critical Depth	0.49	m
Velocity Downstream	1.62	m/s	Critical Slope	0.019053	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1200 mm		Rise	1.20	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	35.79	m	Upstream Velocity Head	0.11	m
Ke	0.50		Entrance Loss	0.06	m

Inlet Control Properties					
Inlet Control HW Elev.	35.64	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.4	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV14

Peak Discharge Method: User-Specified					
Design Discharge	6.5000	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	72.26	m	Invert Downstream	72.05	m
Length	23.23	m	Slope	0.009040	m/m
Drop	0.21	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	6.5000	m³/s	Bottom Elevation	72.05	m
Depth	0.95	m	Velocity	1.76	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-3	1-4200 x 1400 mm Box	6.5000 m³/s	73.35 m	1.63 m/s

Culvert Designer/Analyzer
Report CV14

Design:Trial-3

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	73.35	m	Discharge	6.5000	m³/s
Headwater Depth/Height	0.78		Tailwater Elevation	73.00	m
Inlet Control HW Elev.	73.21	m	Control Type	Outlet Control	
Outlet Control HW Elev.	73.35	m			

Grades					
Upstream Invert	72.26	m	Downstream Invert	72.05	m
Length	23.23	m	Constructed Slope	0.009040	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.95	m
Slope Type	Mild		Normal Depth	0.73	m
Flow Regime	Subcritical		Critical Depth	0.63	m
Velocity Downstream	1.63	m/s	Critical Slope	0.014610	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	4.20	m
Section Size	4200 x 1400 mm		Rise	1.40	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	73.35	m	Upstream Velocity Head	0.18	m
Ke	0.50		Entrance Loss	0.09	m

Inlet Control Properties					
Inlet Control HW Elev.	73.21	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	5.9	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV15

Peak Discharge Method: User-Specified					
Design Discharge	6.5000	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	71.80	m	Invert Downstream	71.60	m
Length	60.00	m	Slope	0.003333	m/m
Drop	0.20	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	6.5000	m³/s	Bottom Elevation	71.60	m
Depth	1.27	m	Velocity	1.13	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-3700 x 1700 mm Box	6.5000 m³/s	73.18 m	1.39 m/s

Culvert Designer/Analyzer
Report CV15

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	73.18	m	Discharge	6.5000	m³/s
Headwater Depth/Height	0.81		Tailwater Elevation	72.87	m
Inlet Control HW Elev.	72.87	m	Control Type	Outlet Control	
Outlet Control HW Elev.	73.18	m			

Grades					
Upstream Invert	71.80	m	Downstream Invert	71.60	m
Length	60.00	m	Constructed Slope	0.003333	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	1.27	m
Slope Type	Mild		Normal Depth	1.15	m
Flow Regime	Subcritical		Critical Depth	0.68	m
Velocity Downstream	1.39	m/s	Critical Slope	0.015236	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	3.70	m
Section Size	3700 x 1700 mm		Rise	1.70	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	73.18	m	Upstream Velocity Head	0.11	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	72.87	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	6.3	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV16

Peak Discharge Method: User-Specified					
Design Discharge	6.5000	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	71.45	m	Invert Downstream	71.30	m
Length	22.71	m	Slope	0.006605	m/m
Drop	0.15	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	6.5000	m³/s	Bottom Elevation	71.30	m
Depth	1.47	m	Velocity	1.54	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-3700 x 1800 mm Box	6.5000 m³/s	72.93 m	1.20 m/s

Culvert Designer/Analyzer
Report CV16

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	72.93	m	Discharge	6.5000	m³/s
Headwater Depth/Height	0.82		Tailwater Elevation	72.77	m
Inlet Control HW Elev.	72.77	m	Control Type	Outlet Control	
Outlet Control HW Elev.	72.93	m			

Grades					
Upstream Invert	71.45	m	Downstream Invert	71.30	m
Length	22.71	m	Constructed Slope	0.006605	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	1.47	m
Slope Type	Mild		Normal Depth	0.90	m
Flow Regime	Subcritical		Critical Depth	0.68	m
Velocity Downstream	1.20	m/s	Critical Slope	0.015236	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	3.70	m
Section Size	3700 x 1800 mm		Rise	1.80	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	72.93	m	Upstream Velocity Head	0.09	m
Ke	0.50		Entrance Loss	0.04	m

Inlet Control Properties					
Inlet Control HW Elev.	72.77	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	6.7	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV18

Peak Discharge Method: User-Specified					
Design Discharge	2.2900	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	82.51	m	Invert Downstream	82.27	m
Length	48.40	m	Slope	0.004959	m/m
Drop	0.24	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.2900	m³/s	Bottom Elevation	82.27	m
Depth	0.46	m	Velocity	2.41	m/s

Name	Description	Discharge	HW Elev.	Velocity
x Trial-2	1-2000 x 1300 mm RCB	2.2900 m³/s	83.46 m	2.24 m/s

Culvert Designer/Analyzer
Report CV18

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	83.46	m	Discharge	2.2900	m³/s
Headwater Depth/Height	0.73		Tailwater Elevation	82.73	m
Inlet Control HW Elev.	83.28	m	Control Type	Outlet Control	
Outlet Control HW Elev.	83.46	m			

Grades					
Upstream Invert	82.51	m	Downstream Invert	82.27	m
Length	48.40	m	Constructed Slope	0.004959	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.51	m
Slope Type	Mild		Normal Depth	0.83	m
Flow Regime	Subcritical		Critical Depth	0.51	m
Velocity Downstream	2.24	m/s	Critical Slope	0.019143	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1300 mm		Rise	1.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	83.46	m	Upstream Velocity Head	0.11	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	83.28	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV19

Peak Discharge Method: User-Specified					
Design Discharge	2.2900	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	80.55	m	Invert Downstream	80.37	m
Length	36.00	m	Slope	0.005000	m/m
Drop	0.18	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.2900	m³/s	Bottom Elevation	80.37	m
Depth	0.61	m	Velocity	1.68	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-2	1-2000 x 1300 mm RCP	2.2900 m³/s	81.49 m	1.86 m/s

Culvert Designer/Analyzer
Report CV19

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	81.49	m	Discharge	2.2900	m³/s
Headwater Depth/Height	0.72		Tailwater Elevation	80.98	m
Inlet Control HW Elev.	81.32	m	Control Type	Outlet Control	
Outlet Control HW Elev.	81.49	m			

Grades					
Upstream Invert	80.55	m	Downstream Invert	80.37	m
Length	36.00	m	Constructed Slope	0.005000	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.61	m
Slope Type	Mild		Normal Depth	0.82	m
Flow Regime	Subcritical		Critical Depth	0.51	m
Velocity Downstream	1.86	m/s	Critical Slope	0.019143	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1300 mm		Rise	1.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	81.49	m	Upstream Velocity Head	0.11	m
Ke	0.50		Entrance Loss	0.06	m

Inlet Control Properties					
Inlet Control HW Elev.	81.32	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV20

Peak Discharge Method: User-Specified					
Design Discharge	4.3400	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	70.03	m	Invert Downstream	69.80	m
Length	60.00	m	Slope	0.003833	m/m
Drop	0.23	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	4.3400	m³/s	Bottom Elevation	69.80	m
Depth	0.92	m	Velocity	1.67	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-3200 x 1400 mm RCB	4.3400 m³/s	71.12 m	1.48 m/s

Culvert Designer/Analyzer
Report CV20

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	71.12	m	Discharge	4.3400	m³/s
Headwater Depth/Height	0.78		Tailwater Elevation	70.72	m
Inlet Control HW Elev.	70.89	m	Control Type	Outlet Control	
Outlet Control HW Elev.	71.12	m			

Grades					
Upstream Invert	70.03	m	Downstream Invert	69.80	m
Length	60.00	m	Constructed Slope	0.003833	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.92	m
Slope Type	Mild		Normal Depth	0.93	m
Flow Regime	Subcritical		Critical Depth	0.57	m
Velocity Downstream	1.48	m/s	Critical Slope	0.015982	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	3.20	m
Section Size	3200 x 1400 mm		Rise	1.40	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	71.12	m	Upstream Velocity Head	0.11	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	70.89	m	Flow Control	N/A	
Inlet Type	30° to 75° wingwall flares (CIRIA)		Area Full	4.5	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
CV21

Comments:

Peak Discharge Method: User-Specified					
Design Discharge	1.5800	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	66.04	m	Invert Downstream	65.90	m
Length	16.50	m	Slope	0.008485	m/m
Drop	0.14	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	1.5800	m³/s	Bottom Elevation	65.90	m
Depth	0.59	m	Velocity	1.24	m/s

Name	Description	Discharge	HW Elev.	Velocity
x Trial-2	1-2800 x 900 mm Box	1.5800 m³/s	66.63 m	0.96 m/s

Culvert Designer/Analyzer
Report CV21

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	66.63	m	Discharge	1.5800	m³/s
Headwater Depth/Height	0.65		Tailwater Elevation	66.49	m
Inlet Control HW Elev.	66.52	m	Control Type	Outlet Control	
Outlet Control HW Elev.	66.63	m			

Grades					
Upstream Invert	66.04	m	Downstream Invert	65.90	m
Length	16.50	m	Constructed Slope	0.008485	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.59	m
Slope Type	Mild		Normal Depth	0.40	m
Flow Regime	Subcritical		Critical Depth	0.32	m
Velocity Downstream	0.96	m/s	Critical Slope	0.016983	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.80	m
Section Size	2800 x 900 mm		Rise	0.90	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	66.63	m	Upstream Velocity Head	0.07	m
Ke	0.50		Entrance Loss	0.03	m

Inlet Control Properties					
Inlet Control HW Elev.	66.52	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.5	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV22

Peak Discharge Method: User-Specified					
Design Discharge	1.5800	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	65.80	m	Invert Downstream	65.65	m
Length	34.60	m	Slope	0.004335	m/m
Drop	0.15	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	1.5800	m³/s	Bottom Elevation	65.65	m
Depth	0.70	m	Velocity	0.93	m/s

Name	Description	Discharge	HW Elev.	Velocity
x Trial-2	1-2800 x 1000 mm Box	1.5800 m³/s	66.48 m	0.80 m/s

Culvert Designer/Analyzer
Report CV22

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	66.48	m	Discharge	1.5800	m³/s
Headwater Depth/Height	0.68		Tailwater Elevation	66.35	m
Inlet Control HW Elev.	66.35	m	Control Type	Outlet Control	
Outlet Control HW Elev.	66.48	m			

Grades					
Upstream Invert	65.80	m	Downstream Invert	65.65	m
Length	34.60	m	Constructed Slope	0.004335	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.70	m
Slope Type	Mild		Normal Depth	0.50	m
Flow Regime	Subcritical		Critical Depth	0.32	m
Velocity Downstream	0.80	m/s	Critical Slope	0.016983	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.80	m
Section Size	2800 x 1000 mm		Rise	1.00	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	66.48	m	Upstream Velocity Head	0.04	m
Ke	0.50		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	66.35	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.8	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV23

Peak Discharge Method: User-Specified					
Design Discharge	1.5800	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	65.22	m	Invert Downstream	65.10	m
Length	23.66	m	Slope	0.005072	m/m
Drop	0.12	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	1.5800	m³/s	Bottom Elevation	65.10	m
Depth	0.49	m	Velocity	1.64	m/s

Name	Description	Discharge	HW Elev.	Velocity
x Trial-2	1-2200 x 1000 mm Box	1.5800 m³/s	65.90 m	1.47 m/s

Culvert Designer/Analyzer
Report CV23

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	65.90	m	Discharge	1.5800	m³/s
Headwater Depth/Height	0.68		Tailwater Elevation	65.59	m
Inlet Control HW Elev.	65.78	m	Control Type	Outlet Control	
Outlet Control HW Elev.	65.90	m			

Grades					
Upstream Invert	65.22	m	Downstream Invert	65.10	m
Length	23.66	m	Constructed Slope	0.005072	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.49	m
Slope Type	Mild		Normal Depth	0.58	m
Flow Regime	Subcritical		Critical Depth	0.37	m
Velocity Downstream	1.47	m/s	Critical Slope	0.018097	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.20	m
Section Size	2200 x 1000 mm		Rise	1.00	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	65.90	m	Upstream Velocity Head	0.09	m
Ke	0.50		Entrance Loss	0.04	m

Inlet Control Properties					
Inlet Control HW Elev.	65.78	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.2	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
S3-CV24

Peak Discharge Method: User-Specified					
Design Discharge	15.0600	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	34.15	m	Invert Downstream	34.11	m
Length	17.70	m	Slope	0.002260	m/m
Drop	0.04	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	15.0600	m³/s	Bottom Elevation	34.11	m
Depth	2.01	m	Velocity	1.25	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-6.00 X 2.50 m Box	15.0600 m³/s	36.26 m	1.25 m/s

Culvert Designer/Analyzer Report
S3-CV24

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	36.26	m	Discharge	15.0600	m³/s
Headwater Depth/Height	0.84		Tailwater Elevation	36.12	m
Inlet Control HW Elev.	36.12	m	Control Type	Outlet Control	
Outlet Control HW Elev.	36.26	m			

Grades					
Upstream Invert	34.15	m	Downstream Invert	34.11	m
Length	17.70	m	Constructed Slope	0.002260	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	2.01	m
Slope Type	Mild		Normal Depth	1.56	m
Flow Regime	Subcritical		Critical Depth	0.86	m
Velocity Downstream	1.25	m/s	Critical Slope	0.012987	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	6.00	m
Section Size	6.00 X 2.50 m		Rise	2.50	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	36.26	m	Upstream Velocity Head	0.08	m
Ke	0.50		Entrance Loss	0.04	m

Inlet Control Properties					
Inlet Control HW Elev.	36.12	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	15.0	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
S3-CV25

Peak Discharge Method: User-Specified					
Design Discharge	2.6000	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	21.55	m	Invert Downstream	21.40	m
Length	50.20	m	Slope	0.002988	m/m
Drop	0.15	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.6000	m³/s	Bottom Elevation	21.40	m
Depth	0.57	m	Velocity	1.77	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-2	1-2000 x 1400 mm Box	2.6000 m³/s	22.51 m	2.27 m/s

Culvert Designer/Analyzer Report
S3-CV25

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	22.51	m	Discharge	2.6000	m³/s
Headwater Depth/Height	0.69		Tailwater Elevation	21.97	m
Inlet Control HW Elev.	22.39	m	Control Type	Outlet Control	
Outlet Control HW Elev.	22.51	m			

Grades					
Upstream Invert	21.55	m	Downstream Invert	21.40	m
Length	50.20	m	Constructed Slope	0.002988	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.57	m
Slope Type	Mild		Normal Depth	0.60	m
Flow Regime	Subcritical		Critical Depth	0.56	m
Velocity Downstream	2.27	m/s	Critical Slope	0.003635	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1400	mm	Rise	1.40	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	22.51	m	Upstream Velocity Head	0.24	m
Ke	0.50		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	22.39	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.8	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
S3-CV26

Peak Discharge Method: User-Specified					
Design Discharge	2.6000	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	21.30	m	Invert Downstream	21.00	m
Length	59.00	m	Slope	0.005085	m/m
Drop	0.30	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.6000	m³/s	Bottom Elevation	21.00	m
Depth	0.69	m	Velocity	1.41	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2000 x 1400 mm Box	2.6000 m³/s	22.34 m	1.90 m/s

Culvert Designer/Analyzer Report
S3-CV26

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	22.34	m	Discharge	2.6000	m³/s
Headwater Depth/Height	0.74		Tailwater Elevation	21.69	m
Inlet Control HW Elev.	22.14	m	Control Type	Outlet Control	
Outlet Control HW Elev.	22.34	m			

Grades					
Upstream Invert	21.30	m	Downstream Invert	21.00	m
Length	59.00	m	Constructed Slope	0.005085	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.69	m
Slope Type	Mild		Normal Depth	0.90	m
Flow Regime	Subcritical		Critical Depth	0.56	m
Velocity Downstream	1.90	m/s	Critical Slope	0.019356	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1400	mm	Rise	1.40	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	22.34	m	Upstream Velocity Head	0.12	m
Ke	0.50		Entrance Loss	0.06	m

Inlet Control Properties					
Inlet Control HW Elev.	22.14	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.8	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV28

Peak Discharge Method: User-Specified					
Design Discharge	2.0900	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	1.69	m	Invert Downstream	1.39	m
Length	60.00	m	Slope	0.005000	m/m
Drop	0.30	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.0900	m³/s	Bottom Elevation	1.39	m
Depth	0.90	m	Velocity	0.82	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2000 x 1300 mm RCB	2.0900 m³/s	2.63 m	1.16 m/s

Culvert Designer/Analyzer
Report CV28

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	2.63	m	Discharge	2.0900	m³/s
Headwater Depth/Height	0.72		Tailwater Elevation	2.29	m
Inlet Control HW Elev.	2.41	m	Control Type	Outlet Control	
Outlet Control HW Elev.	2.63	m			

Grades					
Upstream Invert	1.69	m	Downstream Invert	1.39	m
Length	60.00	m	Constructed Slope	0.005000	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.90	m
Slope Type	Mild		Normal Depth	0.77	m
Flow Regime	Subcritical		Critical Depth	0.48	m
Velocity Downstream	1.16	m/s	Critical Slope	0.019016	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1300 mm		Rise	1.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	2.63	m	Upstream Velocity Head	0.08	m
Ke	0.50		Entrance Loss	0.04	m

Inlet Control Properties					
Inlet Control HW Elev.	2.41	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
S3-CUL.29

Peak Discharge Method: User-Specified					
Design Discharge	4.6600	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	0.63	m	Invert Downstream	0.36	m
Length	54.50	m	Slope	0.004954	m/m
Drop	0.27	m			

Headwater Model: Unspecified

Tailwater Conditions: Constant Tailwater		
Tailwater Elevation	1.16	m

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2800 x 1700 Box	4.6600 m³/s	1.82 m	2.08 m/s

Culvert Designer/Analyzer Report
S3-CUL.29

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	1.82	m	Discharge	4.6600	m³/s
Headwater Depth/Height	0.70		Tailwater Elevation	1.16	m
Inlet Control HW Elev.	1.62	m	Control Type	Outlet Control	
Outlet Control HW Elev.	1.82	m			

Grades					
Upstream Invert	0.63	m	Downstream Invert	0.36	m
Length	54.50	m	Constructed Slope	0.004954	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.80	m
Slope Type	Mild		Normal Depth	1.01	m
Flow Regime	Subcritical		Critical Depth	0.66	m
Velocity Downstream	2.08	m/s	Critical Slope	0.016956	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.80	m
Section Size	2800 x 1700		Rise	1.70	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	1.82	m	Upstream Velocity Head	0.15	m
Ke	0.50		Entrance Loss	0.08	m

Inlet Control Properties					
Inlet Control HW Elev.	1.62	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	4.8	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer
Report CV30

Comments:

Peak Discharge Method: User-Specified					
Design Discharge	2.6200	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	4.50	m	Invert Downstream	3.50	m
Length	66.00	m	Slope	0.015152	m/m
Drop	1.00	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.6200	m³/s	Bottom Elevation	3.50	m
Depth	0.91	m	Velocity	1.50	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2000 x 1300 mm RCBC	2.6200 m³/s	5.46 m	1.44 m/s

Culvert Designer/Analyzer
Report CV30

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	5.46	m	Discharge	2.6200	m³/s
Headwater Depth/Height	0.74		Tailwater Elevation	4.41	m
Inlet Control HW Elev.	5.35	m	Control Type	Outlet Control	
Outlet Control HW Elev.	5.46	m			

Grades					
Upstream Invert	4.50	m	Downstream Invert	3.50	m
Length	66.00	m	Constructed Slope	0.015152	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.91	m
Slope Type	Mild		Normal Depth	0.61	m
Flow Regime	Subcritical		Critical Depth	0.56	m
Velocity Downstream	1.44	m/s	Critical Slope	0.019370	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	2.00	m
Section Size	2000 x 1300 mm		Rise	1.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	5.46	m	Upstream Velocity Head	0.24	m
Ke	0.50		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	5.35	m	Flow Control	N/A	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.6	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Culvert Designer/Analyzer Report
S3-CV31

Peak Discharge Method: User-Specified					
Design Discharge	2.1100	m³/s	Check Discharge	0.0000	m³/s

Grades Model: Inverts					
Invert Upstream	25.78	m	Invert Downstream	19.35	m
Length	70.50	m	Slope	0.091206	m/m
Drop	6.43	m			

Headwater Model: Unspecified

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.1100	m³/s	Bottom Elevation	19.35	m
Depth	0.47	m	Velocity	3.05	m/s

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-2	1-1800 x 1300 mm Box	2.1100 m³/s	26.69 m	3.78 m/s

Culvert Designer/Analyzer Report
S3-CV31

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	m	Storm Event	Design	
Computed Headwater Elev	26.69	m	Discharge	2.1100	m³/s
Headwater Depth/Height	0.70		Tailwater Elevation	19.82	m
Inlet Control HW Elev.	26.56	m	Control Type	Entrance Control	
Outlet Control HW Elev.	26.69	m			

Grades					
Upstream Invert	25.78	m	Downstream Invert	19.35	m
Length	70.50	m	Constructed Slope	0.091206	m/m

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.31	m
Slope Type	Steep		Normal Depth	0.31	m
Flow Regime	Supercritical		Critical Depth	0.52	m
Velocity Downstream	3.78	m/s	Critical Slope	0.020156	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.030	
Section Material	Concrete		Span	1.80	m
Section Size	1800 x 1300 mm		Rise	1.30	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	26.69	m	Upstream Velocity Head	0.26	m
Ke	0.50		Entrance Loss	0.13	m

Inlet Control Properties					
Inlet Control HW Elev.	26.56	m	Flow Control	Unsubmerged	
Inlet Type	30 to 75° wingwall flares (CIRIA)		Area Full	2.3	m²
K	0.46900		HDS 5 Chart	8	
M	0.69600		HDS 5 Scale	1	
C	0.03300		Equation Form	2	
Y	0.75100				

Project	Ten-T Priority Route Improvement Project, Donegal	BARRY TRANSPORTATION	
Subject	OPW Section 50_CV27	Job No	Y16112
Prepared by:	SH	Date	17/11/2021
Checked by:	RF	Revision	P01

Calculation of channel flow for a range of depths

Channel characteristics - Upstream tie in to Culvert Inlet

Upstream bed level =	19.36	LH side slope 1v:Xh=	1.00
Downstream bed level =	19.03	RH side slope 1v:Xh=	1.00
Length =	26.36	Bed width=	4.00
Slope S =	0.01252	(value used)	
1/S =	79.8788	Manning's n =	0.04

Channel flow

Starting depth of flow =	1	FLOW =	18.95
Depth of flow increment =	0.01	FLOOD LEVEL =	20.380
		BANK HEIGHT =	203.400
		FLOOD	NO

Depth of flow	width of flow	Xsect area	wetted perimeter	Q	v
1.000	6.000	5.000	6.828	11.362	2.272
1.010	6.020	5.060	6.857	11.559	2.284
1.020	6.040	5.120	6.885	11.757	2.296
1.030	6.060	5.181	6.913	11.957	2.308
1.040	6.080	5.242	6.942	12.158	2.320
1.050	6.100	5.303	6.970	12.361	2.331
1.060	6.120	5.364	6.998	12.565	2.343
1.070	6.140	5.425	7.026	12.771	2.354
1.080	6.160	5.486	7.055	12.978	2.366
1.090	6.180	5.548	7.083	13.187	2.377
1.100	6.200	5.610	7.111	13.398	2.388
1.110	6.220	5.672	7.140	13.610	2.399
1.120	6.240	5.734	7.168	13.823	2.411
1.130	6.260	5.797	7.196	14.038	2.422
1.140	6.280	5.860	7.224	14.255	2.433
1.150	6.300	5.923	7.253	14.473	2.444
1.160	6.320	5.986	7.281	14.693	2.455
1.170	6.340	6.049	7.309	14.914	2.466
1.180	6.360	6.112	7.338	15.137	2.476
1.190	6.380	6.176	7.366	15.362	2.487
1.200	6.400	6.240	7.394	15.587	2.498
1.210	6.420	6.304	7.422	15.815	2.509
1.220	6.440	6.368	7.451	16.044	2.519
1.230	6.460	6.433	7.479	16.275	2.530
1.240	6.480	6.498	7.507	16.507	2.540
1.250	6.500	6.563	7.536	16.740	2.551
1.260	6.520	6.628	7.564	16.976	2.561
1.270	6.540	6.693	7.592	17.212	2.572
1.280	6.560	6.758	7.620	17.451	2.582
1.290	6.580	6.824	7.649	17.691	2.592
1.300	6.600	6.890	7.677	17.932	2.603
1.310	6.620	6.956	7.705	18.175	2.613
1.320	6.640	7.022	7.734	18.420	2.623
1.330	6.660	7.089	7.762	18.666	2.633
1.340	6.680	7.156	7.790	18.914	2.643
1.350	6.700	7.223	7.818	19.163	2.653

Depth= 1.4 m
Width= 4 m

Project	Ten-T Priority Route Improvement Project, Donegal	BARRY TRANSPORTATION	
Subject	OPW Section 50_CV27	Job No	Y16112
Prepared by:	SH	Date	17/11/2021
Checked by:	RF	Revision	P01

Calculation of channel flow for a range of depths

Channel characteristics - Culvert Inlet to Culvert Outlet

Upstream bed level =	19.03	LH side slope 1v:Xh=	1.00
Downstream bed level =	18.85	RH side slope 1v:Xh=	1.00
Length =	36.2	Bed width=	4.00
Slope S =	0.00497 (value used)		
1/S =	201.111	Manning's n =	0.04

Channel flow

Starting depth of flow =	1.4
Depth of flow increment =	0.01

FLOW =	18.95
FLOOD LEVEL (US) =	20.770
FLOOD LEVEL (DS) =	20.590
BANK HEIGHT =	20.600
FLOOD	NO

Depth of flow	width of flow	Xsect area	wetted perimeter	Q	v
1.400	6.800	7.560	7.960	12.877	1.703
1.410	6.820	7.628	7.988	13.040	1.710
1.420	6.840	7.696	8.016	13.204	1.716
1.430	6.860	7.765	8.045	13.369	1.722
1.440	6.880	7.834	8.073	13.535	1.728
1.450	6.900	7.903	8.101	13.702	1.734
1.460	6.920	7.972	8.130	13.870	1.740
1.470	6.940	8.041	8.158	14.039	1.746
1.480	6.960	8.110	8.186	14.209	1.752
1.490	6.980	8.180	8.214	14.380	1.758
1.500	7.000	8.250	8.243	14.552	1.764
1.510	7.020	8.320	8.271	14.725	1.770
1.520	7.040	8.390	8.299	14.899	1.776
1.530	7.060	8.461	8.327	15.074	1.782
1.540	7.080	8.532	8.356	15.250	1.788
1.550	7.100	8.603	8.384	15.427	1.793
1.560	7.120	8.674	8.412	15.605	1.799
1.570	7.140	8.745	8.441	15.784	1.805
1.580	7.160	8.816	8.469	15.965	1.811
1.590	7.180	8.888	8.497	16.146	1.817
1.600	7.200	8.960	8.525	16.328	1.822
1.610	7.220	9.032	8.554	16.511	1.828
1.620	7.240	9.104	8.582	16.695	1.834
1.630	7.260	9.177	8.610	16.880	1.839
1.640	7.280	9.250	8.639	17.066	1.845
1.650	7.300	9.323	8.667	17.253	1.851
1.660	7.320	9.396	8.695	17.441	1.856
1.670	7.340	9.469	8.723	17.630	1.862
1.680	7.360	9.542	8.752	17.821	1.868
1.690	7.380	9.616	8.780	18.012	1.873
1.700	7.400	9.690	8.808	18.204	1.879
1.710	7.420	9.764	8.837	18.397	1.884
1.720	7.440	9.838	8.865	18.591	1.890
1.730	7.460	9.913	8.893	18.787	1.895
1.740	7.480	9.988	8.921	18.983	1.901
1.750	7.500	10.063	8.950	19.180	1.906

Depth= 1.75 m
Bed Width = 4 m
Banks width = 1 m

Culvert clear span=9.5 m
Culvert clear span at skew= 11.4 m

Project	Ten-T Priority Route Improvement Project, Donegal	BARRY TRANSPORTATION	
Subject	OPW Section 50_CV27	Job No	Y16112
Prepared by:	SH	Date	17/11/2021
Checked by:	RF	Revision	P01

Calculation of channel flow for a range of depths

Channel characteristics - Culvert tailwater

Upstream bed level =	18.85	LH side slope 1v:Xh=	1.00
Downstream bed level =	18.01	RH side slope 1v:Xh=	1.00
Length =	28.61	Bed width=	4.00
Slope S =	0.02936	(value used)	
1/S =	34.0595	Manning's n =	0.04

Channel flow

Starting depth of flow =	1
Depth of flow increment =	0.01

FLOW =	18.95
FLOOD LEVEL (US) =	19.900
FLOOD LEVEL (DS) =	19.060
BANK HEIGHT =	19.110
FLOOD	NO

Depth of flow	width of flow	Xsect area	wetted perimeter	Q	v
1.000	6.000	5.000	6.828	17.400	3.480
1.010	6.020	5.060	6.857	17.701	3.498
1.020	6.040	5.120	6.885	18.005	3.516
1.030	6.060	5.181	6.913	18.311	3.534
1.040	6.080	5.242	6.942	18.619	3.552
1.050	6.100	5.303	6.970	18.930	3.570
1.060	6.120	5.364	6.998	19.242	3.588
1.070	6.140	5.425	7.026	19.558	3.605
1.080	6.160	5.486	7.055	19.875	3.623
1.090	6.180	5.548	7.083	20.195	3.640
1.100	6.200	5.610	7.111	20.518	3.657
1.110	6.220	5.672	7.140	20.842	3.675
1.120	6.240	5.734	7.168	21.169	3.692
1.130	6.260	5.797	7.196	21.499	3.709
1.140	6.280	5.860	7.224	21.831	3.726
1.150	6.300	5.923	7.253	22.165	3.742
1.160	6.320	5.986	7.281	22.501	3.759
1.170	6.340	6.049	7.309	22.840	3.776

Depth= 1.1 m
Width= 4 m

Pipe Culverts Calculations

1200mm pipe			
Q = (1.0/ n) R $^{2/3}$ S $^{1/2}$)(A)			
Flow Area (A)	m^2	0.684	Calcs based on channel with 300mm embedment and 300mm freeboard.
Wetted Perimeter (P)	m	2.291	
R=A/P	m	0.298559581	
$R^{2/3}$	m	0.446704857	
Mannings roughness (n)	Non dimensional	0.023	
S (0.001)	m/m		
$S^{1/2}$	m/m		
Q=	m^3/s		

Culvert Ref	US Pipe invert Level	DS pipe invert Level	Length	Slope	Slope (1/2)	Pipe Capacity (m3)	Diameter (mm)	Catchment Flow (m3) 1/100 year	Height of water	Freeboard	Notes
CUL.12	84.2	83.6	62	0.010	0.098	1.307	1200 mm	1.070	0.480	0.420	Catchment 6
CUL.13	73.5	73.17	31.8	0.010	0.102	1.353	1200 mm	1.070	0.460	0.440	Catchment 6
CUL.17	85.6	85.3	49.81	0.006	0.078	1.031	1200 mm	0.660	0.380	0.520	Catchment 8
CUL.32	37.3	35.7	44.5	0.036	0.190	2.519	1200 mm	0.520	0.130	0.770	Catchment 19
CUL.33	49.3	44.69	50.7	0.091	0.302	4.006	1200 mm	0.600	0.095	0.805	Catchment 20

APPENDIX B: DRAWINGS

KEY PLAN

S3-CUL.07

S3-CUL.08

S3-CUL.09

S3-CUL.10

S3-CUL.11

S3-CUL.12

S3-CUL.13

S3-CUL.14

S3-CUL.15

S3-CUL.16

LEGEND:

PROPOSED CULVERTS LOCATION

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P01	29/10/21	LRB	REVIEW & COMMENTS	SHS	RF

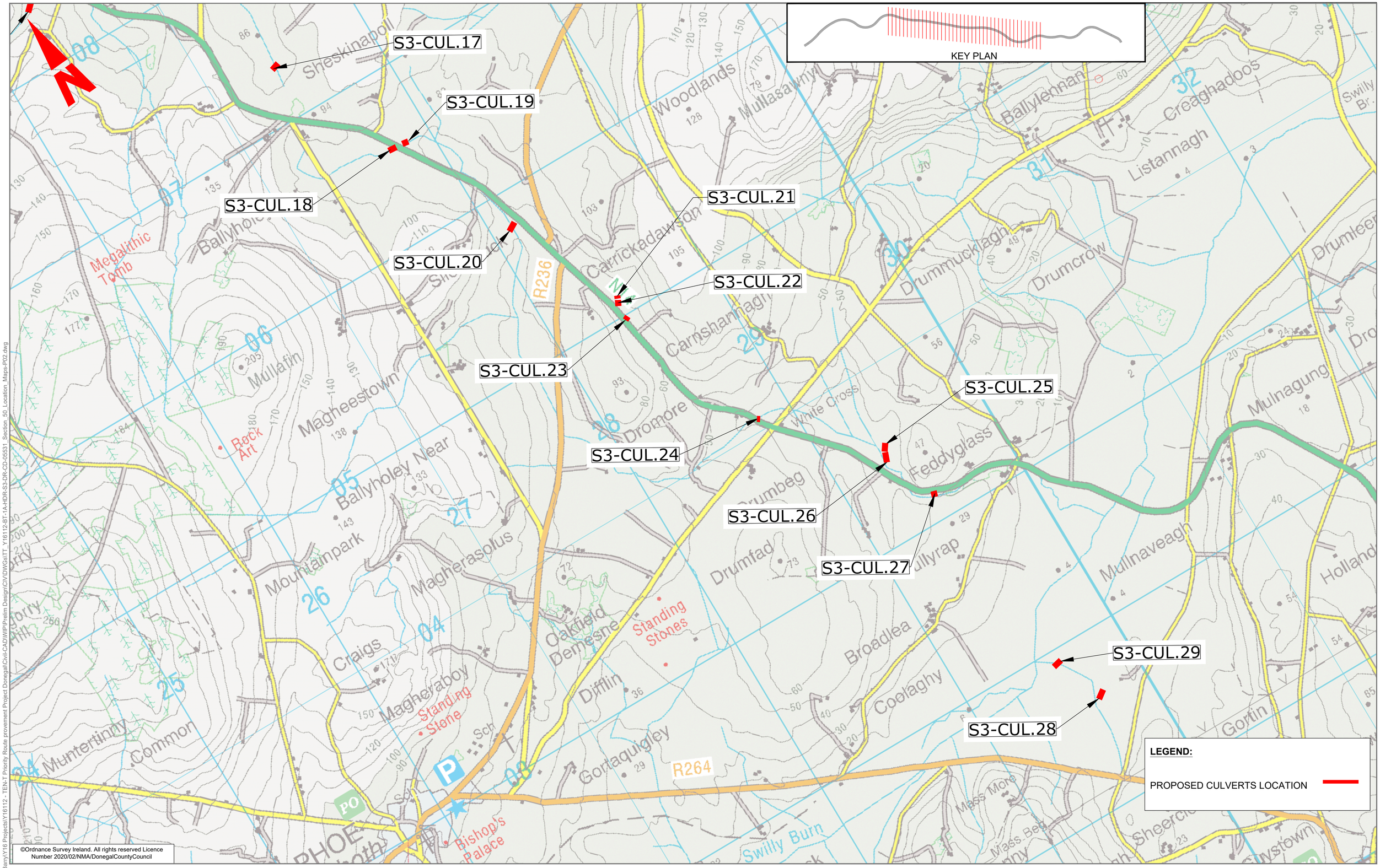
Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Location Maps

Status: S4

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Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Location Maps

Status: S4

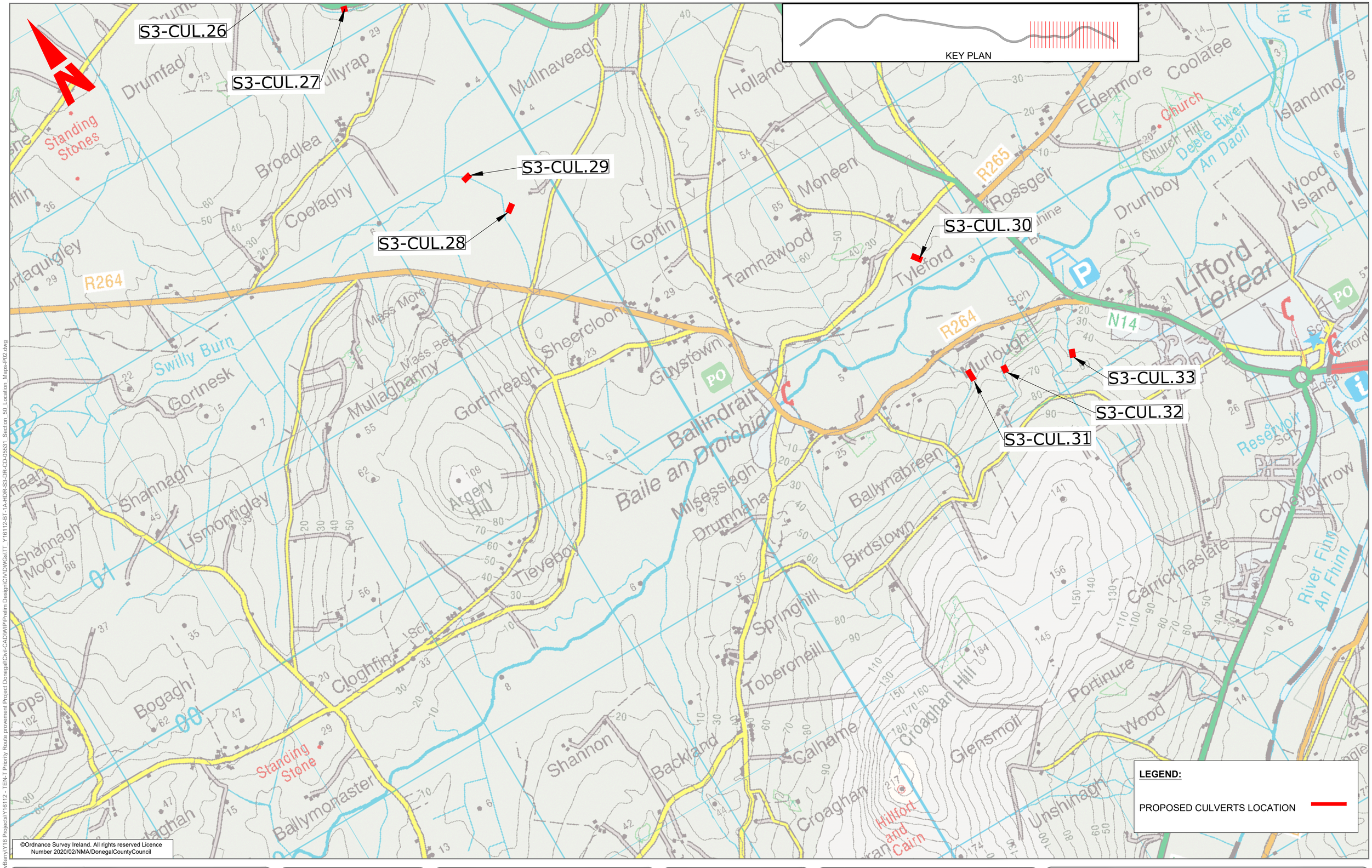
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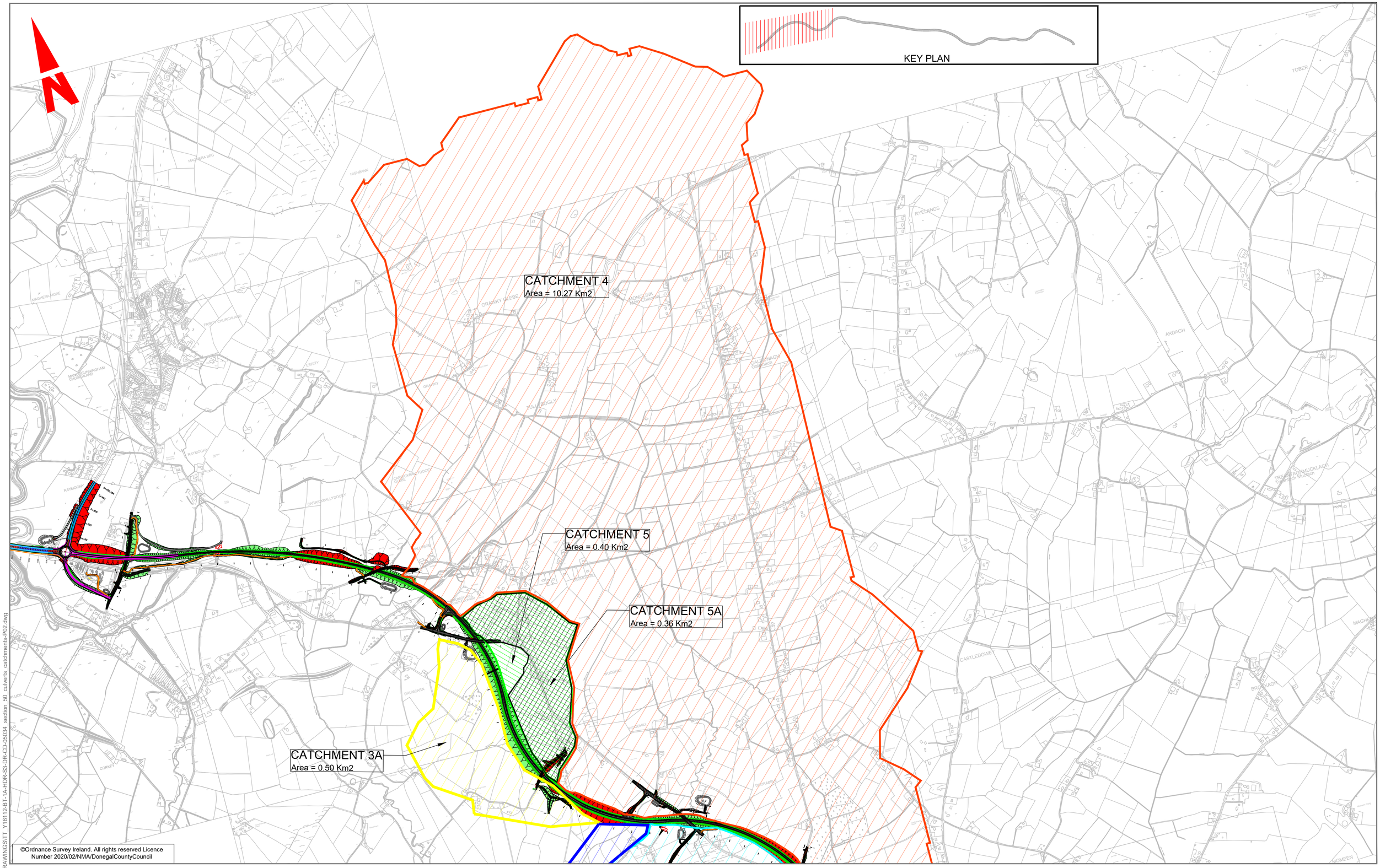
Project Title: TEN-T Priority Route Improvement Project, Donegal
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Drawing Title: Section 50 Location Maps

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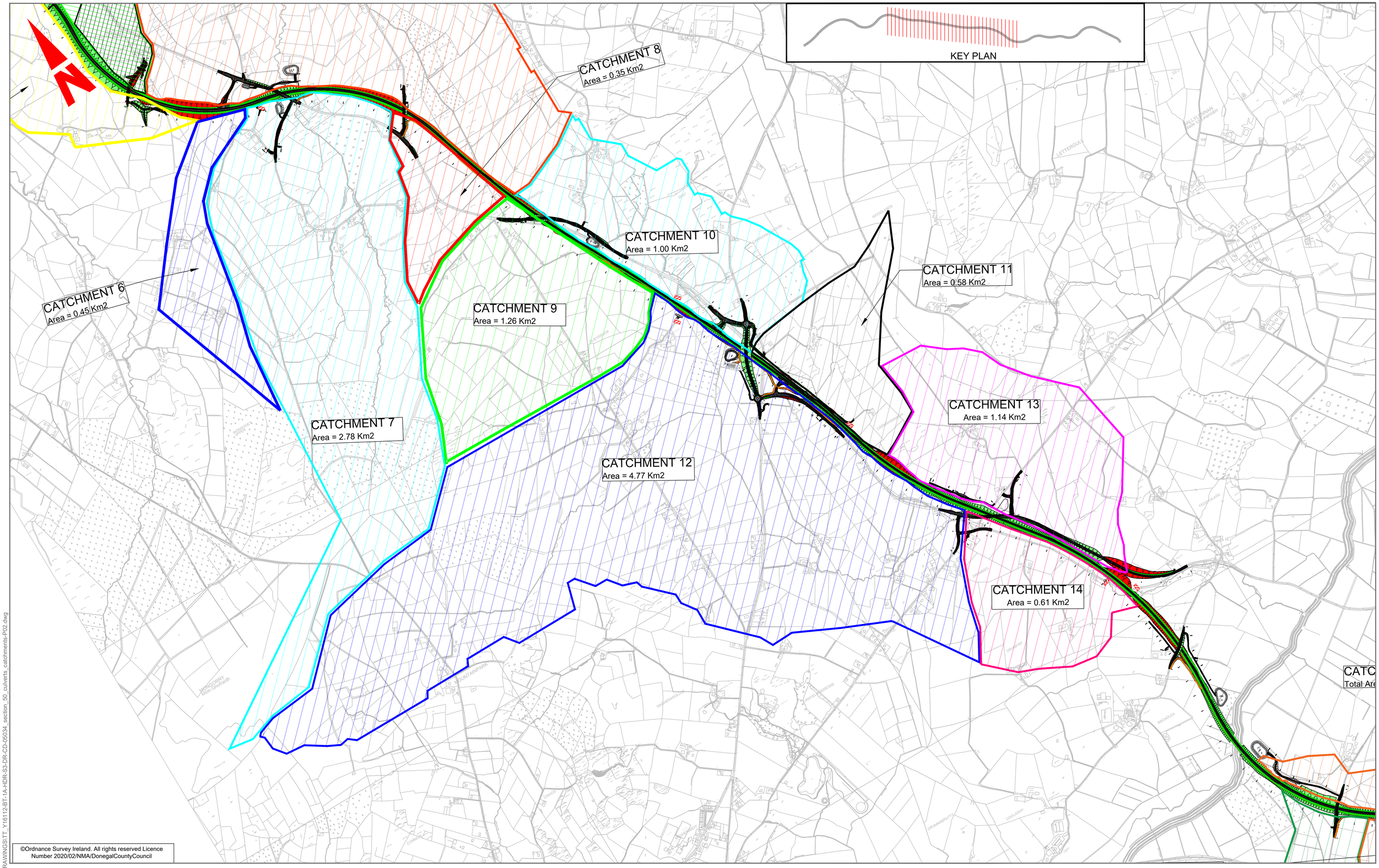
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Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: SECTION 50 CULVERTS CATCHMENTS

Status: S4

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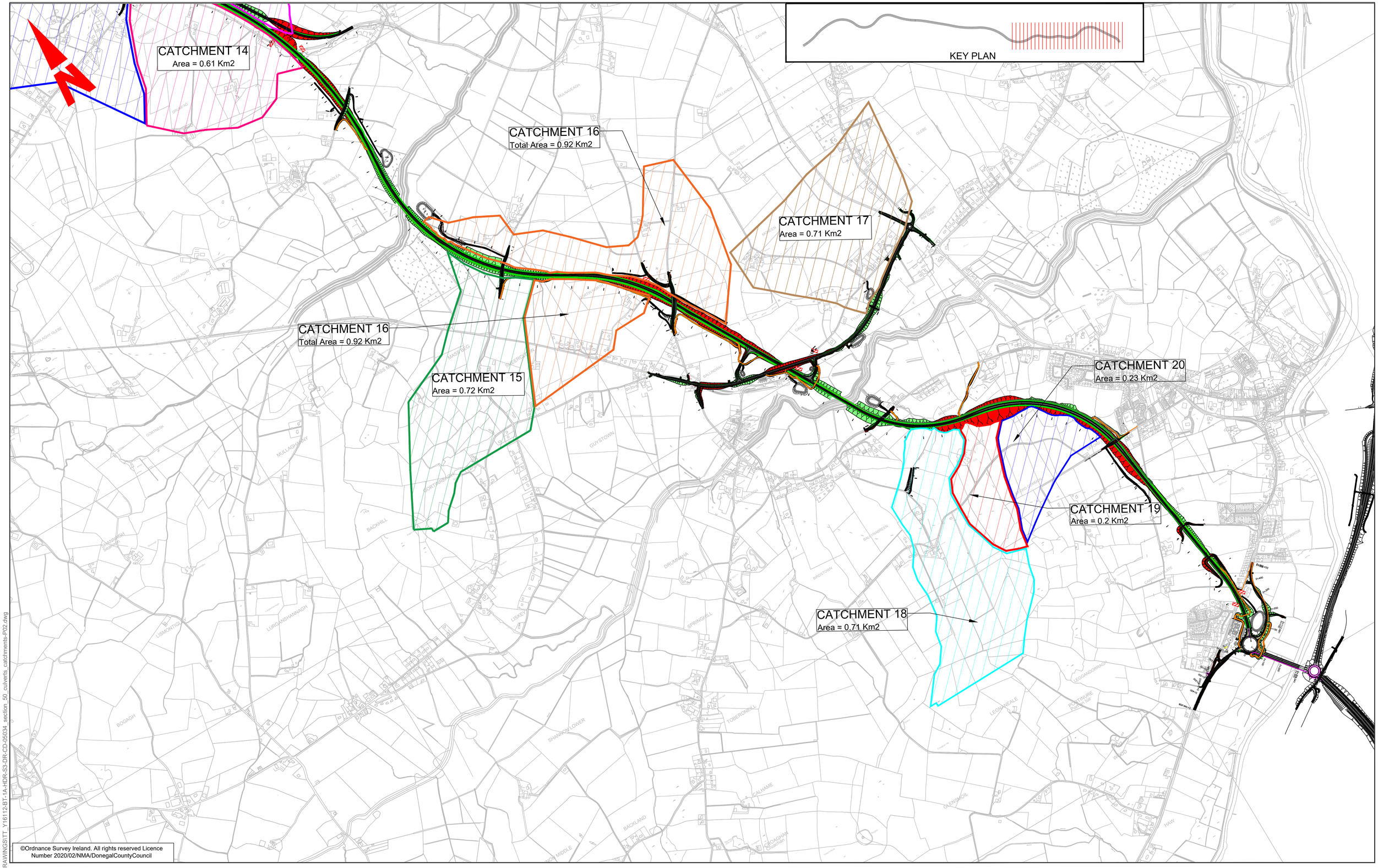
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Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: SECTION 50 CULVERTS CATCHMENTS

Status: S4

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Comhairle Contae Dhún na nGall
Donegal County Council

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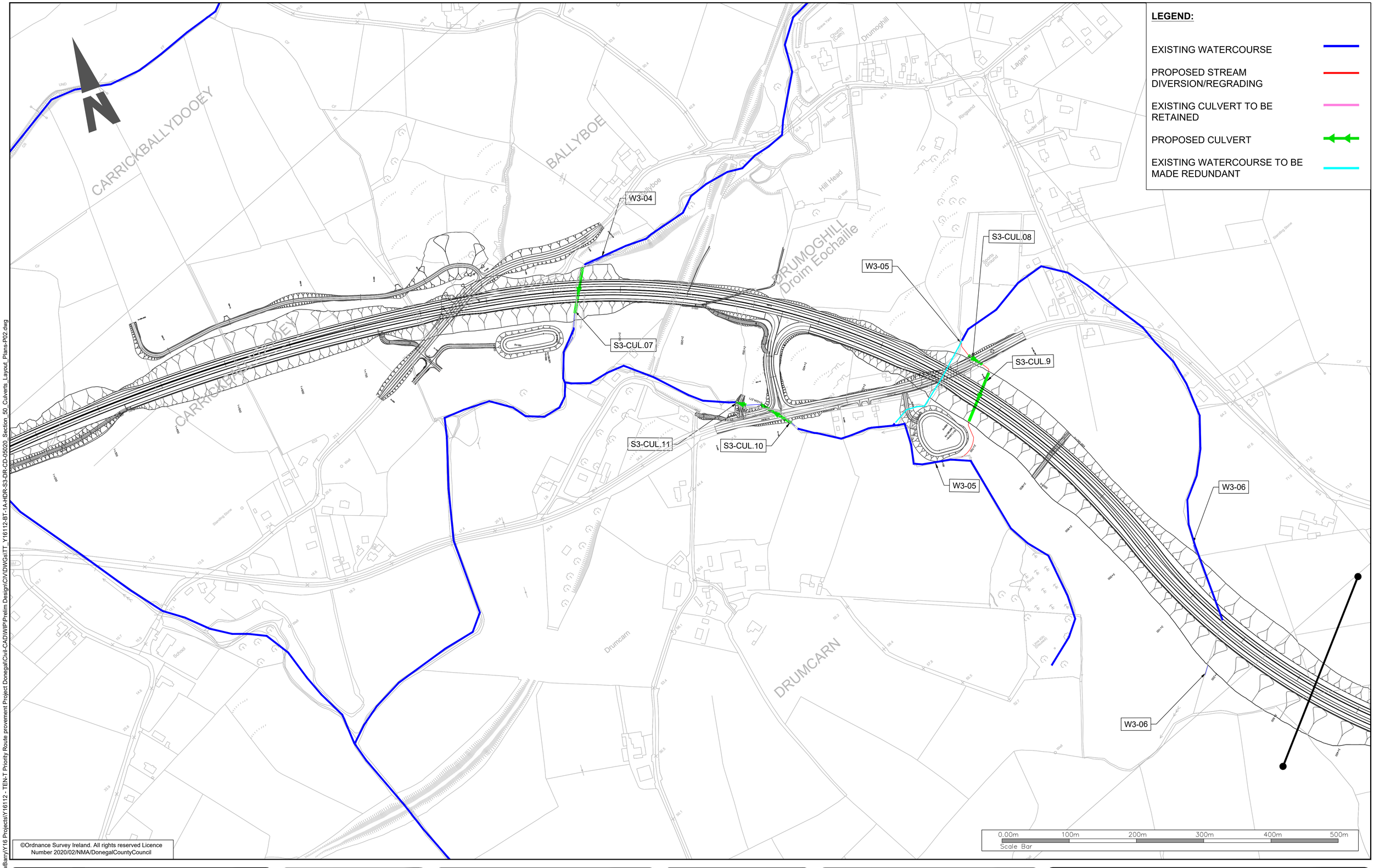
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P01	29/10/21	LRB	REVIEW & COMMENTS	SHS	RF

Project Title: TEN-T Priority Route Improvement Project, Donegal
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: SECTION 50 CULVERTS CATCHMENTS

Status: S4

Designed:	SHS	Date: SEPT. 2022	Model File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05034_section_50_culverts_catchments
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Approved:	ED	@ A3:20000	File Identifier: Y16112-1100-037
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Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

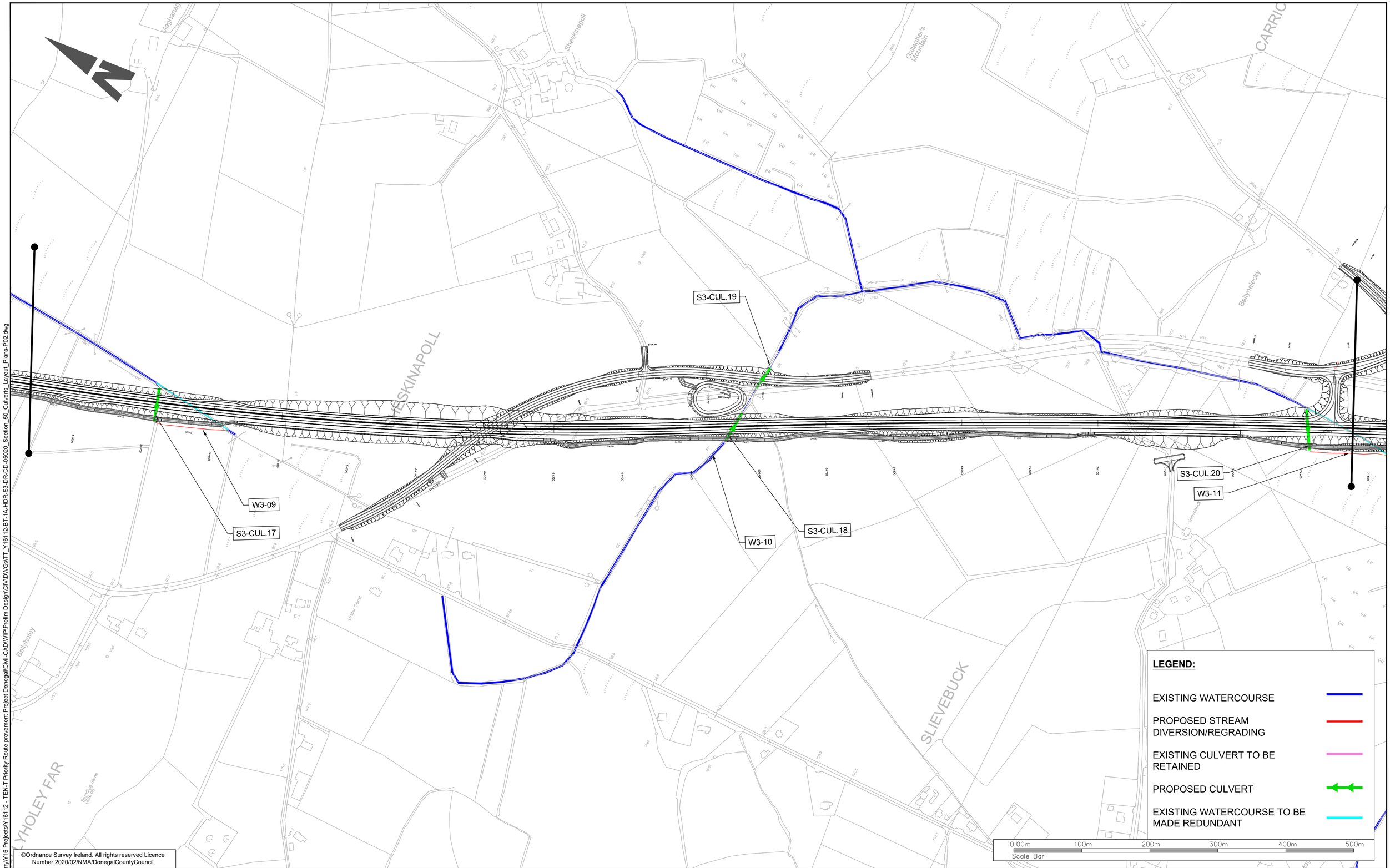
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Status: S4

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W3-08
S3-CUL.16
W3-07
S3-CUL.13
S3-CUL.15
W3-08
S3-CUL.14
S3-CUL.12
W3-07
DOORABBLE
WOODHILL
WOODHILL
Woodhill
Ballyholey
Barrenhill Lower
Stepping Stones (Site of)
Under Const.
Spring
Trough
Trough
Trough



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Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts Plan Layout

Status: S4

Designed:	SHS	Date:	SEPT 2022	Model File Identifier:	Rev:
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Approved:	ED	@ A3:		File Identifier:	P02
Checked:	RF	Sheet:	3 OF 9	Y16112-0500-020	

W3-12A

S3-CUL.21

S3-CUL.22

S3-CUL.23

W3-12A

W3-12

S3-CUL.24

CARNSHANNAGH

DROMORE BIG

Carrickadawson

Carnshannagh

Dromore Upper

Dromore

Drumbeg

LEGEND:

- EXISTING WATERCOURSE
- PROPOSED STREAM DIVERSION/REGRADING
- EXISTING CULVERT TO BE RETAINED
- PROPOSED CULVERT
- EXISTING WATERCOURSE TO BE MADE REDUNDANT

0.00m 100m 200m 300m 400m 500m
Scale Bar

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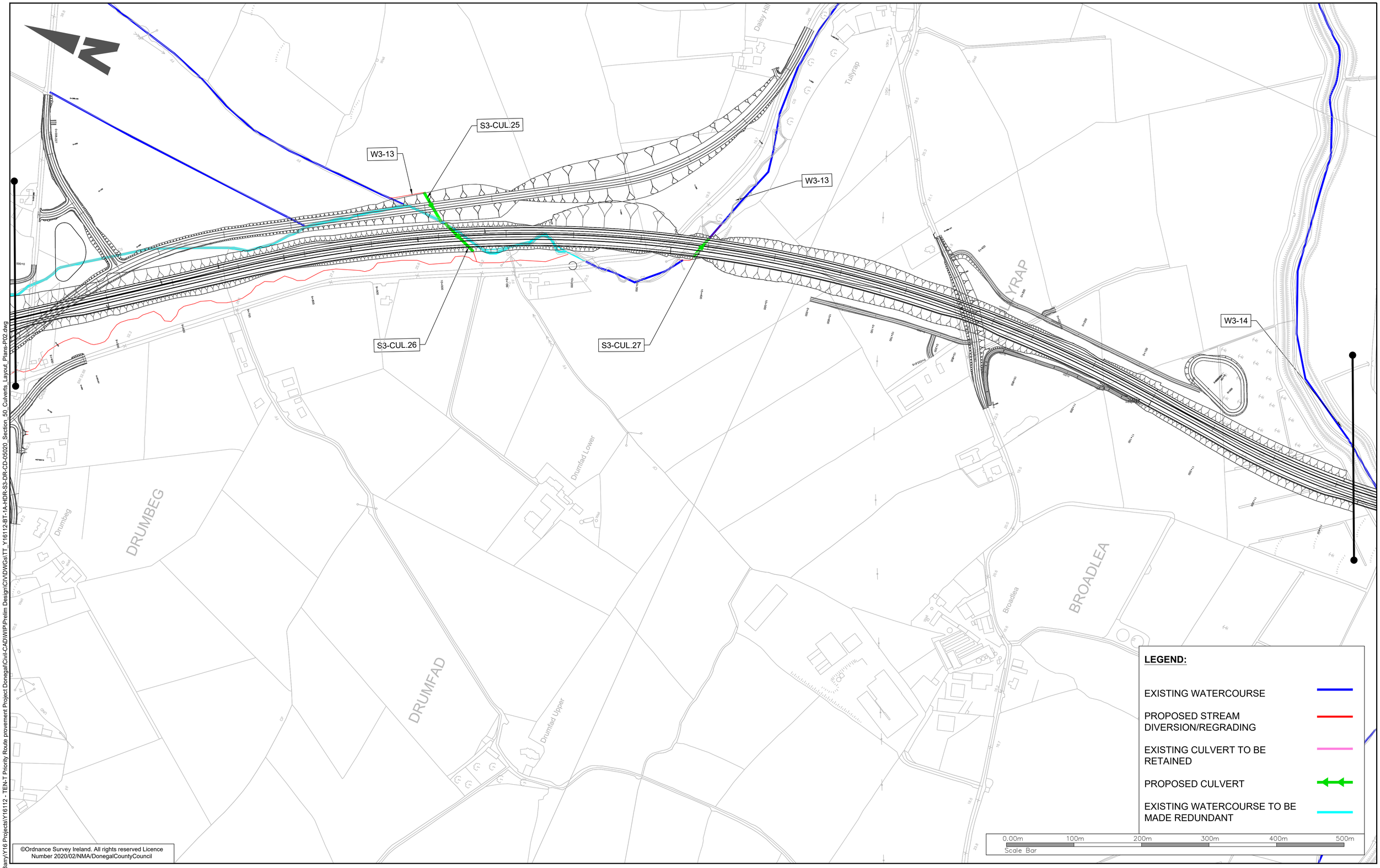
Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts Plan Layout

Status: S4

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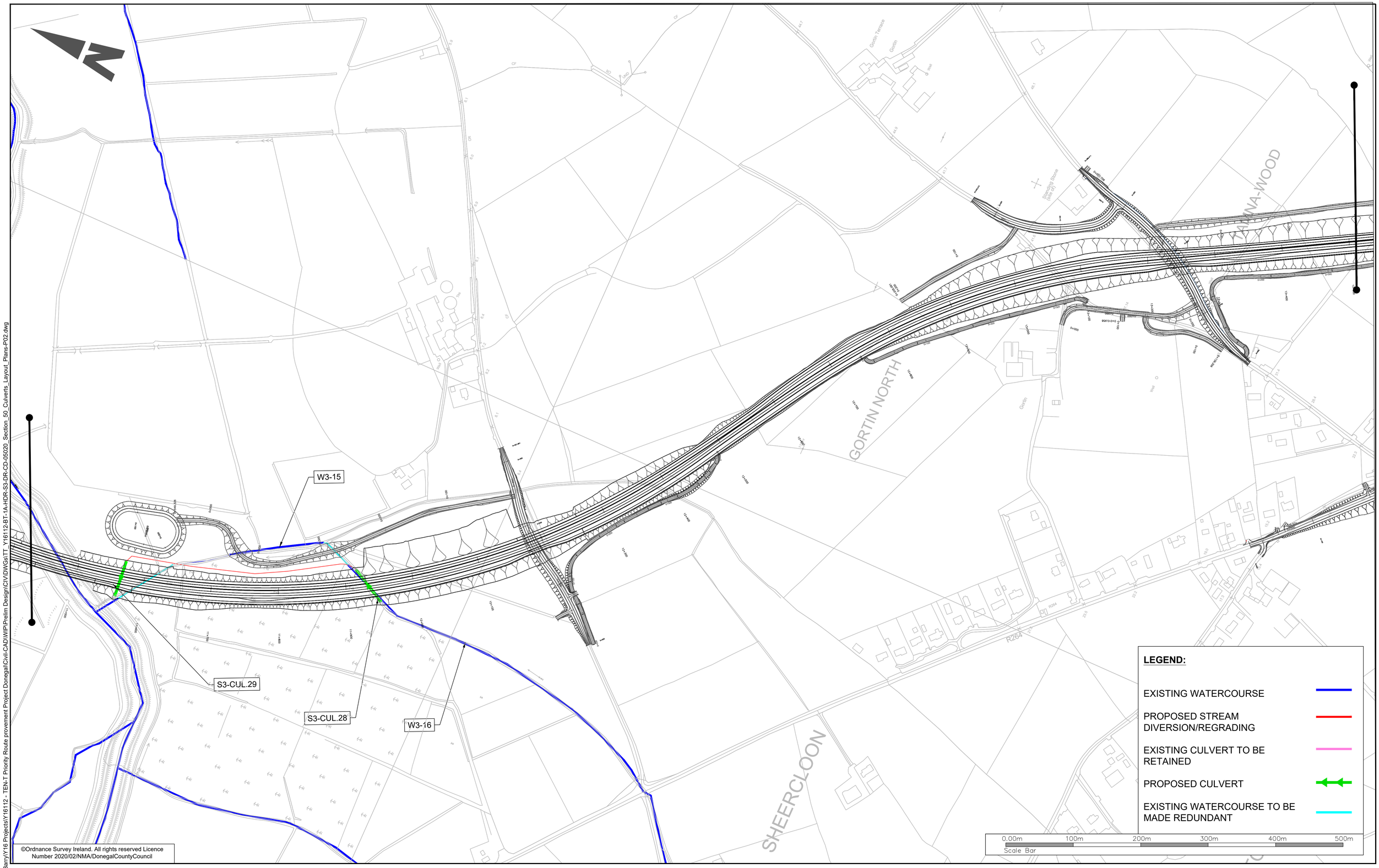
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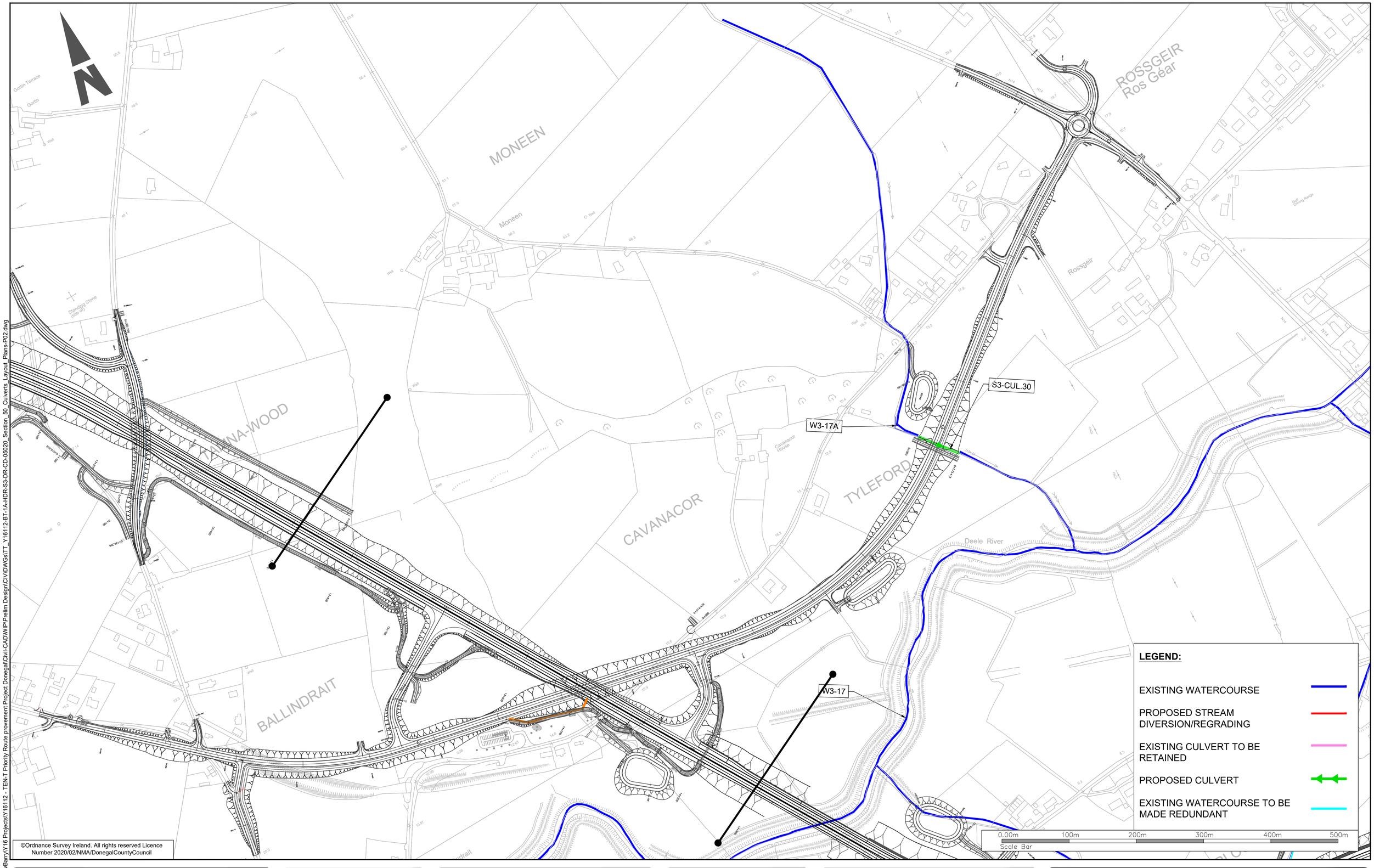
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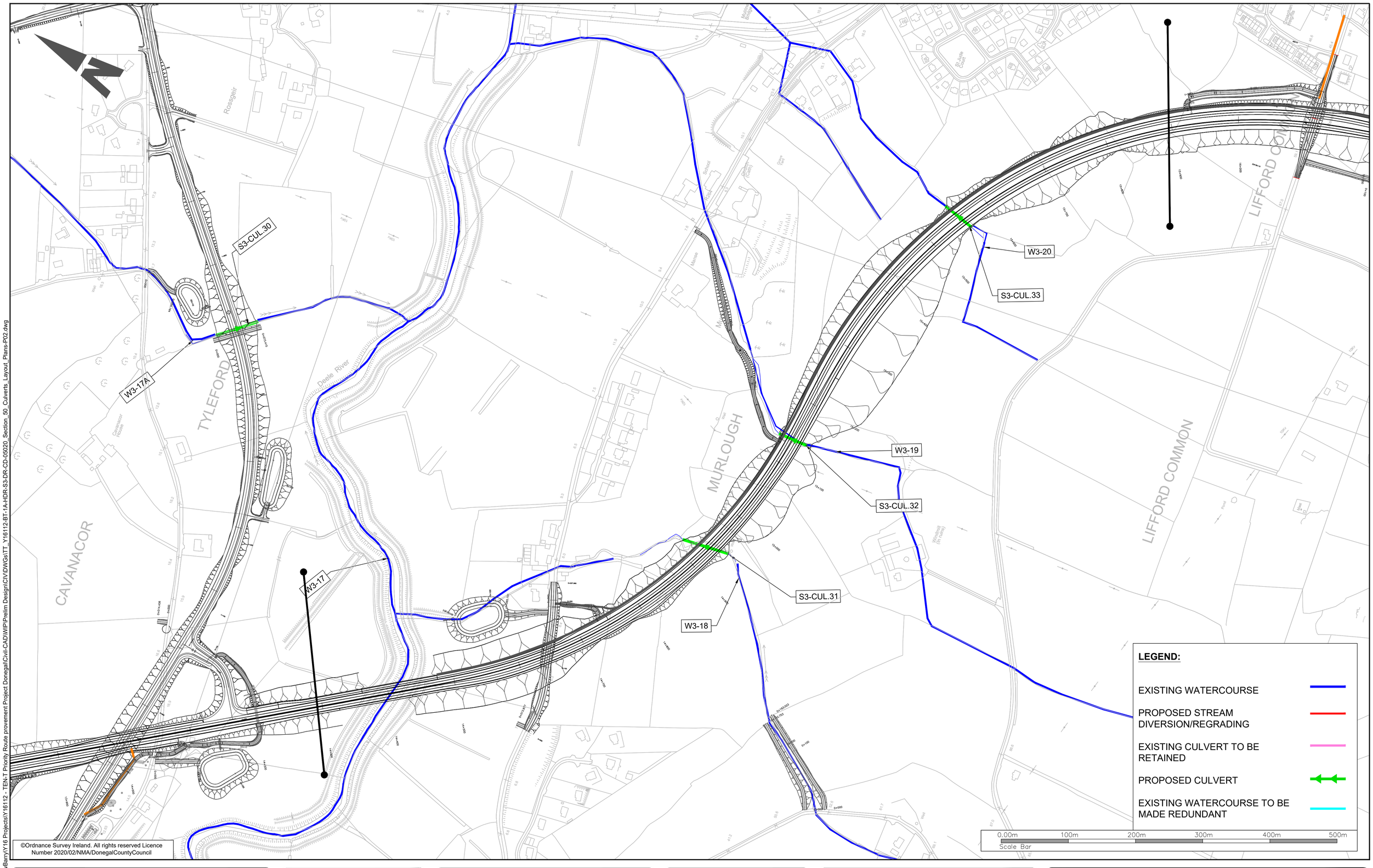
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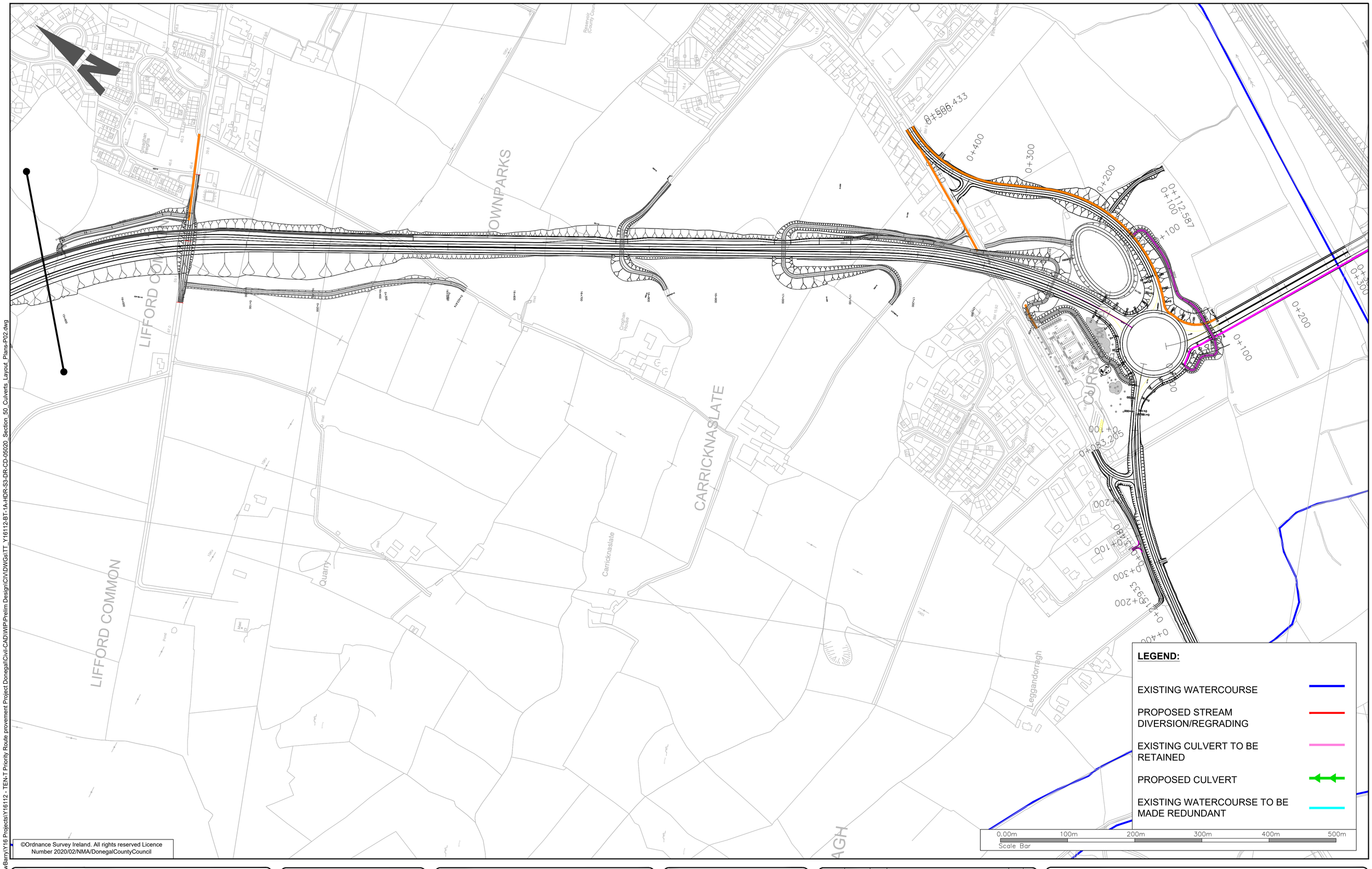
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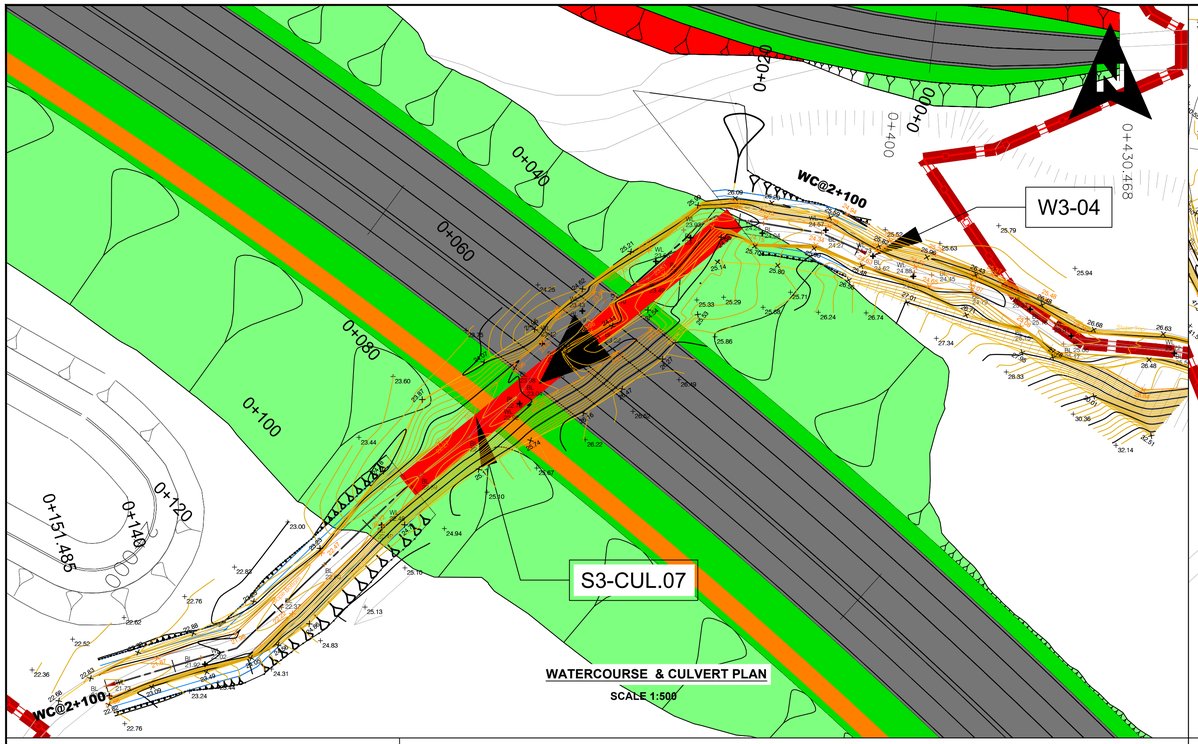
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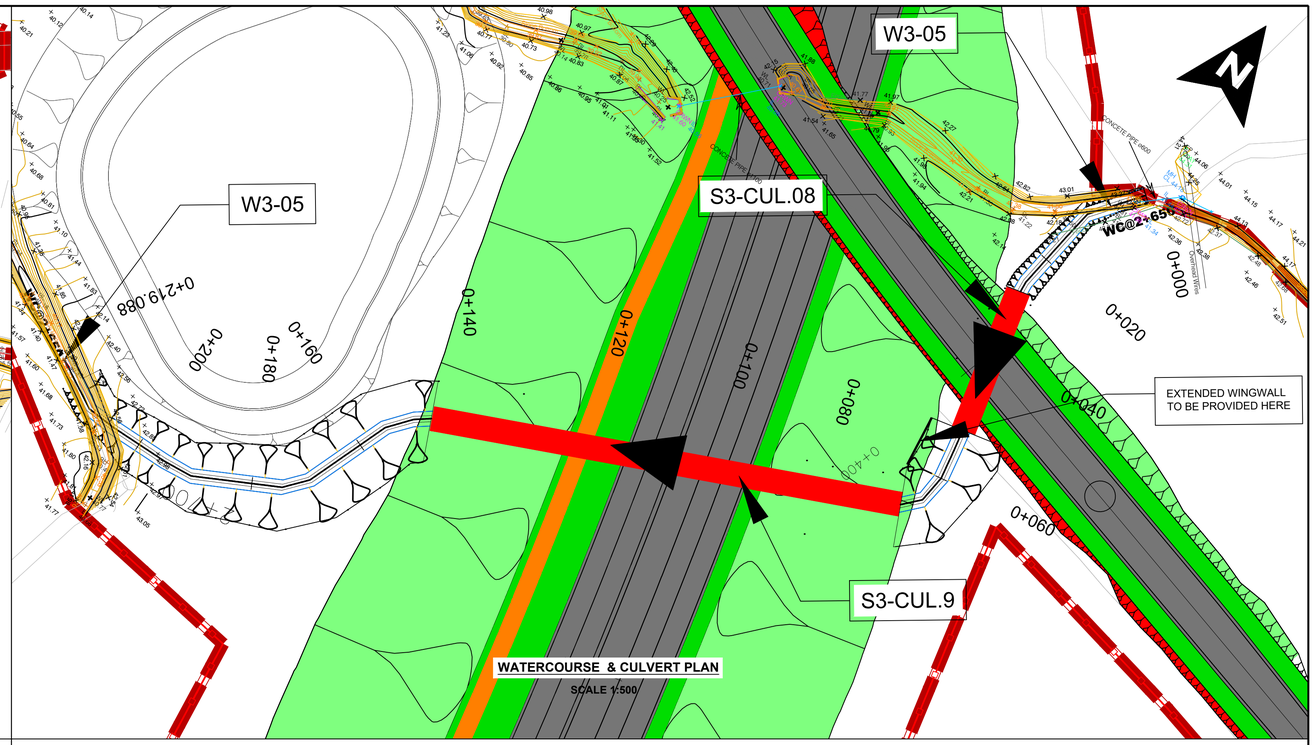
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LIFFORD COMMON
DOWNPARKS
CARRICKNASLATE
Carricknaslate
Quarry
Leggandoragh
Croghan Heights
Croghan House
Retaining Wall (County Council)
Telecommunication Cable
Pylon
Mast
Pump
Well
Spring
Fingal Bridge Cottages
Ballymacool Park
Ballymacool Avenue
Ballymacool Drive
Ballymacool Crescent
Ballymacool Grove
Ballymacool Road
Ballymacool Lawn
Ballymacool Close
Ballymacool Rise
Ballymacool Green
Ballymacool Court
Ballymacool Meadow
Ballymacool Gardens
Ballymacool Mews
Ballymacool Walk
Ballymacool Terrace
Ballymacool Way
Ballymacool Place
Ballymacool Square
Ballymacool Crescent
Ballymacool Grove
Ballymacool Road
Ballymacool Lawn
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Ballymacool Court
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Ballymacool Walk
Ballymacool Terrace
Ballymacool Way
Ballymacool Place
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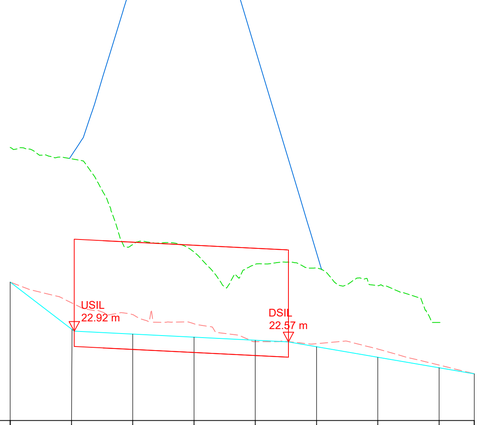


LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

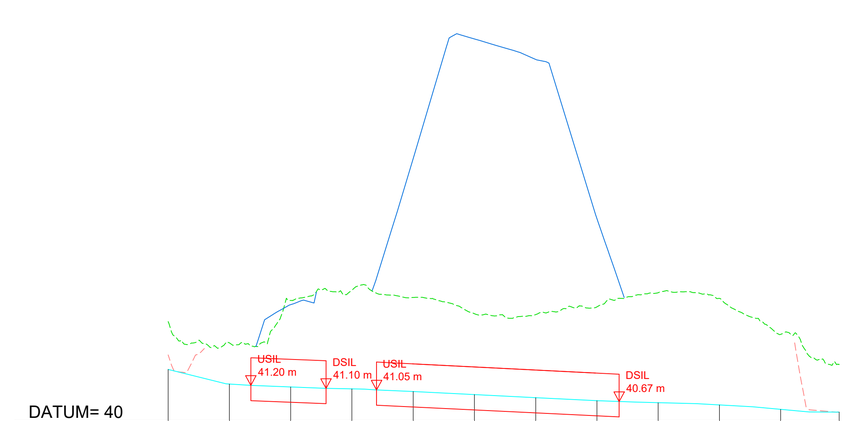
1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
2. In the majority of cases the proposed watercourse diversion is shown tying in with the existing stream inverts (pink line). In some cases an existing stream invert line has not been shown at the tie in, but it is confirmed that the existing stream invert was checked on the topographical survey at this location and that it does tie in. A note in relation to this has been provided where relevant.
3. Headwalls extents have not been indicated on the plan drawings generally. In some cases, notes in relation to the headwalls extents have been provided, where they will be containing an earthworks spill.



DATUM= 20

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+151
PROPOSED LEVELS	24.519	22.970	22.822	22.722	22.622	22.405	22.064	21.722	21.526
EXISTING LEVELS	24.519	23.844	23.457	23.159	22.256	22.510	22.333	21.810	21.5264
LENGTH AND GRADIENT	G=−7.6% L=20.91		G=−0.5% L=69.50			G=−1.7% L=61.1			

WC@2+100-CV07
LONGITUDINAL PROFILE-CH:0-151
Scale-1:1000/100



DATUM= 40

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+219
PROPOSED LEVELS	41.719	41.242	41.147	41.086	40.999	40.898	40.798	40.698	40.632	40.559	40.416	40.324
EXISTING LEVELS	42.194	42.587	43.971	44.305	44.068	43.538	43.507	43.762	44.223	44.038	42.864	40.324
LENGTH AND GRADIENT	G=−2.5% L=18.9	G=0.8% L=8.1	G=−0.4% L=24.6	G=−0.35% L=16.50	G=−0.5% L=79.10			G=−0.47% L=71.83				

WC@2+650-CV08 AND CV09
LONGITUDINAL PROFILE-CH:0-219
Scale-1:1000/100

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Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

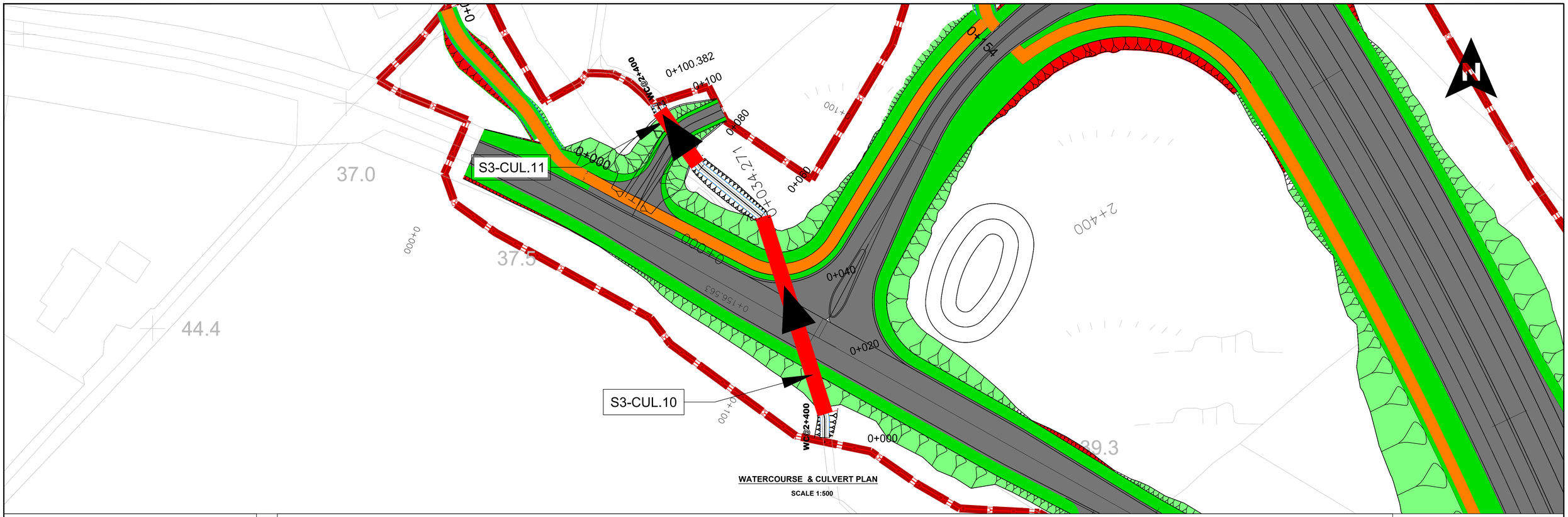
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV07, CV08 & CV09

Status: S4

Designed:	SH	Date:	SEPT. 2022	Model File Identifier:	Rev: P01
Drawn:	SH	Scale @ A1:	AS SHOWN		
Approved:	ED	@ A3:		File Identifier:	
Checked:	RF	Sheet:	1 OF 14	TT_Y16112-BT-1A-HDR-S3-DR-CD-05102	

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WATERCOURSE & CULVERT PLAN

SCALE 1:500

LEGEND

PROPOSED GROUND LEVEL

EXISTING WATERCOURSE INVERT LEVEL

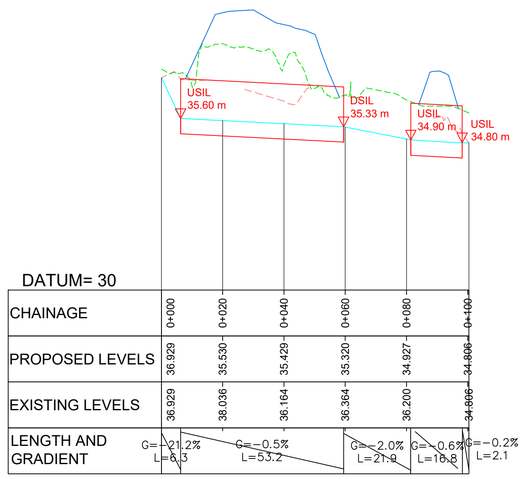
EXISTING GROUND LEVEL

PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
2. In the majority of cases the proposed watercourse diversion is shown tying in with the existing stream inverts (pink line). In some cases an existing stream invert line has not been shown at the tie in, but it is confirmed that the existing stream invert was checked on the topographical survey at this location and that it does tie in. A note in relation to this has been provided where relevant.
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WC@2+400-CV10 AND CV11
LONGITUDINAL PROFILE-CH:0-100
Scale-1:1000/100

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Rialtas na hÉireann Government of Ireland

Tionscadal Éireann Project Ireland 2040

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Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

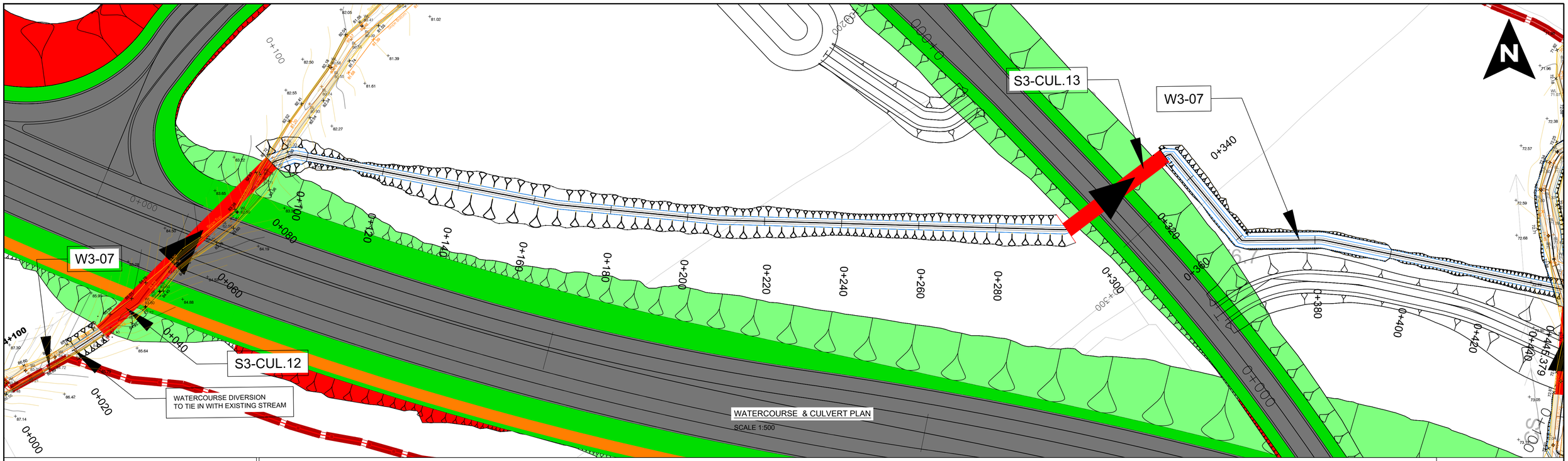
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV10 & CV11

Status: S4

Designed:	SH	Date: SEPT. 2022	Model File Identifier:
Drawn:	SH	Scale @ A1: AS SHOWN @ A3:	Rev: P01
Approved:	ED		File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked:	RF	Sheet: 2 OF 14	

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WATERCOURSE & CULVERT PLAN

SCALE 1:500

LEGEND

PROPOSED GROUND LEVEL

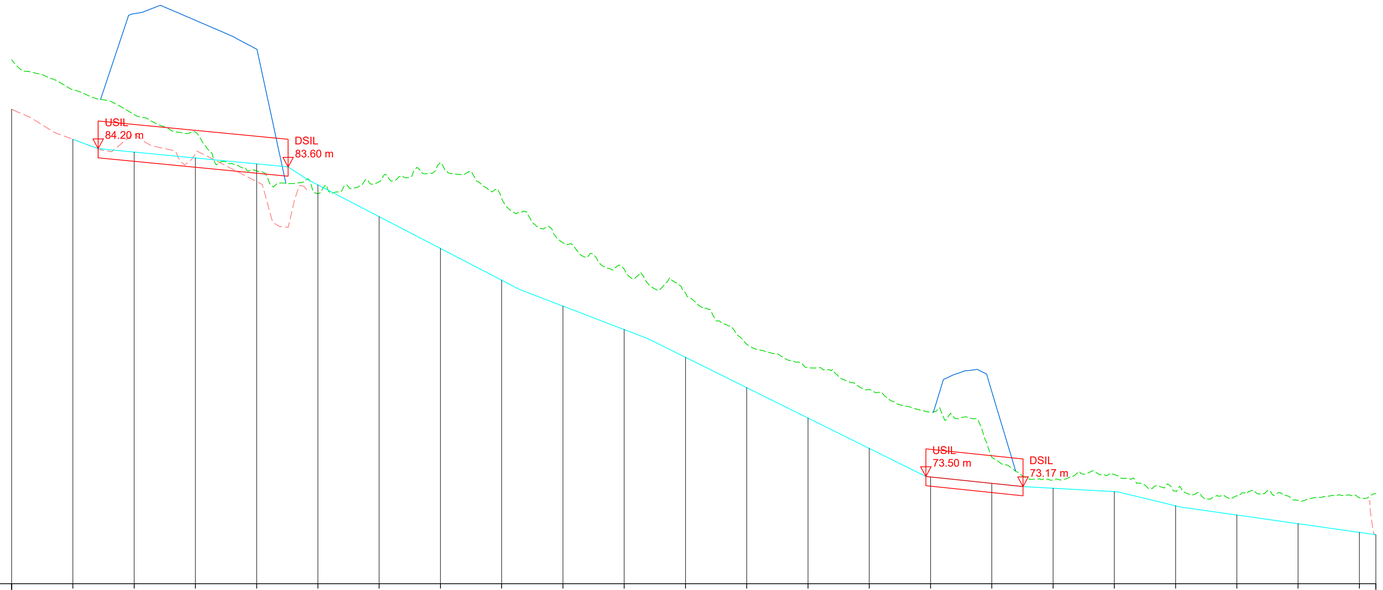
EXISTING WATERCOURSE INVERT LEVEL

EXISTING GROUND LEVEL

PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
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DATUM= 70

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+220	0+240	0+260	0+280	0+300	0+320	0+340	0+360	0+380	0+400	0+420	0+440	0+445
PROPOSED LEVELS	85.482	84.508	84.086	83.893	83.699	83.015	81.978	80.941	79.903	79.059	78.294	77.390	76.399	75.407	74.416	73.484	73.276	73.116	73.006	72.542	72.242	71.959	71.676	71.600
EXISTING LEVELS	85.482	84.508	84.677	84.040	83.122	82.736	83.120	83.741	82.579	81.126	80.259	79.488	77.811	77.053	76.341	75.611	74.123	73.387	73.558	73.019	72.867	72.721	72.806	71.600
LENGTH AND GRADIENT		G=−4.55% L=28.3	G=−1.0% L=62.0	G=−6.5% L=6.2	G=−5.2% L=69.4	G=−3.8% L=41.8	G=−5.0% L=90.8	G=−1.0% L=31.7	G=−0.6% L=30.9	G=−2.4% L=20.7	G=−1.4% L=63.6													

WC@4+100-CV12 AND CV13
LONGITUDINAL PROFILE-CH:0-445
Scale-1:1000/100

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Notes

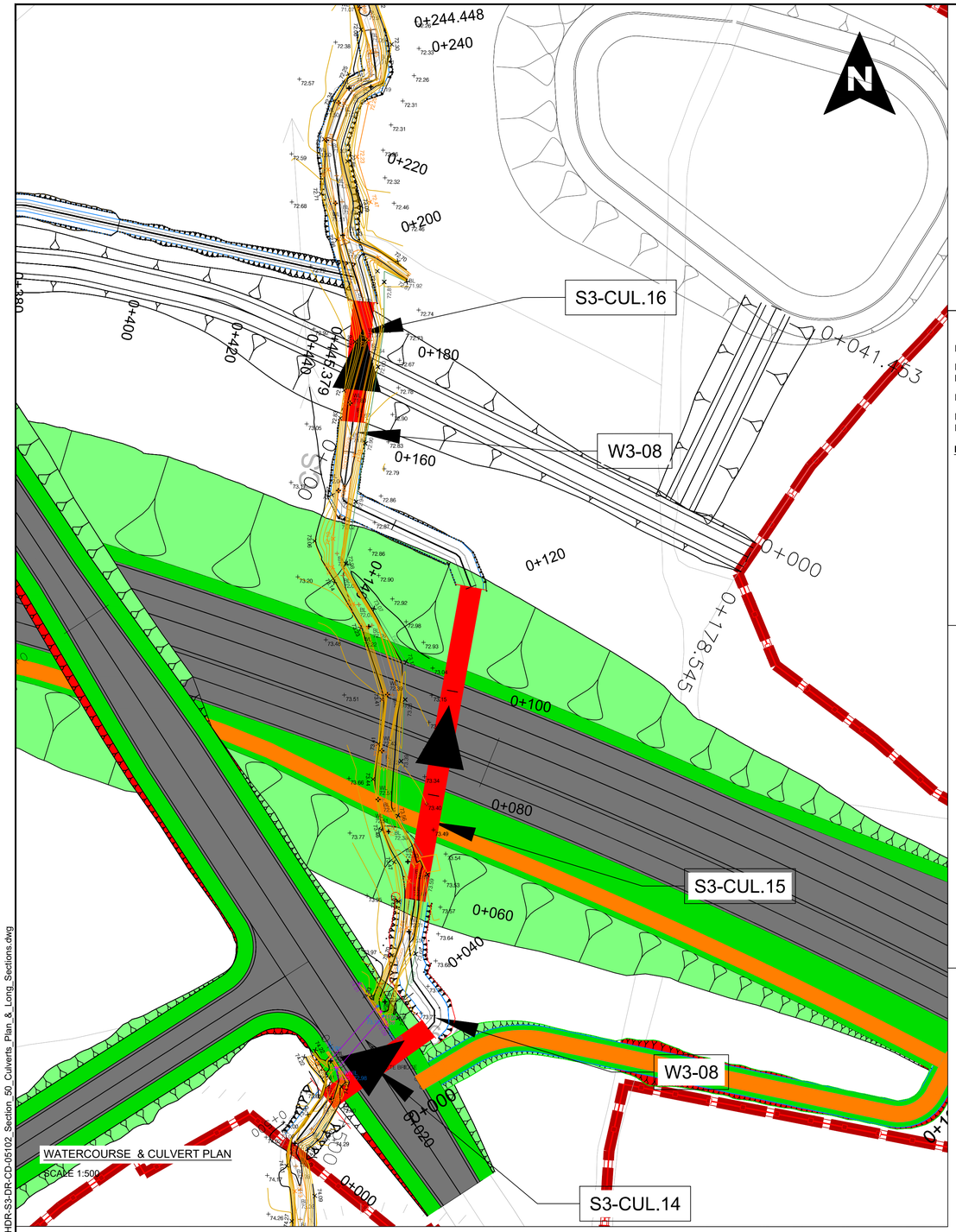
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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title:	TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link		
Drawing Title:	Section 50 Culverts-Plan & Long Sections - CV12 & CV13	Status:	S4
Designed: SH	Date: SEPT. 2022	Model File Identifier:	Rev: P01
Drawn: SH	Scale @ A1: AS SHOWN		
Approved: ED	@ A3:	File Identifier:	TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked: RF	Sheet: 3 OF 14		

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WATERCOURSE & CULVERT PLAN
SCALE 1:500

LEGEND

PROPOSED GROUND LEVEL

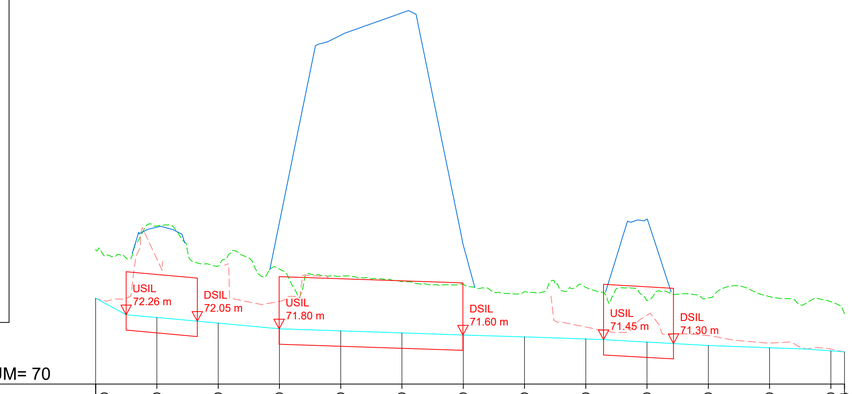
EXISTING WATERCOURSE INVERT LEVEL

EXISTING GROUND LEVEL

PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
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DATUM= 70

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+220	0+240	0+244
PROPOSED LEVELS	72.800	72.169	71.986	71.800	71.733	71.666	71.600	71.538	71.470	71.369	71.255	71.184	71.082	71.048
EXISTING LEVELS	72.800	74.081	73.853	72.695	73.522	73.341	73.256	73.008	71.860	72.244	71.579	71.335	71.137	71.048
LENGTH AND GRADIENT	G=−5.4% L=10.0	G=−0.9% L=23.2	G=−0.9% L=26.7	G=−0.3% L=60.0	G=−0.3% L=45.5	G=−0.6% L=22.8	G=−0.38% L=43.4	G=−0.8% L=12.5						

WC@4+500-CV14, CV15 AND CV16
LONGITUDINAL PROFILE-CH:0-244
Scale-1:1000/100

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

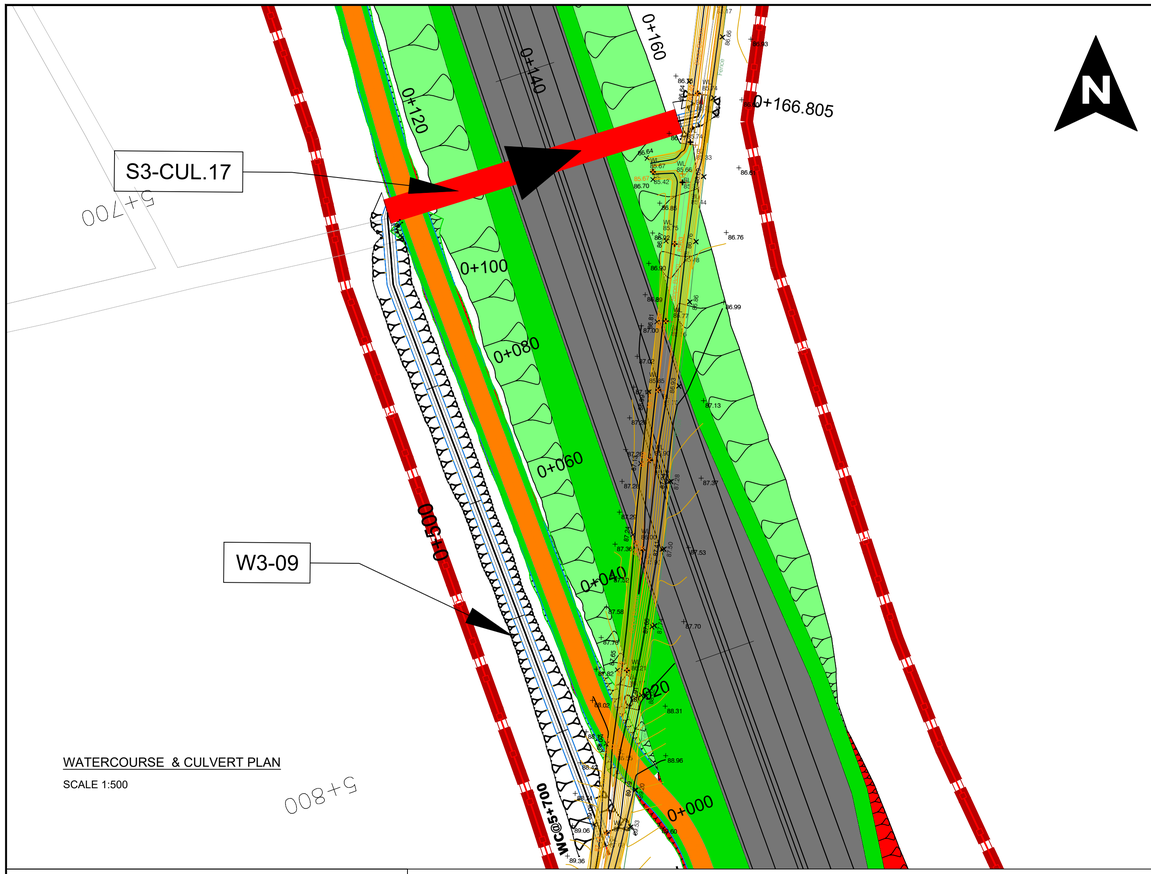
Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV14, CV15 & CV16

Status: S4

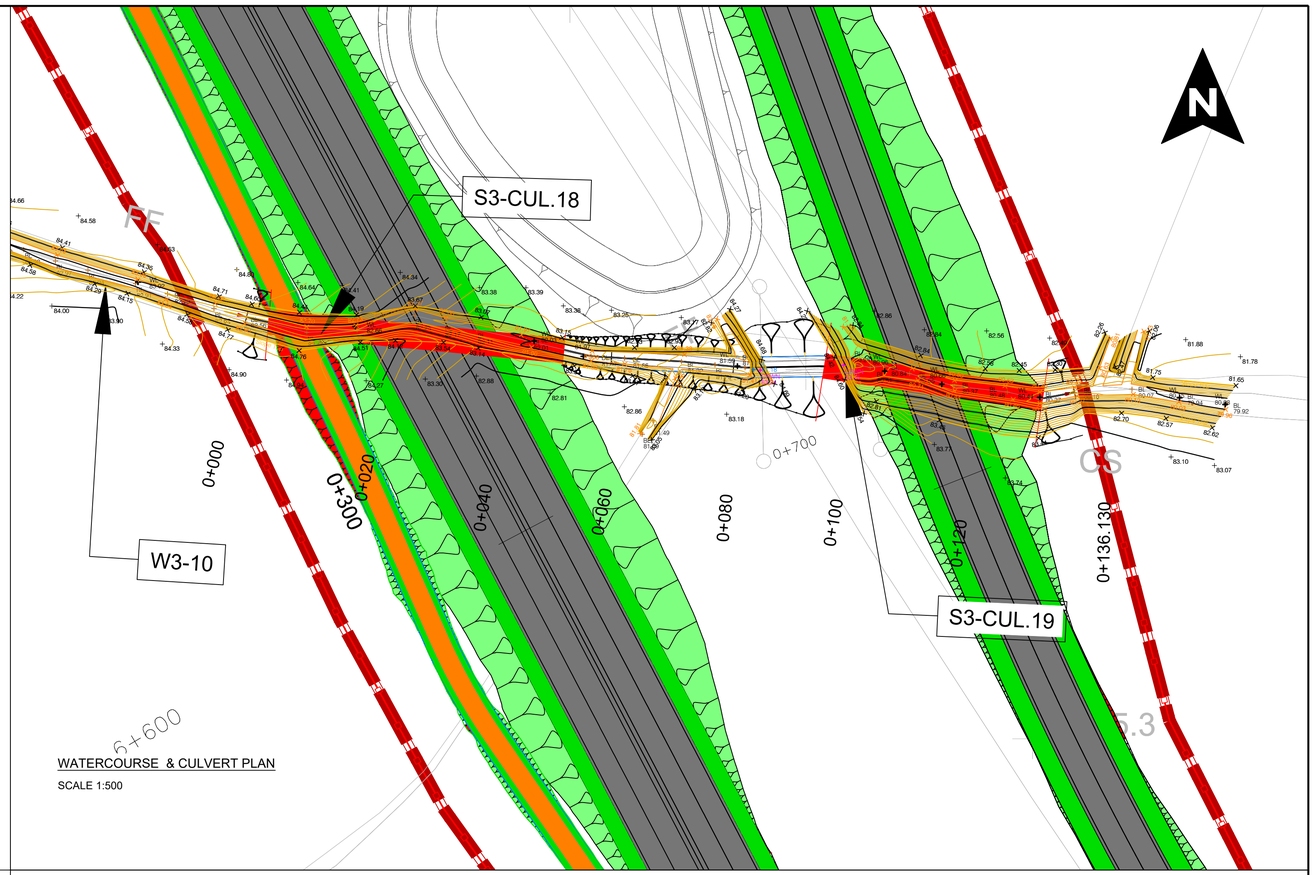
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Drawn: SH	Scale @ A1: AS SHOWN		
Approved: ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102	
Checked: RF	Sheet: 4 OF 14		

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WATERCOURSE & CULVERT PLAN

SCALE 1:500



WATERCOURSE & CULVERT PLAN

SCALE 1:500

LEGEND

PROPOSED GROUND LEVEL

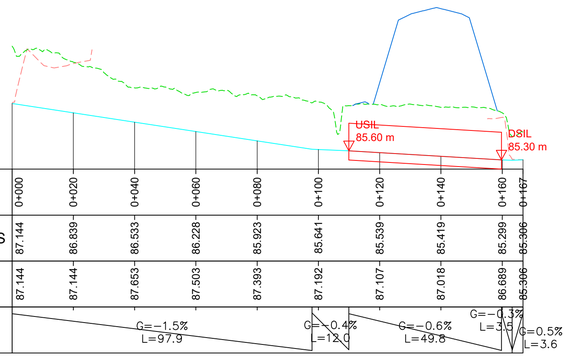
EXISTING WATERCOURSE INVERT LEVEL

EXISTING GROUND LEVEL

PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

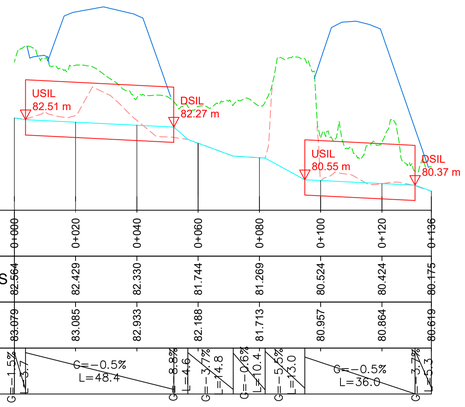
NOTES:

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DATUM= 85										
CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+167
PROPOSED LEVELS	87.144	86.839	86.533	86.228	85.923	85.641	85.539	85.419	85.299	85.366
EXISTING LEVELS	87.144	87.144	87.653	87.503	87.393	87.192	87.107	87.018	86.689	85.366
LENGTH AND GRADIENT			G=−1.5% L=97.9			G=−0.4% L=12.0		G=−0.6% L=49.8	G=−0.3% L=3.5	G=0.5% L=3.6

WC@5+700-CV17
LONGITUDINAL PROFILE-CH:0-167
Scale-1:1000/100



DATUM= 80								
CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+136
PROPOSED LEVELS	82.564	82.429	82.330	81.744	81.269	80.524	80.424	80.175
EXISTING LEVELS	83.079	83.085	82.933	82.188	81.713	80.957	80.864	80.619
LENGTH AND GRADIENT	G=−1.5% L=3.7	G=−0.5% L=48.4	G=−8.8% L=4.6	G=−3.7% L=4.8	G=−0.6% L=10.4	G=−5.5% L=13.0	G=−0.5% L=36.0	G=−3.7% L=5.3

WC@6+550-CV18, CV19
LONGITUDINAL PROFILE-CH:0-136
Scale-1:1000/100

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

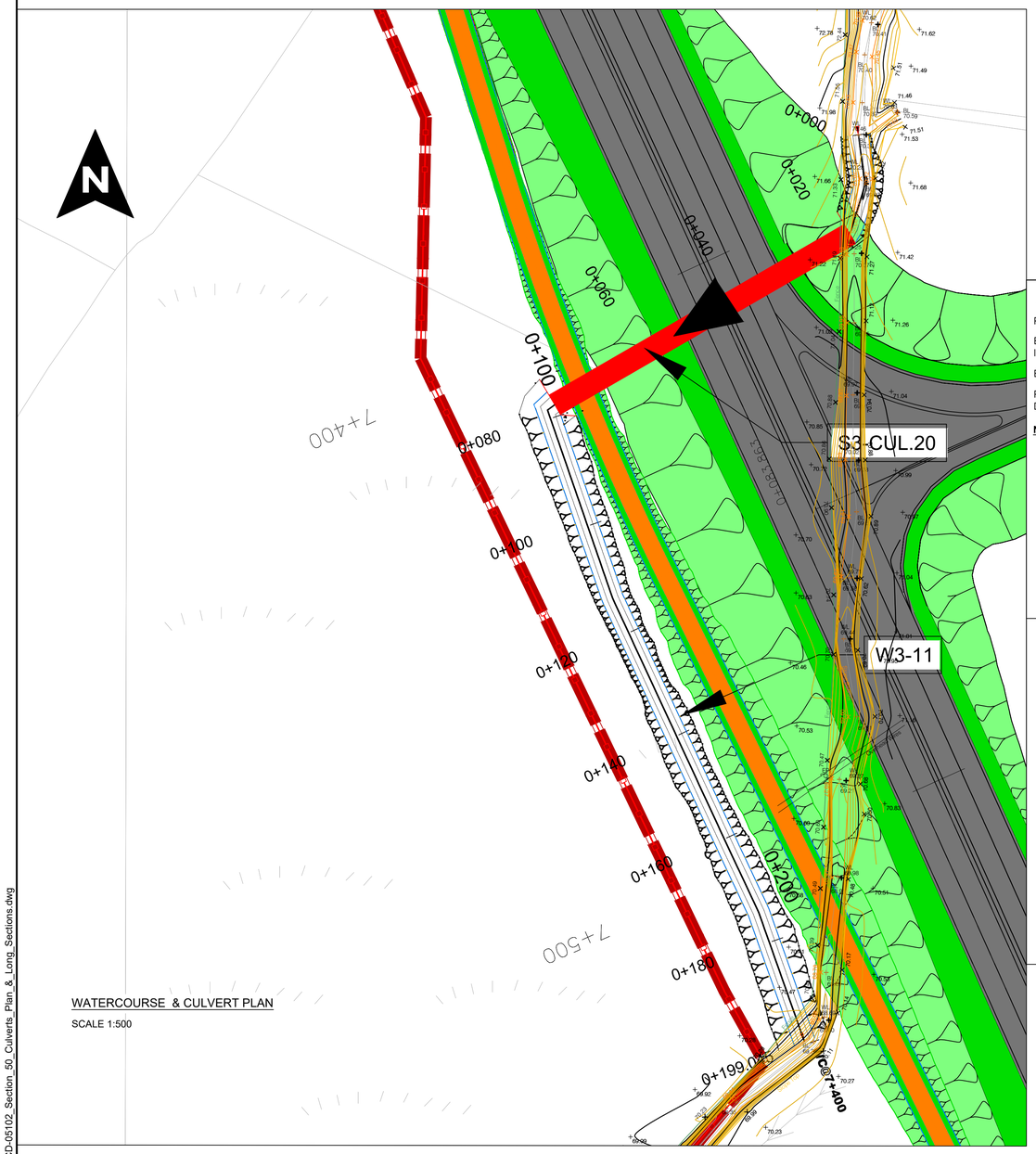
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV17, CV18 & CV19

Status: S4

Designed:	SH	Date: SEPT. 2022	Model File Identifier:
Drawn:	SH	Scale @ A1: AS SHOWN	
Approved:	ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked:	RF	Sheet: 5 OF 14	Rev: P01

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WATERCOURSE & CULVERT PLAN

SCALE 1:500

LEGEND

PROPOSED GROUND LEVEL

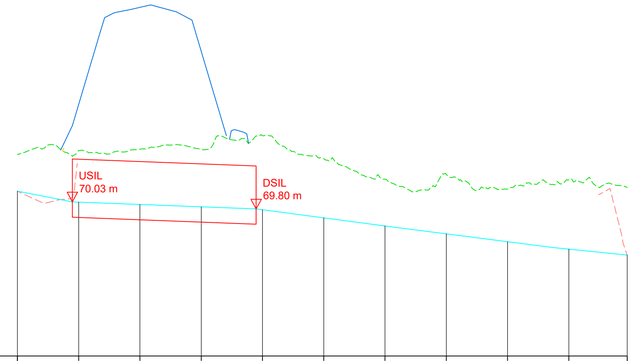
EXISTING WATERCOURSE INVERT LEVEL

EXISTING GROUND LEVEL

PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

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DATUM= 65											
CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+199
PROPOSED LEVELS	70.380	70.022	69.945	69.869	69.773	69.509	69.245	68.988	68.731	68.489	68.296
EXISTING LEVELS	70.380	71.703	71.749	71.742	72.190	71.440	70.774	70.931	70.447	70.745	68.296
LENGTH AND GRADIENT	G=−2.0% L=17.9		G=−0.4% L=60.0		G=−1.3% L=43.8		G=−1.3% L=53.2			G=−1.0% L=24.1	

WC@7+400-CV20
LONGITUDINAL PROFILE-CH:0-199
Scale-1:1000/100

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P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

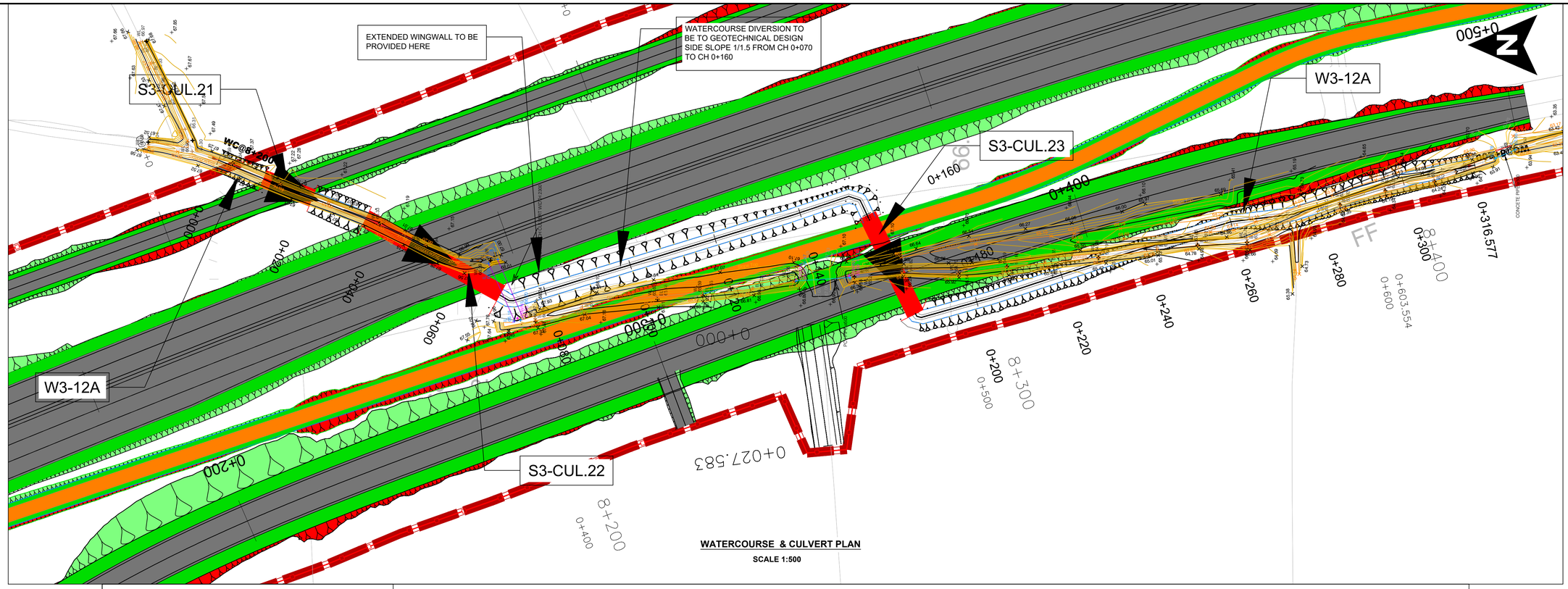
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV20

Status: S4

Designed:	SH	Date: SEPT. 2022	Model File Identifier:
Drawn:	SH	Scale @ A1: AS SHOWN	Rev: P01
Approved:	ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked:	RF	Sheet: 6 OF 14	

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WATERCOURSE & CULVERT PLAN

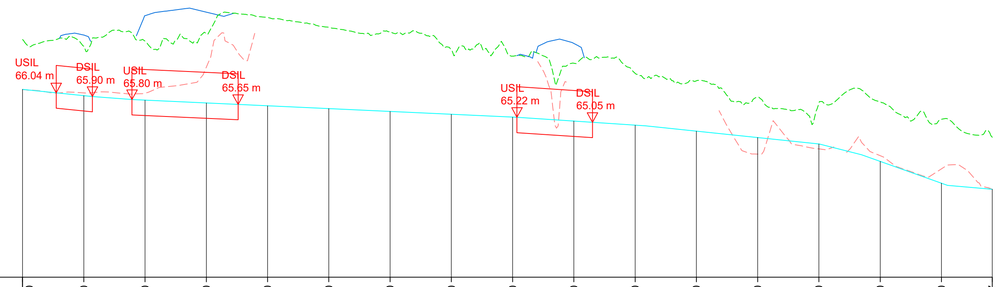
SCALE 1:500

LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
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DATUM= 60

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+220	0+240	0+260	0+280	0+300	0+317
PROPOSED LEVELS	66.129	65.928	65.780	65.688	65.596	65.503	65.411	65.319	65.227	65.097	64.964	64.768	64.560	64.351	63.784	63.070	62.874
EXISTING LEVELS	66.1293	66.017	66.011	66.854	68.476	68.160	68.017	67.431	67.218	66.984	66.656	66.410	64.020	64.188	63.969	63.537	62.874
LENGTH AND GRADIENT	G=−1.0% L=11.0	G=−1.0% L=11.841	G=−0.8% L=12.9	G=−0.43% L=34.647	G=−0.5% L=91.0				G=−0.7% L=24.661	G=−0.7% L=17.383	G=−1.0% L=56.7			G=−2.5% L=13.8	G=−3.6% L=28.9	G=−0.9% L=14.6	

WC@8+200-CV21, CV22 AND CV23
LONGITUDINAL PROFILE-CH:0-317
Scale-1:1000/100

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Comhairle Contae Dhún na nGall Donegal County Council
RPS BARRY TRANSPORTATION

Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

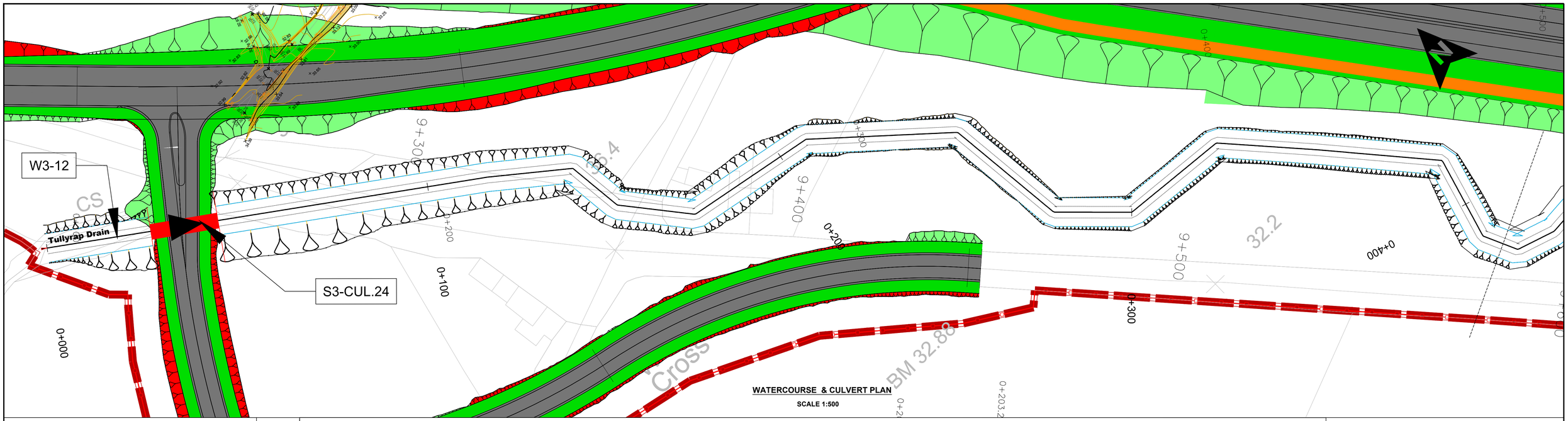
Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV21, CV22 & CV23

Status: S4

Designed:	SH	Date: SEPT. 2022	Model File Identifier:
Drawn:	SH	Scale @ A1: AS SHOWN	
Approved:	ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked:	RF	Sheet: 7 OF 14	Rev: P01

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WATERCOURSE & CULVERT PLAN

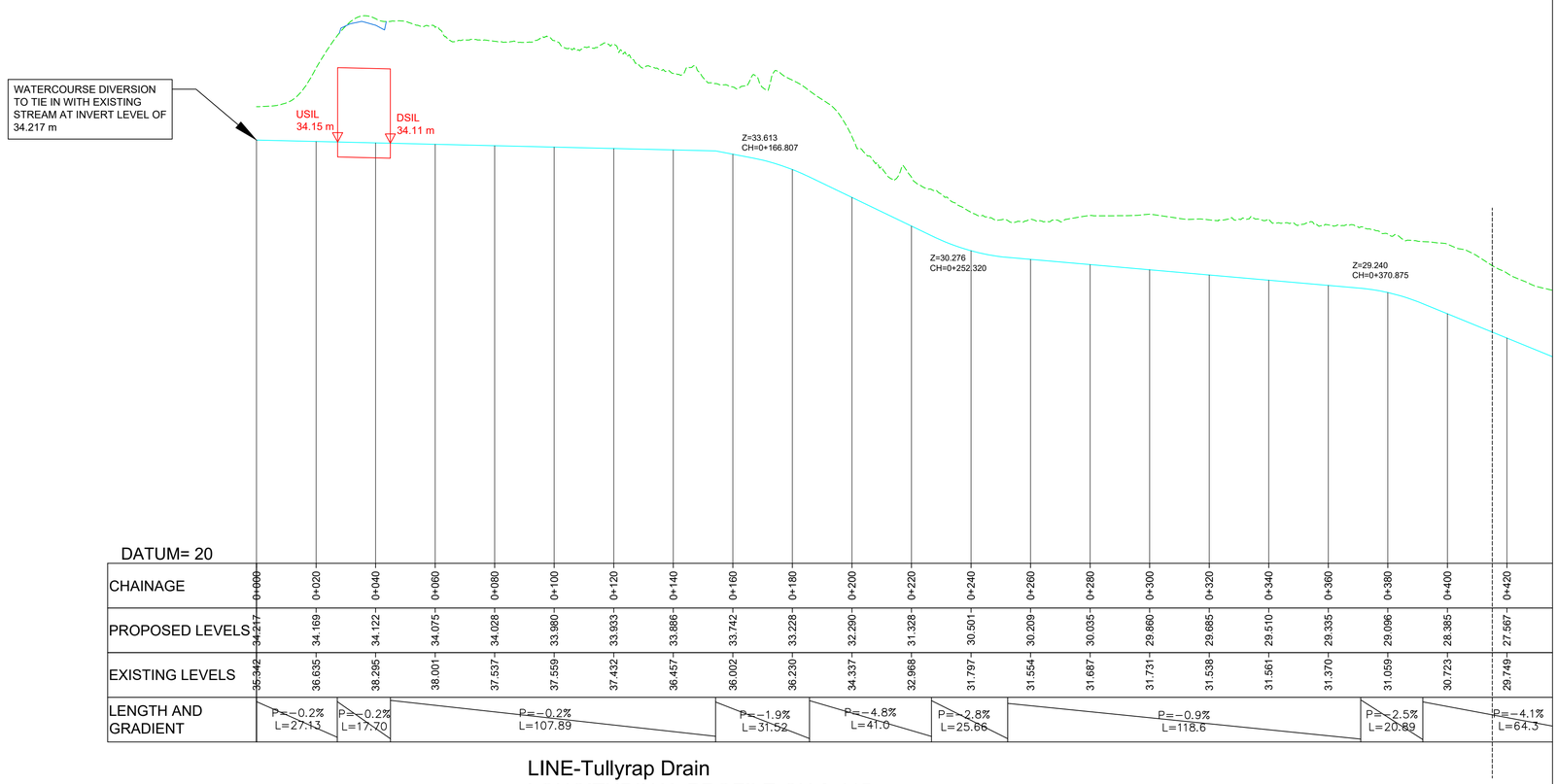
SCALE 1:500

LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

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DATUM= 20

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+220	0+240	0+260	0+280	0+300	0+320	0+340	0+360	0+380	0+400	0+420
PROPOSED LEVELS	34.217	34.169	34.122	34.075	34.028	33.980	33.933	33.886	33.742	33.228	32.290	31.328	30.501	30.209	30.035	29.860	29.685	29.510	29.335	29.096	28.385	27.567
EXISTING LEVELS	35.342	36.635	38.295	38.001	37.537	37.559	37.432	36.457	36.002	36.230	34.337	32.968	31.797	31.554	31.687	31.731	31.538	31.561	31.370	31.059	30.723	29.749
LENGTH AND GRADIENT		P=-0.2% L=27.13	P=-0.2% L=17.70	P=-0.2% L=107.89					P=-1.9% L=31.52	P=-4.8% L=41.0	P=-2.8% L=25.66	P=-0.9% L=118.6							P=-2.5% L=20.89	P=-4.1% L=64.3		

LINE-Tullyrap Drain
LONGITUDINAL PROFILE-CH:0-415
Scale-1:1000/100

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Comhairle Contae Dhún na nGall Donegal County Council

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Notes

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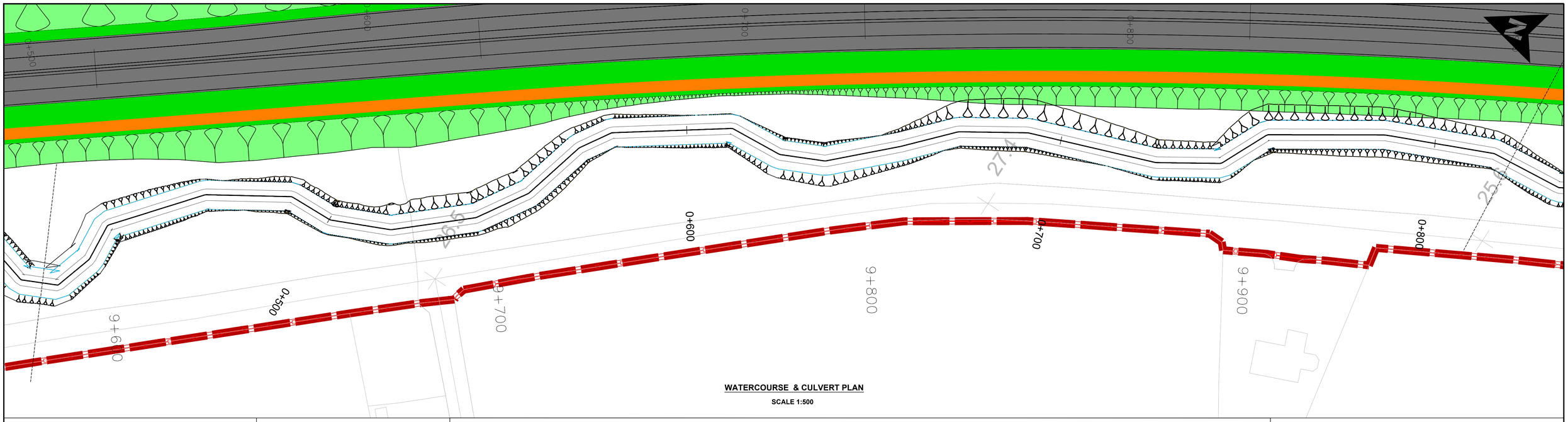
Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV24

Status: S4

Designed:	SH	Date: SEPT. 2022	Model File Identifier:
Drawn:	SH	Scale @ A1: AS SHOWN	Rev: P01
Approved:	ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked:	RF	Sheet: 8 OF 14	



WATERCOURSE & CULVERT PLAN

SCALE 1:500

LEGEND

PROPOSED GROUND LEVEL

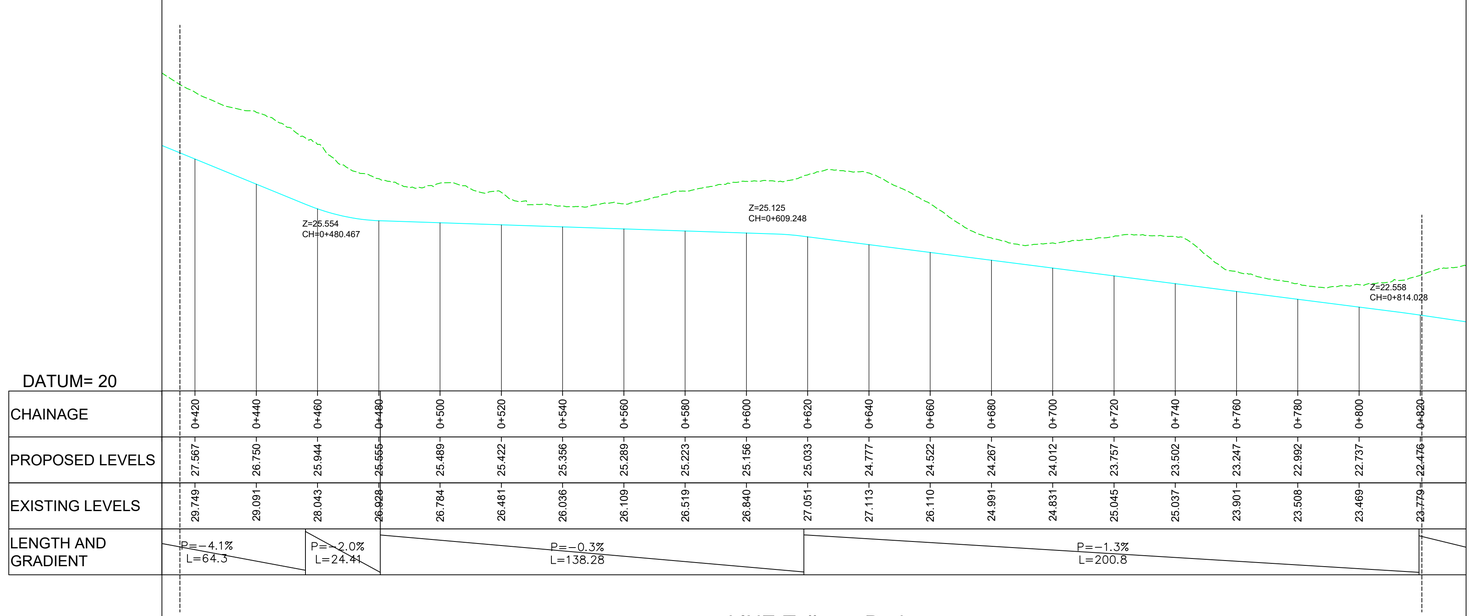
EXISTING WATERCOURSE INVERT LEVEL

EXISTING GROUND LEVEL

PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
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DATUM= 20

CHAINAGE	0+420	0+440	0+460	0+480	0+500	0+520	0+540	0+560	0+580	0+600	0+620	0+640	0+660	0+680	0+700	0+720	0+740	0+760	0+780	0+800	0+820
PROPOSED LEVELS	27.567	26.750	25.944	25.555	25.489	25.422	25.356	25.289	25.223	25.156	25.033	24.777	24.522	24.267	24.012	23.757	23.502	23.247	22.992	22.737	22.476
EXISTING LEVELS	29.749	29.091	28.043	26.928	26.784	26.481	26.036	26.109	26.519	26.840	27.051	27.113	26.110	24.991	24.831	25.045	25.037	23.901	23.508	23.469	23.779
LENGTH AND GRADIENT	P=−4.1% L=64.3		P=−2.0% L=24.41		P=−0.3% L=138.28						P=−1.3% L=200.8										

LINE-Tullyrap Drain
LONGITUDINAL PROFILE-CH:0-415 TO 0-820
Scale-1:1000/100

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Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

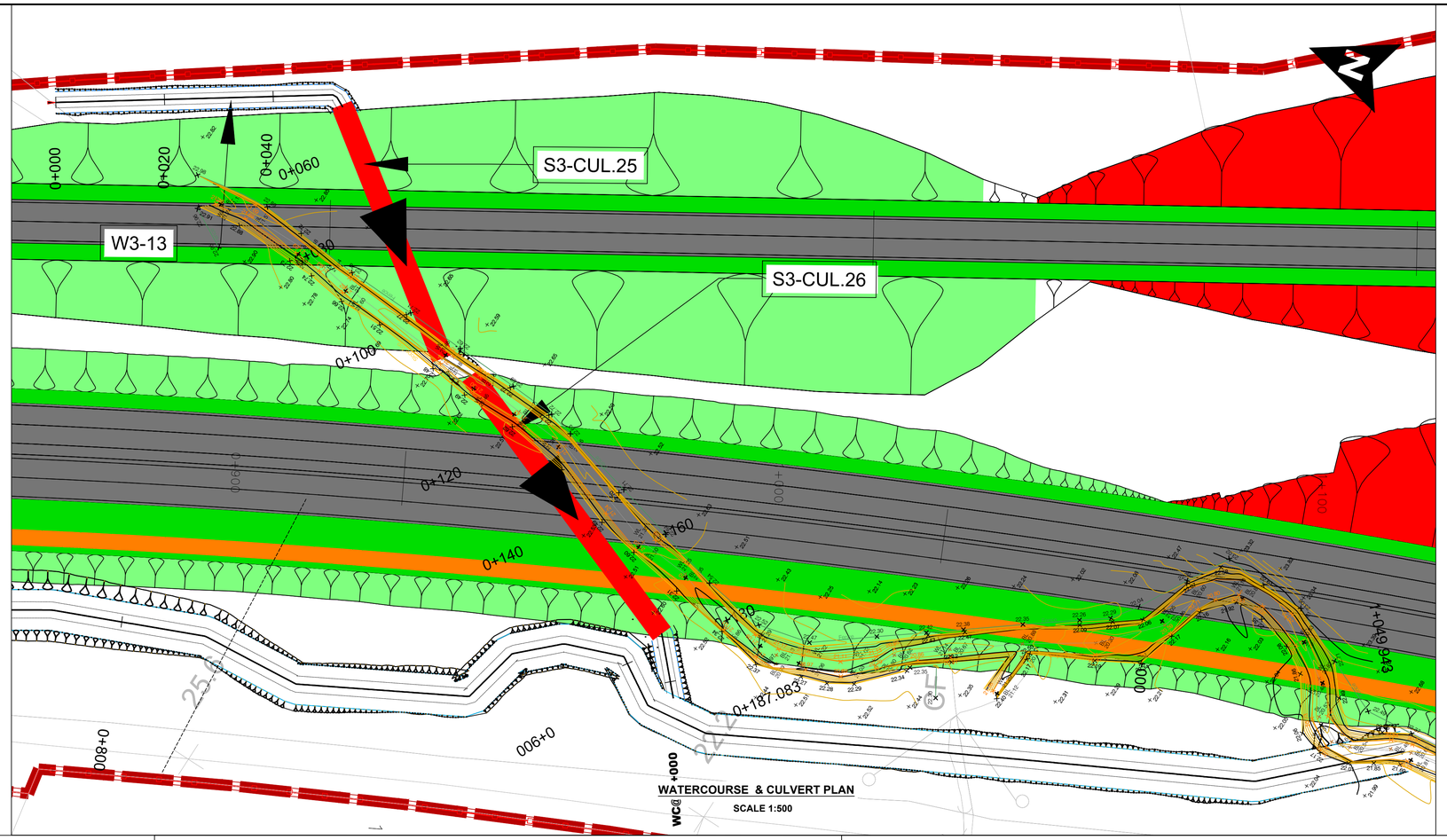
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections

Status: S4

Designed:	SH	Date: SEPT. 2022	Model File Identifier:
Drawn:	SH	Scale @ A1: AS SHOWN	Rev: P01
Approved:	ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
Checked:	RF	Sheet: 9 OF 14	

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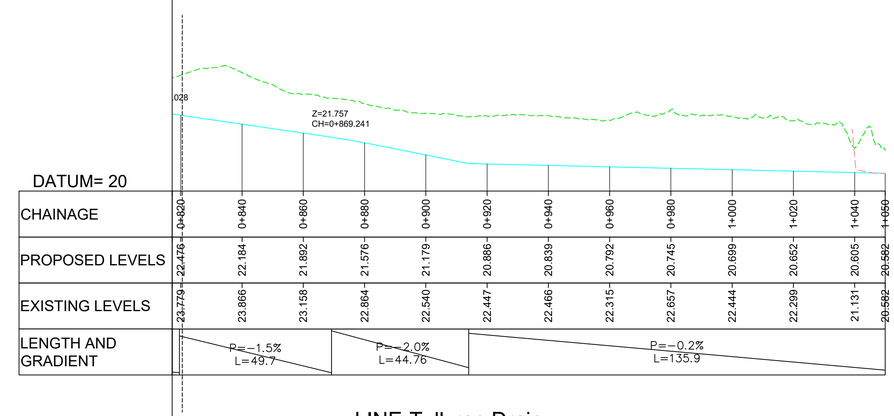
WATERCOURSE & CULVERT PLAN
SCALE 1:500

LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

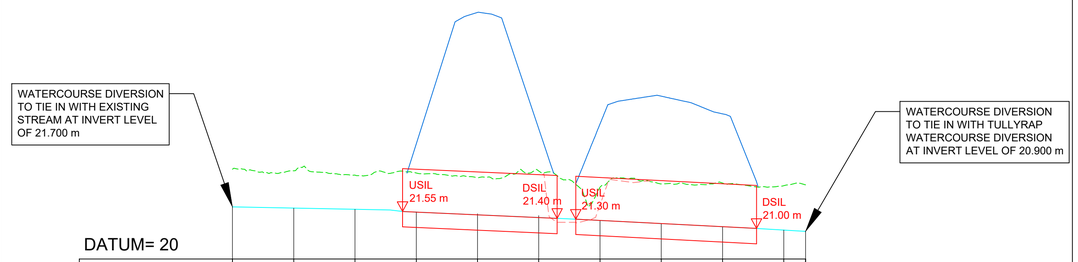
NOTES:

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DATUM= 20												
CHAINAGE	0+820	0+840	0+860	0+880	0+900	0+920	0+940	0+960	0+980	1+000	1+020	1+040	1+050
PROPOSED LEVELS	22.476	22.184	21.892	21.576	21.179	20.886	20.839	20.792	20.745	20.699	20.652	20.605	20.582
EXISTING LEVELS	23.779	23.866	23.158	22.864	22.540	22.447	22.466	22.315	22.657	22.444	22.299	21.131	20.582
LENGTH AND GRADIENT		P=−1.5% L=49.7		P=−2.0% L=44.76		P=−0.2% L=135.9							

LINE-Tullyrap Drain
LONGITUDINAL PROFILE-CH: 0-820 TO 1-050
Scale-1:1000/100



DATUM= 20										
CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+187
PROPOSED LEVELS	21.700	21.661	21.622	21.537	21.478	21.418	21.259	21.157	21.055	20.944	20.900
EXISTING LEVELS	22.929	22.879	22.735	22.808	22.659	22.870	21.773	22.452	22.478	22.393	22.423
LENGTH AND GRADIENT		P=−0.2% L=55.7		P=−0.3% L=50.2		P=−1.7% L=6.0	P=−0.5% L=59.0			P=−0.6% L=18.0	

WC@10+000-CV25 AND CV26
LONGITUDINAL PROFILE-CH:0-187
Scale-1:1000/100

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Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

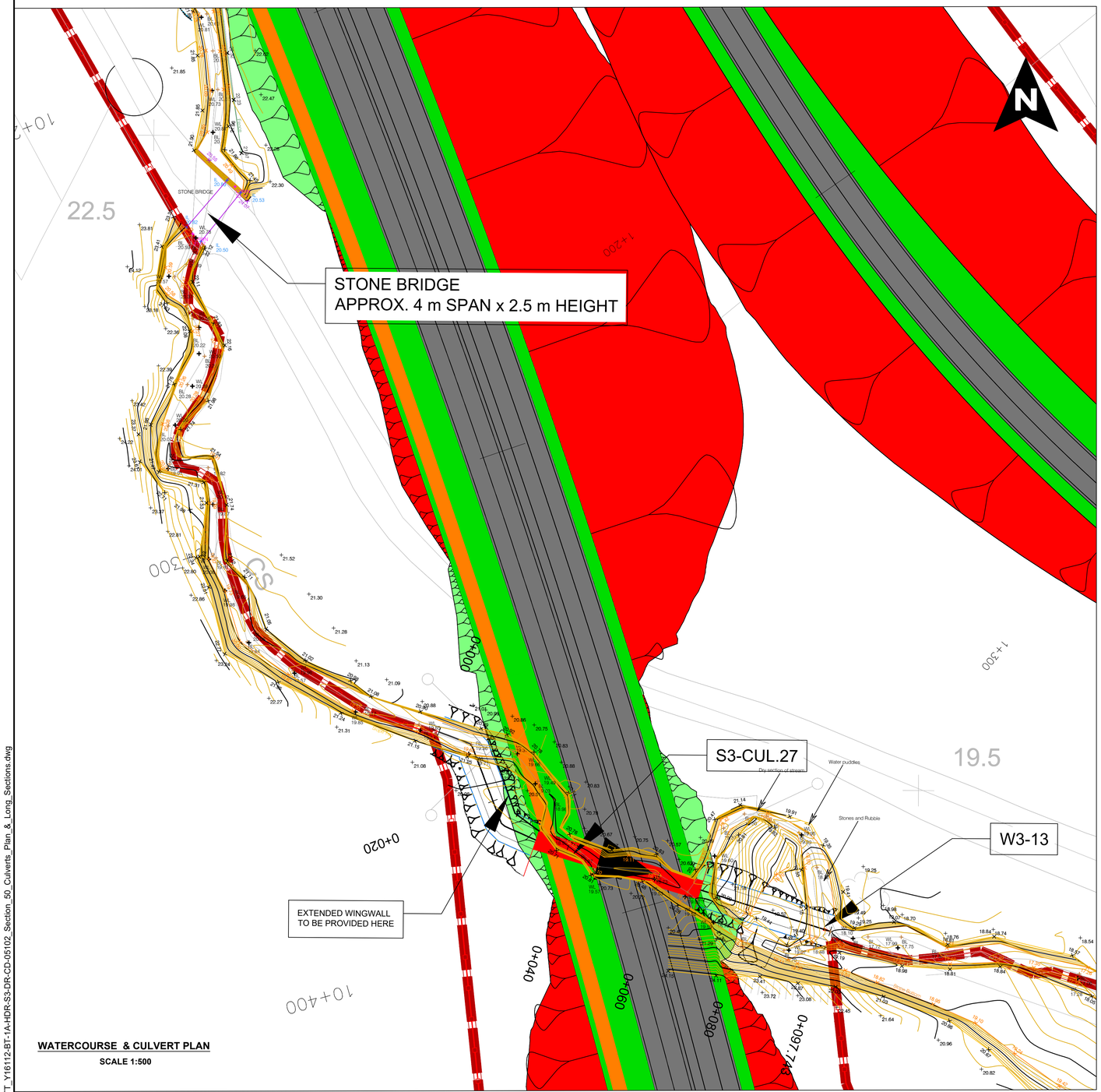
Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV25 & CV26

Status: S4

Designed:	SH	Date:	SEPT. 2022	Model File Identifier:	Rev: P01
Drawn:	SH	Scale @ A1:	AS SHOWN		
Approved:	ED	@ A3:		File Identifier:	
Checked:	RF	Sheet:	10 OF 14	TT_Y16112-BT-1A-HDR-S3-DR-CD-05102	

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WATERCOURSE & CULVERT PLAN

SCALE 1:500

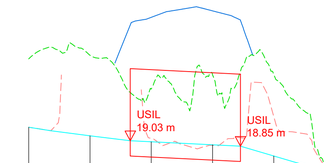
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LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

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DATUM= 15						
CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+098
PROPOSED LEVELS	19.470	19.189	18.996	18.896	18.530	18.007
EXISTING LEVELS	19.470	21.818	19.106	18.876	19.815	18.007
LENGTH AND GRADIENT		G= -1.3% L=33.1		G= -0.5% L=36.0		G= -2.9% L=28.6

WC@10+400-CV27
LONGITUDINAL PROFILE-CH:0-98
Scale-1:1000/100

Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

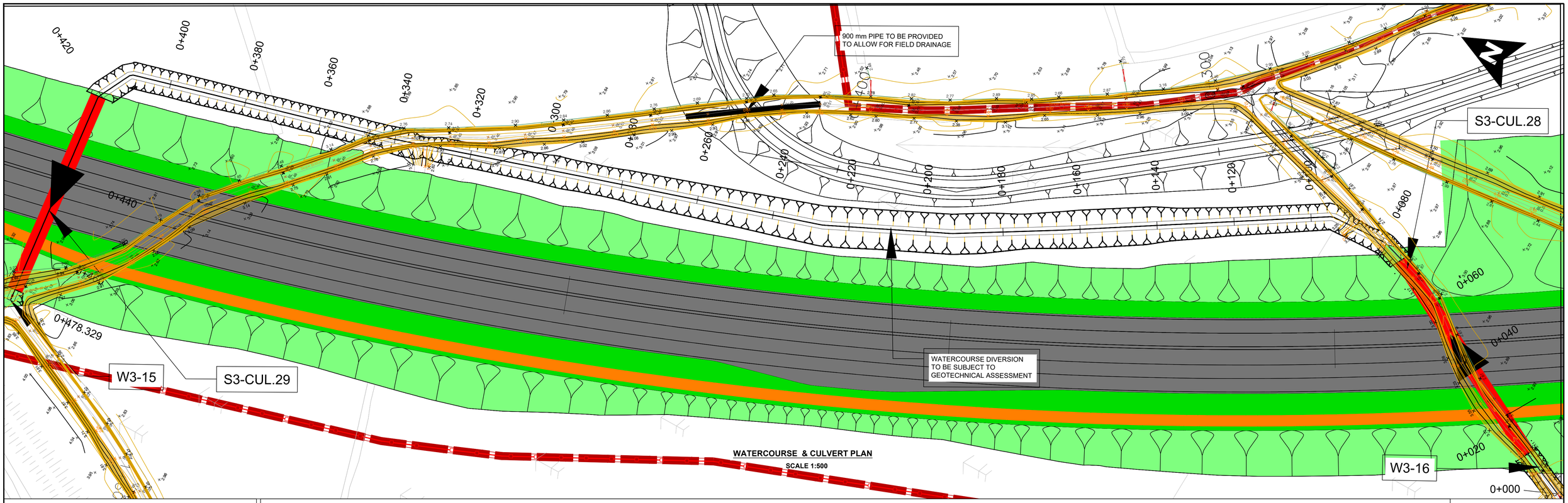
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV27

Status: S4

Designed: SH	Date: SEPT. 2022	Model File Identifier:	Rev: P01
Drawn: SH	Scale @ A1: AS SHOWN		
Approved: ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102	
Checked: RF	Sheet: 11 OF 14		

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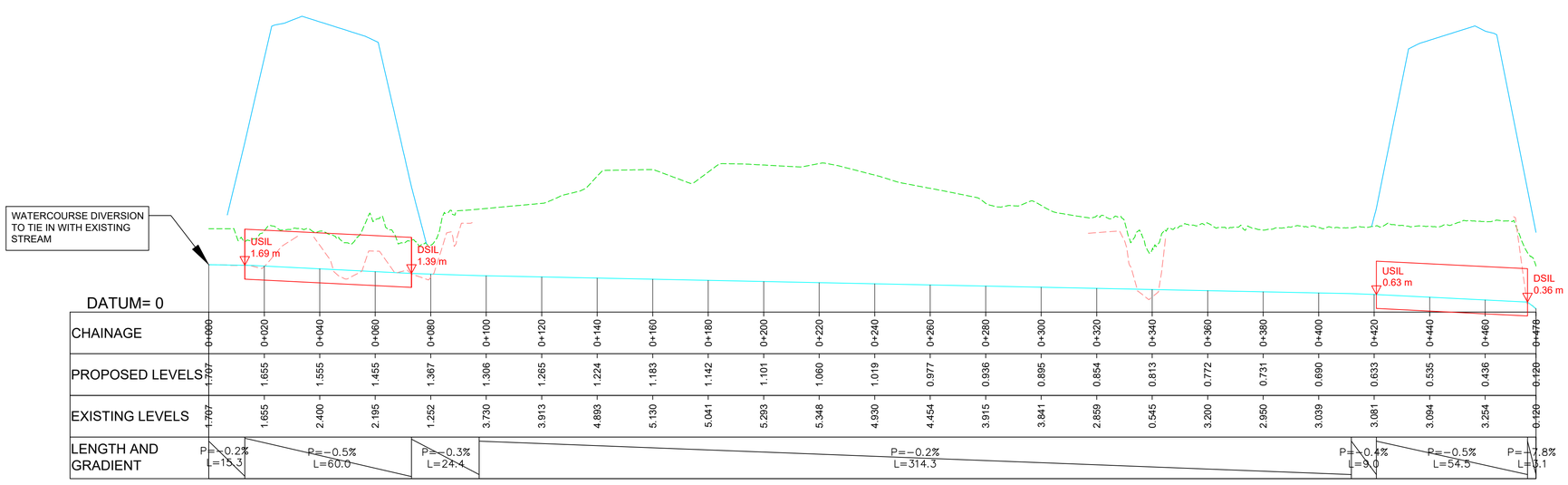
WATERCOURSE & CULVERT PLAN
SCALE 1:500

LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

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WC@11+600-CV28 AND CV29
LONGITUDINAL PROFILE-CH:0-478
Scale-1:1000/100

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

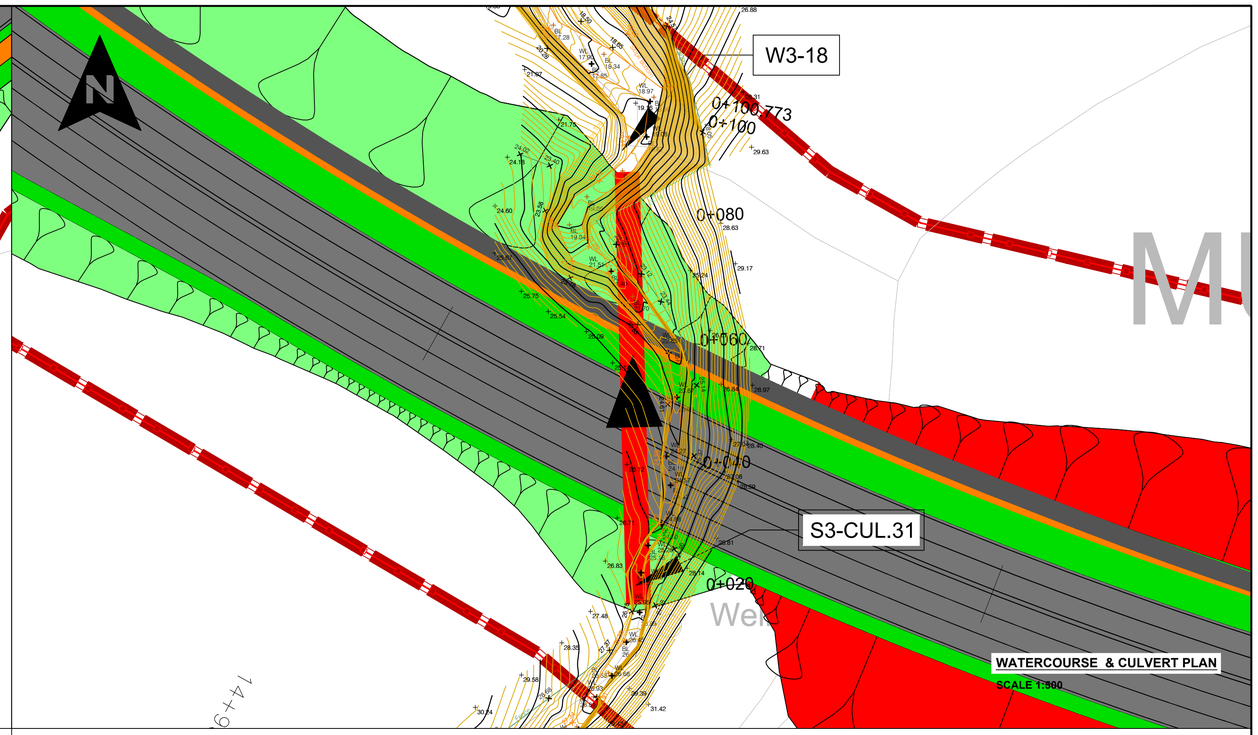
Drawing Title: Section 50 Culverts-Plan & Long Sections - CV28 & CV29

Status: S4

Designed: SH	Date: SEPT. 2022	Model File Identifier:	Rev: P01
Drawn: SH	Scale @ A1: AS SHOWN		
Approved: ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102	
Checked: RF	Sheet: 12 OF 14		

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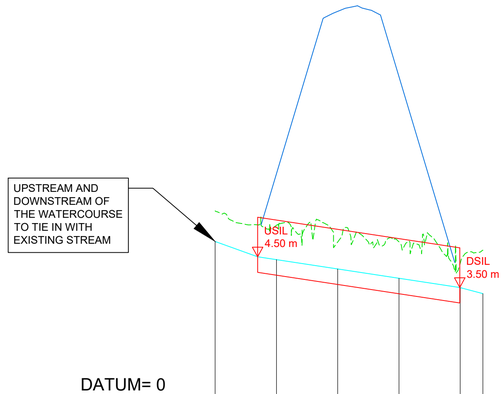


LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

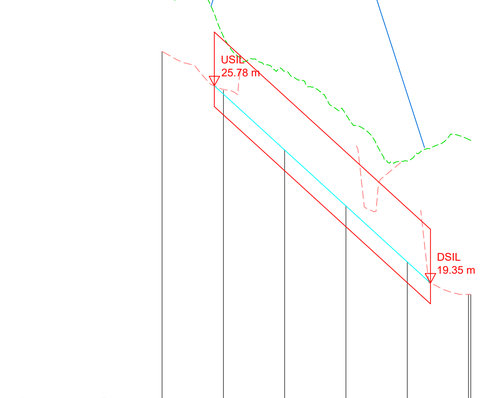
1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
2. In the majority of cases the proposed watercourse diversion is shown tying in with the existing stream inverts (pink line). In some cases an existing stream invert line has not been shown at the tie in, but it is confirmed that the existing stream invert was checked on the topographical survey at this location and that it does tie in. A note in relation to this has been provided where relevant.
3. Headwalls extents have not been indicated on the plan drawings generally. In some cases, notes in relation to the headwalls extents have been provided, where they will be containing an earthworks spill.



DATUM= 0

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+087
PROPOSED LEVELS	5.000	4.407	4.104	3.801	3.496	3.390
EXISTING LEVELS	6.000	5.530	4.985	4.988	4.298	4.747
LENGTH AND GRADIENT	G=−3.6% L=13.9		G=−1.5% L=66.0		G=−2.6% L=7.5	

WC@Ballin_1+500-CV30
LONGITUDINAL PROFILE-CH:0-87
Scale-1:1000/100



DATUM= 15

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+101
PROPOSED LEVELS	26.912	25.644	23.690	21.868	20.040	18.974	18.987
EXISTING LEVELS	26.912	25.644	26.268	24.851	23.337	18.974	18.987
LENGTH AND GRADIENT	P=−6.0% L=17.3		P=−9.1% L=70.5		P=−7.6% L=13.2		

WC@14+900-CV31
LONGITUDINAL PROFILE-CH:0-101
Scale-1:1000/100

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Notes

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

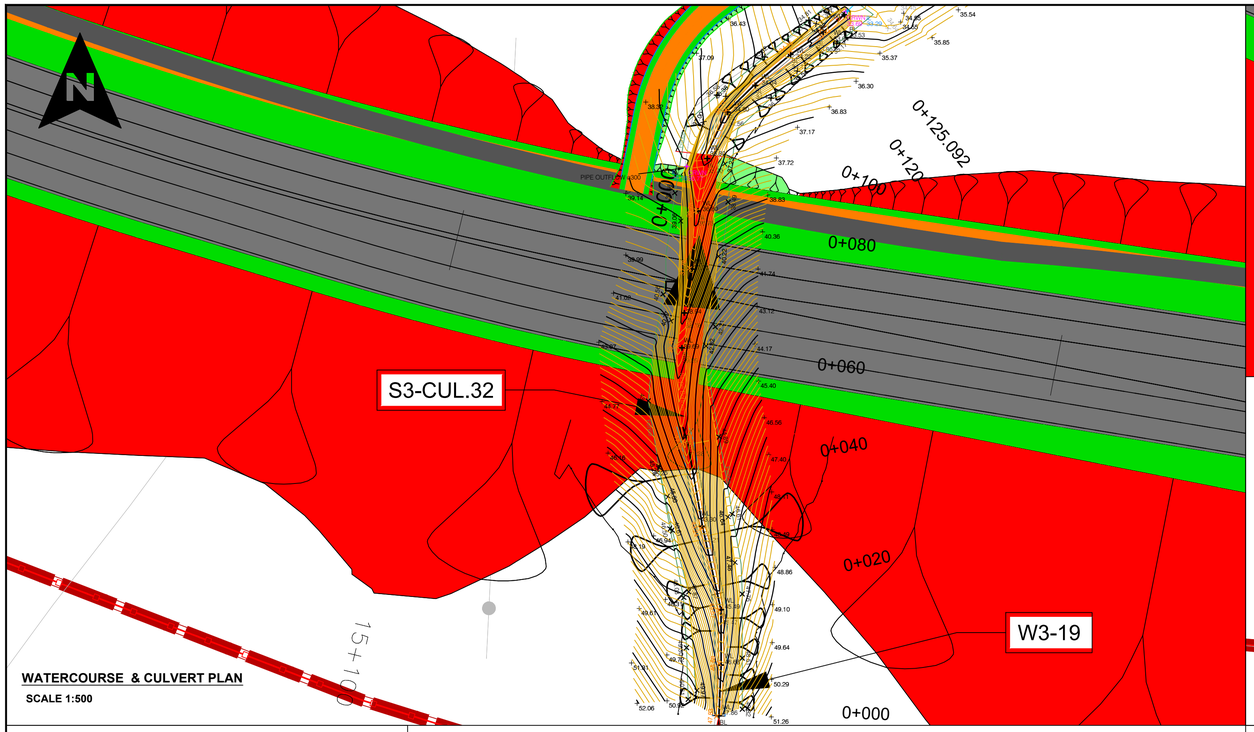
Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV30 & CV31

Status: S4

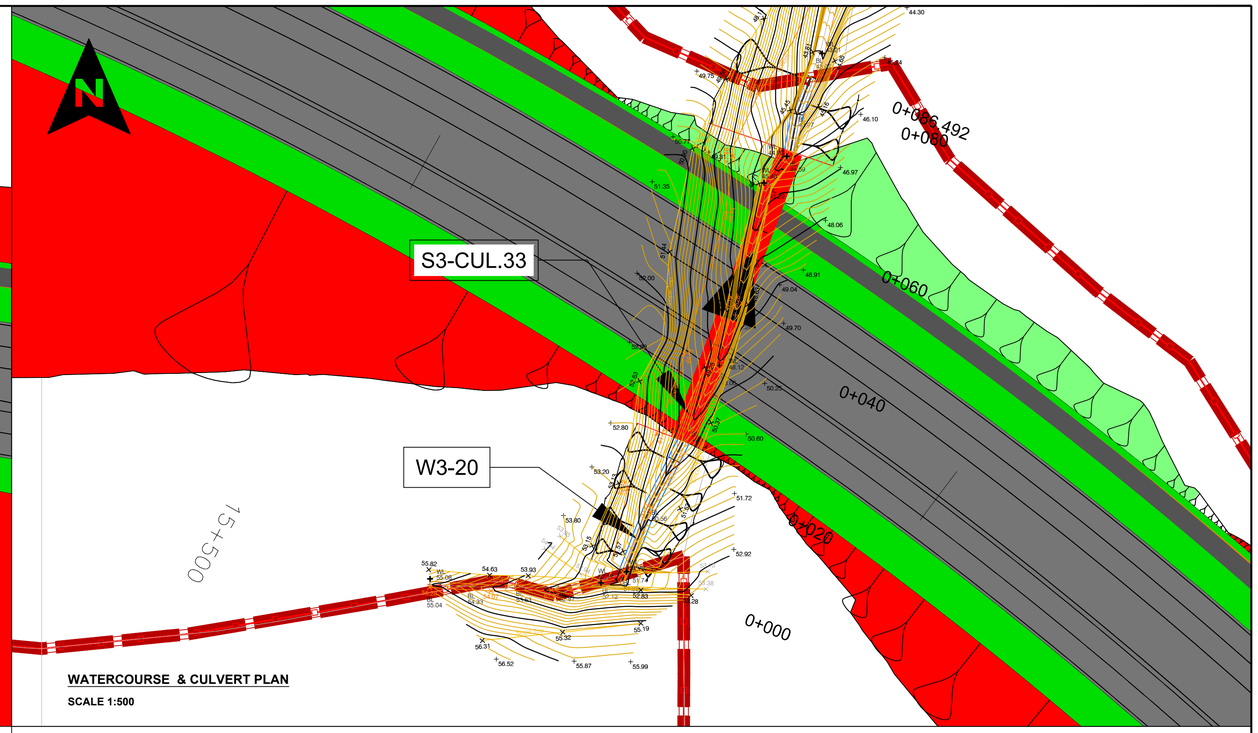
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Drawn: SH	Scale @ A1: AS SHOWN		
Approved: ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102	
Checked: RF	Sheet: 13 OF 14		

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WATERCOURSE & CULVERT PLAN

SCALE 1:500



WATERCOURSE & CULVERT PLAN

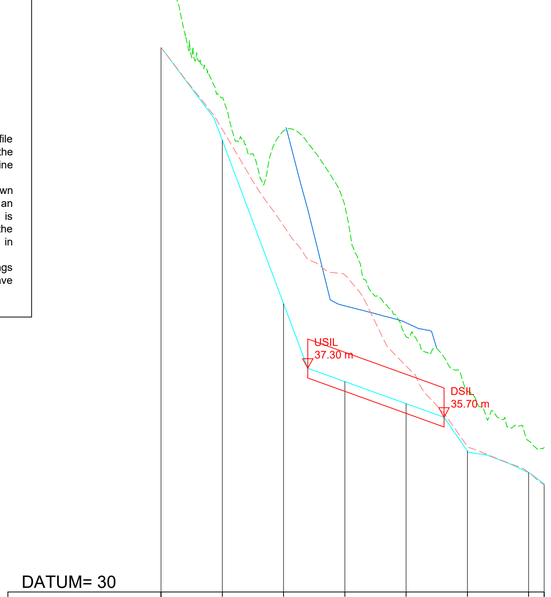
SCALE 1:500

LEGEND

- PROPOSED GROUND LEVEL
- EXISTING WATERCOURSE INVERT LEVEL
- EXISTING GROUND LEVEL
- PROPOSED WATERCOURSE DIVERSION INVERT LEVEL

NOTES:

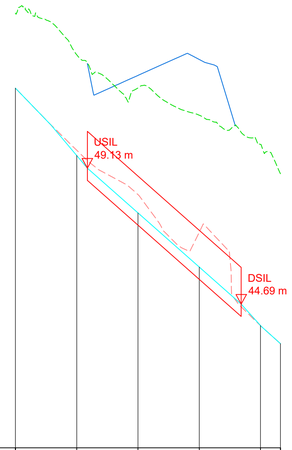
1. Existing Ground Level (green line) represents the existing ground profile which does not take into account of the stream inverts. Where the ground profile is along the line of an existing stream, the green line represents the top of bank level of this watercourse.
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3. Headwalls extents have not been indicated on the plan drawings generally. In some cases, notes in relation to the headwalls extents have been provided, where they will be containing an earthworks spill.



DATUM= 30

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+125
PROPOSED LEVELS	47.772	44.744	39.410	36.865	36.146	34.600	33.895	33.520
EXISTING LEVELS	47.772	45.097	41.950	40.347	37.378	34.755	33.903	33.496
LENGTH AND GRADIENT	G=-13.3% L=17.3	G=-26.7% L=30.6	G=-3.6% L=44.5	G=-14.4% L=7.9	G=-4.2% L=24.9			

LINE-WC@15+150-CV32
LONGITUDINAL PROFILE-CH:0-125
Scale-1:1000/100



DATUM= 40

CHAINAGE	0+000	0+020	0+040	0+060	0+080	0+086
PROPOSED LEVELS	51.739	49.541	47.669	45.901	43.991	43.400
EXISTING LEVELS	51.739	49.715	48.266	47.042	43.987	43.400
LENGTH AND GRADIENT	G=-11.1% L=23.5	G=-8.8% L=50.2	G=-10.1% L=12.8			

WC@15+550-CV33
LONGITUDINAL PROFILE-CH:0-86
Scale-1:1000/100

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	30/06/22	SH	ISSUED FOR SECTION 50 APPROVAL	RF	ED

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL

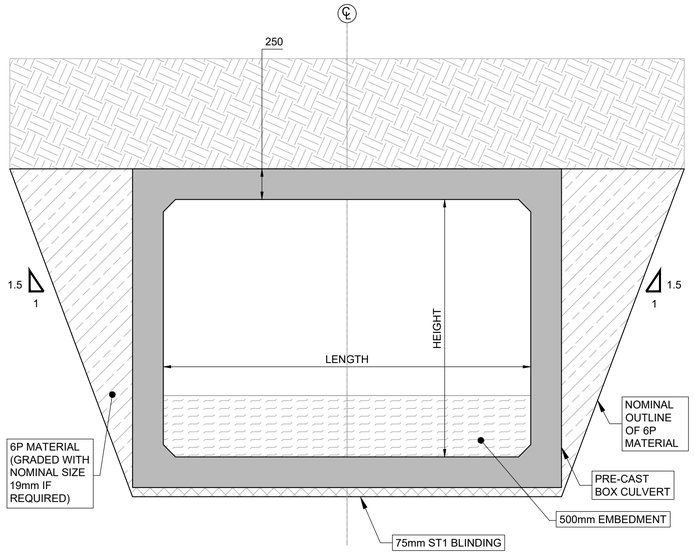
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts-Plan & Long Sections - CV32 & CV33

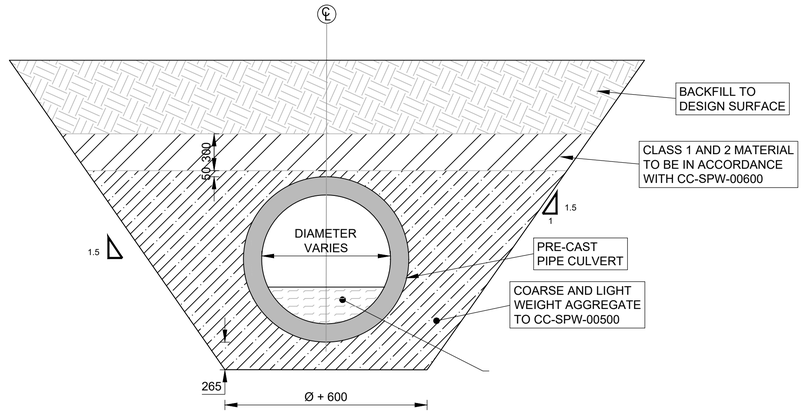
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Designed:	SH	Date: SEPT. 2022	Model File Identifier:
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Approved:	ED	@ A3:	File Identifier: TT_Y16112-BT-1A-HDR-S3-DR-CD-05102
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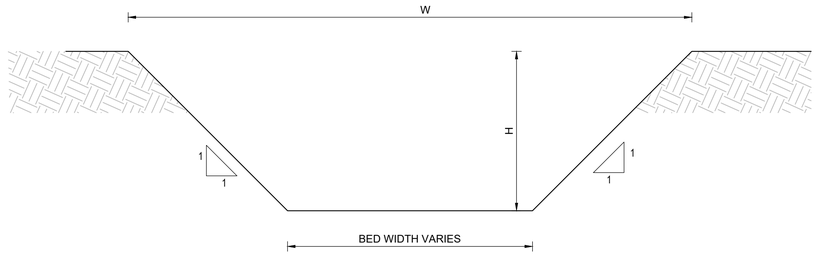
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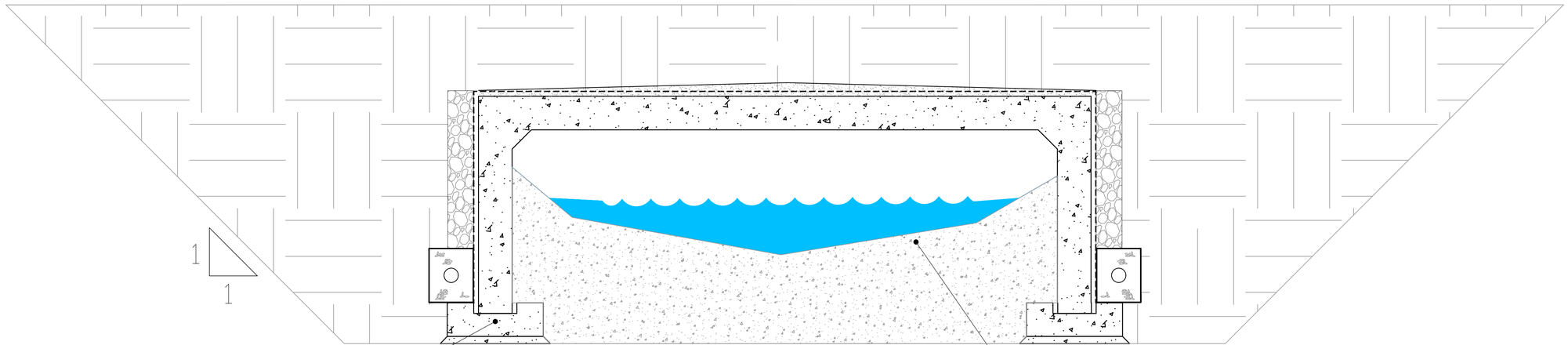
BOX CULVERT
TYPICAL CROSS SECTION SCALE 1:25 @A1 ; 1:50 @A3



PIPE CULVERT
TYPICAL CROSS SECTION SCALE 1:25 @A1 ; 1:50 @A3



WATERCOURSE DIVERSION
TYPICAL CROSS SECTION SCALE 1:25 @A1 ; 1:50 @A3



BOTTOMLESS CULVERT
TYPICAL CROSS SECTION SCALE 1:25 @A1 ; 1:50 @A3

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Rev.	Date	Drawn	Description	Chk'd	Appr.
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P01	30/08/21	LRB	FOR REVIEW AND COMMENTS	SHS	RF

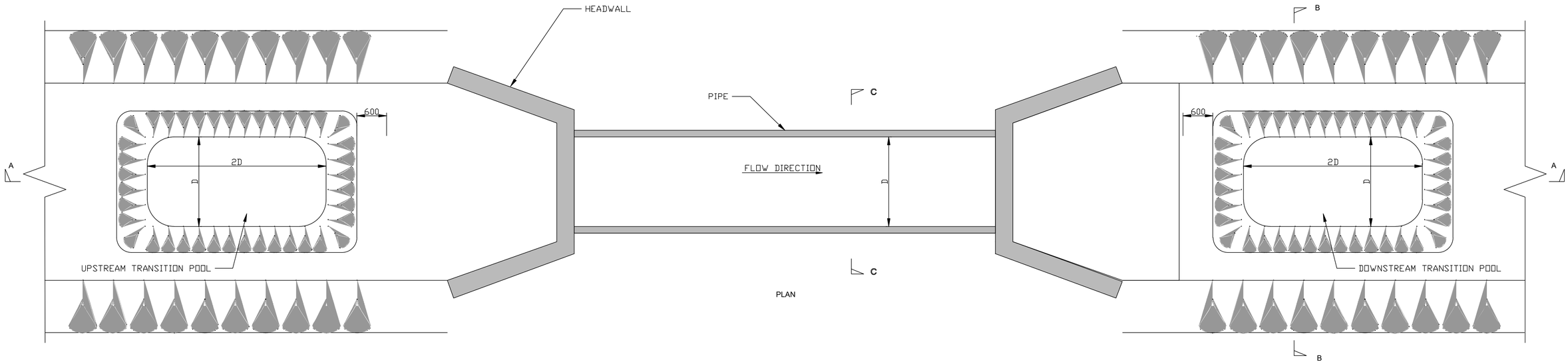
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Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Section 50 Culverts- Standard Details

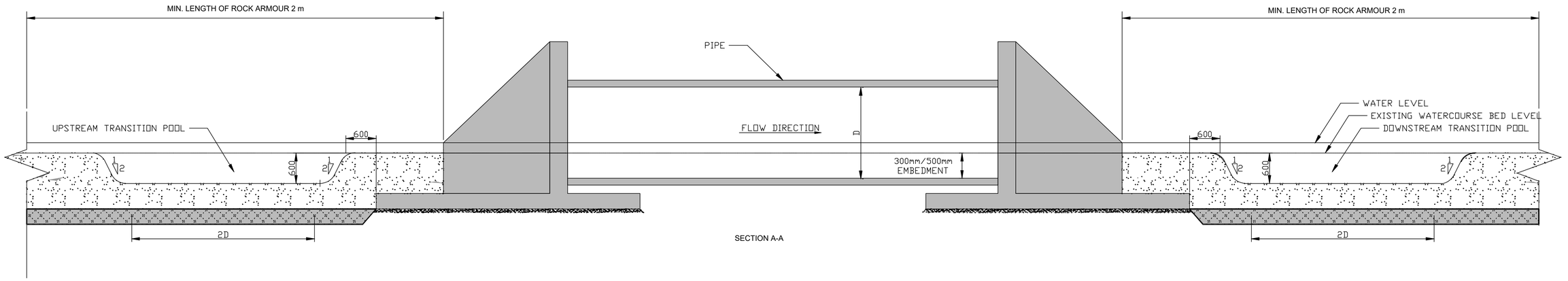
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Approved:	ED	@ A3:	File Identifier: Y16112-0500-035
Checked:	RF	Sheet: 1 OF 3	Rev: P02

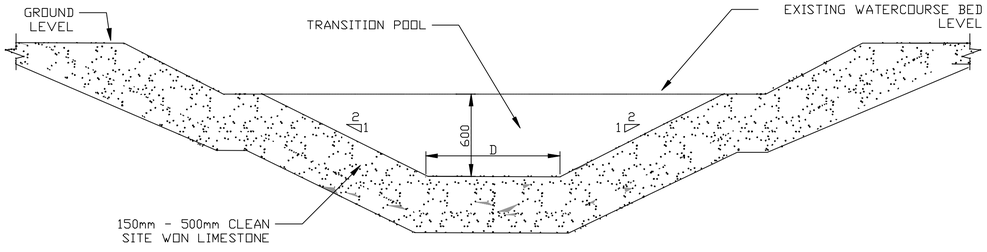
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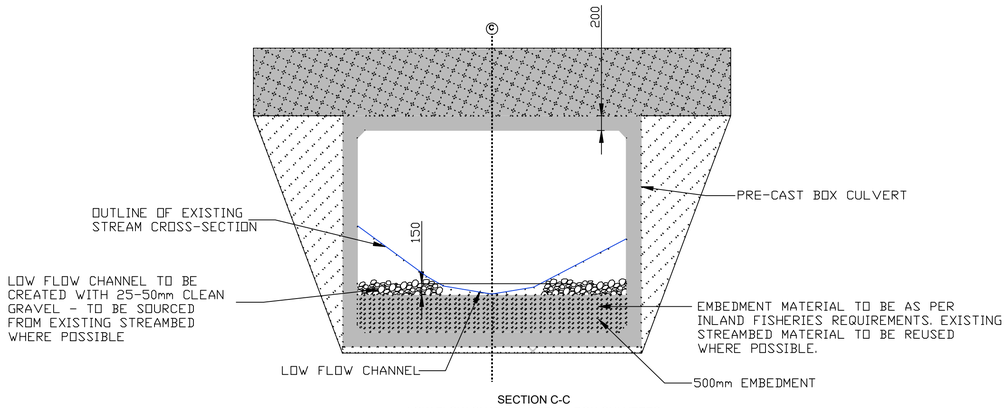
PLAN



SECTION A-A



SECTION B-B
TRANSITION POOL DETAIL



SECTION C-C
LOW FLOW CHANNEL DETAIL- BOX CULVERTS

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Rev.	Date	Drawn	Description	Chk'd	Appr.
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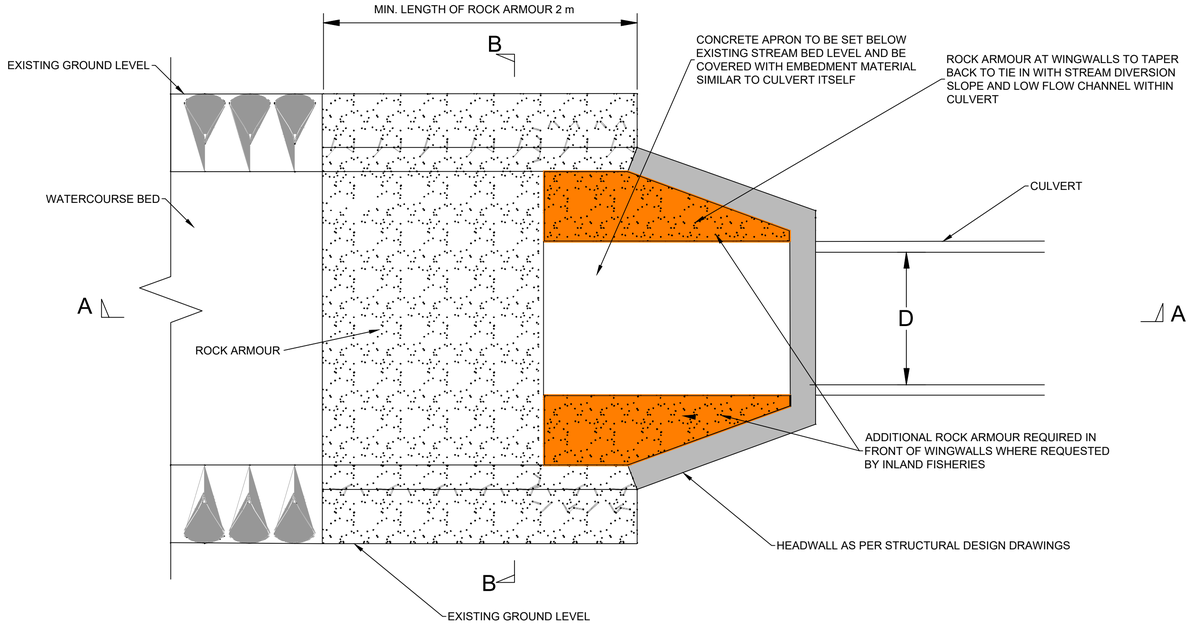
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Drawing Title:	Section 50 Culverts- Standard Details
Status:	S4
Designed: SHS	Date: SEPT. 2022
Drawn: SHS	Scale @ A1: NTS
Approved: ED	@ A3:
Checked: RF	Sheet: 2 OF 3
Model File Identifier:	TT_Y16112-BT-1A-HDR-ZZ -DR-CD-05033_Culvert_Section_50
File Identifier:	Y16112-0500-035
Rev:	P01

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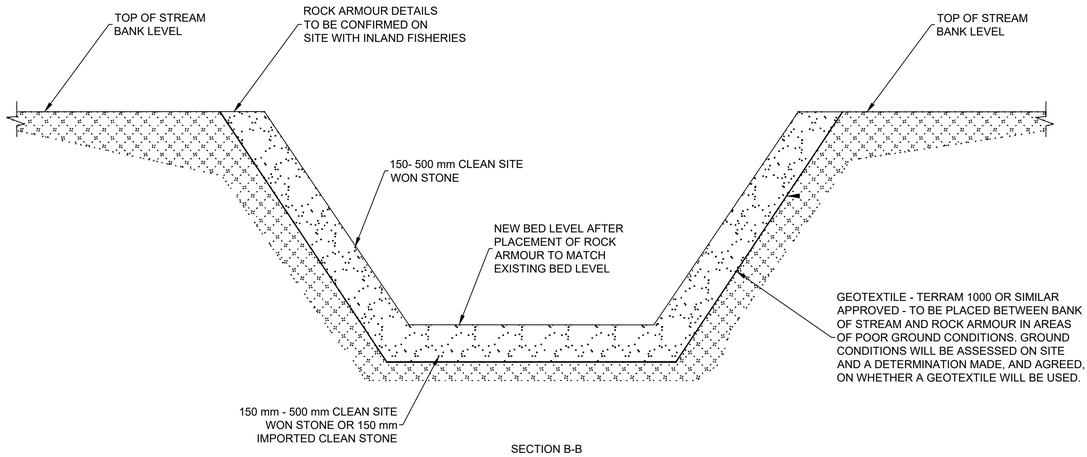
NOTE:
ROCK ARMOUR DETAIL IS TO BE PROVIDED AT EVERY CULVERT THROUGHOUT THE PROJECT.

REFER TO CC-SCD-00553 FOR DETAILS ON PIPE CULVERT HEADWALL GEOMETRY, SUBGRADE AND FOUNDATION REQUIREMENTS.

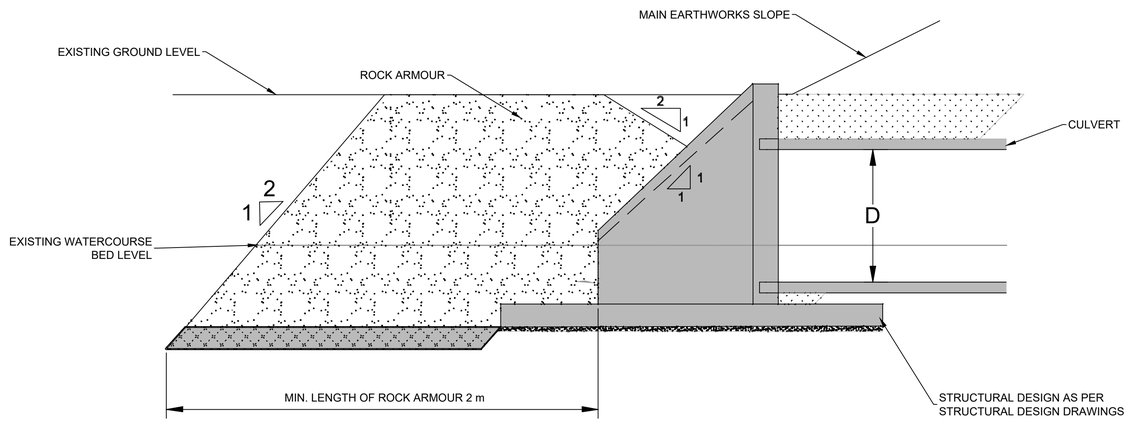
APPROACH TO BACKFILLING CULVERTS (WHERE REQUIRED BY INLAND FISHERIES) TO BE AGREED ON SITE WITH INLAND FISHERIES.



PLAN



SECTION B-B



SECTION A-A

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	04/09/22	SHS	ISSUED FOR SECTION 50 APPROVAL	RF	RF

Project Title:	TEN-T Priority Route Improvement Project, Donegal Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link		
Drawing Title:	Section 50 Culverts - Standard Details		Status: S4
Designed: SHS	Date: SEPT. 2022	Model File Identifier:	Rev:
Drawn: SHS	Scale @ A1: NTS	TT_Y16112-BT-1A-HDR-ZZ -DR-CD-05033_Culvert_Section_50	P01
Approved: ED	@ A3:	File Identifier:	
Checked: RF	Sheet: 3 OF 3	Y16112-0500-035	

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APPENDIX C: PHOTOS

W3-04





W3-05





W3-07





W3-08





W3-09





W3-10





W3-11





W3-12





W3-12A





W3-13





W3-15





W3-16





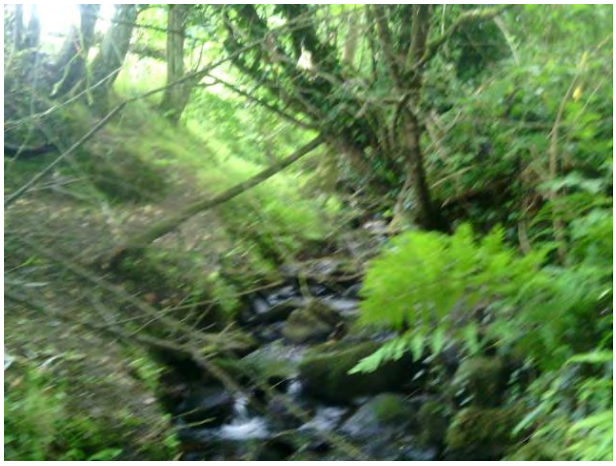
W3-17A





W3-18





W3-19





W3-20





APPENDIX D: SECTION 50 APPLICATIONS

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.07**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing				
Watercourse:	**Leslie Hill Stream_020 (W3-04)**		Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X: **225382.04**		Y: **410100.09**	
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**13.85** Km^2		Road Reference:	**N14 Mainline**
Design Flood Flow:	**24.04** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*						
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**12.15**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**4.2 m wide by 3.5 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 69.50 m.**
Effective Conveyance Area *4	**11.17 m2 (Upstream), 5.84 m^2 (Downstream)**
Upstream Invert Level **22.42** mOD Bed level **22.92** mOD	Downstream Invert Level **22.07** mOD Bed level **22.57** mOD
Upstream Soffit Level **25.92** mOD	Downstream Soffit Level **25.57** mOD
Upstream Design Flood Level **25.58** mOD	Downstream Design Flood Level **23.96** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.08**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-05)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**225735.39**	Y:	**409626.73**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.360** Km^2		Road Reference:	**Existing N14 (realigned)**	
Design Flood Flow:	**0.92** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.44**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	**0.92**
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
Regional growth factor by FSR 1975	**1.88**

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**1.8 m wide by 1.4 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 24.50 m.**
Effective Conveyance Area *4	**1.06 m2 (Upstream), 0.94 m^2 (Downstream)**

Upstream Invert Level **40.7** mOD Bed level **41.20** mOD	Downstream Invert Level **40.60** mOD Bed level **41.10** mOD
Upstream Soffit Level **42.10** mOD	Downstream Soffit Level **42.00** mOD
Upstream Design Flood Level **41.79** mOD	Downstream Design Flood Level **41.62** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

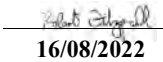
Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.09**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-05)**		Catchment:	**Lough Swilly**	
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**225745.64**	Y:	**409587.16**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.402** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**1.00** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.48**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**1.8 m wide by 1.4 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 79.10 m.**		
Effective Conveyance Area *4	**1.08 m2 (Upstream), 0.97 m^2 (Downstream)**		
Upstream Invert Level	**40.55** mOD	Downstream Invert Level	**40.17** mOD
Bed level	**41.05** mOD	Bed level	**40.67** mOD
Upstream Soffit Level	**41.95** mOD	Downstream Soffit Level	**41.57** mOD
Upstream Design Flood Level	**41.65** mOD	Downstream Design Flood Level	**41.21** mOD

NOTES :

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3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.10**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-05)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**225471.21**	Y:	**409725.11**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.902** Km^2		Road Reference:	**Existing N14 (realigned)**	
Design Flood Flow:	**2.15** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.06**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2 m wide by 1.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 53.50 m.**
Effective Conveyance Area *4	**1.84 m2 (Upstream), 1.38 m^2 (Downstream)**

Upstream Invert Level **35.10** mOD Bed level **35.60** mOD	Downstream Invert Level **34.83** mOD Bed level **35.33** mOD
Upstream Soffit Level **36.90** mOD	Downstream Soffit Level **36.63** mOD
Upstream Design Flood Level **36.52** mOD	Downstream Design Flood Level **36.02** mOD

NOTES :

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4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.11**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing				
Watercourse:	**Leslie Hill Stream_020 (W3-05)**		Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**225436.51**	Y:	**409785.83**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**0.902** Km^2		Road Reference:	**Existing N14(realigned)-Access track**
Design Flood Flow:	**2.15** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.06**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2 m wide by 1.7 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 19 m.**		
Effective Conveyance Area *4	**1.78 m2 (Upstream), 1.32 m^2 (Downstream)**		
Upstream Invert Level	**34.40** mOD	Downstream Invert Level	**34.30** mOD
Bed level	**34.90** mOD	Bed level	**34.80** mOD
Upstream Soffit Level	**36.10** mOD	Downstream Soffit Level	**36.00** mOD
Upstream Design Flood Level	**35.79** mOD	Downstream Design Flood Level	**35.46** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
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4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.12**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-07)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**226290.86**	Y:	**408347.04**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.45** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**1.07** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.53**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**1.2 m diameter pipe. It is proposed to provide a bed suppression of the culvert foundation of 300 mm. Length = 62 m.**
Effective Conveyance Area *4	**0.55 m2 (Upstream), 0.55 m^2 (Downstream)**

Upstream Invert Level **83.90** mOD Bed level **84.20** mOD	Downstream Invert Level **83.30** mOD Bed level **83.60** mOD
Upstream Soffit Level **85.10** mOD	Downstream Soffit Level **84.50** mOD
Upstream Design Flood Level **84.68** mOD	Downstream Design Flood Level **84.08** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.13**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-07)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14,Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**226542.61**	Y:	**408370.52**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.45** Km^2		Road Reference:	**Existing N14**	
Design Flood Flow:	**1.07** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.53**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**1.2 m diameter pipe. It is proposed to provide a bed suppression of the culvert foundation of 300 mm. Length = 31.80 m.**
Effective Conveyance Area *4	**0.53 m2 (Upstream), 0.53 m^2 (Downstream)**
Upstream Invert Level **73.20** mOD Bed level **73.50** mOD	Downstream Invert Level **72.87** mOD Bed level **73.17** mOD
Upstream Soffit Level **74.40** mOD	Downstream Soffit Level **74.07** mOD
Upstream Design Flood Level **73.96** mOD	Downstream Design Flood Level **73.63 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.14**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-08)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**226665.99**	Y:	**408197.89**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**2.778** Km^2		Road Reference:	**Existing N14**	
Design Flood Flow:	**6.50** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.66**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**4.2 m wide by 1.9 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 23.23 m.**
Effective Conveyance Area *4	**4.58 m2 (Upstream), 3.99 m^2 (Downstream)**

Upstream Invert Level **71.76** mOD Bed level **72.26** mOD	Downstream Invert Level **71.55** mOD Bed level **72.05** mOD
Upstream Soffit Level **73.66** mOD	Downstream Soffit Level **73.45** mOD
Upstream Design Flood Level **73.35** mOD	Downstream Design Flood Level **73.00 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.15**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-08)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**226680.02**	Y:	**408225.65**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**2.778** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**6.50** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.66**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	
FSR ☐	FSU ☒	Other ☒
Comments: Refer to the report for the different methods applied.		

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
Tidal ☐	
Comments	

Hydraulic/Structure Details

Description of Structure*3	**3.7 m wide by 2.2 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 60.00 m.**		
Effective Conveyance Area *4	**5.11 m2 (Upstream), 4.70 m^2 (Downstream)**		
Upstream Invert Level	**71.30** mOD	Downstream Invert Level	**71.10** mOD
Bed level	**71.80** mOD	Bed level	**71.60** mOD
Upstream Soffit Level	**73.50** mOD	Downstream Soffit Level	**73.30** mOD
Upstream Design Flood Level	**73.18** mOD	Downstream Design Flood Level	**72.87 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
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3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.16**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-08)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**226670.77**	Y:	**408326.16**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**2.778** Km^2		Road Reference:	**N14 (Access Track)**	
Design Flood Flow:	**6.50** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS [*1]	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.66**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**3.7 m wide by 2.3 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 22.71 m.**
Effective Conveyance Area *4	**5.48 m2 (Upstream), 5.44 m^2 (Downstream)**

Upstream Invert Level **70.95** mOD Bed level **71.45** mOD	Downstream Invert Level **70.80** mOD Bed level **71.30** mOD
Upstream Soffit Level **73.25** mOD	Downstream Soffit Level **73.10** mOD
Upstream Design Flood Level **72.93** mOD	Downstream Design Flood Level **72.77 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.17**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Leslie Hill Stream_020 (W3-09)**			Catchment:	**Lough Swilly**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**227364.24**	Y:	**407314.62**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.346** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**0.66** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.41**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
Regional growth factor by FSR 1975	**1.88**

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**1.2 m diameter pipe. It is proposed to provide a bed suppression of the culvert foundation of 300 mm. Length = 49.82 m.**		
Effective Conveyance Area *4	**0.44 m2 (Upstream), 0.44 m^2 (Downstream)**		
Upstream Invert Level	**85.30** mOD	Downstream Invert Level	**85.00** mOD
Bed level	**85.60** mOD	Bed level	**85.30** mOD
Upstream Soffit Level	**86.50** mOD	Downstream Soffit Level	**86.20** mOD
Upstream Design Flood Level	**85.98** mOD	Downstream Design Flood Level	**85.68 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.18**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Swilly Burn_030 (W3-10)**			Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**227712.05**	Y:	**406548.67**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**1.26** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**2.29** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.32**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.0 m wide by 1.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 48.40 m.**
Effective Conveyance Area *4	**1.90 m2 (Upstream), 0.92 m^2 (Downstream)**

Upstream Invert Level **82.01** mOD Bed level **82.51** mOD	Downstream Invert Level **81.77** mOD Bed level **82.27** mOD
Upstream Soffit Level **83.81** mOD	Downstream Soffit Level **83.57** mOD
Upstream Design Flood Level **83.46** mOD	Downstream Design Flood Level **82.73 mOD**

NOTES :

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2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.19**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing				
Watercourse:	**Swilly Burn_030 (W3-10)**		Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**227796.45**	Y:	**406542.44**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**1.26** Km^2		Road Reference:	**Existing N14 (realigned)**
Design Flood Flow:	**2.29** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.32**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.0 m wide by 1.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 36.00 m.**
Effective Conveyance Area *4	**1.88 m2 (Upstream), 1.22 m^2 (Downstream)**

Upstream Invert Level **80.05** mOD Bed level **80.55** mOD	Downstream Invert Level **79.87** mOD Bed level **80.37** mOD
Upstream Soffit Level **81.85** mOD	Downstream Soffit Level **81.67** mOD
Upstream Design Flood Level **81.49** mOD	Downstream Design Flood Level **80.98 mOD**

NOTES :

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2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.20**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Swilly Burn_030 (W3-11)**			Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**228128.69**	Y:	**405803.79**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**2.26** Km^2		Road Reference:	**N14**	
Design Flood Flow:	**4.34** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

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OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.38**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**3.2 m wide by 1.9 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 60.00 m.**
Effective Conveyance Area *4	**3.50 m2 (Upstream), 2.94 m^2 (Downstream)**

Upstream Invert Level **69.53** mOD Bed level **70.03** mOD	Downstream Invert Level **69.30** mOD Bed level **69.80** mOD
Upstream Soffit Level **71.43** mOD	Downstream Soffit Level **71.20** mOD
Upstream Design Flood Level **71.12** mOD	Downstream Design Flood Level **70.72 mOD**

NOTES :

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4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.21**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing				
Watercourse:	**W3-12A**		Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**228421.76**	Y:	**405102.84**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**0.576** Km^2		Road Reference:	**N14 Side road**
Design Flood Flow:	**1.58** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS [*1]	☐

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	*OPW Register No:*	
	Consent Issued	☐

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.65**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.8 m wide by 1.4 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 16.50 m.**
Effective Conveyance Area *4	**1.65 m2 (Upstream), 1.65 m^2 (Downstream)**

Upstream Invert Level **65.54** mOD Bed level **66.04** mOD	Downstream Invert Level **65.40** mOD Bed level **65.90** mOD
Upstream Soffit Level **66.94** mOD	Downstream Soffit Level **66.80** mOD
Upstream Design Flood Level **66.63** mOD	Downstream Design Flood Level **66.49 mOD**

NOTES :

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2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.22**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing				
Watercourse:	**W3-12A**		Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**228418.35**	Y:	**405093.51**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**0.576** Km^2		Road Reference:	**N14**
Design Flood Flow:	**1.58** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS [*1]	☐

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	*OPW Register No:*	
	Consent Issued	☐

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.65**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.8 m wide by 1.5 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 34.60 m.**
Effective Conveyance Area *4	**1.90 m2 (Upstream), 1.96 m^2 (Downstream)**
Upstream Invert Level **65.30** mOD Bed level **65.80** mOD	Downstream Invert Level **65.15** mOD Bed level **65.65** mOD
Upstream Soffit Level **66.80** mOD	Downstream Soffit Level **66.65** mOD
Upstream Design Flood Level **66.48** mOD	Downstream Design Flood Level **66.35 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

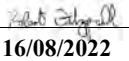
Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.23**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing				
Watercourse:	**W3-12A**		Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**228417.27**	Y:	**404979.73**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**0.576** Km^2		Road Reference:	**Existing N14 (realigned)**
Design Flood Flow:	**1.58** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS [*1]	☐

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	*OPW Register No:*	
	Consent Issued	☐

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.65**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.2 m wide by 1.5 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 23.66 m.**
Effective Conveyance Area *4	**1.49 m2 (Upstream), 1.08 m^2 (Downstream)**

Upstream Invert Level **64.72** mOD Bed level **65.22** mOD	Downstream Invert Level **64.60** mOD Bed level **65.10** mOD
Upstream Soffit Level **66.22** mOD	Downstream Soffit Level **66.10** mOD
Upstream Design Flood Level **65.90** mOD	Downstream Design Flood Level **65.59 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3- CUL.24**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing				
Watercourse:	**Swilly Burn_030 (W3-12)**		Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X: **228794.39**		Y:	**404046.68**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**7.61** Km^2		Road Reference:	**N14 Side Road**
Design Flood Flow:	**15.06** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**7.28**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**6 m wide by 3.0 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 17.70 m.**
Effective Conveyance Area *4	**12.66 m2 (Upstream), 12.06 m^2 (Downstream)**

Upstream Invert Level **33.65** mOD Bed level **34.15** mOD	Downstream Invert Level **33.61** mOD Bed level **34.11** mOD
Upstream Soffit Level **36.65** mOD	Downstream Soffit Level **36.61** mOD
Upstream Design Flood Level **36.26** mOD	Downstream Design Flood Level **36.12 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.25**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing				
Watercourse:	**Swilly Burn_030 (W3-13)**		Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**			
Grid Reference	X:	**229343.93**	Y:	**403555.27**
Hydrometric Station(s) utilized (including reference number): NA				
Area of Contributing Catchment:	**1.14 Km^2**		Road Reference:	**Existing N14 (realigned)**
Design Flood Flow:	**2.6** m^3/s		Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.19**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.0 m wide by 1.9 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 50.20 m.**		
Effective Conveyance Area *4	**1.92 m2 (Upstream), 1.14 m^2 (Downstream)**		
Upstream Invert Level Bed level	**21.05** mOD **21.55** mOD	Downstream Invert Level Bed level	**20.90** mOD **21.40** mOD
Upstream Soffit Level	**22.95** mOD	Downstream Soffit Level	**22.80** mOD
Upstream Design Flood Level	**22.51** mOD	Downstream Design Flood Level	**21.97 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.26**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Swilly Burn_030 (W3-13)**			Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**229333.19**	Y:	**403475.25**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**1.14 Km^2**		Road Reference:	**N14**	
Design Flood Flow:	**2.6** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *[1]	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.19**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2 m wide by 1.9 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 59.00 m.**
Effective Conveyance Area *4	**2.42 m2 (Upstream), 2.35 m^2 (Downstream)**

Upstream Invert Level **20.80** mOD Bed level **21.30** mOD	Downstream Invert Level **20.50** mOD Bed level **21.00** mOD
Upstream Soffit Level **22.70** mOD	Downstream Soffit Level **22.40** mOD
Upstream Design Flood Level **22.30** mOD	Downstream Design Flood Level **22.07 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.27**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Swilly Burn_030 (W3-13)**			Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**229410.77**	Y:	**403172.10**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**9.366 Km^2**		Road Reference:	**N14**	
Design Flood Flow:	**18.95** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**9.16**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**9.5 m wide by 2.9 m deep bottomless culvert. Length = 36.20 m.**
Effective Conveyance Area *4	**7.22 m2 (Upstream), 9.98 m^2 (Downstream)**

Upstream Invert Level **18.53** mOD Bed level **19.03** mOD	Downstream Invert Level **18.35** mOD Bed level **18.85** mOD
Upstream Soffit Level **21.43** mOD	Downstream Soffit Level **21.25** mOD
Upstream Design Flood Level **20.38** mOD	Downstream Design Flood Level **20.59 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.28**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Swilly Burn_030 (W3-16)**			Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**229647.24**	Y:	**401599.97**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.72 Km^2**		Road Reference:	**N14**	
Design Flood Flow:	**2.09** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *[1]	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.25**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**1.6**

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.0 m wide by 1.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 60.00 m.**
Effective Conveyance Area *4	**1.88 m2 (Upstream), 1.80 m^2 (Downstream)**

Upstream Invert Level **1.19** mOD Bed level **1.69** mOD	Downstream Invert Level **0.89** mOD Bed level **1.39** mOD
Upstream Soffit Level **2.99** mOD	Downstream Soffit Level **2.69** mOD
Upstream Design Flood Level **2.63** mOD	Downstream Design Flood Level **2.29 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.29**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Swilly Burn_030 (W3-15)**			Catchment:	**Foyle**
Address (Townland – County):	**N14, Kincraigy ED, Letterkenny, County Donegal**				
Grid Reference	X:	**229577.25**	Y:	**401917.19**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**1.645 Km^2**		Road Reference:	**N14**	
Design Flood Flow:	**4.66** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*	

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West* ☐
Correspondence Number			*OPW Register No:*				
			Consent Issued	☐			

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**2.82**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**1.6**

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2.8 m wide by 2.2 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 54.50 m.**
Effective Conveyance Area *4	**3.33 m2 (Upstream), 2.24 m^2 (Downstream)**
Upstream Invert Level **0.13** mOD Bed level **0.63** mOD	Downstream Invert Level **- 0.14** mOD Bed level **0.36** mOD
Upstream Soffit Level **2.33** mOD	Downstream Soffit Level **2.06** mOD
Upstream Design Flood Level **1.82** mOD	Downstream Design Flood Level **1.16** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.30**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing					
Watercourse:	**Deele (Donegal)_050 (W3-17A)**			Catchment:	**Foyle**
Address (Townland – County):	**Clonleigh North ED, Lifford-Stranorlar Municipal District, County Donegal**				
Grid Reference	X:	**231588.14**	Y:	**400153.58**	
Hydrometric Station(s) utilized (including reference number): NA					
Area of Contributing Catchment:	**0.71 Km^2**		Road Reference:	**N14 (Side Road)**	
Design Flood Flow:	**2.62** m^3/s		Annual Exceedance Probability (AEP):	**1**	%

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**1.23**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☐	
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
OPW Arterial Drainage Scheme	**1.6**

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**2 m wide by 1.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 66.00 m.**
Effective Conveyance Area *4	**1.92 m2 (Upstream), 1.82 m^2 (Downstream)**

Upstream Invert Level **4.00** mOD Bed level **4.50** mOD	Downstream Invert Level **3.00** mOD Bed level **3.50** mOD
Upstream Soffit Level **5.80** mOD	Downstream Soffit Level **4.80** mOD
Upstream Design Flood Level **5.46** mOD	Downstream Design Flood Level **4.41** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.31**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing			
Watercourse:	**Deele (Donegal)_050 (W3-18)**	Catchment:	**Foyle**
Address (Townland – County):	**Clonleigh South ED, Lifford-Stranorlar Municipal District, County Donegal**		
Grid Reference	X **231526.63**	Y:	**399321.60**
Hydrometric Station(s) utilized (including reference number): NA			
Area of Contributing Catchment:	**0.71 Km^2**	Road Reference:	**N14**
Design Flood Flow:	**2.11** m^3/s	Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied			Factors Applied	
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)	Type of Factor	Value Used
6 – Variable Catchment characteristics			Climate Change	**1.2**
			Irish Growth Curve	**1.96**
			Factor for Standard Error	**Varies. Refer to report.**
3 – Variable Catchment Characteristics			Other	
IH 124	☒	**0.77**		
Gauged Flow	☐			
Unit Hydrograph	☐		Tidal	☐
ADAS	☐		Comments	
Other	☐			
FSR ☐	FSU ☒	Other ☒		
Comments: Refer to the report for the different methods applied.				

Hydraulic/Structure Details

Description of Structure*3	**1.8 m wide by 1.8 m deep box culvert. It is proposed to provide a bed suppression of the culvert foundation of 500 mm. Length = 70.50 m.**
Effective Conveyance Area *4	**1.64 m2 (Upstream), 0.85 m^2 (Downstream)**
Upstream Invert Level **25.28** mOD Bed level **25.78** mOD	Downstream Invert Level **18.85** mOD Bed level **19.35** mOD
Upstream Soffit Level **27.08** mOD	Downstream Soffit Level **20.65** mOD
Upstream Design Flood Level **26.69** mOD	Downstream Design Flood Level **19.82 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.32**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name:	**Donegal County Council**
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**
Contact Person:	**Aine McHugh**
Phone: 074 9724500	Fax: **NA**
E-mail:	**Aine.mchugh@dnrdo.ie**

Agent (Correspondence will issue to agent)	
Company or Organisation Name:	**Barry Transportation**
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**
Phone:	**+353 94 906 8950** Fax:
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**

Location and Parameters of crossing			
Watercourse:	**Deele (Donegal)_050 (W3-19)**	Catchment:	**Foyle**
Address (Townland – County):	**Clonleigh South ED, Lifford-Stranorlar Municipal District, County Donegal**		
Grid Reference	X **231720.03**	Y:	**399256.11**
Hydrometric Station(s) utilized (including reference number): NA			
Area of Contributing Catchment:	**0.20 Km^2**	Road Reference:	**N14**
Design Flood Flow:	**0.52** m^3/s	Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.32**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	**0.52**
Other	☐	

FSR ☐ FSU ☒ Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied

Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
Regional growth factor by FSR 1975	**1.88**

Tidal ☐

Comments

Hydraulic/Structure Details

Description of Structure*3	**1.2 m diameter pipe. It is proposed to provide a bed suppression of the culvert foundation of 300 mm. Length = 44.50 m.**
Effective Conveyance Area *4	**0.14 m2 (Upstream), 0.14 m^2 (Downstream)**
Upstream Invert Level **37.00** mOD Bed level **37.30** mOD	Downstream Invert Level **35.40** mOD Bed level **35.70** mOD
Upstream Soffit Level **38.20** mOD	Downstream Soffit Level **36.60** mOD
Upstream Design Flood Level **37.43** mOD	Downstream Design Flood Level **35.83 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

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Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**TEN-T Priority Route Improvement, Project Donegal, Section 3 "N14 Manorcunningham to Lifford/ Strabane/A5 Link**	Structure Ref No.	**S3-CUL.33**

Applicant (Correspondence will issue to agent)			
Company or Organisation Name:	**Donegal County Council**		
Postal Address:	**Donegal National Roads Office, Public Services Centre, Drumlonagher, Donegal Town, Co. Donegal**		
Contact Person:	**Aine McHugh**		
Phone: 074 9724500		Fax:	**NA**
E-mail:	**Aine.mchugh@dnrdo.ie**		

Agent (Correspondence will issue to agent)			
Company or Organisation Name:	**Barry Transportation**		
Postal Address:	**Unit 14C, N5 Business Park, Moneen Road, Castlebar, Co. Mayo, F23 YY39**		
Contact Person:	**Robert Fitzgerald/ Sara Hernandez Sosa**		
Phone:	**+353 94 906 8950**	Fax:	
E-mail:	**fitzgeraldr@jbbarry.ie/ ssosa@jbbarry.ie**		

Location and Parameters of crossing			
Watercourse:	**Deele (Donegal)_050 (W3-20)**	Catchment:	**Foyle**
Address (Townland – County):	**Clonleigh South ED, Lifford-Stranorlar Municipal District, County Donegal**		
Grid Reference	X **232102.50**	Y:	**399135.75**
Hydrometric Station(s) utilized (including reference number): NA			
Area of Contributing Catchment:	**0.23 Km^2**	Road Reference:	**N14**
Design Flood Flow:	**0.60** m^3/s	Annual Exceedance Probability (AEP):	**1** %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	**Robert Fitzgerald**
Company/Organisation:	**Barry Transportation**
Signature:	
Date:	**16/08/2022**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☒
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐
Correspondence Number			*OPW Register No:*					
			Consent Issued	☐				

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics		
3 – Variable Catchment Characteristics		
IH 124	☒	**0.36**
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	**0.60**
Other	☐	
FSR ☐	FSU ☒	Other ☒

Comments: Refer to the report for the different methods applied.

Factors Applied	
Type of Factor	Value Used
Climate Change	**1.2**
Irish Growth Curve	**1.96**
Factor for Standard Error	**Varies. Refer to report.**
Other	
Regional growth factor by FSR 1975	**1.88**
Tidal ☐	
Comments	

Hydraulic/Structure Details

Description of Structure*3	**1.2 m diameter pipe. It is proposed to provide a bed suppression of the culvert foundation of 300 mm. Length = 50.70 m.**		
Effective Conveyance Area *4	**0.11 m2 (Upstream), 0.11 m^2 (Downstream)**		
Upstream Invert Level	**48.83** mOD	Downstream Invert Level	**44.39** mOD
Bed level	**49.13** mOD	Bed level	**44.69** mOD
Upstream Soffit Level	**50.03** mOD	Downstream Soffit Level	**45.59** mOD
Upstream Design Flood Level	**49.23** mOD	Downstream Design Flood Level	**44.79 mOD**

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.
3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

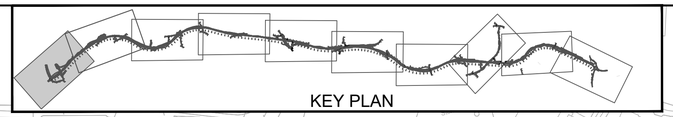
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EIAR APPENDIX C11.03

SECTION 3 FLOOD RISK ASSESSMENT REPORT

APPENDIX F:

ROAD DRAINAGE LAYOUTS



ROSSBRACKAN
RAYMOGHY
Raymoghy Sheddings
Herdgee Hill
Craig Head
Camp Hill
Black Bush
Connaghan's Town
Connaghan's Bridge
Shot
Pluck
GLEBE
Highest Point to which Ordinary Tides flow
Halting Site
Ruin
Standing Stone
Well
Spring
Water Works
Water Course
Gas Marker
Telecom
Overhead Line
Underground Line
HWM
FB
CR
CS
CF
UND
0+452.454
0+400
0+300
0+200
0+100
0+000
0+599.849
0+020.900
0+024.880
0+226.434
0+171.678
0+225
0+200
0+100
0+000
Q=Q100
Q=100
S3-CD-001
S3-CD-002
S3-CD-003
S3-CD-004
S3-CD-005
S3-CD-006
S3-CD-007
S3-CD-008
S3-CD-009
S3-CD-010
S3-ML-DN-01
S3-SR-DN-01
S3-SR-DN-02
S3-PED-IT-01
S3-CUL.01
S3-CUL.02
S3-CUL.03
S3-CUL.04
S3-CUL.05
S3-CUL.06
W3-01
W3-02
W3-03
Attenuation Pond 01
Attenuation Pond 02
Attenuation Pond 17
Outfall 01
Outfall 02
DROP MANHOLE TO BE PROVIDED
POND TO BE BUNDED BY 500 mm ABOVE 1 IN 100 YEAR FLOOD LEVEL
SECTION 2
SECTION 3
MATCHLINE SHEET 1
MATCHLINE SHEET 2
3050
3100
3150
3200
3250
3300
3350
3400
3450
3500
3550
3600
3650
3700
1+000
1+100
1+200
1+300
1+400
1+500
1+600
1+700
1+800
1+900
1+963

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
- CROSS DRAIN
- SURFACE WATER CHANNEL COLLECTION NETWORK
- OPEN DRAIN (USED AS CUT OFF DRAIN)
- CULVERT
- INFILTRATION TRENCHES
- CARRIER PIPE
- FILTER DRAIN
- KERBING DRAINAGE (KERBS AND GULLIES OR DRAINAGE KERB BLOCKS)
- WATERCOURSE DIVERSION
- FLOOD COMPENSATION AREAS

0.00m 100m 200m 300m 400m 500m
Scale Bar

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Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Proposed Drainage Layout

Status: S5

Designed:	SHS	Date: JUN 2025	Model File Identifier: tt_y16112-bt-1a-hdr-s3-m3-cd-05120_drainage
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Checked:	RF	Sheet: 1 OF 10	File Identifier: Y16112-0500-021

KEY PLAN

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
- CROSS DRAIN
- SURFACE WATER CHANNEL COLLECTION NETWORK
- OPEN DRAIN (USED AS CUT OFF DRAIN)
- CULVERT
- INFILTRATION TRENCHES
- CARRIER PIPE
- FILTER DRAIN
- KERBING DRAINAGE (KERBS AND GULLIES OR DRAINAGE KERB BLOCKS)
- WATERCOURSE DIVERSION
- FLOOD COMPENSATION AREAS

S3-CD-012
S3-CD-011
S3-CD-013
S3-CD-016
S3-ML-DN-02
S3-CD-017
W3-04
S3-CD-018
W3-05
S3-CD-019
S3-ML-DN-02
S3-CUL.08
S3-CUL.9
S3-CD-021
S3-CUL.07
S3-SR-DN-04
Outfall 05
S3-CD-020
DROP MANHOLE TO BE PROVIDED HERE
S3-CD-014
S3-CD-015
Outfall 03
Attenuation Pond 03
S3-ML-DN-01
Outfall 04
S3-SR-DN-03
S3-CUL.11
S3-CUL.10
Attenuation Pond 18
S3-SR-DN-04
Outfall 06
S3-ML-DN-03
W3-05
Attenuation Pond 04
S3-CD-022
W3-06
MATCHLINE SHEET 1
MATCHLINE SHEET 2
MATCHLINE SHEET 2
MATCHLINE SHEET 3
CARRICKBALLYDOOEY
BALLYBOE
DRUMCARN
DRUMOGHILL
Drumcarn
Lagan
Hill Head
Sports Ground
School
Ringsend
Standing Stone
Scale Bar 0.00m 100m 200m 300m 400m 500m

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Drawing Title: Proposed Drainage Layout

Status: S5

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KEY PLAN

MATCHLINE SHEET 2

MATCHLINE SHEET 3

MATCHLINE SHEET 4

S3-CD-023
S3-CD-024
S3-CD-025
S3-CD-026
S3-CD-027
S3-CD-028
S3-CD-029
S3-CD-029A
S3-CD-029B
S3-CD-030
S3-CD-031
S3-CD-032
S3-CD-033
S3-CD-034
S3-CD-035
S3-CD-036
S3-CD-037
S3-CD-038
S3-CUL.12
S3-CUL.13
S3-CUL.14
S3-CUL.15
S3-CUL.16
S3-ML-DN-04
S3-ML-DN-05
S3-SR-DN-05
S3-SR-DN-06
S3-SR-DN-07
S3-SR-DN-08
W3-07
W3-08
Attenuation Pond 05
Attenuation Pond 06
Attenuation Pond 19
Outfall 07
ATTENUATION DITCH TO BE PROVIDED HERE
ATTENUATION DITCH TO BE REQUIRED BEFORE OUTFALLING INTO EXISTING PIPE

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
- CROSS DRAIN
- SURFACE WATER CHANNEL COLLECTION NETWORK
- OPEN DRAIN (USED AS CUT OFF DRAIN)
- CULVERT
- INFILTRATION TRENCHES
- CARRIER PIPE
- FILTER DRAIN
- KERBING DRAINAGE (KERBS AND GULLIES OR DRAINAGE KERB BLOCKS)
- WATERCOURSE DIVERSION
- FLOOD COMPENSATION AREAS

0.00m 100m 200m 300m 400m 500m
Scale Bar

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Drawing Title: Proposed Drainage Layout

Status: S5

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KEY PLAN

MATCHLINE SHEET 3

MATCHLINE SHEET 4

Outfall 08

S3-ML-DN-06

S3-CUL.17

W3-09

S3-PED-IT-02

S3-SR-DN-09

S3-CD-039

S3-CUL.19

Outfall 09

Attenuation Pond 07

W3-10

S3-ML-DN-07

S3-CUL.18

S3-CD-040

S3-CD-041

S3-CUL.20A

W3-11

S3-CUL.20

W3-11

ATTENUATION DITCH TO BE PROVIDED HERE

S3-ML-DN-07

Outfall 10

S3-ML-DN-0

SLIEVEBUCK

Ballynalecky

Ballyholey

YHOLEY FAR

Gallagher's Mountain

CARRIC

Magnanas

Under Constr.

Sewerage

Slieveduff

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
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- WATERCOURSE DIVERSION
- FLOOD COMPENSATION AREAS

0.00m 100m 200m 300m 400m 500m

Scale Bar

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Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Proposed Drainage Layout

Status: S5

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KEY PLAN

S3-CD-043
S3-CD-044
S3-CD-046A
S3-ML-DN-07
S3-CD-046B
S3-CD-046D
S3-CD-042
S3-CD-046C
W3-12A
S3-CUL.21
S3-CUL.22
S3-CD-051
S3-ML-DN-08
ATTENUATION DITCH TO BE PROVIDED HERE
MATCHLINE SHEET 4
MATCHLINE SHEET 6
MATCHLINE SHEET 5
MATCHLINE SHEET 8
S3-ML-DN-07
Outfall 10
S3-ML-DN-08
S3-SR-DN-10
S3-CD-047
S3-CD-045
S3-CD-048
S3-CD-049
S3-PED-IT-03
Attenuation Pond 08
S3-SR-DN-11
ATTENUATION DITCH TO BE PROVIDED BEFORE DISCHARGING INTO THE WATERCOURSE
S3-CUL.23
S3-CD-050
W3-12A
Outfall 11
S3-SR-DN-12
S3-CD-052
S3-CUL.24
W3-12
CARNSHANNAGH
DROMORE BIG
Carnickadawson
Carnshannagh
Dromore Upper
Dromore
Aghleestown

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
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- WATERCOURSE DIVERSION
- FLOOD COMPENSATION AREAS

0.00m 100m 200m 300m 400m 500m
Scale Bar

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Drawing Title: Proposed Drainage Layout

Status: S5

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Approved: ED	@ A3: 1:5000	File Identifier: Y16112-0500-025	
Checked: RF	Sheet: 5 OF 10		

KEY PLAN

Outfall 12
S3-CD-057
S3-CD-058
Attenuation Pond 22
W3-13
S3-SR-DN-14
S3-CUL.25
S3-SR-DN-13
Attenuation Pond 20
S3-CD-056
Attenuation Pond 21
W3-13
S3-CD-054
Attenuation Pond 09
S3-CD-055
S3-ML-DN-09
S3-CUL.26
S3-CUL.27
S3-SR-DN-15
S3-CD-062
Attenuation Pond 10
W3-14
S3-CD-059
S3-CD-060
S3-CD-061
Outfall 13
S3-ML-DN-10
S3-CD-063A
S3-CD-053
MATCHLINE SHEET 5
MATCHLINE SHEET 6
MATCHLINE SHEET 7
DRUMBEG
DRUMFAD
BROADLEA
Daisy Hill
Drumbeg
Drumlad Lower
Drumlad Upper
Broadlea

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
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- OPEN DRAIN (USED AS CUT OFF DRAIN)
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- FLOOD COMPENSATION AREAS

0.00m 100m 200m 300m 400m 500m
Scale Bar

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Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Proposed Drainage Layout

Status: S5

Designed:	SHS	Date: JUN 2025	Model File Identifier: tt_y16112-bt-1a-hdr-s3-m3-cd-05120_drainage
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Checked:	RF	Sheet: 6 OF 10	File Identifier: Y16112-0500-026

KEY PLAN

MATCHLINE SHEET 6

MATCHLINE SHEET 7

MATCHLINE SHEET 7

MATCHLINE SHEET 8

Attenuation Pond 11

W3-15

S3-CD-063

S3-CD-064

S3-CD-067

S3-CD-065

S3-CD-066

S3-SR-DN-16

S3-CUL.29

S3-CUL.28

W3-16

S3-CD-070

S3-CD-068

S3-CD-069

S3-ML-DN-11

S3-SR-DN-17

S3-PED-IT-04

S3-PED-IT-05

S3-CD-071

S3-PED-IT-06

GORTIN NORTH

GORTIN-WOOD

SHEERCLOON

R264

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
- CROSS DRAIN
- SURFACE WATER CHANNEL COLLECTION NETWORK
- OPEN DRAIN (USED AS CUT OFF DRAIN)
- CULVERT
- INFILTRATION TRENCHES
- CARRIER PIPE
- FILTER DRAIN
- KERBING DRAINAGE (KERBS AND GULLIES OR DRAINAGE KERB BLOCKS)
- WATERCOURSE DIVERSION
- FLOOD COMPENSATION AREAS

0.00m 100m 200m 300m 400m 500m
Scale Bar

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P03	25/06/25	MG	FOR STAGE APPROVAL	JM	ED
P02	14/11/2022	AG	ISSUED FOR REVIEW	SHS	RF
P01	09/03/22	SM	ISSUED FOR REVIEW	SHS	RF

Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Proposed Drainage Layout

Status: S5

Designed: SHS | Date: JUN 2025 | Model File Identifier: tt_y16112-bt-1a-hdr-s3-m3-cd-05120_drainage

Drawn: SM | Scale @ A1:1:2500 | @ A3:1:5000

Approved: ED

Checked: RF | Sheet: 7 OF 10 | File Identifier: Y16112-0500-027

Rev: P03

KEY PLAN

S3-CD-085
S3-CD-086
S3-CD-087
S3-PED-IT-12
S3-PED-IT-11
S3-CD-084
S3-CD-083
S3-PED-IT-10
S3-CD-082
S3-SR-DN-21
S3-CUL.30
Attenuation Pond 15
S3-CD-080
W3-17A
Outfall 17
S3-CD-081
S3-CD-078
Outfall 16
S3-CD-079
Attenuation Pond 14
S3-CD-088
ATTENUATION DITCH TO BE PROVIDED HERE
W3-17
S3-SR-DN-22
Outfall 14
Attenuation Pond 13
S3-CD-089
MATCHLINE SHEET 8
MATCHLINE SHEET 9
MATCHLINE SHEET 7
S3-ML-DN-11
S3-SR-DN-18
S3-CD-075
S3-CD-072
S3-SR-DN-19
S3-CD-074
S3-CD-076
Attenuation Pond 23
S3-PED-IT-08
S3-CD-073
S3-PED-IT-07
S3-PED-IT-09
S3-SR-DN-20
S3-CD-077
Outfall 15
Attenuation Pond 12
S3-ML-DN-

MONEEN
CAVANACOR
TYLEFORD
BALLINDRAIT
MULROUGH
ROSSGEIR Rural Gear
Moneen
Ballindrait
Cavanacor House
Marian School
Convent
Cemetery
Old Bridge
Well
Spring
Culvert
Ford
Pump
Tank
Quarry
Slip & Pier
Cliff
Sloping Ground
Rocky Outcrop
Tree
Hedge
Fence
Wall
Ruin
Gate
Stile
Footbridge
Electricity Pole
Telephone Pole
Telephone Box
Post Box
Transformer
Manhole
Gully
Catch Pit
Inspection Chamber
Valve
Hydrant
Meter
Bench Mark
Trig Point
Spot Height
Contour
Road
Track
Path
Steps
Bridge
Building
Church
Graveyard
Public House
Shop
Post Office
Petrol Station
Car Park
Pylon
Mast
Aerial
Radio Station
Radar Station
Weather Station
Lighthouse
Coastguard Station
Lifeboat Station
Helicopter Station
Airport
Heliport
Runway
Taxiway
Apron
Hangar
Control Tower
Terminal
Cargo Terminal
Fuel Depot
Fuel Pump
Fuel Tank
Fuel Truck
Fuel Truck Parking
Fuel Truck Loading
Fuel Truck Unloading
Fuel Truck Maintenance
Fuel Truck Repair
Fuel Truck Wash
Fuel Truck Storage
Fuel Truck Parking
Fuel Truck Loading
Fuel Truck Unloading
Fuel Truck Maintenance
Fuel Truck Repair
Fuel Truck Wash
Fuel Truck Storage

LEGEND
- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
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0.00m 100m 200m 300m 400m 500m
Scale Bar

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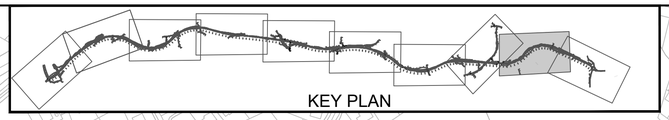
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Project Title: TEN-T PRIORITY ROUTE IMPROVEMENT PROJECT DONEGAL
Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Proposed Drainage Layout

Status: S5

Designed:	SHS	Date: JUN 2025	Model File Identifier: tt_y16112-bt-1a-hdr-s3-m3-cd-05120_drainage
Drawn:	SM	Scale @ A1: 1:2500	
Approved:	ED	@ A3: 1:5000	File Identifier: Y16112-0500-028
Checked:	RF	Sheet: 8 OF 10	Rev: P03



S3-PED-IT-13

MATCHLINE SHEET 9

MATCHLINE SHEET 10

MATCHLINE SHEET 8

MATCHLINE SHEET 9

S3-CD-094

S3-CD-095

S3-ML-DN-13

W3-20

S3-CUL.33

W3-19

S3-CUL.32

S3-CUL.31

W3-18

S3-CD-093

S3-CD-091

S3-CD-090

S3-SR-DN-23

S3-ML-DN-12

S3-CD-092

S3-CD-089

W3-17

Attenuation Pond 13

LIFFORD COMMON

DOWNPARKS

Quarry

Carricknaslate

LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- ACTIVE TRAVEL NETWORK
- INFILTRATION BASIN / ATTENUATION POND
- CROSS DRAIN
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0.00m 100m 200m 300m 400m 500m

Scale Bar

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Section 3 - N14 Manorcunningham to Lifford/Strabane/A5 Link

Drawing Title: Proposed Drainage Layout

Status: S5

Designed: SHS	Date: JUN 2025	Model File Identifier: tt_y16112-bt-1a-hdr-s3-m3-cd-05120_drainage	Rev: P03
Drawn: SM	Scale @ A1:1:2500 @ A3:1:5000		
Approved: ED		File Identifier: Y16112-0500-029	
Checked: RF	Sheet: 9 OF 10		

KEY PLAN

MATCHLINE SHEET 9

MATCHLINE SHEET 10

S3-PED-IT-14

S3-CD-101

Attenuation Pond 16

ATTENUATION DITCH TO BE PROVIDED HERE

S3-CD-102

S3-CD-103

Outfall 18

S3-CD-104

S3-CD-105

S3-CD-098

S3-CD-099

S3-CD-100

S3-CD-097

S3-SR-DN-25

S3-CD-096

S3-SR-DN-24

0+000 0+100 0+200 0+300 0+400 0+500 0+600 0+700 0+800 0+900 1+000 1+100 1+200 1+300 1+400 1+500 1+600 1+700 1+800 1+900 2+000 2+100 2+200 2+300 2+400 2+500 2+600 2+700 2+800 2+900 3+000 3+100 3+200 3+300 3+400 3+500 3+600 3+700 3+800 3+900