Appendix A.8.6

Flood Risk Assessment

Hydro Environmental Ltd

N6 Galway City Ring Road

Flood Risk Assessment Study

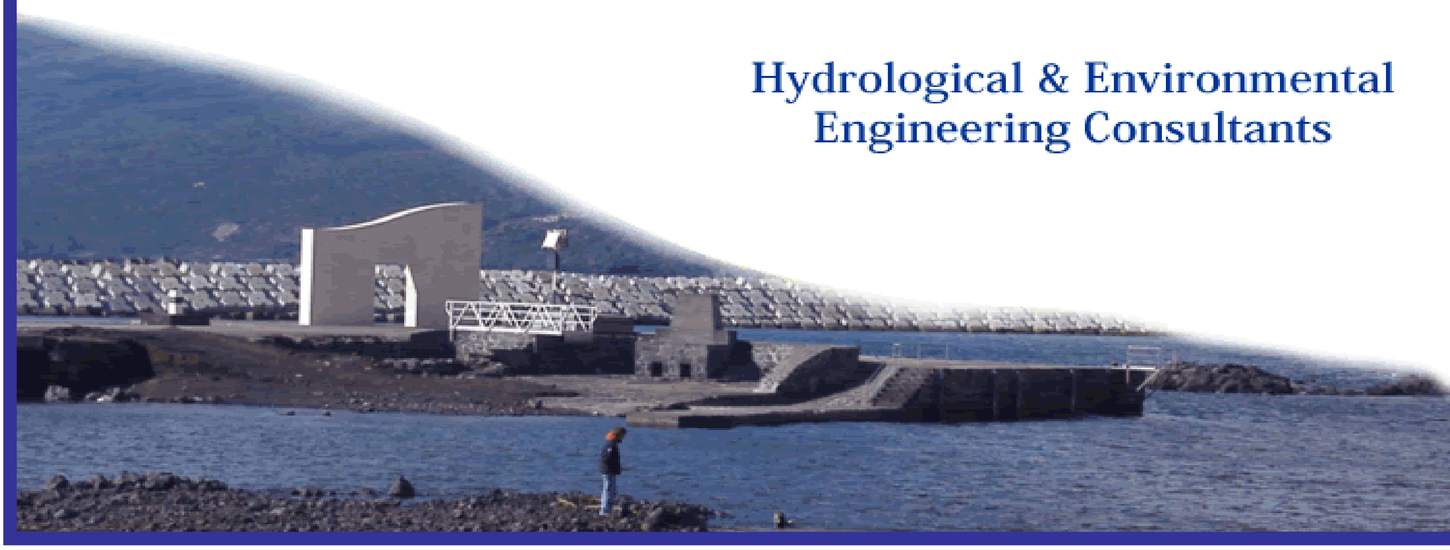
Report No. HEL209002_v2.1

Galway Co. Council NRDO

22nd February 2018

1D2O8797 Photo: Peter Barrow Tel: 087-2559638, 3rd January 2016 12:55:02

Hydrological & Environmental Engineering Consultants



N6 Galway City Ring Road

Flood Risk Assessment Study

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Table of Contents

Appendices

Appendix A – Flood Hydrology Assessment for Section 50 Approval of Proposed Watercourse Crossings (July 2017)

Appendix B – Flood Hydrology Assessment for Section 50 Approval of Proposed River Corrib Bridge Crossings (November 2016)

Appendix C – pFRA Flood Risk Mapping

1. INTRODUCTION

Hydro Environmental Ltd in association with Arup was by appointed by Galway County Council in partnership with TII to carry out a Flood Risk Assessment (FRA) for the proposed N6 Galway City Ring Road (GCRR).

The proposed N6 GCRR begins west of Bearna Village, passes to the north of Galway City and joins the existing N6 at Coolagh. The proposed road development lies within hydrometric areas 29, 30 and 31. The proposed road development crosses the River Corrib near Menlo Castle (approximately 160m to the southwest) on the eastern bank and on the western side it passes through NUIG Recreational Facilities at Dangan. The River Corrib channel at the crossing site is within the Lough Corrib candidate Special Area of Conservation (cSAC) (000297).

The proposed road development intercepts a number of watercourses to the west of the River Corrib which will require culverting. To the east of the River Corrib due to the highly Karst nature of the terrain, there is a very sparse to non-existent network of surface drainage channels and streams with rainwater generally infiltrating to ground through the generally free draining limestone till and the karstified limestone bedrock rather than running off. As a consequence only one dry ditch was noted as being intercepted near the Coolagh Lakes complex to the east of the River Corrib. Whereas, to the west of the River Corrib the bedrock and quaternary changes to a more impervious type (undulating Granite bedrock and peaty soils) resulting in a much higher density of surface water features with little ability for rainwater to infiltrate to groundwater. This gives rise to wetter conditions with peatlands and marshy areas common.

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 completed in 2015 and the catchment management plans and the Strategic Environmental Assessment (SEA) process 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.

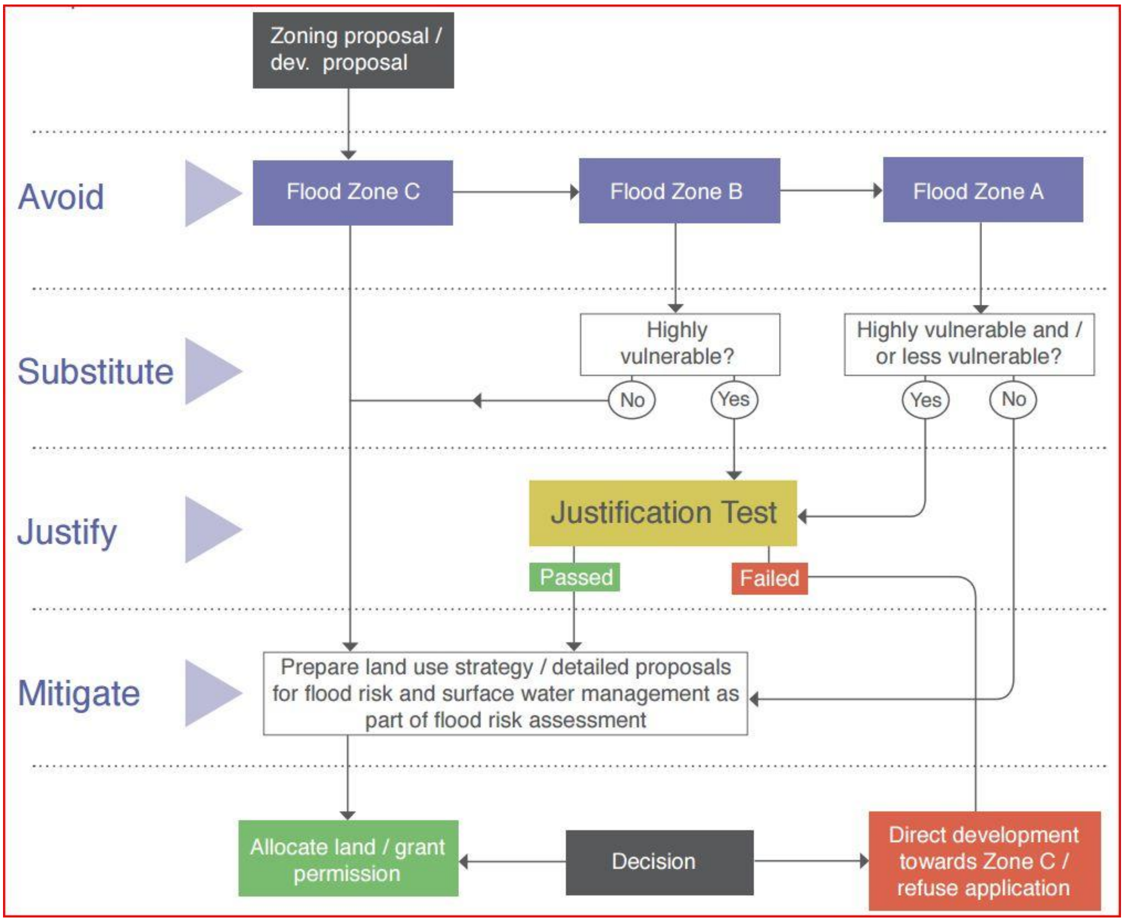


Figure 1 Sequential approach mechanism in the planning process (Fig. 3.2 from the Flood Risk Management Planning Guidelines)

The Sequential Approach is based on the following principles:

AVOID
Preferably choose lower flood risk zones for new developments

SUBSTITUTE
Ensure proposed development type is not especially vulnerable to the adverse impacts of flooding

JUSTIFY
Ensure that the development being considered is for strategic reasons

MITIGATE
Ensure that flood risk is reduced to acceptable levels

PROCEED
Only where Justification Test passed. Ensure emergency planning measures are in place.

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, <u>without</u> 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 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

Vulnerability Class	Land uses and types of development which include*:
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 • 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 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.

Plate 1 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 N6 GCRR 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 N6 GALWAY CITY RING ROAD

3.1 Introduction

The Proposed N6 Galway City Ring Road runs from the existing M6 at Ardaun on the east side of the city, passing to the north of the city and eventually joining with this Spiddle coast road just east of Bearna Village. The proposed route lies within hydrometric Areas 29, 30 and 31. The proposed road intercepts a number of watercourses to the West of the Corrib which will require culverting. To the east of the Corrib due to the highly Karst nature of the terrain there is a very sparse network of surface drainage channels and streams with rainwater generally infiltrating to ground through the porous karstified limestone bedrock rather than running off. As a consequence, only one dry ditch was noted as being intercepted near the Coolagh lakes complex to the east of the Corrib. Whereas, to the west of the Corrib the bedrock and quaternary changes to a more impervious type resulting in a much higher density of surface water features with little ability for rainwater to infiltrate to groundwater. This gives rise to wetter conditions with peatlands and marshy areas common.

The drainage and hydrological characteristics of the proposed N6 GCRR, hereafter referred to as the proposed road development are presented in this chapter.

Figure 2 N6 GCRR route and National routes linking to the City Centre Access Network

3.2 River Corrib Bridge Crossing

A large bridge superstructure is proposed at the River Corrib crossing at Menlo/Dangan. This structure will clear span the entire river channel and will continue on a viaduct west of the River Corrib to maintain access for the NUIG Recreational Facilities. The structure provides a full clear span of 150m span width of the river channel (from pier face to pier face). The riverside support piers are located a distance greater than 5m from the river channel bank edge on the eastern (Menlough) side and over 10m from the river edge on the western (Dangan) side of the river. The location of the bridge crossing is presented in Figure 3. Section 50 approval has been granted for the River Corrib Bridge crossing.

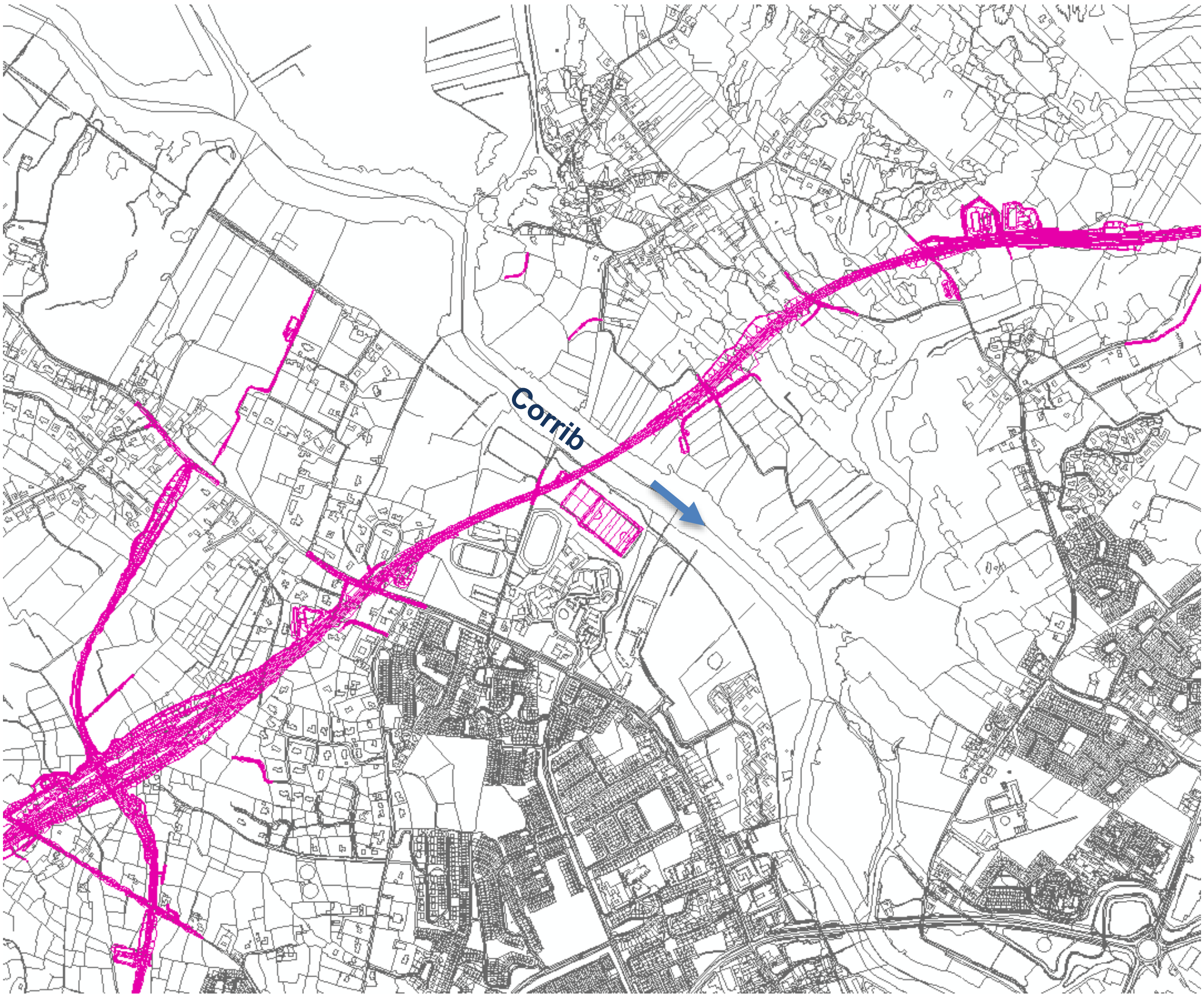


Figure 3 Location map of proposed N6 Galway City Ring Road alignment and River Corrib crossing point.

3.3 Culvert Crossings along Proposed Road

Excluding the River Corrib there are a total of 17 stream road crossing sites that will require culverting, 16 of these culvert sites are located in the western section and 1 in the eastern section, refer to Figure 4 for the general location of the culverts. The catchment areas of these watercourses is generally very small ranging from a number of hectares to the largest crossing of the Bearna Stream with an upstream catchment area of only 5.5km^2, refer to Figure 5 for the contributing catchment areas of the culverts. The majority of these watercourses flow in a southerly direction discharging into Galway Bay with watercourses east of the Bearna Stream discharging to the designated Galway Bay Complex cSAC (000268) and watercourses west of the Bearna Stream to Galway Bay outside of the Galway Bay Complex cSAC. These watercourse crossings are summarised below in Table 3. Section 50 approval has been granted for all proposed watercourse culvert crossings.

Table 3 Proposed Culvert Details

Ref	N6 GCRR Ref	X	Y	Mainline Chainage	Catchment Area km^2	Qdesign cumec	Watercourse
1	**C00/01**	521324.58	723181.58	0+650	0.47	1.26	Sruthán na Libeirtí
2	**C00/02**	521521.68	723446.01	1+000	0.324	0.89	Sruthán na Libeirtí
3	**C01/01**	521983.64	723778.87	1+500	0.06	0.09	Small Coastal Stream
4	**C02/01a**	523086.54	724283.58	2+800	1.192	1.63	Trusky Stream
5	**C02/01b**	523179.61	724198.04	2+850	1.192	1.63	Trusky Stream
6	**C03/01**	523354.16	724244.47	3+050	0.08	0.12	Trusky Minor Drain
7	**C03/02**	523615.65	724390.32	3+350	0.15	0.23	Trusky Minor Drain
8	**C03/03** **C03/04**	524066.24 & 524079.03	724705.91 & 724722.20	3+925 3+950	0.692	1.09	Bearna Tribitary
9	**C04/01**	524201.84	724845.74	4+100	5.485	7.58	Bearna Stream
10	**C04/02**	524895.00	725274.42	4+900	1.652	2.13	Tonabrocky
11	**Channel Diversion**	524918.98 525096.21	725303.36 725475.14	4+965 - 5+200	1.517	1.97	Tonabrocky
12	**C06/01**	526420.87	726389.37	6+850	0.138	0.20	Knocknacarra Minor Drain
13	**C07/02B**	526710.48	726684.02	7+250	0.209	0.30	Knocknacarra Minor Drain

Ref	N6 GCRR Ref	X	Y	Mainline Chainage	Catchment Area km^2	Qdesign cumec	Watercourse
14	**C07/02A**	526698.49	726637.16	7+225	0.209	0.30	Knocknacarra Minor Drain
15	**C08/01**	527663.93	727211.93	8+375	0.159	0.23	Minor Drain Dangan
16	**C10/02**	529687.79	728412.26	10+730	0.629	0.19	Minor Drain Coolagh
17	**C07/01a**	527147.52	726262.40	N59 Link Rd south 1+600	0.38	0.55	Knocknacarra Minor Drain

The design flow presented in the above table includes the best flood flow estimate using either IH124 or the Flood Studies Update (FSU, 2015) method and multiplied by the factorial standard error of the equation and increased a further 20% to include for climate change allowance.

Figure 4 Location Map of Culverts (note reference 11 represents a channel diversion to the northwest of the alignment to achieve a single stream crossing at reference 10)

Figure 5 Contributing Catchment Area of Culverts (red polygons)

3.4 Proposed Road Drainage Features

There is a total of 52 proposed road drainage outfalls for the proposed road development, 23 of which discharge to surface watercourses, 9 road drainage outfalls infiltrate to groundwater through engineered infiltration fields and 17 outfalls discharge existing public surface water sewers, 2 (covered tunnel sections) are pumped to the public foul sewer and 1 to an existing road infiltration basin.

The total surface drainage area for the proposed road development is estimated to be 94.9ha and the hard paved area is 61.2ha. This gives the average percentage impervious area for the road of 64.5%. The total drainage area discharging to surface water outfalls is 62.4ha with hard paved area of 39.6ha and the total drainage area discharging to groundwater is 32.4 ha with hard paved area of 21.6ha.

The proposed tunnel sections are closed systems which do not contribute the surface drainage area and are collected in sumps and discharged (by pumping) into the foul drainage system for suitable waste water treatment and disposal. The tunnelled section will not receive direct rainfall and will not have any external catchment contributing to it. A separate spillage containment sump of 25m^3 is provided for both the Lackagh Tunnel and Galway Racecourse Tunnel, these are to cater for potential spillages.

The paved area contributing to proposed road drainage outfalls has an average pavement area of 1.2ha, which is a reasonably small ratio of pavement area to outfall.

The largest surface water outfall services a paved area of 4.58ha and the largest groundwater outfall services a paved area of 4.82ha. A summary of the proposed road drainage outfalls discharging to surface watercourses is presented in Table 4 and those storm outfalls discharging to groundwater are presented in Table 5.

Table 4 Proposed Road Drainage Outfalls to Watercourses

Drainage Network Reference	Chainage	Total Drainage Area (ha)	Pavement Area (ha)	Watercourse
S1	MLN Chainage 0 to 700	2.05	1.29	Sruthán na Líbeirtí
S2	MLN Chainage 700 to 1000	0.55	0.38	Sruthán na Líbeirtí
S3	MLN Chainage 1000 to 1475	2.31	1.28	Sruthán na Líbeirtí
S4A	MLN Chainage 1475 to 1900	0.96	0.62	Trusky Tributary
S5A	MLN Chainage 1900 to 2850	2.45	1.53	Trusky Stream
S7A	MLN Chainage 2850 to 3050	0.30	0.24	Bearna Stream
S7B	MLN Chainage 3050 to 3910	2.94	1.07	Bearna Stream
S8	MLN Chainage 3910 to 4125	0.42	0.26	Bearna Stream
S9	MLN Chainage 4125 to 4900	1.75	1.19	Bearna Stream
S10	MLN Chainage 4900 to 5640	2.19	1.22	Bearna Tributary
S12	MLN Chainage 6325 to 7300	3.15	2.45	Knocknacarra Tributary
S13	MLN Chainage 7300 to 7525	0.91	0.63	Knocknacarra Tributary
S14B	MLN Chainage 8250 to 8525	0.85	0.65	River Corrib Tributary
S18A	MLN Chainage 8525 to 9250	1.75	1.58	River Corrib Tributary West Bank
S18B	MLN Chainage 9250 to 10150	2.27	1.95	River Corrib Tributary East Bank
S21A	MLN Chainage 11850 to 12450	3.31	1.36	Ballindooley Lough Tributary
S4B	MLN Chainage 1500	0.12	0.07	Trusky Tributary
S15	Link Road - N59 Link Road North Chainage 0 to 625	1.89	0.73	River Corrib Tributary West Bank
S5B	MLN Chainage 2800	0.24	0.14	Trusky Stream

Drainage Network Reference	Chainage	Total Drainage Area (ha)	Pavement Area (ha)	Watercourse
S36A	MLN Chainage 3350	0.24	0.17	Bearna Tributary
S36B	MLN Chainage 3350	0.10	0.08	Trusky Stream
S31A	MLN Chainage 7250	0.09	0.06	Knocknacarra Tributary
S31B	MLN Chainage 7250	0.15	0.12	Knocknacarra Tributary

Table 5 Proposed Road Drainage Outfalls to Infiltration Basins

Drainage Network Reference	Chainage	Total Drainage Area (ha)	Pavement Area (ha)
S19A	MLN Chainage 10150 to 10730	1.949	1.660
S19B	MLN Chainage 10730 to 11150	2.222	1.683
S20	MLN Chainage 11420 to 12020	4.950	2.233
S21B	MLN Chainage 12020 to 13630	8.283	4.82
S22A	MLN Chainage 13360 to 14350	5.681	3.941
S22B	MLN Chainage 14350 to 14950	3.064	2.761
S27	MLN Chainage 16750 to 17535	5.473	N/A
S22E	MLN Chainage 14400	0.791	0.686
S22C2	MLN Chainage 14400	0.546	0.517
S40	MLN Chainage 10475	0.16	0.12

The remaining 17 drainage areas discharge to the existing public storm drainage infrastructure, refer to Table 6. The permissible discharge rates have been set based on consideration of natural greenfield flood runoff rates and also the current capacity in the receiving storm drainage system.

Attenuation storage and flow control has been provided for all drainage areas so that the design flood discharge in the case of surface discharges achieves predetermined greenfield flood runoff rates and in the case of groundwater disposal meets the infiltration capacity of the percolation field.

Table 6 Storm Outfall discharging to Public Storm Sewers

Catchment	Chainage	Total Drainage Area (ha)	Paved Area (ha)	Receiving Storm Sewer Size (mm)	Peak Discharge Rate 1 in 100 (l/s)
S11	MLN Chainage 5640 to 6325	2.02	1.57	300	7.8
S26	MLN Chainage 15750 to 16750	5.12	3.47	900	4.5

Catchment	Chainage	Total Drainage Area (ha)	Paved Area (ha)	Receiving Storm Sewer Size (mm)	Peak Discharge Rate 1 in 100 (l/s)
S29	MLN Chainage 16500	2.73	2.07	900	5.0
S30	MLN Chainage 15200 to 15900 & 16150 to 16+450	6.33	4.58	900	5.7
S16A	N59 Link Road South Chainage 625 to 1625	4.16	2.15	450	16.1
S17A	N59 Link Road South Chainage 1625 to 2210	1.08	0.98	1500	5.7
S14A	MLN Chainage 7525 to 8250	5.66	2.20	1200	21
S22C1	MLN Chainage 14400	1.46	1.36	900	5.0
S37	MLN Chainage 4450	0.21	0.19	450	5.4
S32	MLN Chainage 6300	0.80	0.40	375	5.6
S16B	N59 Link Road South Chainage 1625	0.12	0.10	450	4.7
S17B	N59 Link Road South Chainage 2210	0.34	0.27	1500	5.2
S31C	MLN Chainage 7250	0.25	0.16	450	4.9
S38	MLN Chainage 5650	0.14	0.10	300	46.7
S41	MLN Chainage 13150	0.24	0.23	225	66.7
S39	MLN Chainage 7575	0.22	0.15	225	68.6
S33	MLN Chainage 1500	0.83	0.54	600	5

The total number of attenuation ponds and infiltration basins along the proposed road development is 35, having storage depths typically ranging from 0.4m up to 1.85m (average 1.1m). The flood storage area of these ponds and basins varies depending on the drainage area from 0.006ha to 0.328ha with the median at 0.12ha. These attenuation ponds and infiltration basins are combined with engineered wetland areas for water quality treatment prior to disposal to surface waters or groundwaters. These attenuation ponds and infiltration basins would be considered to represent a source of local residual flood risk of moderate significance in the event of overspilling through lack of maintenance, outfall blockage, impoundment bank failure and overtopping at times of extreme flooding. This residual flood risk can be managed through a program of regular inspection (3 monthly inspections) and maintenance. A controlled overflow facility will be provided at each pond and basin in the event that the outflow throttle device (hydrobrake, vortex control or orifice plate) becomes blocked or infiltration reduces and freeboard allowance is provided for each pond to prevent overtopping.

The culvert locations are shown on Figures 5.1.01 to 5.1.14 in the EIA Report and the drainage network and outfalls are presented in Figures 11.6.101 to 11.6.115 in the EIA Report.

4. FLOOD RISK ASSESSMENT

4.1 Stage 1 - Identification of Sources of Flooding

This FRA has reviewed the potential for flood risk from fluvial coastal, pluvial and groundwater flooding as a result of the proposed road development which involved consulting the following sources:

- The OPW National Preliminary Flood Risk Assessment (pFRA) Mapping
- The OPW Draft CFRAM (Catchment Flood Risk Assessment and Management) mapping for the Areas for Further Assessment (AFA) of Galway City and Oughterard village and associated hydrological reports
- The Irish Coastal Protection Strategic Study - Western Coast and other relevant mapping including historical OSI mapping
- The OPW River Corrib Benefiting Lands mapping (developed as part of the River Corrib-Clare Arterial Drainage Scheme)
- Known historical flooding areas and extents
- Relevant drainage reports

The web portal floodmaps.ie provides a national archive of information on historical flood events including locations, reports, photographs, drawings and newspaper archives, which assists in the compilation of historical flood information. Other sources consulted as reference information are the FRAs for the various development plans including the Galway County and Galway City Development Plans and various LAPS including Bearna and Oranmore sFRAs and the Galway Transport Strategy sFRA.

The sources of information on flood risk along the proposed road development are summarised in Table 8 below

Table 7 Flood Risk Source Evaluation

Title	Description	Quality	Confidence
OPW – Arterial Drainage Land benefitting maps	Mapping of lands identified through walkover and consultation by OPW of lands	Medium	Low to medium
Historical flood records including photos and reports	Various sources including various local authority records, reports, photos, archives and the floodmaps.ie repository	Variable	Low to high
OPW pFRA Mapping	The Preliminary Flood Risk Assessment (PFRA) national screening exercise to identify areas at flood risk and	Medium	Medium

Title	Description	Quality	Confidence
	includes, pluvial, fluvial, groundwater and tidal		
Irish Coastal Protection Strategy Study	Prediction of tidal events under storm surge events for the western region which includes tidal levels and coastal erosion of soft shoreline areas	High	High
Walkover Survey	Specific visits to selected locations and key structures and flood defences	Medium	Low
Western CFRAM (draft)	Draft Western CFRAM maps	High	High
SFRA for Development Plans	Stage 2 SFRA undertaken for Local Area and city and county Plans (Bearna, Galway City and Galway County) Galway Transport Strategy (2016)	Medium	Medium

The pFRA mapping is generally used in Ireland in combination with other information as a screening tool for identifying potential flood hazard and the requirement for further more detailed stage 2 and stage 3 flood risk assessments. This pFRA national mapping was produced from simplified river, pluvial and tidal surge hydraulic models using relatively coarse lidar data for flood routing purposes. Historical mapping and aerial flood photos were also relied upon in respect to groundwater and pluvial flooding. The pFRA mapping should only be treated as coarse, indicative mapping of potential flood hazards and should be combined with other information sources.

The more detailed CFRAM study, carried out for identified AFA's (relevant to this strategy is the Galway City CFRAM, which involved more detailed channel and floodplain survey, lidar topographical survey, hydrological analysis and hydraulic flood modelling and provides more accurate and refined mapping for fluvial and coastal flood processes. It should be noted that the villages of Bearna and Oranmore were not identified as AFA's and therefore do not have detailed CFRAM flood mapping available.

4.1.1 Tidal and Coastal Flooding

The proposed road development avoids coastal flood risk zones over its entire length with the alignment sufficiently inland and elevated not to be at risk from tidal flooding both present day scenario and 100 years in the future under sea level rise scenarios.

4.1.2 Fluvial Flooding

The study area falls within hydrometric areas 29, 30 and 31 (29 Galway Bay Southeast Catchment, 30 The Corrib Catchment, 31 The Galway Bay North).
The principal rivers/streams within the study area are:

- Sruthán na Líbeirtí
- Trusky Stream
- Bearna River
- Knocknacarra Stream
- River Corrib and its canal system
- Terryland River (indirect)

The River Corrib represents the largest watercourse having a catchment area of some 3,136 km^2 to Wolfe Tone Bridge in Galway City. The OPW regulate water levels in the River Corrib and Lough Corrib through gated control at the Salmon Weir Barrage. The regulation level range for the lake is set at 28ft to 30ft Poolbeg (5.8 to 6.4m OD Malin) for navigation and flooding control. Gates are opened and closed by the OPW depending on existing and forecasted rainfall conditions. The canals and mill races through the city are fed by the River Corrib upstream of the Salmon Weir Barrage and outfall into the River Corrib Estuary. The Eglington Canal is prone to siltation as the flow through this is restricted by lock gates, weirs and turbines. The other rivers/streams have catchments that are very minor in area in comparison and do not represent a significant source of flood risk with only localised flooding along their reaches.

Figures 11.3.101 to 11.3.114 of the EIA Report show the fluvial flood areas as outlined in the PFRA mapping.

4.1.3 Pluvial Flooding Sources

Pluvial flooding results in the filling and ponding of rainfall runoff waters within local depressional areas which can result when rainfall intensity and duration exceed the infiltration capacity of the underlying soil causing temporary (over a few hours) building up of flood waters in such areas. In the national PFRA study a simplified model for pluvial flooding was developed which identified from aerial lidar data local depressions and their surrounding contributing catchment area. The potential for ponding and the extent of ponding was determined for these depressions using Met Éireann storm rainfall statistics and soil infiltration characteristics based on soil, subsoil and groundwater aquifer maps. These pluvial flood areas were mapped and presented in Figures 11.2.101 to 11.2.114 in the EIA Report

Potential pluvial flood risk areas are shown scattered throughout the study area and are generally small and of limited consequence for the proposed road development.

An area of pluvial flood risk that potentially could impact the proposed road development is the existing N17 Tuam Road section at Twomileditch. Regular flooding occurs during intense rainfall events with runoff from the steep hill slopes to the east causing flooding of the N17 Tuam Road and adjoining properties (ref. Ryan Hanley Report (2004) N17 Flood Relief Project for Galway City Council). The N17 Tuam Road in times of severe flood can act almost as a stream bed over its 1800m length, conveying flood water along the road to discharge eventually to groundwater to the northeast of the N17 Tuam Road. This groundwater discharge zone is potentially linked to the Castlegar area and the Terryland River Basin via groundwater flow.

A second location is pluvial flooding in the Doughiska area 400m southwest of Ch. 16+500. This area in the PFRA is shown to have extensive groundwater flooding also and is discussed below under groundwater flooding.

4.1.4 Groundwater

Groundwater flooding is associated with areas of high water table levels which can generally result in small areas of winter ponding of lands gradually filling and emptying between autumn and spring. These flood areas are generally referred to as seasonal lakes or turloughs. They are generally slow to fill and often slower to recede and empty. These features are generally associated with the karst limestone bedrock to the east of the N59 Moycullen Road. The N59 Moycullen Road generally represents the boundary between granite and limestone bedrock. The limestone areas to the east of the city give rise to a range of small turlough features, karst springs and swallow-hole systems and areas vulnerable to flooding are the Doughiska / Ardaun area.

A flood relief culvert has been provided to relieve flooding in Doughiska area taking the pluvial and groundwater flows and discharging to the sea in the Ballyloughaun Renmore area via a large 1500mm diameter storm pipe. The Terryland River flows east to northeast from the River Corrib for approximately 4km before discharging to ground via two known swallow-holes at Glenanail, Castlegar. The inflow from the River Corrib is via a manmade channel referred to as the Galway Bore which is also the abstraction / intake channel to the Terryland water treatment plant. This treatment plant serves the potable water needs of Galway City. The excess flow overspills with a fall of 3m down into the Terryland River Basin. Historical maps (1819) showed the entire Terryland River valley as inundated and part of the River Corrib system. The capacity of the swallow-holes is unknown and a previous 1998 KT Cullen Study for Galway City Council recommended that development levels are set above 7m OD which is equivalent to the River Corrib level in severe flood (> 100year Return Period in River Corrib upstream of Salmon Weir Barrage).

The CFRAM model study makes certain assumptions with predicted levels significantly lower at 3.4 and 4.94m OD for the 100 and 1000 year events for the Terryland River valley. A level of uncertainty over the current and future capacity of the swallow holes remains and therefore a residual flood risk exists for the Terryland basin.

4.1.5 Urban Stormwater Drainage

The urban storm water drainage system in Galway City varies between new separated storm sewers and older separated and combined storm sewers. The storm water sewer system in places has been upgraded so as to reduce flash storm water flooding. The design standard varies but generally for the more recent storm water sewers a 30year surcharge charge capacity is provided. Storm water gullies are prone to blockage which can give rise to localised flooding issues as can storm water outfalls. The use of attenuation tanks for housing developments, hard paved areas and roadways to throttle back the flow to that of a greenfield site as part of SUDS (Sustainable Urban Drainage System) can give rise to flood hazards where the outfall is blocked through lack of maintenance or its storage capacity has been exceeded.

4.2 Stage 2 Initial Flood Risk Assessment

This Stage 2 assessment investigates in more detail the flood risk implications for the proposed road development from available sources. Table 9 below presents the identified features of flood risk along the route of the proposed road development and assesses the significance of the flood risk. The draft CFRAM maps where available were used to inform the Stage 2 assessment in respect to fluvial and coastal sources. Although the CFRAM mapping is currently in draft format, this mapping has undergone public consultation and a full review and is considered to be finalised mapping. It is expected that this mapping and the CFRAM assessments will be regularly updated and reviewed into the future.

Figures 11.5.101 to 11.5.114 of the EIA Report show the CFRAM Flood Zones superimposed on the proposed road development.

The proposed road development and its various road linkages and junction upgrades are shown, from the various flood risk mapping sources, to have the potential to intercept fluvial, groundwater and pluvial flood risk sources. The proposed road development crosses the River Corrib at the townlands of Dangan and Menlough where it has the potential to encroach on the river channel and its floodplain. The proposed road development also crosses a number of smaller streams to the west towards Bearna including the Knocknacarra Stream, Tonabrocky Stream, Bearna

Stream, Trusky Stream and Sruthán na Líbeirtí. A potential source of groundwater flooding is identified adjacent to the proposed road development at Doughiska, Coolagh and Castlegar and potential pluvial sources are identified at a number of locations along its route.

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

Table 8 Summary Description of the Proposed N6 GCRR FRA

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
650	Fluvial Flood Risk	Sruthán na Líbeirtí	Minor	Minor	Small stream which can easily be culverted and with no extensive floodplain area. The predicted extreme (1000year) flood level at the road crossing is 33.7m OD and the proposed road development is above 36.2m OD. This stream has a catchment area of only 47ha
1000	Fluvial Flood Risk	Sruthán na Líbeirtí	Minor	Minor	Small stream which can easily be culverted and with no extensive floodplain area. The estimated extreme (1000year) flood level at the road crossing is 40.2m OD and the proposed road development is above 42.3m OD. This stream has a catchment area of only 32.4ha
1450	Pluvial Flood risk - pFRA mapping	Local Depression	Minor	Minor	A local pluvial flood area to the northwest of the proposed road development. The proposed road development does not encroach into this flood area and the proposed road elevation is 51.14m OD. The area drains to a small drainage ditch that is culverted under the road. There are no implications to flood risk from this feature.
1500	Fluvial Flood Risk	Very minor drain	Minor	Minor	A small drain/stream which drains the Pluvial Flood risk area at Ch. 1+450. The extreme flood level is estimated to be 48.35m O.D. No extensive flood plain and proposed road development above 51.8m OD
2850	Fluvial Flood Risk	Trusky Stream	Minor	Minor	Small stream which can easily be culverted and with no extensive floodplain area. The predicted extreme (1000year) flood level upstream of the road crossing is 39.3m OD and the proposed road

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
					development is above 44m OD. This stream has a relatively small catchment area of 120ha.
3050	Fluvial Flood Risk	Trusky minor drain	Minor	Minor	Small drain that can easily be culverted and with no extensive floodplain area. The predicted extreme (1000year) flood level at the road crossing is 39.3m OD and the proposed road development is above 40.5m OD. This stream has a catchment area of only 8ha.
3350	Fluvial Flood Risk	Trusky minor drain	Minor	Minor	Small drain that can easily be culverted and with no extensive floodplain area. The predicted extreme (1000year) flood level at the proposed road development crossing is 37.3m OD and the proposed local road is at 38.7 and the mainline is in cut at 31.7m OD. This drain is to be intercepted by the proposed road drainage which is designed to cater for this drain which has a small catchment area of 15ha.
3930	Fluvial Flood Risk	Bearna Tributary Stream	Minor	Minor	A small tributary stream of the Bearna Stream with catchment area of less than 70ha. The extreme flood level at the crossing is estimated to be 19.7m and the potential flood plain width is 25m. Large twin culverts are proposed at the crossing spaced 20m apart which will minimise any upstream afflux. The potential loss of flood storage is minor in the context of downstream flooding with this tributary stream joining the mainline channel a short distance downstream of the proposed road culverts.
4100	Fluvial Flood Risk	Bearna Stream	Minor	Minor	The Bearna stream crossing is the largest stream crossing on the proposed road development. However its catchment area is not very large at 550ha. The computed extreme flood level at the crossing is 22.5m OD. The proposed road development elevation at the crossing point is 25.2m O.D. The topography of the stream channel at the crossing is a relatively narrow valley resulting in a relatively minor encroachment of the flood zone by <0.07ha at crossing. The proposed culvert crossing is a box culvert that completely spans the channel width and results in no significant impact on flooding or flood risk.

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
4925	Fluvial Flood Risk	Tonabrocky Stream	Minor	Minor	The Tonabrocky Stream is to be culverted at this location. The predicted design flood level is 45.33m OD and the stream is steep and reasonably channelised at the crossing location and therefore there will be minimal encroachment and potential loss of floodplain area. The catchment area is small at 165ha and the design flood flow of approximately 2.13cumec can easily be accommodated within the proposed box culvert. The road finish elevation is 48.6m O.D.
4980 - 5220	Fluvial Flood Risk	Tonabrocky Stream diversion	Moderate	Minor	The proposed road development from Ch. 5+220 to 4+890 runs on top of the Tonabrocky Stream channel and consequently this stream channel is to be realigned to run parallel to the proposed road development along its northern toe in a new cut trapezoidal channel of approximately 230m in length. The predicted design flood levels upstream of the diversion channel is 51m OD and 46.7m downstream, whereas the road elevation is 54.7 to 47.9m OD respectively. The catchment area is small at 150ha and the design flood flow of approximately 2cumec can easily be accommodated within the new channel.
5700	Pluvial flood risk - pFRA mapping	Local depression	Minor	Minor	Local depression feature with potential extreme flood level of 57.75m O.D. and 0.12ha flood area immediately to the north of the proposed road development. The proposed road encroaches this feature. There are no implications for flood risk from this feature and the proposed road development is at c. 59.7m OD
6000	Pluvial flood risk - pFRA mapping	Local depression	Minor	Minor	Local depression feature with potential extreme flood level of 54.75m O.D. and 0.2ha flood area. The proposed road encroaches this feature. There are no implications for flood risk as a result of the loss of this feature and the proposed road development is sufficiently elevated at c. 58m OD.
6200	Pluvial flood risk - pFRA mapping	Local depression	Minor	Minor	Local depression with catchment area of c. 4.5ha and potential extreme flood level of 53m O.D. and 0.5ha flood area. The proposed road development encroaches this feature. There are no implications for flood risk as a result of the loss of this feature and the proposed road

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
					development is sufficiently elevated at c. 62m OD.
6850	Fluvial flood risk source drain shown on OSI vector mapping	Minor drain of the Knocknacarra Stream	Minor	Minor	Minor hill slope drain of the Knocknacarra Stream system without any extensive floodplain area and easily conveyed within a small stream channel. The catchment is c. 14ha and flood flows are minor producing an extreme flood level of 54.1m OD.
7210	Fluvial flood risk source drain shown on OSI vector mapping	Minor drain of the Knocknacarra Stream	Minor	Minor	Minor hill slope drain of the Knocknacarra Stream system without any extensive floodplain area and easily conveyed within a small stream channel. The catchment is c. 20ha and flood flows are minor producing an extreme flood level of 57.9m OD.
8350	Fluvial flood risk source drain shown on OSI vector mapping	minor drain at Bushypark /Dangan	Minor	Minor	Minor hill slope drain at Bushypark/ Dangan which is to be culverted beneath the proposed road development without any potential impact on conveyance or floodplain loss. The catchment is small at c. 16ha and flood flows are minor producing an extreme flood level of 33.75m OD upstream. The road at this location is in significant embankment at this location with a proposed road elevation of 40.7m O.D.
9250 to 9400	Fluvial Flood risk pFRA, CFRAM	River Corrib Floodplain	Minor	Minor	The River Corrib is to be crossed by a full spanning 150m long superstructure with no direct encroachment into the floodplain. At Ch. 9+850 to Ch. 9+900 on the eastern side of the River Corrib, there is a slight encroachment of the road embankment into the floodplain area of the River Corrib to the north of the Inner Coolagh Lake. The area of encroachment at the 1000year flood level is 0.27ha and at the 100year it is 0.11ha. The proposed crossing will not have any perceptible impact on flooding and flood risk by this small local encroachment and the road itself is at an elevation of 20.5 to 22.8m OD at the river crossing and 25.3m OD at Ch. 9+880, which is significantly elevated above maximum flood levels due to navigation and vertical alignment purposes.

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
11425 to 11750	Pluvial flood risk	Lackagh Quarry Floor	Moderate	Significant	Large excavated quarry floor area having a lower bench at less 15m OD at 5ha in area and below 14m OD at 2.4ha in area. The contributing area is limited to 17.4ha. Pluvial ponding in the quarry is intermittent and temporary. During extreme winter flooding, such as flooding observed in December 2015/January 2016 the groundwater table rises above the quarry floor. The proposed road elevation at entrance to the tunnel is slightly in excess of 17m. The maximum observed groundwater level was 15.2m OD providing a clearance of 1.8m.
12350	Fluvial flood risk	Ballindooley Lough Flood Extents	Minor	Minor	Very slight encroachment of the floodplain with historical maximum flood levels reaching 10.3m OD and extreme flood level estimated at approximately 10.5 to 11m OD. There are no flood implications from the very slight encroachment of the floodplain area and the road itself is sufficiently elevated at c. 26m OD.
13000	Small pond and pluvial flood risk pFRA	Small enclosed depression	Moderate	Minor	This represents a small semi-permanent pond feature which has a contributing catchment area of 7.2ha and has a flood level of c. 14 to 15m OD with a pond area of 0.2ha. The feature is enclosed to 18m OD and the road level is at c. 22.2m OD and slightly encroach this feature. It potentially drains SSW to the Terryland Basin. The proposed road has a stormwater infiltration basin adjacent to this feature.
13800	Pluvial - pFRA mapping and existing N17 Tuam Rd drainage	large enclosed depression	Significant	Significant	Existing flood risk on the N17 Tuam Road at Twomileditch with no natural surface water outflow and existing road drainage infiltrating to groundwater. The proposed road development crosses through a low-lying enclosed depression with pluvial flood risk immediately to the west of the existing N17 Tuam Road. The potential extreme flood level in this feature is estimated to be 18.5m OD Malin. There is no risk to the proposed road development itself as its elevation is at c. 26.5m OD. Significant flood risk exists for the existing N17 Tuam Road and adjacent low-lying dwelling houses from the overland flow off the Ballybrit hillside and storm flow from the N17 Tuam Road itself exists. The proposed road development has the

Chainage	Flood Source	Description	Potential Flood Risk	Residual Flood Risk	Description of Flood Risk
					potential to increase drainage flow rates in this area, to encroach into a pluvial flood risk area and potentially interfere with the natural infiltration of overland flows. Without careful design the proposed road development could exacerbate the existing flood risk in this area.
15350	Pluvial - pFRA mapping	Local minor depression	Minor	Minor	Minor area limited contribution with potential pluvial extent of <0.5ha and estimated flood level 41m O.D. will be accommodated within the road drainage network.
16000	Pluvial pFRA mapping	Local minor depression	Minor	Minor	A small depression feature with very minor contributing catchment area having a potential flood level of 41m OD with road at 47.5m O.D. This pluvial flood area can easily be removed and the drainage accommodated in the road drainage network.
16500	Groundwater and Pluvial	Large depressional area	Minor	Minor	This flood risk area has been drained by a 1500mm diameter storm pipe that discharges to the sea at Renmore (proposed road level is 33.2m OD and worst case scenario if storm pipe was blocked is a flood level of 28m OD. The proposed road development does not encroach into the flood zone and therefore impact is anticipated.
N59 Link 1+550 to 2+200 realignments of Gort Na Bró and Rahoon to Western Distributer	Fluvial	Flood risk area identified along historical stream channel	Significant	Moderate	The historical watercourse and floodplain area is no longer active or present with watercourse replaced and diverted by a large storm water pipe as part of the urban land development initiative.

4.3 Stage 3 Detailed Flood Risk Assessment

4.3.1 Small Watercourse Culvert Crossings

As part of the OPW Section 50 approval process for culverting of watercourses a hydrology flood report was submitted with the applications for the proposed culverting of 16 watercourses encountered. 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. This report is included in Appendix A and a summary of the findings included below. Section 50 approval for all of the proposed culverts was received on the 22nd August 2016.

The proposed culverts were hydraulically assessed in terms of flow capacity and resultant upstream and downstream flood levels for the design flow condition using the 1-D river network hydraulic model HEC-RAS. Specific topographical channel surveys were conducted to provide the geometry information for the modelling exercise. Other sources of topographical information including 2m and 5m gridded lidar was used to define the geometry of the floodplain area.

All of the proposed stream crossings are considered to have small contributing catchment areas and therefore involve relatively small flood flows. None of these streams were assessed by the OPW as part of the Galway CFRAM study as they were not considered to represent a high or medium priority watercourse.

The design flood flow considered for each of the culverts is the estimated 100-year return period flood flow multiplied by the factorial error of the estimation method and further multiplied by a climate change allowance factor of 1.2. Such a design Flood is equivalent to the present day 1000year return period flood (0.1% annual exceedance probability).

The channel roughness of the existing channels was specified as 0.1 Manning's n representing high roughness as they are generally unmaintained. The roughness of the proposed culverts as modelled using a roughness of 0.025 for the near bed section and 0.015 for the upper concrete section of the culvert.

A summary of the results for each of the culvert references is presented below in Table 9 and presents the computed upstream and downstream flood level relative to Malin Head datum.

The proposed culvert sizes are very generous in respect to the provision of effective open area and flow conveyance and do not for any of the 16 proposed culvert crossing sites represent a constriction to flow. In a lot of cases they have been upsized further to cater for mammal passage with ledges and for bat passage. Where ledges have been included the width of the ledge included is 0.5m on both internal box culvert faces and were modelled hydraulically as being 1m narrower than the width specified (i.e. culvert Ref. 9 (Bearna Stream crossing) was modelled as 4m wide as opposed to 5m wide). Generally the minimum size provided for this scheme is a 1200mm diameter pipe which is typically buried by 150mm (except for culvert reference 7 which has a 900mm diameter). All of the structures have inlet and outlet wing and head wall structures. Potential for debris blockage is small given the nature of catchments involved and generous dimensions provided.

The hillside nature of the drainage catchments involved will in flood conditions result in supercritical flow occurring in a lot of cases and therefore where the stream bed is not sitting onto bedrock some armouring / channel protection may be required. Therefore, all diversion channels and transitions to and from culverts will be designed and armoured so as to protect against scouring based on design velocity and design depth.

Table 9 Estimated head and Tailwater design flood levels for proposed road development culverts

Culvert	N6 GCRR Ref	Design Q100	u/s invert	d/s invert	u/s Flood Level	d/s Flood Level	u/s soffit	d/s soffit
Ref		**cumec**	**mOD**	**mOD**	**mOD**	**mOD**	**mOD**	**mOD**
1	C00/01	1.26	32.99	30.9	33.68	32.10	34.34	32.25
2	C00/02	0.89	39.62	37.94	40.20	39.09	40.82	39.14
3	C01/01	0.09	48	46.82	48.34	47.8	49.20	48.02
4	C02/01a	1.63	39.73	39.04	40.88	40.08	41.53	40.84
5	C02/01b	1.63	38.48	37.25	39.3	38.18	40.98	39.75
6	C03/01	0.12	38.63	37.44	39.01	37.94	39.83	38.64
7	C03/02	0.23	36.83	36.58	37.26	37.29	37.73	37.48
8	C03/03	1.09	18.93	18.51	19.65	19.65	21.43	21.01
	C03/04	1.09	18.82	18.62	19.67	19.67	21.32	21.12
9	C04/01	7.58	21.17	20.69	22.51	22.16	23.67	23.19
10	C04/02	2.13	44.56	42.32	45.33	43.0	47.06	44.82
11*	Diversion	1.97	50.1	45.9	51.00	46.72		
12	C06/01	0.20	53.6	51.69	54.04	52.16	56.1	54.19
13	C07/02B	0.30	57.84	57.65	58.71	58.71	59.04	58.85
14	C07/02A	0.30	56.88	55.79	57.84	57.65	59.38	58.29
15	C08/01	0.23	32.5	29.035	33.74	29.435	33.7	30.235
16	C10/02	0.19	11.58	11.3	11.95	11.62	12.78	12.5
17	C07/01a	0.55	35.89	35.57	38.58	38.56	37.09	36.77

11* is a channel realignment / diversion of the Tonabrocky Stream

4.3.2 Road Drainage Outfalls and Attenuation Ponds

The proposed road development drainage solution involves the collection of pavement runoff and intercepted flow and the discharge of this storm water to either surface watercourses, groundwater via engineered infiltration basins or discharge to existing urban drainage infrastructure. To mitigate potential flood impact when discharging to surface watercourses, these waters are attenuated in suitably sized attenuation ponds (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, infiltration basin or receiving sewer. The pond attenuation depths range from 0.4m up to 1.85m (average 1.1m) which are not very deep and therefore potential failure of the pond is unlikely to result in catastrophic consequences. Regular inspection of the ponds and their flow control outfall device is proposed and such inspections will significantly reduce the potential residual risk.

4.3.3 Stormwater Infiltration Basins

The sealed road drainage network is required principally within the limestone bedrock area of the proposed road development (east of the N59 Moycullen Road) for groundwater pollution protection which results in point loading at the outfalls. Consequently, an added risk from the road drainage network is the performance of the various large infiltration basins in the eastern karst limestone section of the proposed road development when subject to extreme design storm runoff conditions. In order to minimise the potential residual flood risk from discharging to ground a factor of safety is applied in both the sizing of the infiltration basin required and the determined soil infiltration capacity. Additionally infiltration basins are designed so as to half empty in a period of 24hours or less, this ensures there is capacity available for consecutive storms. Regular inspection of the wetlands and infiltration basins is proposed and should further reduce the local residual flood risk posed by the infiltration basins.

4.3.4 Beneficial Deposition Areas

A number of potential disposition 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.

The Lackagh quarry near the proposed tunnel entrance has been identified as a large material deposit area. This site due to the former quarrying activity has an identified pluvial and groundwater flood risk. However, the site is self-contained and the placement of material as proposed will not impact flood risk on surrounding area or to the proposed road development.

The contractor is to assess the suitability of all of the material deposition areas in context of the Flood Risk Management Planning Guidelines (DoEHLG, 2009) and evaluate the potential impact on flood risk and necessary flood mitigation measures including avoidance.

4.3.5 Tunnels

There are two relatively short tunnel sections included in the proposed road development. The tunnel sections are covered and therefore the rainwater does not contribute directly to the internal drainage network within the tunnel. The tunnels are to be fully sealed and groundwater ingress will be prevented. A pumping system and sump storage is provided to deal with the tunnel wash down and firefighting volumes and also to cater for potential accidental spillages within the tunnel itself. In the case of major spillages or a fire flow situation the tunnel section would be closed off and contaminated waters within the tunnel sumps or spillage containment area pumped out to the foul sewer or disposed of in an appropriate manner as per agreement with Irish Water. The potential flood risk and residual flood risk for the Galway Racecourse Tunnel section is minor, whereas the Lackagh Tunnel is rated as representing a moderate flood risk due to the existing pluvial/groundwater flood risk at Lackagh Quarry. This higher risk is associated with the Lackagh Tunnel as the eastern portal entrance is located at the base of a limestone quarry floor where there is potential for high groundwater levels. Groundwater flood risk within the quarry is also compounded with pluvial flooding which occurs in periods of high intensity rainfall.

4.3.6 River Corrib Bridge Crossing

A separate Section 50 application was made to the OPW for the proposed bridge crossing of the River Corrib at Menlough/Dangan. The application included a detailed flood risk assessment of the proposed bridge structure crossing. A copy of the Flood Assessment Report is Included in Appendix B of this report and a summary of the findings is included below. Section 50 approval for this structure from the OPW was received on the 23rd November 2016.

The following peak flows are used in the modelling to predict flood data levels at the River Corrib Bridge site 150m downstream of the Dangan gauge. The inundation maps for the 100year, 1000year and 100year with climate change allowance are presented in Figures 6 to 8 and show that the River Corrib floodplain at the crossing location is constrained to the river channel section by the existing topography.

Table 10 Computed Flood Level Results for Proposed River Corrib Bridge Site

Return Period (years)	Specified QT Flood Flow (cumec)	Computed Flood Level Bridge Upstream (m OD)	Computed Flood Level Bridge Downstream (m OD)
10yr	389	6.72	6.70
100yr	520	7.20	7.18
1000yr	648	7.62	7.61
100yr+CC	624	7.54	7.53

The predicted flood level for the 100 year + Climate Change design flood flow of 624cumec is 7.54m OD Malin. The proposed 150m clear span structure and the location of the support piers on either river bank will not result in any encroachment into the active floodplain area, being located just to the edge of the floodplain. The 1000-year flood level which defines Flood Zone C (low probability of flooding) is 7.62m OD Malin at the bridge site. The support piers based on the OPW 2m lidar dataset and the topographic survey remain outside the active floodplain area for the predicted 1000-year flood flow event.

It is also concluded that the draft CFRAM flood levels and in particular the estimated 1000-year flood level at Dangan Gauge of 8.02m OD Malin is significantly overestimated. Notwithstanding this higher flood level estimate in the CFRAM study the proposed large single span structure of 150m will not result in any potential impact to flood levels and flood risk either locally or in the upstream and downstream reaches and no discernible impact on flow depths or velocities as a result of the bridge support piers.

The proposed River Corrib Bridge provides ample freeboard of c.10m above the design flood level at mid-span for navigation purposes which easily exceeds the OPW freeboard requirements for flooding and avoidance of floating debris of 1 to 2m. There are no implications for change to the channel morphology at the bridge site as there is no obvious encroachment within the conveying section of the river, refer to velocity plot of 100-year plus climate change scenario presented in Figure 9.

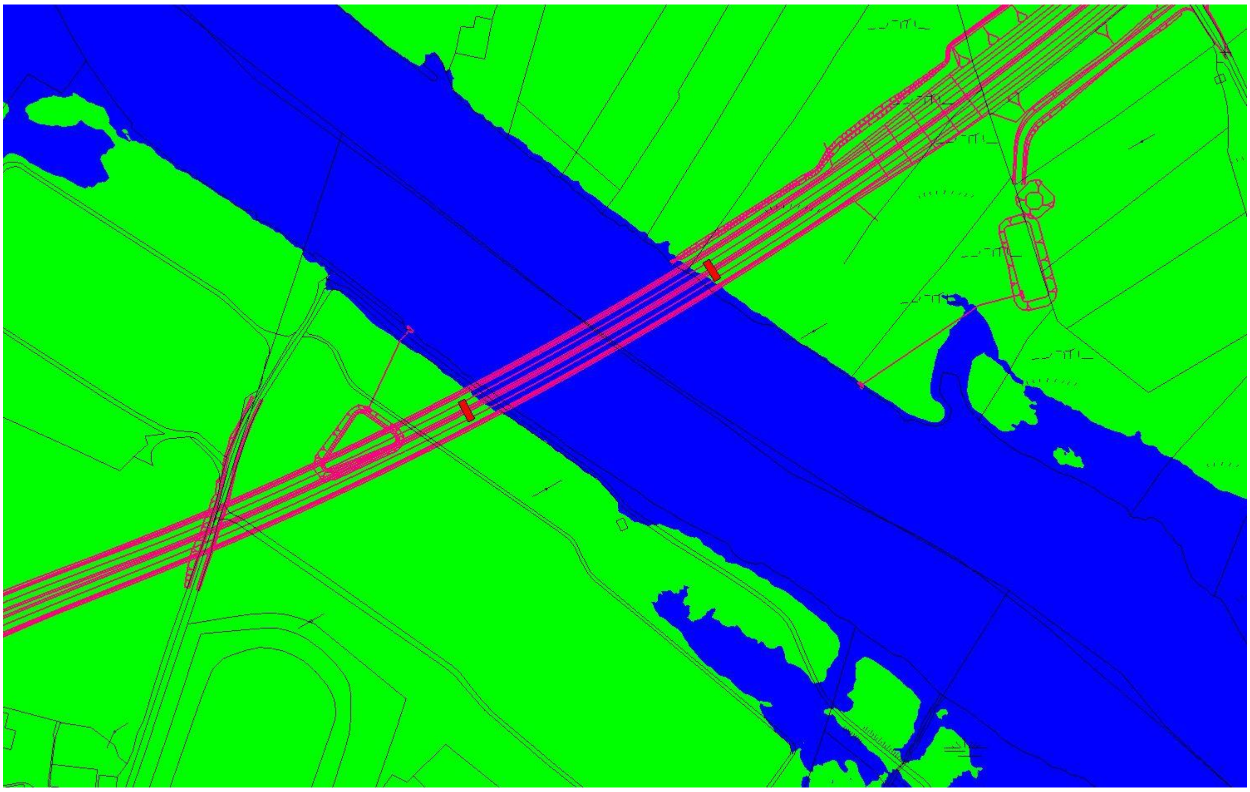


Figure 6 Flood inundation at River Corrib crossing for the 100 year flood event

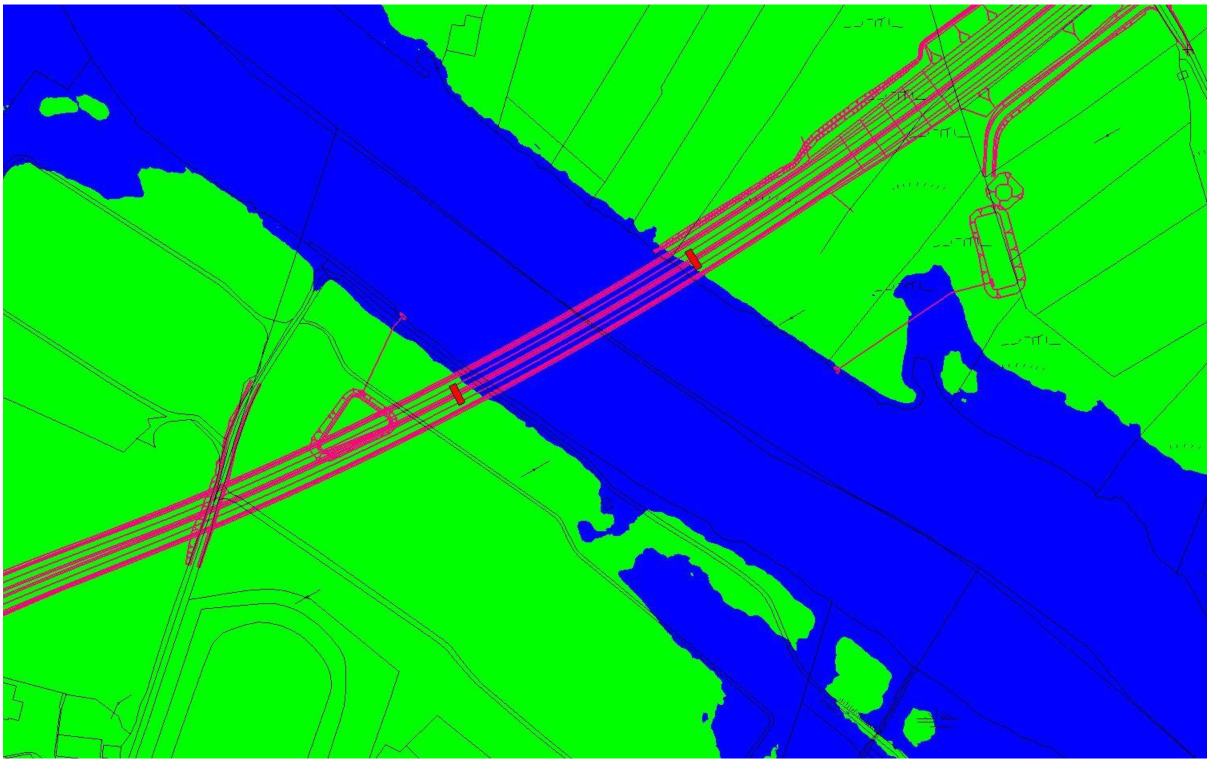


Figure 7 Flood inundation at River Corrib crossing for the 1000 year flood event

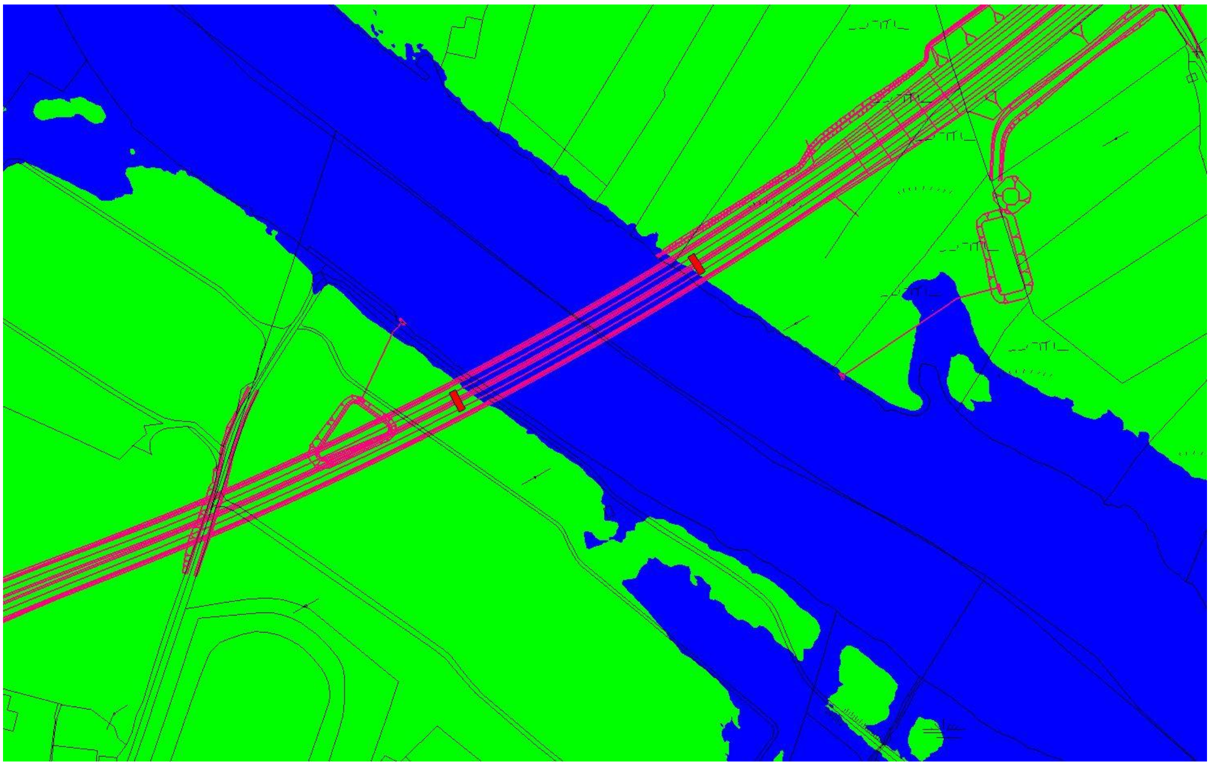


Figure 8 Flood inundation at River Corrib crossing for the 100 year with Climate Change flood event

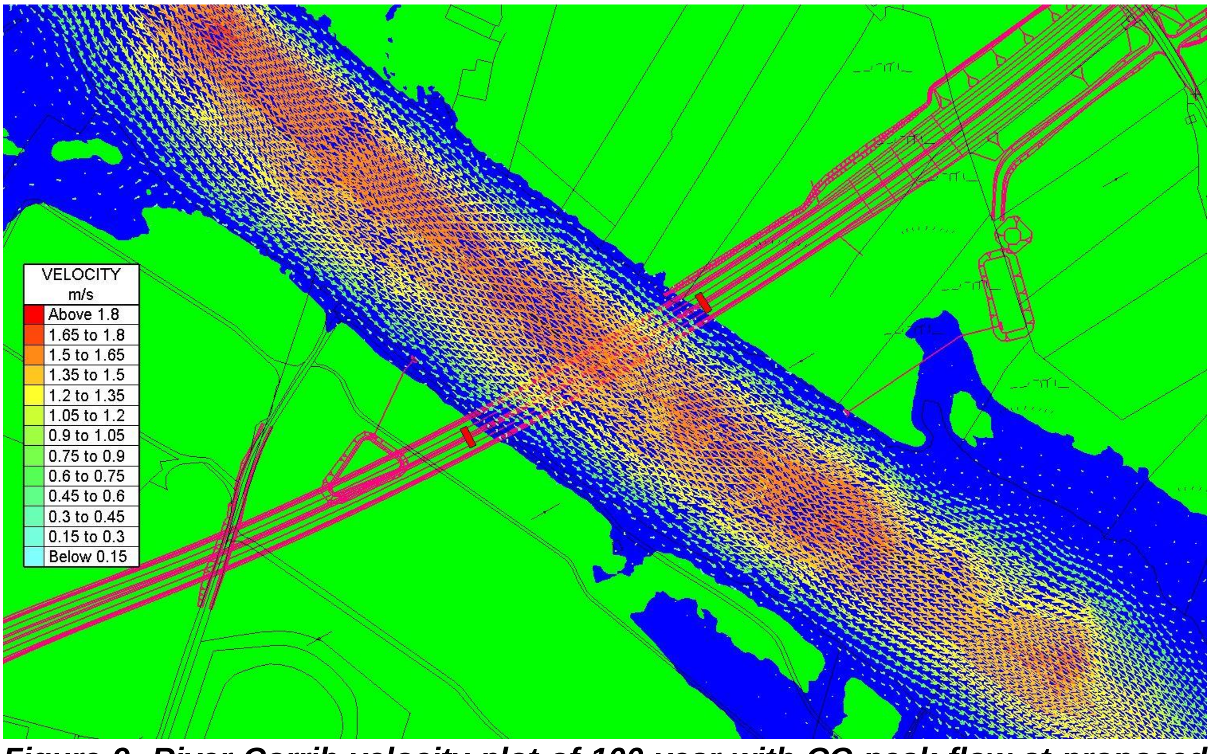


Figure 9 River Corrib velocity plot of 100 year with CC peak flow at proposed bridge crossing

4.3.7 Redevelopment of Pitches at NUI Galway Dangan Recreational Facility

The proposed road development impacts the NUIG Recreational Facilities at Dangan with direct impacts on one of the two existing GAA pitches adjacent to the River Corrib and a training pitch to the front of the existing sports pavilion. The latter has received planning permission for conversion to an all-weather sports pitch (planning reference 14104) which would be floodlit. To mitigate the impact to these two pitches, it is proposed to construct an all-weather full size GAA pitch and a training pitch at the location of the existing GAA pitches adjacent to the River Corrib.

An all-weather sports pitch utilises artificial surfacing which aims to replicate the appearance of natural grass and facilitates use in all-weather conditions. Its benefits include lesser maintenance on items such as irrigation and trimming.

Flood risk mapping of the River Corrib at Dangan presented in Figure 10 shows the proposed reconfigured pitches to be generally in Flood Zone C (green shading i.e. low risk of flooding) at existing elevations above the predicted 1,000year flood level of 7.62m OD Malin. The second, larger playing pitch is shown along its northeast side to be within the 100year flood level (blue shading) Flood Zone A and 1,000year flood level (cyan shading). The development of the pitches is likely to result in the raising of land so that the pitches are free from flooding and can drain effectively. The pitch drainage will be directed to a local existing drainage ditch to the southeast which has ample capacity to discharge the pitch drainage and the local drainage waters safely to the River Corrib. This drainage runoff will have no impact on the flow regime or hydrochemistry of the receiving River Corrib.

The potential loss of floodplain storage is miniscule in comparison to the available flood storage in the River Corrib and will not impact the flow regime in the River Corrib or affect flood risk elsewhere. Recreational/sports pitches are considered suitable development within high and moderate Flood Zones A and B under the flood risk management planning guidelines (2009). For longevity of the artificial surface the pitch elevation should be set above the estimated 100year flood level plus 250mm freeboard suggesting a minimum finish surface level of 6.8m OD.

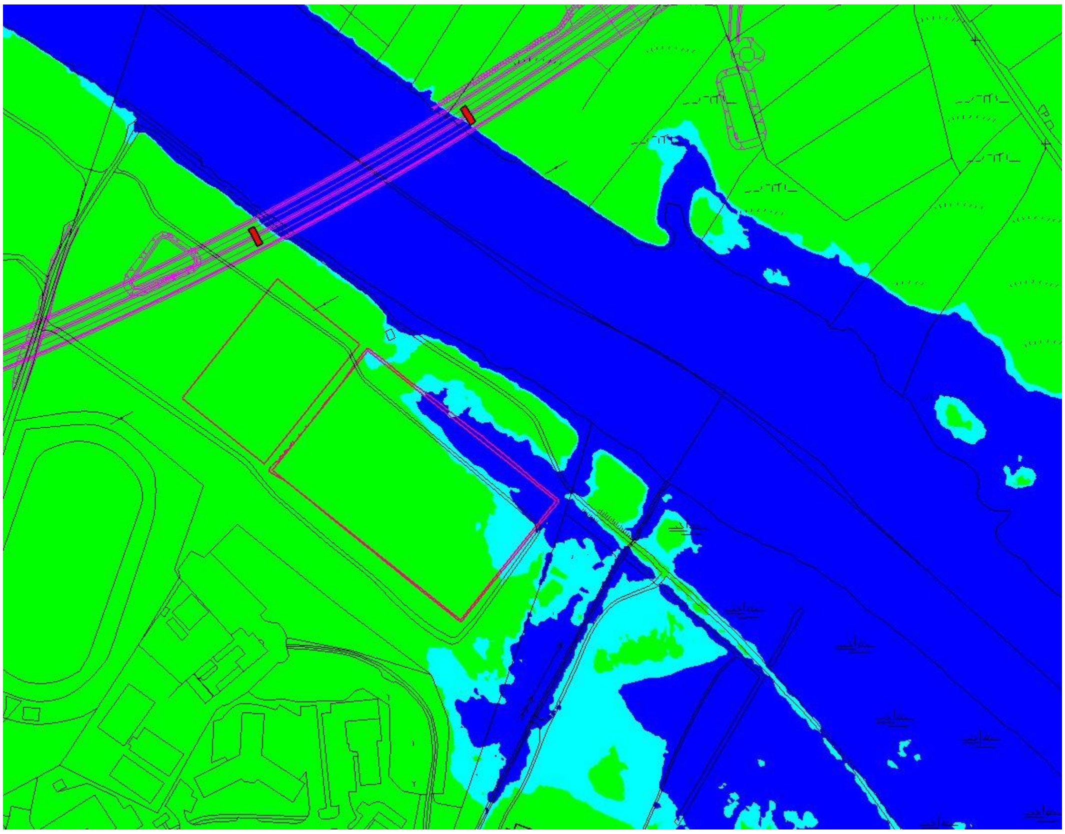


Figure 10 Flood Risk Mapping of proposed NUIG pitches at Dangan.

4.3.8 Fluvial Flood Risk Assessment of the proposed road development at Knocknacarra

The proposed N59 Link Road from Chainage 1+550 to 2+200 and the proposed upgrade and realignment to the Gort Na Bró and the Rahoon to Western Distributer Road are shown to be extensively located in the fluvial flood risk Zone A (High Flood Risk) of the Knocknacarra Stream, based on the Galway City Strategic Flood Risk Assessment (SFRA) flood zone mapping prepared by JBA (30th September 2015) and the OPW pFRA mapping. Both the Galway City Council SFRA and the OPW pFRA mapping are very coarse and do not include details of the stream channel or its various culverts. These preliminary assessments used the EPA/OSI historic watercourse alignment which no longer exists having been replaced and realigned by a large storm water pipeline as part of a land development initiative in c. 1996. This flood risk mapping only allowed for overland flow based on coarse resolution DTM lidar data and did not include for the within channel / storm pipe conveyance capacity.

Examination of this flood risk mapping against the OPW lidar 2m DTM ground levels clearly indicates that this mapping is unrealistic and coarse as the flood outline does not follow the local contours. As part of this FRA for the proposed road development the Knocknacarra Stream storm pipe trunk main was modelled using the Microdrainage software program with pipe invert levels, pipe diameters, manhole locations and cover levels specified using the storm drainage data provided by Galway City Council. The estimated design flows from the FSU method were input at various nodal points. The details of flows are contained in Table 11 below. The micro-drainage simulation run showed ample capacity at the 1000-year flood event within the storm pipe as not to result in flooding in the vicinity of the proposed link road or the various realigned junctions at Gort Na Bró and the Rahoon to Western Distributer Road. It is concluded that the proposed road development does not encroach the floodplain area or the flood risk zones of the Knocknacarra Stream and therefore will not impact on flooding. In keeping with the Galway City sustainable urban drainage policy all storm discharge from the proposed road development to the existing culverted Knocknacarra stream will be attenuated to the natural greenfield runoff rates and therefore will not impact on the natural flow regime, flood flows and associated flooding.

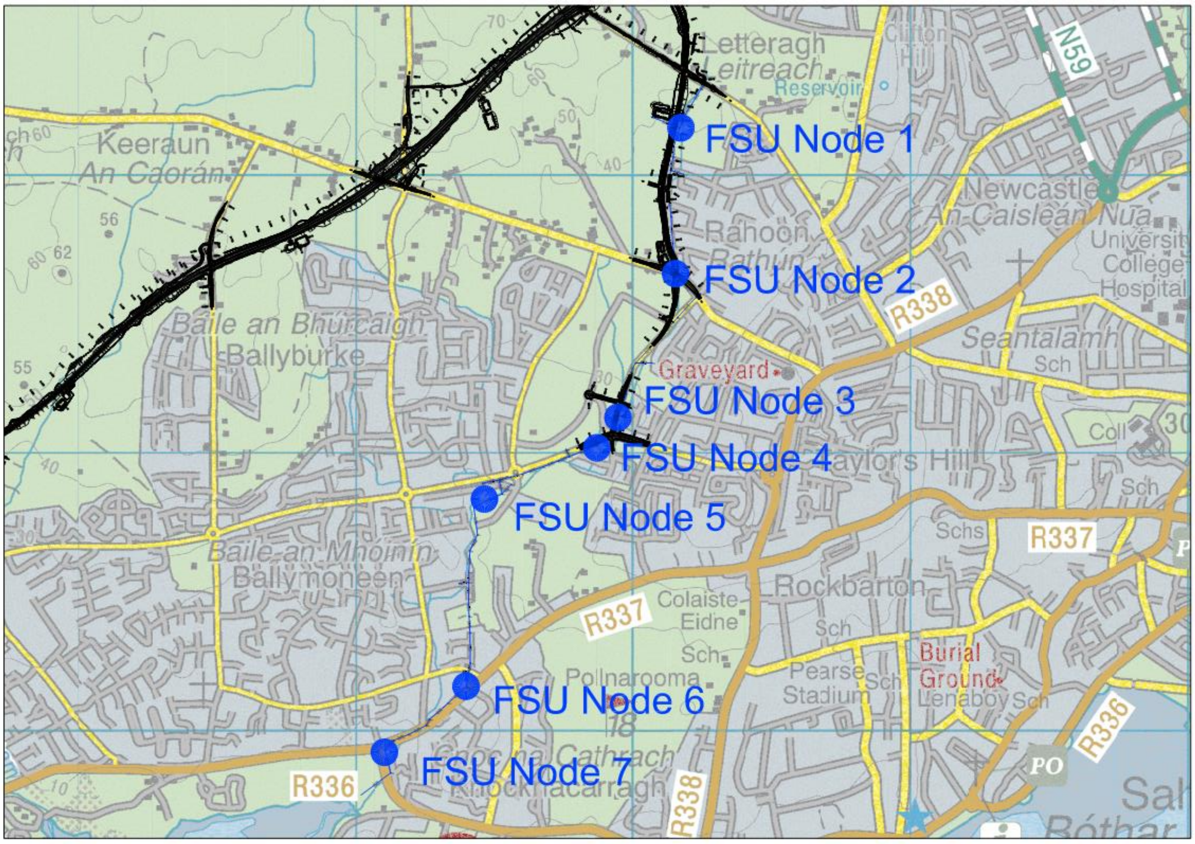


Figure 11 Main Trunk Storm Sewer and FSU Node Locations for Knocknacarra

Table 11 – Design Flows using FSU Catchment Nodes

Return Period	Growth Factor	Design Flow (m^3/s)						
		Node 1	**Node 2**	**Node 3**	**Node 4**	**Node 5**	**Node 6**	**Node 7**
Qmed (Urban Estimate)		0.315	0.426	0.741	0.931	1.998	2.561	2.817
Q5	1.3	0.410	0.553	0.964	1.211	2.598	3.329	3.662
Q10	1.5	0.473	0.638	1.112	1.397	2.997	3.842	4.226
Q20	1.68	0.529	0.715	1.245	1.565	3.357	4.303	4.733
Q50	1.93	0.608	0.821	1.431	1.797	3.857	4.943	5.437
Q100	2.11	0.665	0.898	1.564	1.965	4.216	5.404	5.944
Q1000	2.71	0.854	1.153	2.009	2.524	5.415	6.941	7.634

Table 12 – Flow Capacity Simulation Summary for Knocknacarra Storm Sewer

Pipe Number	USCL (m AOD)	DSCL (m AOD)	USIL (m AOD)	DSIL (m AOD)	Length (m)	Slope (1:X)	Diameter (mm)	Capacity (l/s)	1000 Year FSU Design Flow	Status	FSU Node Reference
S1.000	43.0	40.4	39.308	38.27	14.39	14	600	1856	641	ok	
S1.001	40.4	39.1	38.27	37.426	65.057	77	600	785	641	ok	
S1.002	39.1	38.1	37.426	36.38	29.509	28	600	1300	641	ok	
S1.003	38.1	36.3	36.38	34.331	36.906	18	600	1628	641	ok	
S1.004	36.3	36.3	34.331	34.229	30.299	297	600	398	641	flood risk	
S1.005	36.3	35.9	34.229	33.999	70.258	306	600	392	854	surcharged	Node 1
S1.006	35.9	36.0	33.999	32.039	37.404	19	600	1581	854	ok	
S1.007	36.0	35.5	31.439	30.998	49.425	112	1200	3996	854	ok	
S1.008	35.5	34.9	30.998	30.684	72.859	232	1200	2773	854	ok	
S1.009	34.9	34.2	30.684	30.24	93.604	211	1200	2910	854	ok	
S1.010	34.2	33.8	29.94	29.858	95.544	1165	1500	2205	854	ok	
S1.011	33.8	33.1	29.858	29.736	85.734	703	1500	2846	854	ok	
S1.012	33.1	33.3	29.736	29.408	42.554	130	1500	6653	1153	ok	Node 2
S1.013	33.3	33.9	29.408	28.948	94.183	205	1500	5291	1153	ok	
S1.014	33.9	32.1	28.948	28.55	99.292	250	1500	4791	1153	ok	
S1.015	32.1	32.0	28.55	28.023	99.114	188	1500	5522	1153	ok	
S1.016	32.0	31.7	28.023	27.281	123.811	167	1500	5864	1153	ok	
S1.017	31.7	30.1	27.281	26.626	55.529	85	1500	8236	1153	ok	
S1.018	30.1	30.0	26.626	26.557	62.398	904	1500	2506	1153	ok	
S1.019	30.0	29.0	26.557	26.3	37.041	144	1500	6314	1153	ok	
S1.020	29.0	28.9	26.3	26.137	23.595	145	1500	6297	1153	ok	
S1.021	28.9	29.1	26.137	25.627	63.998	126	1500	6765	2009	ok	Node 3
S1.022	29.1	29.0	25.627	25.267	48.425	135	1500	6533	2009	ok	
S1.023	29.0	27.8	25.267	24.892	46.537	124	1500	6803	2009	ok	
S1.024	27.8	25.4	24.892	21.17	107.337	29	1500	14137	2524	ok	Node 4
S1.025	25.4	24.5	21.17	20.458	42.107	59	1500	9865	2524	ok	
S1.026	24.5	23.6	20.458	19.495	58.694	61	1500	9717	2524	ok	

Pipe Number	USCL (m AOD)	DSCL (m AOD)	USIL (m AOD)	DSIL (m AOD)	Length (m)	Slope (1:X)	Diameter (mm)	Capacity (l/s)	1000 Year FSU Design Flow	Status	FSU Node Reference
S1.027	23.6	22.0	19.495	18.318	80.593	69	1500	9166	2524	ok	
S1.028	22.0	21.4	18.318	17.586	41.689	57	1500	10053	2524	ok	
S1.029	21.4	20.7	17.586	16.978	40.37	66	1500	9309	2524	ok	
S1.030	20.7	20.6	16.678	16.656	4.034	183	1800	9002	2526	ok	
S1.031	20.6	19.5	16.656	16.248	49.184	121	1800	11110	2526	ok	
S1.032	19.5	19.1	16.248	16.106	112.381	791	1800	4316	5415	surcharged	Node 5
S1.033	19.1	19.7	16.106	15.704	100.92	251	1800	7688	5411	ok	

4.3.9 Pluvial Flood Risk Assessment of the proposed road development at the N17 Tuam Road, Twomileditch.

The Twomileditch area on the N17 Tuam Road has a drainage basin that is 1.21km^2 (121ha) in area that includes 71ha from the Ballybrit side and 50ha from the northwest/Roadstone Quarry side of the N17 Tuam Road,refer to Figure 12. The road falls over a distance of 1300m from 38m OD at the Parkmore Road junction to 17.8m OD at its low point located mid-way between the Roadstone Quarry entrance and the City North Business Park site. After which the road rises, in the Galway City/Castlegar direction, from 17.8m OD to 26.3m over a distance of c. 500m.

There is no natural overland surface water outflow for this drainage catchment with rainwater generally infiltrating to groundwater. During flood conditions flood waters off the hillslopes regularly pond on the low sections of roadway and in the low-lying fields adjacent to the N17 Tuam Road, where over time this runoff gradually infiltrates to groundwater.

The N17 Tuam Road at Twomileditch in times of flood acts as a stream bed capturing and conveying runoff waters along its 1300m length to the low point where the flood waters flow into the low-lying lands located primarily on the northwest and also on southeast side of the road near the Kenny Galway site. The lands adjacent to the N17 Tuam Road on the southeast side, near Ch. 14+050 and the rear Galway Racecourse access road entrance receive drainage waters from the existing N17 Tuam Road via a gully system piped to a large soakaway. The contributing catchment is predominantly located on the southeast (Ballybrit side) of the N17 Tuam Road off a steep ridge that runs parallel to the N17 Tuam Road. This ridge is generally undeveloped open pastureland except for the Galway Racecourse buildings and associated roads/car park area and the Parkmore East Business Park. It is important to note that the Galway Racecourse development and the Parkmore East Business Park storm runoff discharges in the opposite direction southwards to the public storm sewer and away from the Twomileditch catchment.

The City North Business Park which includes the Kenny Garage and An Post depot has a drainage area of c. 17ha which is within the natural topographical catchment of Twomileditch. The storm water from this development area is discharged by gravity in a large storm sewer (referred to as the Kenny storm sewer) that outfalls to the Terryland River channel near Castlegar.

At present the existing N17 Tuam Road drainage system at this location consists of a length of storm drainage pipe with gullies laid along the southern side of the roadway which discharges into a large stone infiltration/soakpit area inside field boundaries near the Galway Racecourse access road. This present system is incapable of dealing with heavy rainfall events given the poor permeability of the soil beneath the percolation field in this area ponds within the fields and on the road and its hard-shoulder. Along the N17 Tuam Road further to the northeast a number of roadside drainage trenches have been dug to allow floodwaters to spill from the N17 Tuam Road into lower undeveloped fields on the east side of the road where stormwaters is allowed pond and infiltrate .

Anecdotal flood information for the row of 7 bungalow houses located 200m downstream (southwest) of the Roadstone Quarry entrance indicates recurring flooding of the existing road in front of the houses and that one house with a finished floor level of 18.34m OD, has flooded in the past. The remaining six houses are understood to have escaped flooding having finish floor levels ranging from 18.6m to 19.1m OD.

This flooding was caused by flood waters spilling laterally from the hard-shoulder down their driveways. These premises have since been protected by a slightly raised mound across their driveway entrance. Larger flood events could result in some of these shallow entrance mounds being overtopped. It is also noted that Galway City Council during heavy rainfall pump floodwaters from the N17 road into the Kenny Galway storm sewer using temporary pumps.

There are two distinct flooding processes in operation at the Twomileditch section of the N17 Tuam Road:

- A build-up of flood waters at the lowest point on the existing road with the potential to rise in excess of 18.5m OD. This occurs on the section of existing road from Roadstone Quarry entrance to the Kenny Galway site.
- Sheet flow along the existing road with lateral overspill into adjacent roadside properties this generally occurs upstream (northeast) of the Roadstone Quarry entrance.

An important safety feature in regard to limiting flood levels on the N17 Tuam Road currently exists where floodwaters can eventually overspill from the road into low-lying agricultural lands to the northwest which are at much lower elevations of 17 to 17.5m OD with the lowest point in the field at c. 16.5m OD. These low lying lands which have been identified in the pFRA mapping as having a pluvial flood risk are shown in Figure 10. These lands are within an enclosed basin and depend solely on infiltration to groundwater for drainage. Plate 2 presents aerial photo of flood conditions on the 3rd January 2016. This indicates some ponding within the pluvial flood risk lands but not extensive flooding which suggests some infiltration within these lands, particularly given the extreme and prolonged nature of the flooding and rainfalls during the December 2015/January 2016 flood event. It is important to note that during flooding events the local authority pump storm water from the N17 Tuam Road into the Kenny storm sewer where it outfalls into the Terryland River.

The proposed road development which includes a bridge structure over the N17 Tuam Road and merge and diverge slip roads encroach into these flood prone lands, Refer to Figure 13. The proposed paved area of the road development to be drained within this catchment is 7.6ha and total contributing area is 12.7ha. The proposed road drainage will be discharged to groundwater via a series of engineered infiltration basins and the storage within these infiltration basins has been sized to cater for the 100year storm event.

Using lidar topographical level data, the storage available on these lands at various flood levels is presented in Table 13 below with and without the proposed road development. At the critical flood level of 18m O.D., above which the N17 Tuam Road floods and houses are at risk of flooding, the proposed road development will result in a potential reduction in the flood storage volume on these lands by 21.2%.

Table 13 Storage Volume Calculations of Pluvial Flood Risk Lands at Twomileditch

Water level m OD	Existing Storage Volume (m^3)	Storage Volume with N6 GCRR (m^3)	Loss of Storage (m^3)	% Loss of Storage
16	1690	1690	0	0.0
16.5	8190	8190	0	0.0
17	13,200	12490	710	5.4
17.5	22,740	18475	4,270	18.8
18	35,900	28270	7,630	21.2
18.5	54,470	41990	12,480	22.4

The effective lands that contribute to pluvial flooding along the N17 Tuam Road and within the enclosed depression pluvial flood risk area have a catchment area of c. 121ha, 71ha on the east side and 50ha on the west side of the N17 Tuam Road. The high percentage runoff occurs from the very steep hillslopes between N17 and Ballybrit at Soil Type 5 and the remainder of the catchment is categorised conservatively as moderate percentage runoff (Soil Type 3). Depending on the duration and intensity the average percentage runoff of rainfall varies between 42% and 49% for a 1 to 48hour rainstorm duration. The estimated flood runoff volumes for this drainage catchment are presented below in Table 14 for 2, 10 and 100year return period flood events and for various storm durations.

Table 14 Computed flood runoff volumes for various rainfall durations and return periods.

Duration	Rain Depth (mm)			Runoff Volume (m^3)		
hours	2yr	10yr	100yr	2yr	10yr	100yr
1	11.8	17.8	28	6038	9108	14328
2	15.3	22.4	34.1	7829	11462	17449
3	17.8	25.7	38.3	9108	13151	19598
4	19.8	28.2	41.6	10132	14430	21601
6	23.1	32.3	46.7	11820	16528	24859
9	26.9	37	52.5	13765	18933	28539
12	29.9	40.8	57.1	15300	21067	31487
18	34.8	46.7	64.2	17807	24859	36104
24	38.7	51.2	69.5	19803	27712	39608
48	48.5	63.2	84.2	25999	35448	49588

Note existing storage at 18m flood level is 35,900m^3 and proposed road development has a potential to reduce this storage by 7,630m^3 to 28,270m^3.

This loss of flood storage has the potential to increase flood risk to the N17 Tuam Road and adjacent dwellings and lands.

Flood Mitigation

Without suitable mitigation the proposed road development will have a significant impact on pluvial flooding on these lands and will increase the flood risk to other properties. The proposed elevation for the mainline of the proposed road development is sufficiently elevated not to be at risk.

The mitigation measures required to eliminate the flood impact of the proposed road and reduce the existing flood risk are as follows:

- Prevent the upgraded portion of the N17 Tuam Road from spilling laterally westwards into the driveways of existing houses by :
  - Upgrading and providing effective road drainage along the N17 Tuam Road which will convey, treat and attenuate the flow before being infiltrated to ground as part of the mainline drainage network.
  - Provision of an interceptor ditch to intercept and collect the overland runoff from the steep hills to the east of the N17 Tuam Road.
  - Provision of an infiltration trench to allow the runoff collected by the interceptor ditch for the less severe rain storm events to infiltrate to ground.

  - Provision of a series of overflow culverts from the infiltration trench to the low lying lands northwest of the proposed road development.

- Compensate flood storage lost below 18m OD by providing compensation storage of 8030m^3 in the form of an excavated rectangular flood compensation storage area having an invert level of 16m OD and a top elevation of 17.5m OD.
- Connect the proposed flood compensation storage area to the remaining low-lying natural storage and floodplain lands located to the northwest of the proposed road development through the series of 1200mm culverts.
- Where possible divert storm flows from the proposed development road catchment to the gravity Kenny storm sewer.
- Provision of a permanent pumping station connecting the flood compensation storage area to the Kenny storm sewer via a rising main with a pumping capacity of 250l/s.

Table 15 Required flood water storage required for different pumping rates

Duration hours	Pumping 250 l/s	Storage Volume Required (m^3)		
		2yr	10yr	100yr
1	900	5138	8208	13428
2	1800	6029	9662	15649
3	2700	6408	10451	16898
4	3600	**6532**	10830	18001
6	5400	6420	**11128**	19459
9	8100	5665	10833	20439
12	10800	4500	10267	**20687**
18	16200	1607	8659	19904
24	21600	0	6112	18008
48	43200	0	0	6388

The required flood storage with pumping rate of 0.25cumec is 20,700m^3 for the 100year event. The required flood storage including 20% climate change is 24,800m^3.

The available storage in the flood compensation storage area at the top water level of 17.5m OD is 8030m^3 which in addition to the remaining natural storage with the proposed development in place of 18,470m^3, gives a total available flood storage of 26,500m^3.

The proposed Flood relief measures for the N17 described above are presented in Figure 14 and Drawing GCOB-500-D-600.

Residual Impacts
The residual flood risk associated with the N17 Tuam Road flood relief measures are:

- Discharge of flood water into the Terryland Basin at 250 l/s resulting in a slight increase in flood levels within the Terryland River, refer to Section 4.3.10.
- Reduction of available capacity within the Kenny storm sewer. The full bore capacity is estimated to be 900l/s and therefore the proposed maximum discharge of 250l/s will reduce the available capacity less than one third.
- Residual flood risk associated with pumping station breakdown etc.

Overall the proposed road development with produce a significant positive impact on flooding and flood risk at N17 Tuam Road and Twomileditch.

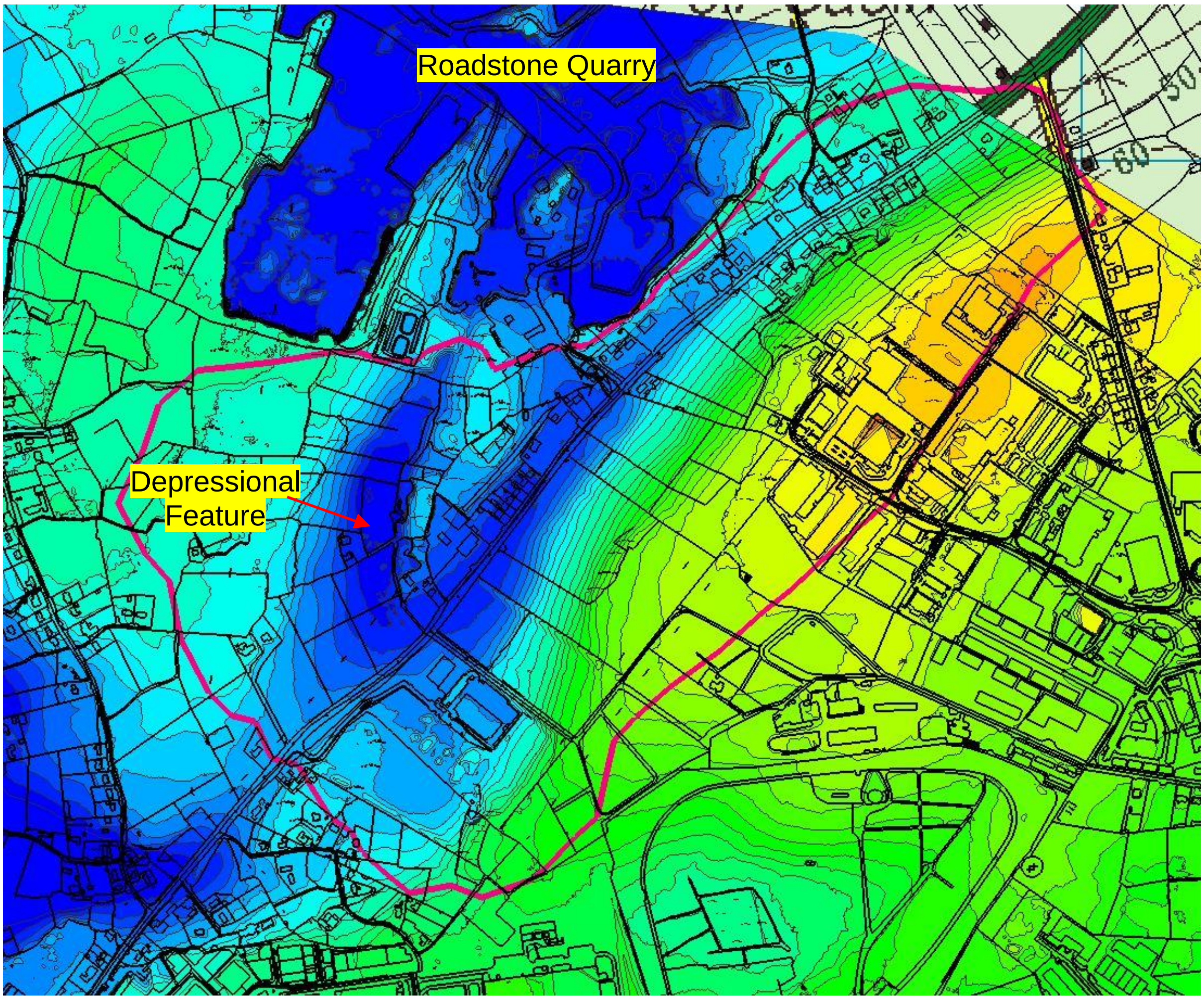


Figure 12 Twomileditch / N17 Tuam Road drainage catchment and 2m contours showing depressional feature that is subject to flooding.

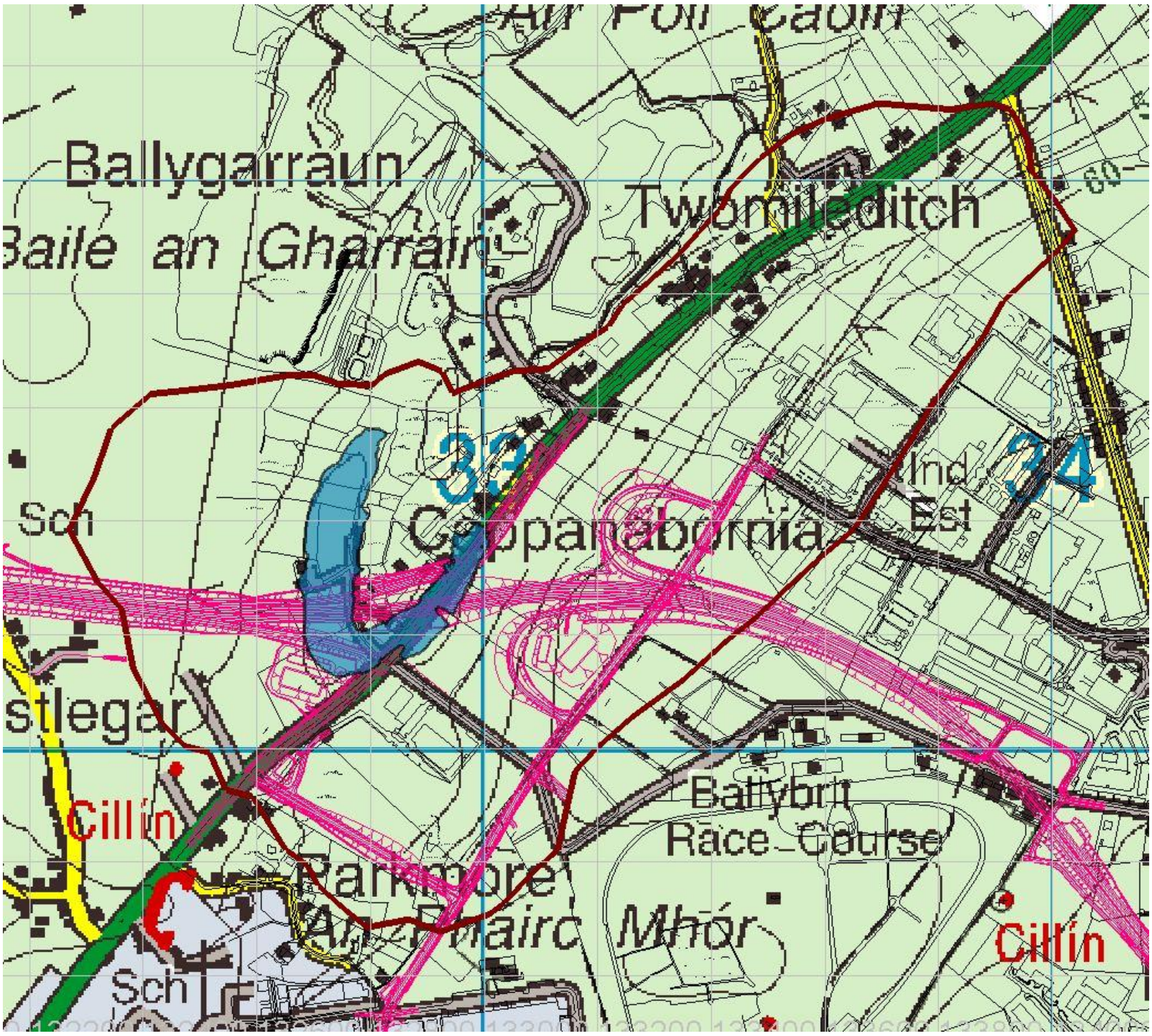


Figure 13 Twomileditch / N17 Tuam Road drainage catchment and the flood risk lands by the 18.5m OD Contour and the proposed road alignment overlaid.

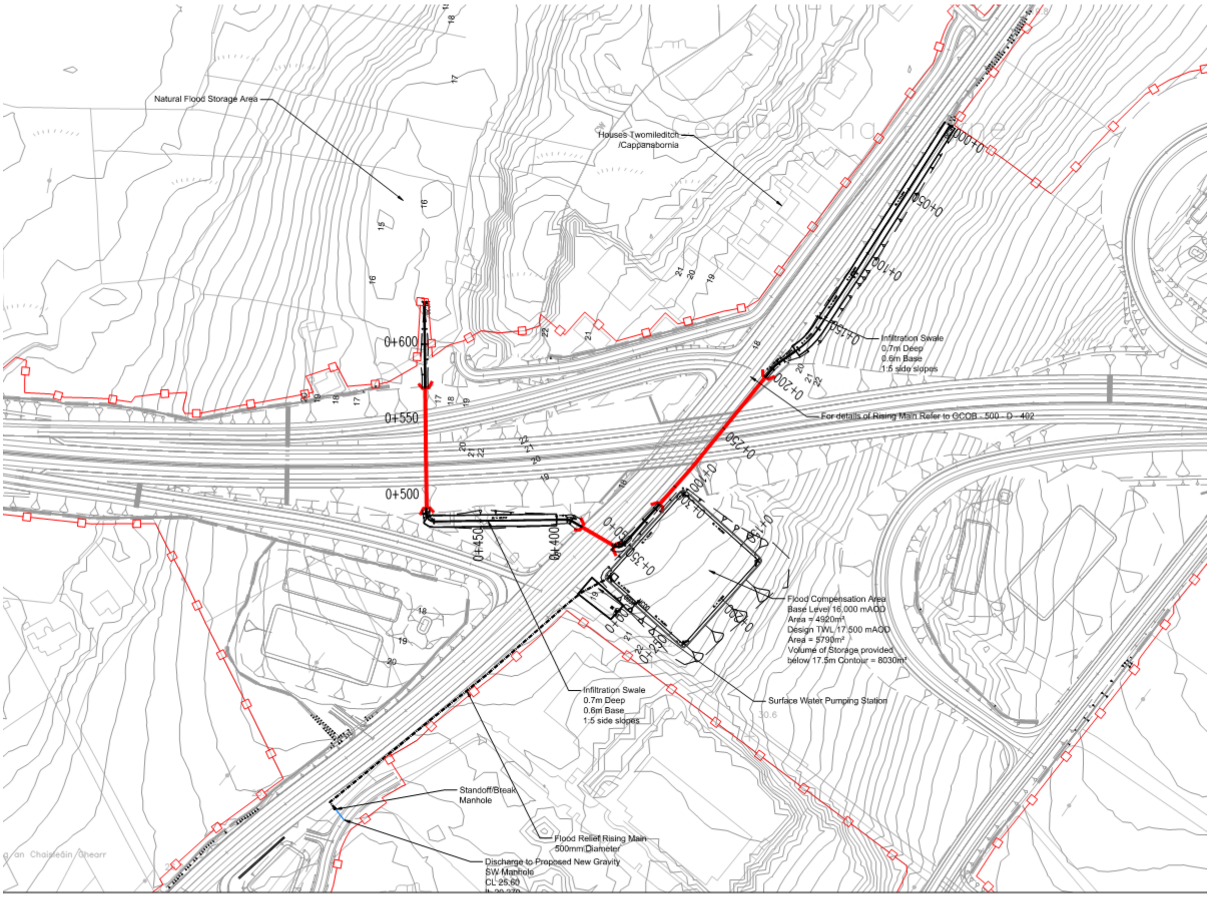


Figure 14 Flood relief mitigation measures for Twomileditch / N17 Tuam Road area

Plate 2 Aerial photo of ponded waters on lands adjacent to the N17 Tuam Road at Twomileditch taken by Barrow Photography on the 3rd January 2016.

Plate 3 Aerial photo showing flooding at Ballindooley Lough and ponding within Lackagh Quarry taken by Barrow Photography on the 3rd January 2016.

Plate 4 Flooding of the River Corrib at Dangan/Menlough taken by Barrow Photography on the 3rd January 2016.

4.3.10 Residual flood Impact on the Terryland River Basin

The Terryland River, also known as the Sandy River, is a small drainage system that essentially drains the Terryland Basin with a total catchment area of c. 6.75km^2, 1.8km^2 of which includes the Ballindooley Lough basin which is an enclosed system with possible groundwater flow connection. The Terryland River discharges to groundwater primarily via two swallow-holes located at Poulavourleen, west of Castlegar Village. There may also be some infiltration to the underlying karst limestone bedrock within the river channel. These swallow holes are believed to discharge to Galway Bay but the location of the outlet in Galway Bay is unknown.

Old historic maps of Galway (Grand Jury Map 1819) show that this stream was a spur off the River Corrib channel and lake like conditions occupied the valley floor during winter flooding in the River Corrib. Arterial drainage works as part of a Public Works Corrib Drainage and Navigation Scheme were carried out in the 1850's and as part of these works, constructed the Dyke Road embankment to prevent flooding from the River Corrib and allow the reclamation of the Terryland valley for farm land. Today, this embankment and the Salmon Weirs control and protect important commercial, industrial and retail developments. These include the Galway Retail Park, Galway Shopping Centre, Terryland Shopping Centre, Terryland Retail Park and Liosbán Industrial Estate within the Terryland basin.

The Terryland River forms part of OPW Corrib Drainage Scheme having arterial drainage works carried out on the river channel in the early 1960's that included regrading, widening and deepening of the channel. The arterial drainage works involved bed deepening, widening and regrading over approximately 3.4km of reach length from Terryland to the swallow holes. The channel bed was deepened and regraded so as to provide a bed slope of c. 0.00021 at a design flow depth of 1.52m and a channel base width of 5.8m (topwidth >8m). The bed elevation over 3.4km falls from 1.42 to 0.83m OD Malin and the bank elevation is typically greater than 3.25m OD.

A water intake channel (Galway Bore) from the River Corrib, near Jordan's Island, provides controlled inflow from the River Corrib to feed the city water supply at the Terryland Galway City Water Treatment Works. A bypass / overflow channel at the treatment works connects to the Terryland River channel via sluices which are generally kept almost closed to limit the spill volume from the River Corrib into the Terryland River.

A study of the Terryland River, performed by KT Cullen and Tobin Consulting Engineers for Galway City Council in 1998, found that water levels in the river varied with the tide from 1.6 to 2.6m OD Malin. The observed water level profile displayed a strong sinusoidal tidal response and a period between highwaters of slightly more than 12hours. The high spring tides were found to produce reasonably similar high water levels to the recorded tidal highwater levels in inner Galway Bay (c. 0.1 to 0.15m lower). The neap highwaters were found to be typically +0.6m higher than the tidal highwater at Galway. The observed tidal signal is 0.7 to 0.8m range on spring tides and 0.3 to 0.4m range on neap tides upstream of the swallow holes. The tidal influences in Galway Bay produce a Mean High Water Spring (MHWS) Tide of 2.19m OD Malin, a Mean High Water Neap (MHWN) tide of 0.99m OD and a Highest Astronomical Tide (HAT) of 2.7mOD Malin. Very similar high tide levels occur between Galway Bay and recorded levels in the Terryland Basin, indicating a direct connection with tidal levels in Galway Bay causing a backing up of waters in the basin during high tides and a slight reversal of flow recorded by the velocity meter on high tides. During spring and neap tides the outflow period is generally in excess of 6hours duration and capable of emptying the inflow and tidal volume in that period.

Historical maps (1819) show the entire Terryland River Valley as inundated and part of the River Corrib system. The capacity of the swallow holes is unknown and a previous 1998 KT Cullen Study for Galway City Council recommended that development levels in the basin be set above 7m OD which is equivalent to the River Corrib level in severe flood (> 100year Return Period in River Corrib upstream of Salmon Weir Barrage).

The CFRAM model study estimates flood levels of 2.95 to 3.15 for the 10year flood event, 3.4 to 3.6m OD for the 100year flood event and 4.9 to 5.0m OD for the 1000 year flood event in the Terryland River Valley.

Table 16 FSR Catchment Characteristics of the Terryland River

Catchment Characteristic	
AREA (km^2)	6.75
Annual Rainfall SAAR (mm)	1160
Winter Rainfall Acceptance potential SOIL Index	0.15 (type 1)
Channel Flood Slope S1085 (m/km)	0.4
URBAN – fraction of catchment	44%

Table 17 FSU Catchment Descriptors of the Terryland River (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km2)	6.75
Annual Rainfall SAAR (mm)	1163
FARL	1
BFISOIL Baseflow Index of Soils	0.5726
Drainage Density DRAIND km per km2	0.529
Channel Flood Slope S1085 (m/km)	0.435
Arterial Drainage Factor ARTDRAIN2	1.0
URBAN – fraction of catchment	0.435

The estimated QMED median flood flow for the Terryland River catchment is 1.92cumec representing a moderate flood runoff rate of 0.284cumec per km^2. This runoff rate almost doubled that of a greenfield rural catchment due to significance of the urbanised fraction at 43.5%. The capacity of the swallow-holes is unknown, but to date have been sufficiently ample as not to result in any significant inundation of the basin area. This suggests that potentially 3.8cumec peak flow would discharge to the swallow holes at times of extreme flood (i.e. 100year) producing a flood level of c. 3.5m OD.

The potential floodplain area and flood storage within the Terryland Basin is presented in figure 15 to 16 for a range of flood elevations. No commercial/residential development has taken place in this basin area below 6.0m OD elevation. The previous recommendation from the Preliminary Report for the Terryland River Valley Drainage Scheme (Feb 1999) was a minimum level of 7mOD

The proposed flood discharge from the N17 road is 0.25cumec during a flood event and could potentially discharge over 24 to 48hours. The critical period is during the incoming flooding tide when tidal levels are elevated and prevent / reduce discharge for a period of less than 6hours. A worst case, very conservative estimate is that no outflow occurs during a 6-hour tidal flooding period. At the 100 and 1000year flood levels in the Terryland basin the impact of the proposed N17 flood relief discharge on water levels in the Terryland River is small at 0.051m and 0.008m respectively and will not cause an unacceptable flood impact to development within the basin.

In conclusion the impact from the proposed flood relief measures for the N17 at Twomileditch will not cause an unacceptable flood impact and the hydrological impact magnitude is rated as slight.

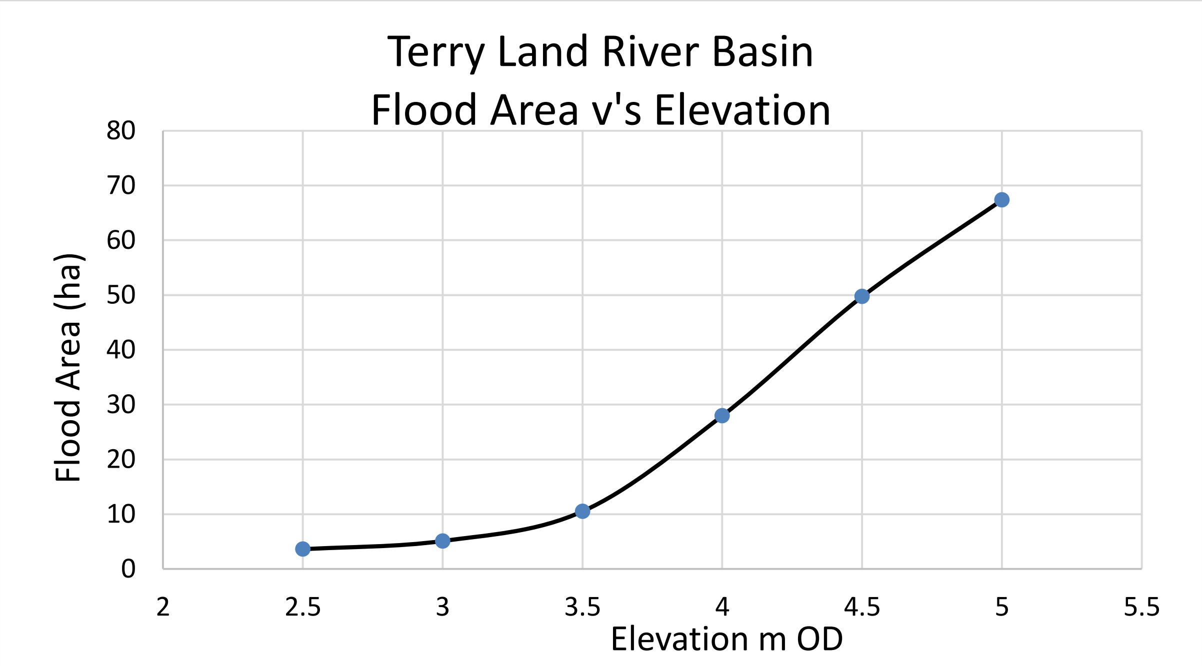


Figure 15 Flood Area – Elevation Relationship in the Terryland Floodplain

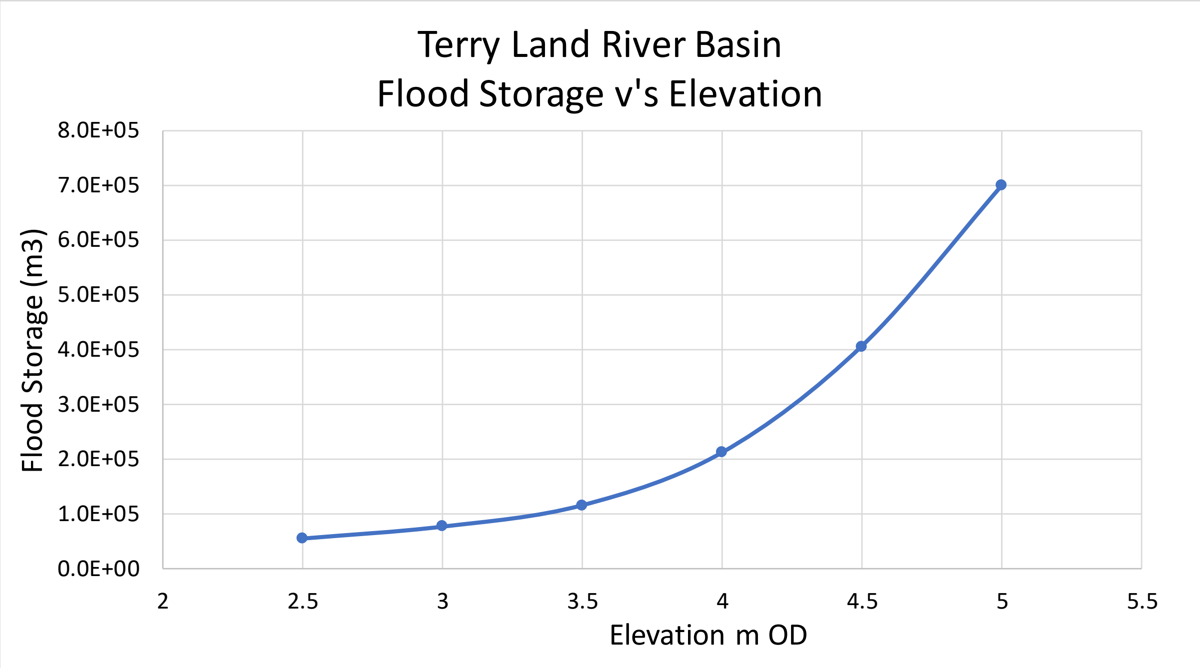


Figure 16 Flood Storage – Elevation Relationship in the Terryland Floodplain

5. CONCLUSIONS AND SUMMARY

A Flood Risk Assessment of the proposed road development was carried out and the findings are summarised in Table 16 below:

Table 16 Proposed Road Development FRA Summary

Site Description	The proposed road development begins west of Bearna Village, passes to the north of Galway City and joins the existing N6 at Coolagh, Briarhill. The proposed road development will comprise of a Type 1 Single Carriageway in the west connecting to a Type 1 Dual Carriageway at the Ballymoneen Road. From the N59 Link Road the proposed road development is an Urban Motorway until its connection with the existing N6 at Coolagh, Briarhill. The alignment of the proposed road development and its associated link roads generally avoids the fluvial floodplain areas. The proposed crossing of the River Corrib at Dangan/Menlough spans the channel, where there is only very slight overbank flooding on both bank edges under 100 year and 1000 year flood flow scenarios.
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 River Corrib, Bearna Stream, Truskey Stream, Knocknacarra Stream, and Sruthán na Líbeirtí and smaller tributary drains. Pluvial flooding at Doughiska and the N17 Tuam Road at Twomileditch. Localised pluvial flooding associated with small topographical depressions at a number of locations along the proposed road development. Groundwater flood risk associated with a small enclosed depression intercepted east of Ballindooly and potential elevated groundwater levels at the disused Lackagh Quarry.

	Coastal flooding is not a source of flood risk for the proposed road development either directly or indirectly.
Benefitting from flood defences or flood relief scheme	The levels in the River Corrib are controlled by the OPW who operate the Salmon Weir Barrage. The River Corrib channel was also deepened as part of the Corrib Arterial Drainage Scheme in the early 1960's with the Salmon Weir replacement barrage constructed by the OPW in 1959.
Historical Flooding	The River Corrib, at the proposed crossing location, flows generally within the channel banks. During extreme flooding such as December 2015/January 2016, winter flood waters were only observed to flood the immediate bank edge (refer to Plate 4). The floor of Lackagh Quarry is flooded regularly during winter flooding with the groundwater table elevated above existing quarry floor (refer to Plate 3). The N17 Tuam Road at Twomileditch regularly floods as a result of overland runoff from the carriageway and local hill slopes at Ballybrit, with the road and a number of houses historically flooding. Galway City Council currently engage in pumping stormwater from the N17 Tuam Road so as to minimise disruption to traffic. Groundwater and pluvial flooding at Doughiska which has since been alleviated by draining via a large 1500mm storm pipe. This services the area and future urban development
Flood Risk	The section of the River Corrib, at the crossing point of the proposed road development, has been modelled in the CFRAM detailed study and predictions for the 100 year and 1000 year events are available. The full spanning structure does not encroach on the effective floodplain area of the River Corrib at the crossing point. There is minor encroachment by the road embankment of the River Corrib floodplain at Coolagh Lakes near Ch. 9+890 which is minor and will not result in a perceptible impact on flooding

	At total of 16 small watercourses and drains will be crossed by the proposed road development and subsequently will be culverted. 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. A significant encroachment of Flood Risk Zone along the Knocknacarra Stream based on the Galway City Council SFRA mapping occurs along the N59 Link Road and associated upgrades to the Gort Na Bró and the Rahoon to Western Distributer Road. This mapping is not accurate and does not reflect the provision of a large storm water sewer system for this stream which has to sufficient capacity to prevent flooding in the vicinity of the road development. Section 50 approval has been obtained from the OPW concerning flooding and flood capacity of all culverts and the River Corrib Bridge. A number of small pluvial flood sources are encountered along the proposed road development associated with small local depressions which will be either fully or partially removed. The assessment indicates that these sources are minor and their drainage can easily be catered for in the proposed road drainage design. A pluvial flood source along the N17 Tuam Road and adjacent low-lying lands to the west and a small section to the east has a significant flood risk with over seven houses at risk and a section of the N17 Tuam Road. The proposed road development potentially encroaches a pluvial Flood Zone A (high probability of flooding zone) with the potential for 21% loss in available flood storage within these flood prone lands. The proposed road development will introduce significant additional paved area to the catchment and the proposed infiltration basins are within the contributing catchment area of this pluvial flood source. Without appropriate flood relief design the proposed road development had a potential to significantly impact on drainage and worsen the flood risk in this vulnerable area.

	Slight encroachment of Ballindooley Lough flood zone by the road embankment. The predicted effect of this on flood risk is negligible. The potential flood risk for the Lackagh Tunnel is rated as representing a moderate flood risk. This risk is associated with the potential for elevated groundwater table within the quarry under more extreme 1000 year flood events and climate change conditions. The proposed road development through the quarry will reduce storage and increase pluvial ponding depths contained within the lower bench of the quarry. 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.
Climate Change	The predicted increases in fluvial flood flows and rainfall of 20% are considered and catered for in the design.
Mitigation Measures	A drainage neutral approach to disposal of surface runoff is required utilising the principals of Sustainable Urban Drainage systems (SUDs) in terms of storm water attenuation and water quality treatment. The mitigation measures required to neutralise the flood impact to the Twomileditch Significant Pluvial Flood Risk area are as follows: • Upgrade and provide effective road drainage along the N17 Tuam Road. • Provide a factor of safety in the infiltration field and attenuation storage design to allow for high vulnerability areas. • Prevent the upgraded portion of the N17 Tuam Road from spilling laterally into the driveways of existing houses by ; • Where possible divert storm flows from the proposed development road catchment to the existing gravity storm water pipe. • Compensate flood storage lost below the 18.0m contour level with like for like flood storage.

	With the mitigation in place the loss of flood storage is compensated and there is a significant positive impact on flooding and flood risk in the Twomileditch and N17 Tuam Road area. Regular Inspection program of drainage facilities that includes, gullies, inspection chambers, pipes, culverts, outfalls, attenuation ponds and infiltration basins. Provide overflow facilities for attenuation ponds and infiltration basins. Provide a Flood Risk Management Plan for the Lackagh Tunnel associated with a potential groundwater flood risk.
Resiual Risk	The proposed tunnels, by virtue that waters require pumping to the foul sewer, retain a residual flood risk e.g. pump failure. The Twomileditch flood risk area will remain a high flood risk zone. The proposed N17 Twomileditch flood relief discharge to the Terryland River will cause a slight increase in flood level in the basin at the lesser return periods but will not cause an unacceptable flood impact. 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 basins along the proposed scheme development represent a potential source of flood risk should these ponds/basins 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 ponds represents a potential source of flood risk should the discharge exceed the infiltration capacity of the basin or the reduction over time of the performance of the basin as a result of silt deposition etc.

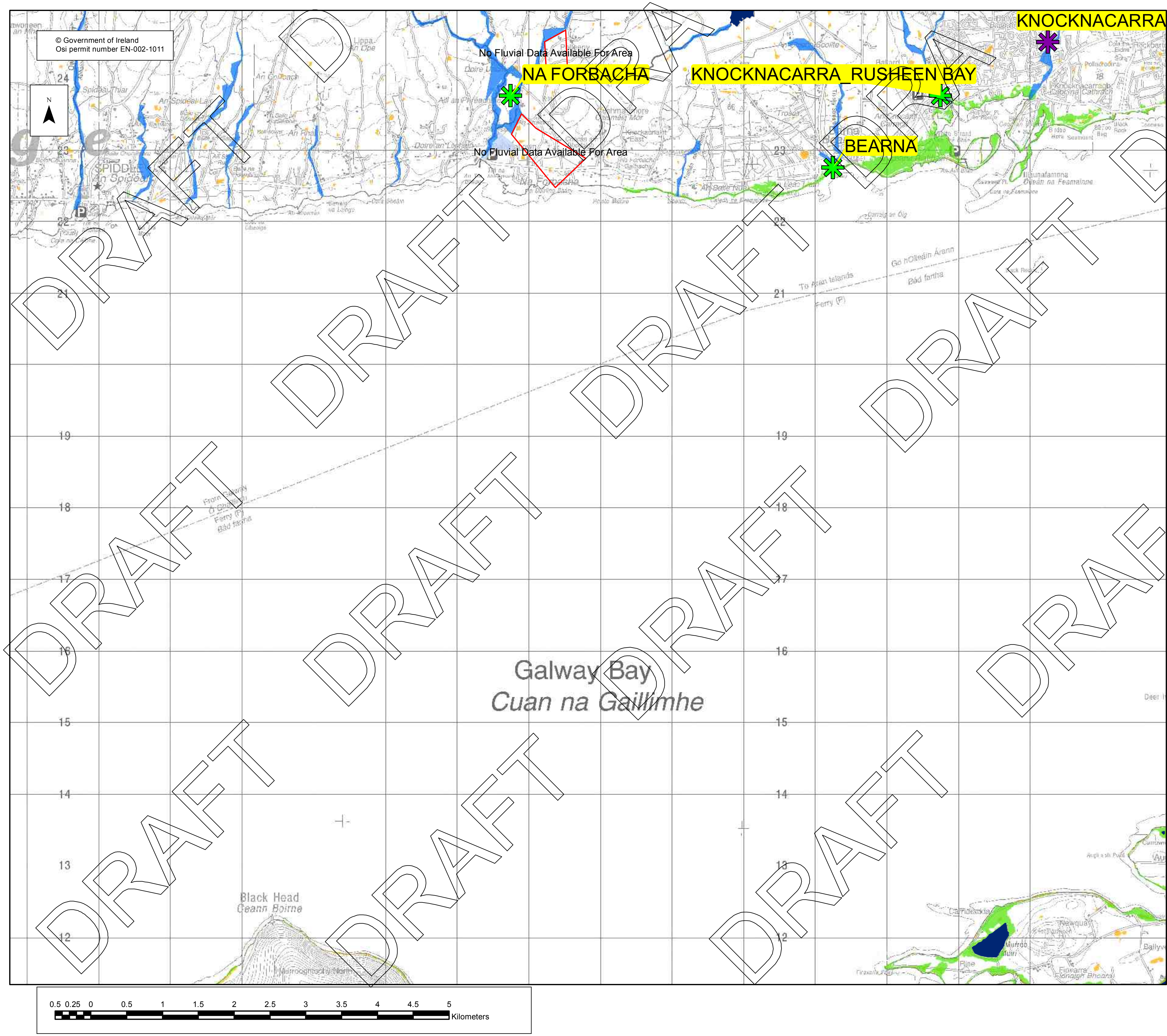
Appendix A – Flood Hydrology Assessment for Section 50 Approval of Proposed Watercourse Crossings (July 2017)

Refer to Appendix A.8.1 of the Design Report

Appendix B – Flood Hydrology Assessment for Section 50 Approval of Proposed River Corrib Bridge Crossings (November 2016)

Refer to Appendix A.8.1 of the Design Report

Appendix C – pFRA Flood Risk Mapping



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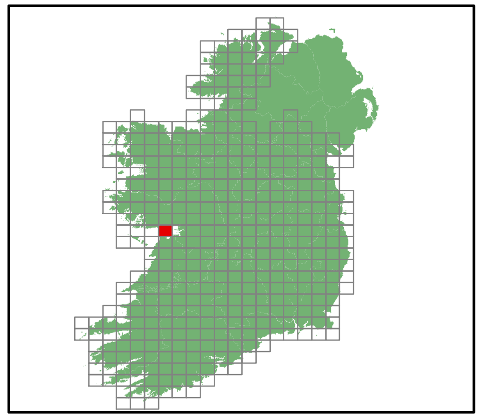

Legend:

Flood Extents

- Fluvial - Indicative 1% AEP (100-yr) Event
- Fluvial - Extreme Event
- Coastal - Indicative 0.5% AEP (200-yr) Event
- Coastal - Extreme Event
- Pluvial - Indicative 1% AEP (100-yr) Event
- Pluvial - Extreme Event
- Groundwater Flood Extents
- Lakes / Turloughs

PFRA Outcomes

- Probable Area for Further Assesment
- Possible Area for Further Assesment

Important User Note:

The flood extents shown on these maps are based on broad-scale simple analysis and may not be accurate for a specific location. Information on the purpose, development and limitations of these maps is available in the relevant reports (see www.cfram.ie). Users should seek professional advice if they intend to rely on the maps in any way.

If you believe that the maps are inaccurate in some way please forward full details by contacting the OPW (refer to PFRA Information leaflets or 'Have Your Say' on www.cfram.ie).

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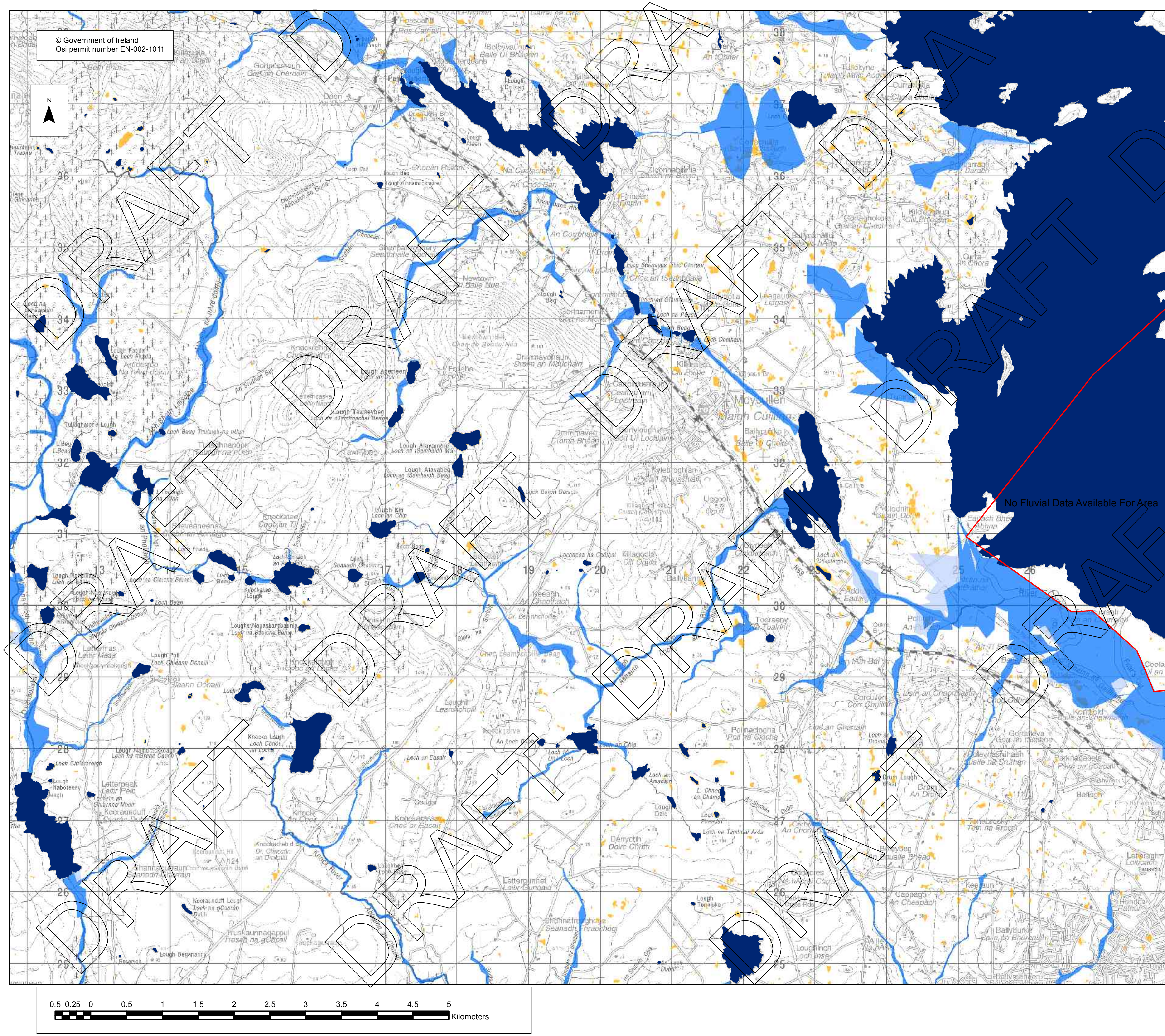
Jonathon Swift Street
Trim
Co Meath
Ireland

Project :
PRELIMINARY FLOOD RISK ASSESMENT (PFRA)

Map :
PFRA Indicative extents and outcomes
- Draft for Consultation

Figure By : PJW	Date : July2011
Checked By : MA	Date : July 2011
Figure No. : 2019 / MAP / 209 / A	Revision 0
Drawing Scale : 1:50,000	Plot Scale : 1:1 @ A3



Location Plan :

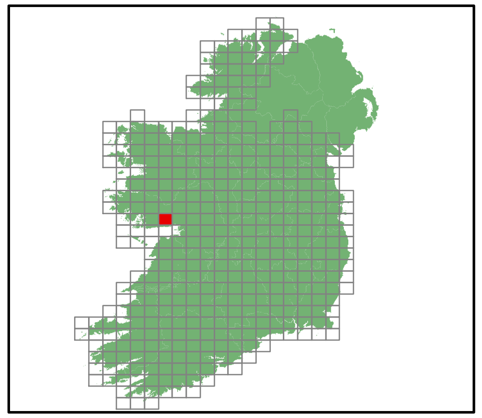


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Figure By : PJW	Date : July2011
Checked By : MA	Date : July 2011
Figure No. : 2019 / MAP / 226 / A	Revision 0
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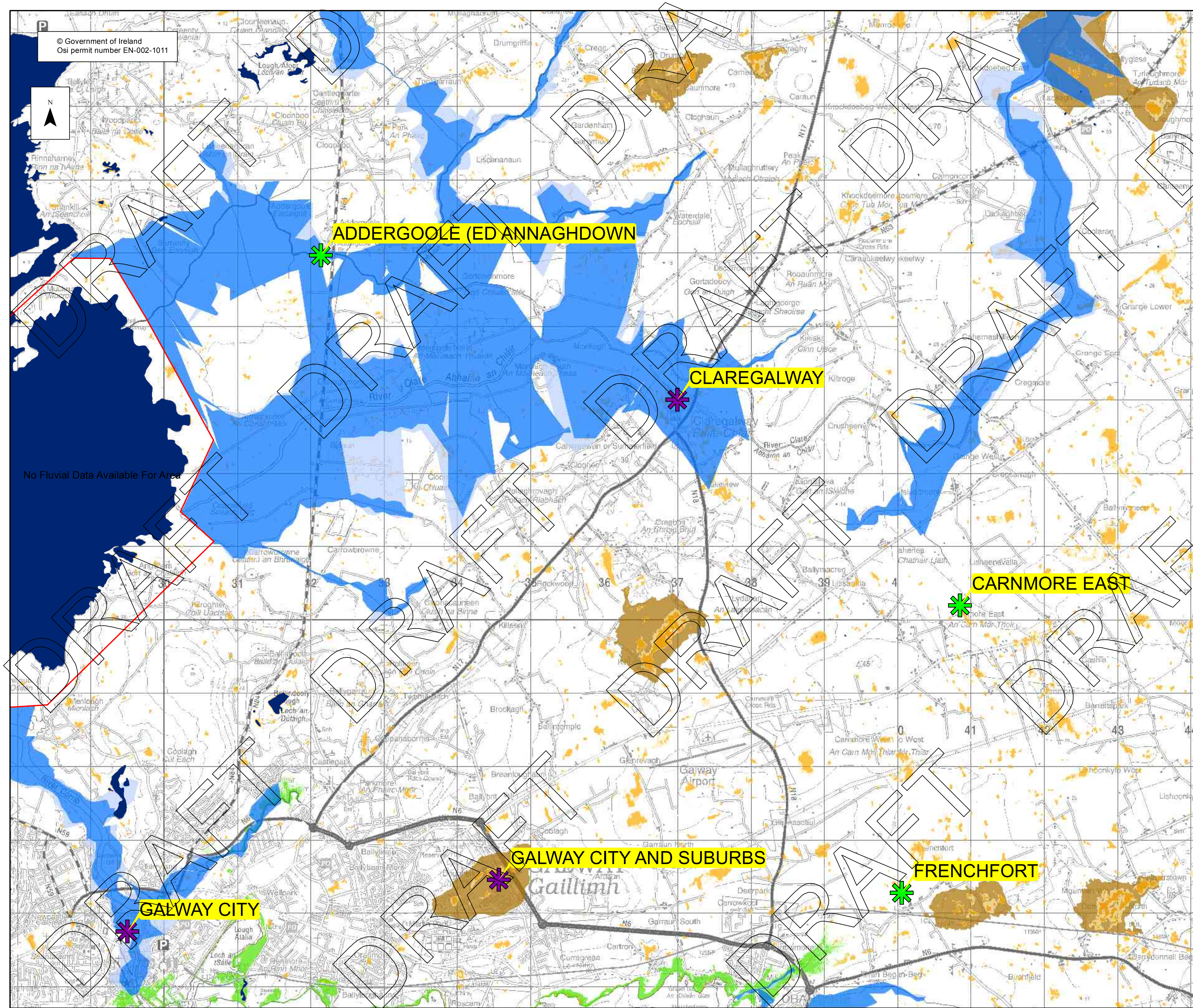
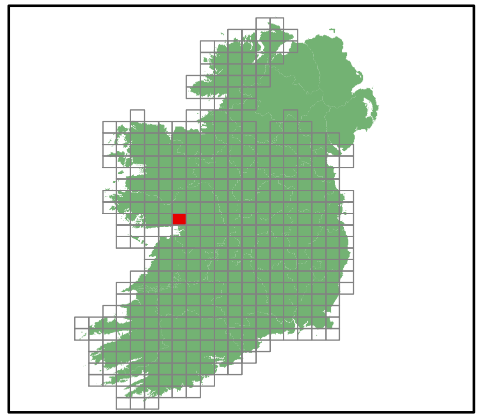


0.5 0.25 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 Kilometers

Location Plan :



Legend:

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Checked By : MA	Date : July 2011
Figure No. : 2019 / MAP / 227 / A	Revision 0
Drawing Scale : 1:50,000	Plot Scale : 1:1 @ A3