Contents

11 Hydrology

11.1 Introduction

This chapter of the EIAR consists of an appraisal of the proposed N6 Galway City Ring Road, hereafter referred to as the proposed road development, under the heading of hydrology.

This chapter initially sets out the methodology followed (**Section 11.2**), describes the receiving environment (**Section 11.3**) and summarises the main characteristics of the proposed road development which are of relevance to hydrology (**Section 11.4**). The evaluation of impacts of the proposed road development on hydrology are described. (**Section 11.5**). Measures are proposed to mitigate these impacts (**Section 11.6**) and residual impacts are described (**Section 11.7**). The chapter concludes with a summary (**Section 11.8**) and reference section (**Section 11.9**).

This chapter has utilised the information gathered during the constraints and route selection studies for the proposed road development to inform the hydrology impact appraisal. **Sections 4.6, 6.5.4** and **7.6.4 of the Route Selection Report** considered the hydrology constraints within the scheme study area and compared the potential of hydrology impacts of the proposed route options respectively. These assessments and sections of the Route Selection Report contributed to the design of the proposed road development which this chapter appraises.

11.2 Methodology

11.2.1 Introduction

The following section outlines the legislation and guidelines considered and the adopted methodology for the preparing of this chapter.

11.2.2 Guidelines

This chapter has been prepared having due regard to the following guidance documents:

- Environmental Protection Agency (EPA) Guidelines on the Information to be contained in Environmental Impact Statements, March 2002
- EPA Advice Notes on Current Practice in the preparation of Environmental Impact Statements, September 2003
- Draft EPA Guidelines on the Information to be contained in Environmental Impact Statements, September 2015
- Draft EPA Advice Notes on Current Practice in the preparation of Environmental Impact Statements, October 2015
- Draft EPA Guidelines on the Information to be Contained in Environmental Impact Assessment Reports, August 2017

- Surface Water and Drainage Guidance in the National Roads Authority Design Manual for Roads and Bridges
- National Road Authority (NRA) Guidelines on Procedures for the Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (referred to as TII Guidelines in this chapter)
- NRA Environmental Impact Assessment of National Roads Schemes – A Practical Guide, November 2008
- DoEHLG (Nov 2009) Flood Risk Management and the Planning System Guidance document
- Inland Fisheries Ireland (IFI) (2016) Guidelines on protection of fisheries during construction works in and adjacent to waters

The methodology follows the guidance outlined in Section 5.6 of the NRA Guidelines on Procedures for the Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes pertaining to the treatment of Hydrology. The impact category, duration and nature of impact have been considered in this assessment. The range criteria for assessing the importance of hydrological features within the study area and the criteria for quantifying the magnitude of impacts are assessed in accordance with the guidelines.

11.2.3 Data Sources and Consultations

The following list of data sources were reviewed as part of this assessment of the impacts on hydrology:

Ordnance Survey Ireland (OSi)

- Discovery Series Mapping (1:50,000) 2017
- Six Inch Raster Maps (1:10,560)
- Six Inch and 25inch OS Vector Mapping
- Orthographic Aerial Mapping 2012 and 2016

Environmental Protection Agency (EPA)

- Teagasc Subsoil Classification Mapping
- Water Quality Monitoring Database and Reports
- Water Framework Directive Classification 2015
- EPA Hydrometric Data System 2017

Office of Public Works (OPW)

- Arterial Drainage scheme land benefitting Mapping for Ireland
- OPW and Drainage District Arterial Drainage Channels and Maintained Channels
- OPW hydrometric Data website 2017
- OPW Floodmaps.ie website 2017

- OPW FSU (Flood Studies Update) Web Portal Site for Flood Flow Estimation
- OPW Preliminary Flood Risk Assessment Mapping (pFRA) 2011
- OPW Draft CFRAM Flood Risk Mapping, draft hydrology, hydraulics and flood risk management reports 2016

Galway County/City Council

- Galway County Development Plan (2015 – 2021)
- Galway City Development Plan (2017 – 2023)
- Galway Transport Strategy (2016)
- Planning Register
- Water Services Section

National Parks and Wildlife Service (NPWS)

- Designated Areas Mapping
- Site Synopsis Reports
- Conservation Objectives Documents

Other sources

- Western River Basin Management Plan (2009 – 2015)
- Aerial survey photography and Lidar
- Geological Survey of Ireland (GSI) Web Mapping
- Specially commissioned bathymetric surveys
- Topographical survey

Consultation took place with all relevant regulatory bodies including various departments of Galway County Council, Galway City Council, the OPW, GSI, National Parks and Wildlife Service (NPWS) and IFI.

11.2.4 Study Area and Baseline Data Collection

The extents of the study area are defined for the hydrology assessment as the lands within a 250m buffer of the proposed development boundary and the associated upstream and downstream catchments as shown on **Figures 11.101** to **11.114**.

Field surveys and walkover assessments were carried out to assess the hydrological impacts of the proposed road development. Detailed stream surveys (including topographical surveys where required) were undertaken at areas where hydrological impacts were likely to occur without appropriate mitigation. Specifically, all culvert and bridge crossing locations, proposed road drainage outfall locations and ecologically sensitive areas were visited and field measurements carried out along with reconnaissance of potential flood risk areas, including site visits during the December 2015/January 2016 winter flood event. The long duration rainfall and flooding in the River Corrib were notable and estimated flood flows in the River

Corrib were the worst since completion of the Salmon Weir Barrage in 1959 and the recorded flood magnitude at the Dangan Gauge represents c. 30 to 50year return period event.

Surface water quality monitoring was carried out of all main watercourses associated with the potential outfall receptors. Flow estimation in selected outfall streams was also conducted as were targeted bathymetric surveys of Coolagh Lakes, Ballindooley Lough and the River Corrib mainline channel.

11.2.5 Impact Assessment Methodology

The Hydrological Impact Assessment Methodology follows the guidance outlined in Section 5.6 of the TII Guidelines pertaining to the treatment of Hydrology. The Impact category, duration and nature of impact have been considered in this assessment. The range criteria for assessing the importance of hydrological features within the study area and the criteria for quantifying the magnitude of impacts are assessed in accordance with the TII Guidelines.

The hydrological assessment has been prepared by expanding and updating the desk study work carried out for constraints and route selection studies. It includes an assessment of published literature available from various sources including a web based search for relevant material. Site specific topographical information and aerial photography has been reviewed to locate any potential features of hydrological interest. These features have been investigated on the ground by walkover surveys to assess the significance of any likely environmental impacts on them.

Available topographical and hydrometric information (field and desk based) has been used to perform hydrological impact assessments of all required culvert crossings of existing watercourses and proposed outfall locations to existing streams and stormwater sewers. All watercourses and water bodies which could be affected directly (i.e. crossed or realigned/diverted) or indirectly (i.e. generally lie within 250m of the proposed development boundary or would receive storm runoff from the proposed road development) were assessed through a series of initial walkover visits followed up by a more detailed survey and hydrological assessment. Due to the nature of the hydrological environment, it is necessary to consider the larger river catchment environments that the proposed road development traverses.

The assessment of hydrological impacts for the proposed road development has been based on the analysis and interpretation of the data acquired during constraints and route selection studies, as well as site specific investigations undertaken as part of the EIA studies, including the ecological study, hydrogeological surveys, ground investigations, agricultural survey, topographical survey and hydrological walkover and surveys.

The key hydrological attributes identified along the proposed road development include:

- European designated sites including: Lough Corrib candidate Special Area of Conservation (cSAC), Galway Bay Complex cSAC, Inner Galway Bay SPA, and Lough Corrib SPA

- Annex I water dependant habitats
- Surface drinking water supply abstraction source from River Corrib at Jordan's Island
- Ecologically sensitive surface water features and catchment systems, fishery streams either locally or downstream, Fens, flushes and wetlands etc.
- Flood Risk Areas

These assessments included the potential hydrological impacts on European sites of the Galway Bay Complex cSAC), Inner Galway Bay SPA, Lough Corrib cSAC and Lough Corrib SPA and also of Ballindooley Lough which provides supporting habitat for birds within the Inner Galway Bay and Lough Corrib SPAs. Other neighbouring European sites such as Connemara Bog Complex cSAC, East Burren Complex cSAC, and Lough Fingall Complex cSAC are not hydrologically linked to the study area of the proposed road development. Other European sites such as, Black-Head-Pouallagh Complex cSAC and Inishmore cSAC, Inishmaan cSAC and Inis Oirr Islands cSAC which share the West of Ireland coastal waters are considered sufficiently remote that even a worst-case pollution event would have no perceptible impact given the travel time involved and the extensive dilution available.

The individual importance of these attributes has been then assessed with respect to their quality, extent / scale and rarity as set out in **Table 11.1** below.

Table 11.1: Criteria for Rating Site Attributes

Importance	Criteria
Extremely High	Attribute has a high quality or value on an international scale
Very High	Attribute has a high quality or value on a regional or national scale
High	Attribute has a high quality or value on a local scale
Medium	Attribute has a medium quality or value on a local scale
Low	Attribute has a low quality or value on a local scale

Types of hydrological impact fall into two broad categories of quantitative and qualitative impacts.

11.2.5.1 Quantitative Impacts

Hydraulic structures such as bridges, culverts, channel diversions and outfalls can, if not appropriately designed, impact negatively on upstream water levels and downstream flows. If a bridge or culvert opening is too narrow or a diversion channel undersized it may impede flow during times of floods thus causing water levels upstream of the structure to be raised above what would occur in the absence of the structure. If instream culvert structures and associated channel diversions and transitions are too wide or steep this can significantly affect the mean and low flow regime of the stream in terms of velocity and water depth changes resulting in low velocities and low water depths which can alter the local sedimentology and flow regime resulting in benthic impacts and potential fishery impacts.

In the design of the proposed road development, the adequacy of culvert sizes for local drainage areas and small river catchments is based on providing conveyance for the 100year return period flood event with recommended climate change allowance in accordance with OPW requirements. Blockage potential and maintenance requirements are also considered and are often the overriding design factor for small stream crossings. In this respect, the design flow used is based on gauged flow data, where available, and/or the upstream catchment characteristics of the crossing including:

- Catchment area
- Annual average rainfall for the catchment
- Mean channel slope (S1085)
- Soil type
- Flood Studies Report (FSR) 100-year flood growth factor of 1.96
- FSU catchment descriptors to estimate the annual index flood (Qmed)
- FSU pooling group flood growth factors

Each method included the standard factorial error for the related estimation method (Institute of Hydrology Report No. 124 3-variable equation (IH-124) = 1.65, Flood Studies Update (FSU) catchment descriptor flood estimation equation = 1.38). A climate change allowance of 20% increase on flows was also included in all flood flow estimations as is currently considered best practice.

Surface water drainage from the proposed carriageway, grassed margins/verges and embankment slopes can lead to localised increased flows and flooding in the receiving streams if not dealt with appropriately. The proposed drainage system is a combination of piped drains and carrier pipes, concrete surface water channels, slot drains, grassed surface water channels, and filter drains where permitted, which convey storm runoff to one of the various surface outfall locations located along the length of proposed road development.

11.2.5.2 Qualitative Impacts

Depending on the hydrological and ecological sensitivities of the receiving waters of the proposed drainage outfall, treatment of the storm water via online or offline detention / water quality improvement ponds are required upstream of the outfall to protect the water quality particularly from spillage and first flush events. The potential contaminant load and accidental spillage risk for a single outfall and sub-catchment area is a function of the design traffic and road pavement area and length.

11.3 Receiving Environment

11.3.1 Regional Overview of Hydrology

The proposed road development connects to the R336 Coast Road west of Bearna Village, passes to the north of Galway City and joins the existing N6 at Coolagh, Briarhill. It crosses the River Corrib near Menlo Castle on the eastern bank and on the western side it passes through National University of Ireland Galway (NUIG) Sporting Campus at Dangan. The River Corrib channel at the crossing site is within the Lough Corrib candidate Special Area of Conservation (cSAC) (000297) as are the Coolagh Lakes further to the southeast. The Lough Corrib SPA boundary includes Lough Corrib and extends down the River Corrib channel to north of Dangan. One proposed road drainage outfall from the proposed N59 Link Road North discharges into the Lough Corrib SPA and Lough Corrib cSAC designated waters. All remaining outfalls for the proposed road development are located downstream of the Lough Corrib SPA, with two proposed road drainage outfalls discharging directly into the Lough Corrib cSAC and the drainage from the proposed NUIG pitches also indirectly discharging to the Lough Corrib cSAC. The proposed road development lies within the OPW/EPA's hydrometric areas 29, 30 and 31.

The proposed road development intercepts several watercourses principally to the west of the River Corrib which will require culverting to maintain existing hydraulic connectivity. To the east of the River Corrib due to the highly karstic nature of the terrain there is a very sparse network of surface water drainage channels, ditches and stream channels. Rainwater generally infiltrates to ground through the limestone till and weathered karstified limestone bedrock, rather than directly running off as overland flow. Consequently, only one dry ditch was noted as being intercepted by the proposed road development near the Coolagh Lakes 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 due to the underlying granite bedrock (east of N59 Moycullen Road) resulting in a much higher density of surface water drainage features with little ability for rainwater to infiltrate to groundwater. This gives rise to wetter conditions with peatlands and marshy areas quite common along the route of the proposed road development.

All of the rivers, streams, drains, lake features and groundwater bodies along the route of proposed road development eventually outfall into Galway Bay via the River Corrib Estuary or directly and indirectly to coastal and transitional waters via the coastal watercourses or via groundwater flow through both diffuse and preferential karst conduit flow pathways. The transitional waters (estuarine waters whose salinity is diluted by the River Corrib outflow and other smaller streams) are located between Salthill to the west and Roscam headland to the east and extend southwards to approximately 0.5 to 1km south of Mutton Island. The designated coastal waters of Galway Bay extend from Blackrock in Salthill east to Roscam Headland and Roscam Point. East of Roscam Point, the Oranmore Bay Transitional Waters are located.

The study area falls within the Western River Basin District (WRBD). The WRBD has classified the transitional coastal waters as good status, the coastal waters as moderate status and Lough Corrib as moderate lake quality (previously classified as poor). The majority of the watercourses and lakes within the study area do not have their status assigned (this includes Coolagh Lakes and Ballindooley Lough and all of the western watercourses). The only watercourses that have been classified are the Terryland River which has a water quality status of poor, the River Corrib which has a status of good and the lower reach of the Bearna Stream which was previously given a pass classification and is currently unassigned. However, all waterbodies within the study area, designated or otherwise, are treated as sensitive. The design approach to waterbodies is to maintain or improve the hydrological regime. This aligns with the objectives of the Water Framework Directive and the Western River Basin Management Plan to achieve Good status for all of its surface watercourses.

The groundwater bodies (GWBs) encountered by the proposed road development are the poorly productive bedrock GWB in the granite bedrock formations to the west of the N59 Moycullen Road and regionally important karst conduit flow limestone bedrock GWB to the east of the N59 Moycullen Road. The groundwater quality classification is good for the entire study area and wider catchment, but the karst GWB's are identified as at risk of not achieving good status whereas the poorly productive bedrock GWB to the west of the N59 Moycullen (Spiddal and Maam-Clonbur GWBs) are expected to achieve good status. For further details, refer to **Chapter 11, Hydrogeology**.

11.3.2 Climatological Data

The mean long term annual rainfall (SAAR) for the proposed road development varies slightly with a tendency for increased rainfall from east to west. The SAAR value for the Bearna area is typically 1275mm, whereas at the River Corrib crossing point, it is 1250mm and in the Ardaun / Doughiska area it is 1140mm.

The Annual Potential Evapotranspiration Rate based on the Athenry Meteorological Station is 508mm and for the Mace Head Station it is 562mm. The Athenry Station is considerably more suitably located to the proposed road development than the Mace Station and therefore considered more applicable. Combining this with the annual rainfall, the typical effective rainfall rate for recharge and runoff is calculated as 714mm.

The Met Éireann Rainstorm Depth-Duration-Frequency Model for the Galway City area is presented below in **Table 11.2** for durations of 0.25hrs to 25days and return periods of 2 to 200years (Annual Exceedance Probability (AEP) 50% to 0.5%).

Table 11.2: Rainstorm Depth-Duration-Frequency Relationship for the Galway City Area

Return Period	Duration (hrs)																				
	0.25	0.5	1	2	3	4	6	9	12	18	24	48	72	96	144	192	240	288	384	480	600
2yr	7.9	10.6	14.3	19.3	23	26	31	36.9	42	50	55.9	69.8	81.6	92.3	111.6	129	146	162	191	220	254
5yr	10.4	13.8	18.3	24.3	28.7	32	38.1	45	51	60	66.8	82.6	96	108.2	130	150	169	186	220	252	290
10yr	12.2	16.1	21.1	27.8	32.7	37	43	50.6	57	67	74.1	91.1	106	118.6	142.1	163	183	202	238	272	313
20yr	14.1	18.5	24.1	31.5	36.9	41	48.1	56.3	63	74	81.6	99.8	115	129.2	154.3	177	198	219	257	293	336
30yr	15.4	20	26	33.8	39.4	44	51.3	59.8	67	78	86.1	105	121	135.6	161.6	185	207	228	268	305	350
50yr	17	22	28.5	36.9	42.9	48	55.5	64.5	72	84	92.1	112	129	144.	171.2	196	219	241	282	321	368
100yr	19.6	25.1	32.3	41.5	48	53	61.7	71.4	79	92	100.9	122	140	156.	184.9	211	236	259	303	344	393
150yr	21.2	27.1	34.7	44.4	51.3	57	65.6	75.7	84	97	106.3	128	147	163.4	193.4	221	246	270	315	358	408
200yr	22.5	28.6	36.5	46.6	53.7	59	68.5	78.9	87	101	110.3	133	152	168.9	199.7	228	254	278	324	368	420

Table 11.3: Monthly Climatological Data Recorded at Mellows College, Athenry Station (2013 to 2016)

a) Total rainfall in millimetres for Athenry Station (Mellows College)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2018	173.2	78	81.4	82.2	32.3								
2017	47.4	87.5	142.6	13.5	61.4	119.5	136.8	103.1	118.3	123.3	88.9	157.7	1200.0
2016	145.2	129.8	79.4	49.2	56.7	98.5	85.1	96.3	138.0	58.4	59.1	78.5	1074.2
2015	191.1	68.7	129.9	74.8	138.0	44.9	138.2	114.6	93.3	66.6	216.3	299.4	1575.8
2014	182.5	177.7	103.1	47.6	103.1	38.6	92.4	104.9	10.4	140.9	139.0	124.1	1264.3
2013	132.2	46.5	36.9	102.4	97.2	61.4	101.5	72.8	47.9	120.0	100.0	220.3	1139.1
Mean	**116.7**	**87.8**	**94.7**	**72.0**	**75.3**	**79.6**	**86.5**	**107.8**	**100.3**	**128.9**	**120.3**	**123.2**	**1192.9**

b) Mean temperature in degrees Celsius for Athenry (Mellows College)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2018	5.3	3.6	4.5	8.6	10								5.9
2017	6.2	6.1	8	8.9	12.2	13.8	14.4	13.8	12.2	11.1	6.8	5.6	10
2016	5.7	4.7	6.3	7.2	11.8	14.9	14.8	15.3	13.7	10.3	5.5	6.8	9.8
2015	4.9	4.5	6.0	8.3	9.8	12.4	13.5	13.5	12.3	10.0	9.0	8.1	9.4
2014	5.3	5.5	6.9	10.1	11.5	14.4	16.1	13.8	13.9	10.5	6.9	5.6	10.1
2013	5.2	4.7	3.8	7.2	10.2	13.3	17.5	15.0	13.6	11.7	6.4	6.9	9.7
Mean	**5.5**	**5.6**	**7.1**	**8.6**	**11.3**	**13.7**	**15.5**	**15.2**	**13.2**	**10.2**	**7.5**	**5.6**	**9.9**

c) Potential Evapotranspiration (mm) for Athenry (Mellows College)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2018	11.1	17	30.9	51.5	25.4								
2017	11.7	17.6	36.6	49.2	84.8	76.9	76.1	61.1	42.1	23.5	10.4	8.7	498.7
2016	13.1	17.3	34.5	53.4	80.3	84.2	72.2	61.2	39.9	26.5	9.8	3.4	495.8
2015	13.2	14.6	33.8	60.7	65.2	78.9	71.3	63.4	43.6	23.9	17.6	16.0	502.2
2014	10.8	19.3	32.6	58.5	65.7	87.4	81.8	66.5	47.9	26.3	9.9	10.6	517.3
2013	6.5	14.6	28.7	52.9	68.4	82.4	98.6	65.0	44.1	27.0	12.4	14.8	515.4
Mean	**11.1**	**16.7**	**32.9**	**54.4**	**65.0**	**82.0**	**80.0**	**63.4**	**43.5**	**25.4**	**12.0**	**10.7**	**497.1**

11.3.3 Hydrological Drainage Features

There are five principal hydrological drainage catchments and their sub-catchments intercepted/potentially impacted by the proposed road development which are labelled from west to east as follows (refer to **Figures 11.1.101** and **11.1.114**):

1. Sruthán Na Libeirtí Stream
2. Trusky Stream
3. Bearna Stream
4. Knocknacarra Stream
5. Corrib Catchment
    a. River Corrib
    b. Coolagh Lakes
    c. Terryland River
    d. Ballindooley Lough System

There are six downstream sub-catchments that also discharge to the Galway Bay Complex cSAC and Inner Galway Bay SPA, namely Lough Atalia, Doughiska, Curragreen, Galway City Coastal, Roscam and Glenascaul drainage areas. These small drainage catchments are located on the eastern side of the River Corrib within the karst limestone bedrock formation and do not have surface drainage features. Effective rainfall from these catchments drains to groundwater or is intercepted by the existing urban storm drainage systems.

Two very minor coastal streams / drains exist at An Baile Nua, Bearna which drain directly into the sea at Bearna.

11.3.4 Hydrological Catchments

11.3.4.1 Sruthán na Libeirtí

Sruthán na Libeirtí is a small stream which rises in a peatland land area 2km north of the R336 Coast Road and flows southwards to the coast outfalling to Galway Bay 2km west of Bearna Village at Cora na Libeirtí at An Baile Nua. This stream is unmaintained, narrow (typically 0.5m to 1m wide) and shallow < 0.5m.

Sruthán na Libeirtí has a catchment area of 1.5 km^2 and high percentage runoff due to its generally impermeable overburden cover and shallow bedrock. There are no sources of gauged flood flow information for this stream given its very minor scale, but this watercourse has been included in the Flood Studies Update (FSU) for flood flow estimation of the index Flood flow magnitude (mean and median flow magnitude) based on catchment descriptors for a number of prediction points along the stream reach.

Table 11.4: FSR Catchment Characteristics for the Sruthán na Libeirtí

Catchment Characteristic	
AREA (km^2)	1.47
Annual Rainfall SAAR (mm)	1300
Winter Rainfall Acceptance potential SOIL Index	0.3 (type 2)
Channel Flood Slope S1085 (m/km)	25.0
URBAN – fraction of catchment	0%

Table 11.5: FSU Catchment Descriptors for the Sruthán na Libeirtí (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2)	1.47
Annual Rainfall SAAR (mm)	1281
FARL	1.0
BFISOIL Baseflow Index of Soils	0.4512
Drainage Density DRAIND km per km^2	2.999
Channel Flood Slope S1085 (m/km)	25.08
Arterial Drainage Factor ARTDRAIN2	0.0
URBAN – fraction of catchment	0.0098

QMED rate =1.135cumec (0.77cumec per km2 representing a moderately high runoff rate)

Note FSR is the Flood Studies Report completed in 1975 and supplementary studies carried out in the late 1970's, 1980's and 1990's for estimating flood flow magnitudes ingauged and ungauged catchments and the FSU represents the OPW Flood Study Update method completed in 2105 succeeds the FSR method.

11.3.4.2 Trusky Stream

The Trusky Stream which flows through Bearna is a relatively small stream having a catchment area of 3.3km^2 and outfalls to Galway Bay at Bearna Harbour. This stream has two main branches, one to the east of the harbour road and one to the west. The stream channel has been culverted and modified through Bearna Village and crosses under the R336 Coast Road in two culverts; an original arch culvert near the Twelve Pins Hotel and a concrete piped culvert, located approximately 170m to the east. This stream potentially represents a flood risk to the village and R336 Coast Road at these culvert crossings as a result of potential debris blockage. This stream rises in peatland to the south of Lough Inch and flows typically southwards 2.5km to the harbour. The channel is not maintained, very vegetated and varying in width (0.5 to 1m channel widths) in its middle and upper reaches. The channel through the lower reach has been significantly modified with sections of culverting and new channel to facilitate urban development. Unlike the Sruthán na Libeirtí, the percentage runoff is moderate to low.

Table 11.6: FSR Catchment Characteristics of the Trusky Stream

Catchment Characteristic	
AREA (km^2)	3.3
Annual Rainfall SAAR (mm)	1300
Winter Rainfall Acceptance potential SOIL Index	0.3 (Type 2)
Channel Flood Slope S1085 (m/km)	21.9
URBAN – fraction of catchment	0%

Table 11.7: FSU Catchment Descriptors of the Trusky Stream (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2) (corrected error in FSU)	3.3
Annual Rainfall SAAR (mm)	1293
FARL	1.0
BFISOIL Baseflow Index of Soils	0.6877
Drainage Density DRAIND km per km^2	1.128
Channel Flood Slope S1085 (m/km)	18.4
Arterial Drainage Factor ARTDRAIN2	0
URBAN – fraction of catchment	0.0622

The median flood flow (Qmed) estimate for this stream from the FSU is 1.26cumec (representing a runoff rate of 0.38cumec per km^2 which is a moderate to low flood runoff rate).

11.3.4.3 Bearna Stream

The Bearna Stream is the largest of the small watercourses encountered by the proposed road development entering Galway Bay cSAC and Inner Galway Bay SPA near Rusheen Bay. Its catchment area measures only 9.1km^2 to its sea outfall in Rusheen Bay and its main tributaries are the An Sruthán Dubh and the Tonabrocky Streams. This river system rises in the townlands of Pollnaclogha, Drum and Tonabrocky 4km to the north. It is an unmaintained stream which in sections is very overgrown particularly in its middle and upper reaches. Flooding is not a significant issue for this stream. The percentage runoff based on overburden and land slope is moderate to low in magnitude.

Table 11.8: FSR Catchment Characteristics of the Bearna Stream

Catchment Characteristic	
AREA (km^2)	9.1
Annual Rainfall SAAR (mm)	1290
Winter Rainfall Acceptance potential SOIL Index	0.3 (Type 2)
Channel Flood Slope S1085 (m/km)	13.5
URBAN – fraction of catchment	0.5%

Table 11.9: FSU Catchment Descriptors of the Bearna Stream (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2)	9.14
Annual Rainfall SAAR (mm)	1292
FARL	0.979
BFISOIL Baseflow Index of Soils	0.601
Drainage Density DRAIND km per km^2	1.422
Channel Flood Slope S1085 (m/km)	0.1
Arterial Drainage Factor ARTDRAIN2	0.0
URBAN – fraction of catchment	0.05

The estimated QMED median Flood flow is 3.41cumec representing a moderate to low runoff rate of 0.37cumec per km^2.

11.3.4.4 Knocknacarra Stream

The Knocknacarra Stream is a small and highly urbanised stream that discharges to Galway Bay Complex cSAC and Inner Galway Bay SPA near Blakes Hill in Salthill. A large portion of its lower reach is culverted almost to its sea outfall and forms part of the Galway City storm drainage system. It rises to the north of Rahoon at Letteragh and flows southwards over a distance of 3km to the sea. It would be considered a highly urbanised watercourse with an urban fraction of almost 50%.

Table 11.10: FSR Catchment Characteristics of the Knocknacarra Stream

Catchment Characteristic	
AREA (km2)	4.4
Annual Rainfall SAAR (mm)	1240
Winter Rainfall Acceptance potential SOIL Index	0.3 (Type 2)
Channel Flood Slope S1085 (m/km)	10.0
URBAN – fraction of catchment	49%

Table 11.11: FSU Catchment Descriptors of the Knocknacarra Stream River (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2)	4.38
Annual Rainfall SAAR (mm)	1239.6
FARL	1.0
BFISOIL Baseflow Index of Soils	0.61
Drainage Density DRAIND km per km^2	0.757
Channel Flood Slope S1085 (m/km)	10.01
Arterial Drainage Factor ARTDRAIN2	0.0

Catchment Characteristic	
URBAN – fraction of catchment	0.5

The estimated QMED median Flood flow is 2.82cumec representing a moderate runoff rate of 0.644cumec per km^2. This runoff rate almost doubled over the rural greenfield runoff due to significant size of the urbanised catchment fraction.

11.3.4.5 Terryland River

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 6.75km^2. The stream's outlet is to groundwater via two swallow-holes located at Poulavourleen, west of Castlegar Village. Old historic maps of Galway (Grand Jury Map 1819) show that this stream was a spur off the River Corrib channel and the valley floor was almost a lake bed during winter flooding. 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 farmland. Today, this embankment and the Salmon weirs gated controls protect important commercial, industrial and retail developments that include the Galway Retail Park, Galway Shopping Centre, Terryland Shopping Centre, Terryland Retail Park and Liosbán Industrial Estate.

A water intake 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 with the excess discharging to the Terryland River. This inflow from the River Corrib to the Terryland River in terms of stream flow is relatively small and not significant in respect to flood flow contribution. The watercourse is partially tidal with the tidal signal (0.7 to 0.8m range on spring tides and 0.3 to 0.4m range on neap tides upstream of the swallow-holes) evident and particularly so on spring tides which produces an almost reversal in flow direction coinciding with the flooding and ebbing spring tides (Terryland River Valley Drainage Scheme Report, 1998). These swallow holes are believed to discharge to Galway Bay but the location of the outlet in Galway Bay is unknown. The integrity of these swallow holes is unknown. Ballindooley Lough is considered to be part of the Terryland catchment but this connection has not been proven. The connection may be possible through the groundwater flow as Ballindooley Lough is at the base of an enclosed depression.

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. The excess flow overspills with a fall of 3m to the Terryland River Basin. 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 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.

Table 11.12: 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	0.44

Table 11.13: FSU Catchment Descriptors of the Terryland River (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2)	6.75
Annual Rainfall SAAR (mm)	1163
FARL	1
BFISOIL Baseflow Index of Soils	0.5726
Drainage Density DRAIND km per km^2	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 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.

11.3.4.6 River Corrib

The River Corrib is essentially a short outflow channel from the Lough Corrib to the sea at the Claddagh, Galway. The Corrib Navigation and Drainage Works (1848-1858) excavated a new wide outlet channel from Lough Corrib known as the Friar's Cut which provides a more direct and deeper channel to service the lough than the meandering old channel (almost 1.5km shorter). Significant excavation of the River Corrib channel has taken place both during the original Corrib Drainage and Navigation Scheme and during the OPW Corrib-Clare Arterial Drainage Scheme (in the early 1960's).

The area of the River Corrib catchment is approximately 3,136 km^2 to Wolfe Tone Bridge and 3121km^2 to Dangan Gauge based on DTM elevation data. This catchment area is quite large by Irish standards and is the biggest river system in the Western River Basin District. This includes a total lake surface area of approximately 314km^2 mainly due to Lough Corrib and Lough Mask but also includes Lough Carra, Finny Lakes and Maam Lakes which attenuate winter flood flows and sustain summer low flows. The register of hydrometric gauges has the catchment area to Wolfe Tone Bridge of 3111km^2 which is slightly less than the FSU estimate.

The River Corrib channel is a navigation channel and is reasonably wide, varying typically from 80m to 130m between river banks and typically 3 to 4 m deep. It is an impounded channel with levels maintained generally close to 6m OD Malin throughout the year by the gated weir at the Salmon Weir.

Table 11.14: Exceedance Percentile at Dangan Gauge

Exceedance Percentile at Dangan Gauge				
1%	5%	50%	95%	99%
6.75mOD	6.32mOD	5.91mOD	5.75mOD	5.70mOD

Much of the channel has been excavated with bed levels at the proposed road development crossing point at 2.75m OD, providing a flow area at summer 99-percentile low flow of 300m^2 and a channel velocity of 0.04m/s.

The River Corrib for flow estimation is gauged at Wolfe Tone Bridge which is a strategic location as it captures the total flow from the Corrib system before entering the bay. This site is tidally backwatered and the flow rating is considered only fair. Flow estimates from this gauge are currently not available due to difficulties and inconsistencies with the rating relationship identified in the gauged record dating back as far back as 2002. As part of the flood risk assessment for the proposed road development a reasonably consistent flood rating relationship was derived for the Dangan Gauge using the OPW flood rating measurements and recorded flood level flooding stage when all gates on the Salmon Weir are opened, which generally applies to winter maximum floods. This rating provided a QMED (2year return period) flow at Dangan of 264.4cumec (gauged period 1986 to 2015). The OPW CFRAM study produced a QMED estimate of 248cumec and the FSU estimate is 244cumec (both based on the Wolfe Tone Bridge gauge data for the record period pre 2002).

The statistical analysis of a derived annual maximum flood flow series for the Dangan of 264.4cumec is considered more reliable than the FSU and CFRAM estimates as it includes the more recent and wetter period post 2002 and avoids using the Wolfe Tone gauge whose rating is inconsistent. The flow duration curve for Wolfe Tone Bridge gauge (OPW hydrometric section) for the period 1970 to 1997 gave a median (50%) flow of 82cumec, a 95% low flow of 24.6cumec and a 99% low flow of 9.1cumec. The EPA Hydrological data publication (1995) for the record period 1970 to 1991 gave an average flow of 95.3cumec and a 95% low flow of 16.9cumec.

A study undertaken by the Department of Hydrology University College Galway (UCG) (now known as NUIG), (1985) as part of their investigation into the hydropower potential of the waterways of Galway City, developed a flow duration curve for the River Corrib at Wolfe Tone Bridge gauge (using OPW flow data from 1950 to 1980), which gave a mean flow rate of 82.5cumec and the lowest recorded flow of 8.9cumec (occurring in 1962). This flow duration curve gave median flow of 74.4cumec, 95-percentile low flow of 14.1cumec and a 99-percentile low flow of 12.13cumec. It should be noted that the period 1950 to 1980 in terms of rainfall would have represented a drier period than 1980 to present day and therefore the flow estimates are lower, particularly for the 1970's and 1950's which were the driest decades. For the purpose of this study, the lower estimates of low flow using a 99-percentile of 12cumec and a 95-percentile of 14cumec will be used. These low flow estimates assume the worst case dilution volumes for the receiving water body in respect to proposed road drainage discharges.

Table 11.15: FSU Catchment Descriptors of the River Corrib to Dangan (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2)	3121
Annual Rainfall SAAR (mm)	1423.6
FARL	0.661
BFISOIL Baseflow Index of Soils	0.781
Drainage Density DRAIND km per km^2	0.94
Channel Flood Slope S1085 (m/km)	0.568
Arterial Drainage Factor ARTDRAIN2	0.411
URBAN – fraction of catchment	0.004

The FSU estimated QMED flood flow for the Corrib at Wolfe Tone is 244cumec representing a relatively low flood runoff rate of approximately 0.078cumec per km^2. The recommended QMED estimate based on the Dangan Gauge is 264.4 giving a slightly higher flood runoff rate of 0.085cumec per km^2.

The typical winter-summer water level range is 0.6m (typically 5.7m to 6.3m OD). The River Corrib channel at Dangan is approximately 110m wide and the channel bed invert near the crossing is typically 2.6 to 2.8m OD giving a flow depth of 3m and a total flow area of $312m^2$ at 5.7m OD and $403m^2$ at 6.3m OD. At a low flow (95-percentile) of 14cumec the average channel flow velocity is small at 0.044m/s and in typical winter flows the average velocity is 0.675m/s.

11.3.4.7 Ballindooley Lough

Ballindooley Lough is an enclosed lough located on the N84 Headford Road at Ballindooley, on the outskirts of Galway City. The lough forms at the floor of a large enclosed depression having a surrounding topographical catchment area of $2.25km^2$. The recent December 2015/January 2016 flood event, during which water levels peaked on the 2 Jan 2016, produced possibly the highest flood levels in at least 50 years both within this system and within the River Corrib system, with the maximum flood level recorded at 10.29m OD Malin. The typical summer lake low water level is approximately 1.5m lower at c.8.8m O.D. and in more severe drought conditions it is likely that lake levels fall below 8.5m O.D. This suggests that the more extreme annual range in lake level is of the order of 2m but for a typical year it is likely to be between 1 and 1.5m.

During the recent December 2015/January 2016 flood event, maximum winter flood levels both in the River Corrib and Lough Corrib reached 6.93m OD and

7.27m OD respectively and water levels in the Terryland Basin near Castlegar were below 4m OD.

A bathymetric survey of the Ballindooley Lough as part of this study showed that the deepest part of lake has a bed level of -2.5m OD Malin (i.e. 2.5m below mean sea level) whereas the overbank floodplain area is typically at an elevation of 9.3 to 9.5m O.D. This bed level suggests that at its deepest location, the water depth is 12m.

At the maximum recorded flood level of 10.29m OD, the surface area of the lake expands to 29.7ha and at the summer low water level of 8.5m OD it reduces to c. 4.5ha (4.2ha main lake and 0.3ha small pond to the southwest, both connected via a 3m wide and 250m long drain). There is over 2.4km of drainage channel draining the floodplain area of this lough, which feeds into the permanent lake. This drainage channel is reasonably maintained and typically the cross-section dimensions are 1.5 to 2m deep and 3m top width. The live storage volume between the winter high of 10.3m OD Malin and the summer low level of 8.5 is 271,500m^3. Approximately 500mm of rainfall (recorded at Met Éireann gauge in Athenry) fell in November and December 2015 and resulted in Ballindooley Lough rising by 1.3m from c. 9m OD to 10.3m OD. This represents a change in lake storage volume of almost 250,000m^3, which is 22% of the recorded rainfall depth over the 2.25km^2 catchment area.

The recession characteristics of the recorded lake levels indicate that the water level empties slowly (falls) by typically 0.8 to 1cm per day with almost similar recession characteristics at both high and low lake levels. In the summer period this fall is likely to represent evaporation losses from the lake surface. This slow almost constant like fall in levels suggests an emptying process influenced by the slower more continuous regional groundwater flow with the lake rising and falling with the groundwater table as opposed to a concentrated point (conduit flow via a swallow hole) outflows. The hydrological monitoring indicates that the lake is perched above the surrounding groundwater table in summer dry periods and influenced by the groundwater table in the wetter winter period. The proposed road development in terms of the groundwater table and groundwater flow is located down gradient of Ballindooley Lough. This feature is explained further in **Chapter 10, Hydrogeology**.

11.3.4.8 Coolagh Lakes

The Coolagh Lakes are part of the River Corrib system and are located within the Lough Corrib cSAC. The lake level within Coolagh Lakes is significantly influenced by the River Corrib water levels and the control imposed by the OPW at the Galway City Salmon Weirs Barrage (regulation 5.82 to 6.43m O.D. which is achieved approximately 85% of the time). This is not always achievable particularly during extreme flood events with lake levels exceeding the regulation levels. The periodic closure and opening of gates by the OPW creates inflow and outflow to the lakes in particular to the outer lake which provides additional flushing to the natural local catchment inflows. The water level in the Coolagh Lakes increases until it has positive head to outflow to the River Corrib channel upstream of Jordan’s Island via its small narrow outflow channel.

A bathymetric survey of the River Corrib and Coolagh Lakes revealed very deep bed levels within the middle of the two lakes with the deepest part of the lakes at c. -10 and -12m OD Malin respectively. This represents a maximum water depth of 16.5 and 18.5m for the inner and outer lakes respectively. Flow velocities within these lakes are very small with mixing principally by thermal differences and surface wind dynamics. These lakes are likely to represent a permanent sink for sediment if it were to enter such a system. The estimated winter 1-percentile water level for Coolagh Lakes is 6.75m OD producing an inundation area of 36ha, whereas the 99% exceedance summer low flow level is 5.73m OD with a lake area of 6.8ha.

The local catchment area draining to these lakes based on the topography is approximately 2.5km^2. Other deeper groundwater connections to karst areas to the northeast and east cannot be ruled out. Spring flow is evident in the Coolagh Lakes at two spring locations to the east and to the north. The mean annual inflow rate to the lakes is estimated to be approximately 30l/s based on water balance calculations. The low flow (95%-percentile) contribution is potentially as low as 2 to 3l/s. The bathymetric survey data for the lake is used to estimate the lake storage-stage relationship which for a summer low water level of 5.7m OD is c.630,000m^3 with a combined lake surface area upper and lower lakes) of c. 6.8ha (i.e. the permanent lake volume). Further storage volume and surface area statistics are presented below in **Table 11.16**.

Table 11.16: Percentile Lake levels, surface areas and storage volumes in the Coolagh Lakes system

Percentiles	1%	5%	50%	95%	99%
Lake level	6.64mOD	6.24mOD	5.86mOD	5.73mOD	5.70mOD
Area	36.0ha	30.4ha	10.9ha	7.2ha	6.8ha
Volume	801,000m^3	694,500m^3	649,000m^3	639,000m^3	637,000m^3

The annual winter-summer difference in storage volume (represented by the difference between the 1 and 99-percentile water levels) is 164,000m^3, therefore the average flushing ratio of this lake system by the River Corrib summer-winter water level variation is approximately 4 years at 5l/s. The natural flushing effect of recharge from the local catchment area is significantly higher at 0.7 years (250 days) at a mean annual inflow of 30l/s and the combined effect of the local recharge and the River Corrib is of the order of 35l/s producing an average hydraulic retention period of 215 days. These hydraulic retention times suggest moderate flushing time / exchange rate for a lake system.

The fringes of Coolagh Lakes dry out and only get inundated in winter by the River Corrib water levels. Alkaline fen habitat has been identified surrounding the lakes which are fed by groundwater flow and seepages. The waters within the lakes are quite alkaline with the hardness values recorded in excess of 200 mg/l CaCO3 and the pH at 7.8 to 8.2.

11.3.5 Surface Water Ecological Status

The locations of the watercourses and their catchment areas encountered along the proposed road development are given in **Figures 11.1.101** to **11.1.114**.

Given the European designation and salmonid status of the River Corrib (part of the Lough Corrib cSAC and Lough Corrib SPA) it is considered to be of International Status with an extremely high attribute value. The River Corrib catchment size is 3136km^2 to Wolfe Tone Bridge. The remaining watercourses encountered within the study area are all minor watercourses, with all such streams having catchment areas of well less than 10km^2, the streams are listed below:

- Coastal Streams at Baile Nua (<0.75km^2)
- Sruthán Na Libeirtí (1.5km^2)
- Trusky Stream (3.3km^2)
- Bearna Stream (9.14km^2)
- Knocknacarra Stream (4.4km^2)
- Terryland Stream (6.7km^2)

These watercourses generally have ecological attribute value of locally higher value.

The Galway Bay Complex cSAC and Inner Galway Bay SPA are coastal/transitional waters with the European designated waters commencing east of White Strand beach.

The Sruthán Na Libeirtí and Trusky Stream and the two minor watercourses at An Baile Nua, Bearna, that outfall to the sea near Bearna do not directly discharge to the Galway Bay Complex cSAC. The remaining streams, that the proposed road development traverse, all outfall directly into the Galway Bay Complex cSAC. The tidal circulation of the coastal waters off Bearna will eventually mix and on the flooding tides potentially enter the Galway Bay Complex cSAC. Therefore, the proposed drainage of the proposed road development will eventually drain into the Galway Bay Complex cSAC.

The Terryland River which has a water intake from the River Corrib at Jordan's Island drains the Terryland basin and disappears underground via karst swallow-holes near Castlegar. The outflow from these swallow holes is unknown but is likely to discharge to the Galway Bay Complex cSAC via submarine springs. The water level in the Terryland River shows a tidal response indicating its outflow point/points are within the tidal zone.

The majority of the above streams have either partially or extensively urbanised catchments. The fishery resource of these streams is assessed in detail in **Chapter 8, Biodiversity** and is summarised below:

- The two minor coastal streams at Baile Nua are not of fishery interest
- Sruthán na Libeirtí is categorised as of local importance (lower value) for European eel and with no salmonids present. The lower reaches have some moderate quality salmonid and European eel habitat

- The Trusky Stream is categorised to be of local importance (higher value) for salmonids, European eel and as a nursery for flounder in its lower reaches at Bearna. Some spawning habitat for trout exists in the lower reaches but this is limited
- The Bearna Stream is salmonid and is categorised to be of local importance (higher value) for Brown trout. Upper reaches are seasonal but moving downstream the habitat becomes an important salmonid river
- An Sruthán Dubh is a tributary of the Bearna Stream and is considered to be an excellent salmonid habitat throughout its upper reaches and is considered an excellent nursery salmonid stream with good numbers of juvenile Brown trout and small numbers of European eel. This is classified to be of local importance higher value for Brown trout and European eel
- The Knocknacarra Stream is categorised to be of local importance (higher value) for European eel and as a nursery for estuarine fish. Upper reaches are seasonal and of no fishery value but lower reaches near the estuary are of importance as a transitional habitat to estuarine fish and European eel
- The River Corrib is an important salmonid river system and is considered to be of International Status with an extremely high attribute value due to its European designation as part of the Lough Corrib cSAC and Lough Corrib SPA
- The Terryland River which continues to be impacted by urban pollution is considered to be of limited fisheries value and categorised to be of local importance (lower value) for European eel
- The Coolagh Lakes is categorised to be of local importance (lower value) for coarse fish species and European eel and despite its connection to the River Corrib is of limited or no value to salmonids
- Ballindooley Lough is considered to be an excellent coarse fishery, but not of importance as a salmonid fishery and is categorised to be of local importance (higher value) for coarse fish species

11.3.6 Surface Water Quality

11.3.6.1 Rivers

EPA Monitoring River Programme

The EPA carries out water quality assessments of rivers as part of a nationwide monitoring programme. Data is collected from physio-chemical and biological surveys, sampling both river water and the benthic substrate (sediment) in contact with the water.

Water sampling is carried out throughout the year and the main parameters analysed include: conductivity, pH, colour, alkalinity, hardness, dissolved oxygen, biochemical oxygen demand (BOD), ammonia, chloride, ortho-phosphate, oxidised nitrogen and temperature.

Biological surveys are normally carried out between the months of June and October. These examine the relationship between water quality and the relative abundance and composition of the macro-invertebrate communities in the sediment of rivers and streams. The macro-invertebrates include the aquatic stages of insects, shrimps, snails and bivalves, worms and leeches. It is generally found that the greater the diversity of species recorded, the better the water quality is.

The collated information relating the water quality and macro-invertebrate community composition is condensed to a numerical scale of Q-values or Biotic Index. The indices are grouped into four classes based on a river's suitability for beneficial uses such as water abstraction, fishery potential, amenity value, etc. (refer to **Table 11.17** below).

Table 11.17: Biological River Water Quality Classification System

Biotic Index (Q value)	Quality Status	Quality Class	Condition
Q5, Q4-5, Q4	Unpolluted	Class A	Satisfactory
Q3-4	Slightly Polluted / Eutrophic	Class B	Transitional
Q3, Q2-3	Moderately Polluted	Class C	Unsatisfactory
Q2, Q1-2, Q1	Seriously Polluted	Class D	Unsatisfactory

The River Corrib is monitored at Wolfe Tone Bridge and is currently categorised as having good status (Q4) for the period (2004 - 2015) and the Terryland River as having poor Status (Q2-3). No Other watercourses within the study area are currently monitored by the EPA as part of the EPA Monitoring River Programme.

11.3.6.2 Lakes

As part of a national water quality monitoring programme, a number of lakes throughout the country are sampled and the trophic status assessed. Lake water quality is most commonly assessed by reference to a scheme proposed by the Organisation for Economic Cooperation and Development (OECD, 1982). This scheme defines the traditional trophic categories by setting boundaries for the annual average values for total phosphorus, chlorophyll and water transparency, and for the maximum and minimum vales of the latter two parameters.

A modified version of these criteria is used in which annual maximum chlorophyll-a concentration is the only parameter used. This has been further subdivided into six water quality categories by reference to the maximum levels of planktonic algae measured during the period (refer to **Table 11.18**). Indicators relating to water quality and the probability of pollution are also shown.

Table 11.18: Trophic Classification Scheme for Lake Waters

Classification Scheme		Category Description				
Lake Trophic Category		**Annual Maximum Chl-a (mg/m^3)**	**Algal Growth**	**Degree of Deoxygenation in Hypolimnion**	**Level of Pollution**	**Impairment of Use of Lake**
Oligotrophic	(O)	<8	Low	Low	Very low	Probably none
Mesotrophic	(M)	8 – 25	Moderate	Moderate	Low	Very little
	Moderately (m-E)	25 – 35	Substantial	May be high	Significant	May be appreciable
Eutrophic	Strongly (s-E)	35 – 55	High	High	Strong	Appreciable
	Highly (h-E)	55 – 75	High	Probably total	High	High
Hypertrophic	(H)	>75	Very high	Probably total	Very high	Very high

The trophic status provides an indication as to what degree the lake is enriched by the presence of nutrients such as phosphorus and to a lesser extent nitrogen in the form of nitrate.

Lough Corrib is currently monitored as part of the EPA water quality reporting and is classified as Oligotrophic/Mesotrophic in terms of water quality indicating that nutrient enrichment is low and eutrophication is not a major concern.

11.3.6.3 Baseline Water Quality Sampling of Receiving Waters

Bi-monthly sampling of surface water quality, in the vicinity of the proposed road development, was carried out over a 14month period commencing November 2015 to December 2016. This was carried out to establish baseline water quality conditions in the receiving waters. The sampling locations are as follows:

1. Sruthán na Libeirtí at the R336 Coast Road culvert upstream
2. Trusky Stream East at the R336 Coast Road culvert upstream
3. Bearna Stream at Cappagh North
4. Bearna Stream at Cappagh South
5. River Corrib at Dangan Slip
6. River Corrib at Terryland Intake Channel, Jordan’s Island
7. Upper Coolagh Lake
8. Lower Coolagh Lake
9. Ballindooley Lough

The water quality sampling results are presented in **Appendix A.11.2**. The locations of the sampling points are identified on a set of figures within the appendix. The results show consistently good quality water at all of the sites with nutrient, BOD, sediments and heavy metal concentrations well within acceptable limits based on the surface water regulations. Bacterial faecal contamination was identified at all locations, possibly associated with the presence of agricultural activities, point septic tank and slurry pit sources within the respective catchments.

As expected the western watercourses (Bearna Stream, Trusky Stream and Sruthán na Libeirtí) associated with the granite bedrock and peatland areas showed slightly lower pH, lower alkalinity and hardness and elevated iron concentrations compared to the eastern limestone watercourses. The most alkaline and highest hardness waters were found within Ballindooley Lough followed by the Coolagh Lakes.

11.3.7 Water Supply Sources

11.3.7.1 Galway City Water Supply

The Galway City Water Supply Scheme at Terryland abstracts water from the River Corrib via an intake channel at Jordan's Island. The Water Treatment plant has recently been upgraded so that it can treat and supply up to 55,000m^3 per day (0.64cumec). The source of this water is from Lough Corrib but also its downstream catchment area, including the Coolagh Lakes outflow to the River Corrib on the eastern bank of the River Corrib. This plant provides full treatment that includes screening, coagulation, flocculation and clarification, followed by gravity filtration, chlorination and UV-disinfection. The Galway City Council / Irish Water objective is to increase this supply and this is likely to require the relocation of the abstraction inlet point into the deeper River Corrib mainline channel possibly to the south of Jordan's Island.

The source zone of contribution for this abstraction extends upstream and includes River Corrib, Lough Corrib and also includes Coolagh lakes.

The Regional Galway County Water supply abstraction and treatment is from the Lough Corrib at Luimnagh. This abstraction is located over 15km upstream of the proposed road development and therefore not within the zone of influence (ZoI) of the proposed road development.

11.4 Characteristics of the Proposed Development

A detailed description of the proposed road development and construction activities are provided in **Chapter 5, Description of Proposed Road Development** and **Chapter 7, Construction Activities**. This section outlines the characteristics and activities of the proposed road development of relevance to hydrology.

11.4.1 Operational Phase

11.4.1.1 Proposed Watercourse Crossings

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 one in the eastern section. 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 5.5km^2. The majority of these watercourses flow in a southerly direction discharging into Galway Bay. The watercourses to the east of the Bearna Stream discharge to the designated Galway Bay Complex cSAC and watercourses to the west of the Bearna Stream discharge to Galway Bay outside of this cSAC. These watercourse crossings are summarised below in **Table 11.19**.

The proposed road development will involve a new bridge crossing of the River Corrib channel at Menlough/Dangan.

Table 11.19: Proposed Watercourse Crossing Locations

Culvert Reference	X	Y	Approx. Chainage	Catchment Area km^2	Qdesign cumec	Watercourse	Ecological Evaluation
C00/01	521325	723182	0+650	0.47	1.26	Sruthán na Libeirtí	Local Lower at site and downstream
C00/02	521522	723446	1+000	0.32	0.89	Sruthán na Libeirtí	Local Lower at site and downstream
C01/01	521984	723779	1+500	0.06	0.09	Small coastal stream	None
C02/01a	523087	724284	2+800	1.19	1.63	Trusky Stream	Local Higher downstream
C02/01b	523180	724198	2+850	1.19	1.63	Trusky Stream	Local Higher downstream
C03/01	523354	724244	3+050	0.08	0.12	Trusky minor drain	Local Higher downstream
C03/02	523616	724390	3+350	0.15	0.23	Trusky minor drain	Local Higher downstream
C03/03 C03/04	524066 524079	724706 724722	3+925 3+940	0.69	1.09	Bearna Tributary	Local Higher downstream
C04/01	524202	724846	4+100	5.49	7.58	Bearna Stream	Local Higher at site and downstream
C04/02	524895	725274	4+900	1.65	2.13	Tonabrocky	Local Higher downstream
C06/01	526421	726389	6+850	0.14	0.20	Knocknacarra Minor Drain	Local Higher downstream
C07/02B	526710	726684	7+250	0.21	0.30	Knocknacarra Minor Drain	Local Higher downstream
C07/02A	526698	726637	7+210	0.21	0.30	Knocknacarra Minor Drain	Local Higher downstream
C08/01	527664	727212	8+375	0.16	0.23	Minor Drain Dangan	Corrib SAC downstream
C10/02	529688	728412	10+730	0.63	0.19	Minor Drain Coolagh	Corrib SAC downstream
C07/01a	527148	726262	N59 Link Road south 1+600	0.38	0.55	Knocknacarra Minor Drain	Local Higher downstream
S08/04			9+250	3134	264	River Corrib	Corrib SAC downstream

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. Further details of the culvert crossings are discussed in **Section 11.5.3.1**.

11.4.1.2 Hydraulic Structures

Culverts

Table 11.20 summarises the propose crossing sizes, effective height and associated embedment depths for each of the proposed culverts at the crossing of watercourses.

Table 11.20: Preliminary Sizing of Watercourse -Crossing Culverts

Ref.	Approx. Chainage	Width (m)	Height (m)	Diameter	Buried Depth	Effective Height	Watercourse
C00/01	0+650	2.5	1.35		0.30	1.05	Sruthán na Libeirtí
C00/02	0+950			1.2	0.15	1.05	Sruthán na Libeirtí
C01/01	1+500			1.2	0.15	1.05	Small coastal stream
C02/01a	2+800	2.1	1.8		0.30	1.5	Trusky Stream
C02/01b	2+825	2.5	2.5		0.30	2.2	Trusky Stream
C03/01	3+050	2.5	1.2		0.30	0.9	Trusky minor drain
C03/02	3+350			0.9	0.00	0.9	Trusky minor drain
C03/03	3+925	2.5	2.5		0.30	2.2	Bearna Tributary
C03/04	3+940	2.5	2.5		0.30	2.2	Bearna Tributary
C04/01	4+100	5.0	2.5		0.30	2.2	Bearna Stream
C04/02	4+900	3.1	2.5		0.30	2.2	Tonabrocky
C06/01	6+850	2.5	2.5		0.30	2.2	Knocknacarra Drain
C07/02B	7+250			1.2	0.15	1.05	Knocknacarra Drain
C07/02A	7+210	2.5	2.5		0.30	2.2	Knocknacarra Drain
C08/01	8+375			1.2	0.00	1.2	Minor Drain Dangan
C10/01	10+730			1.2	0.15	1.05	Minor Drain Coolagh

Ref.	Approx. Chainage	Width (m)	Height (m)	Diameter	Buried Depth	Effective Height	Watercourse
C07/01	N59 link			1.2	0.15	1.05	Knocknacarra Drain

Notes:

1. Suitable channel transition to and from culvert to be provided that allows for gentle flow transition into and from the culvert and protects against scour and deposition effects.
2. The sizes indicated above are full sizes inclusive of any increases required to accommodate depressed inverts or mammal ledges.

The above crossing sizes allow for pipe culverts and box section inverts to be buried beneath the existing bed level by depths of 150mm in respect to pipes and 300mm in respect to the box sections in fishery watercourses. All other watercourses (non-fisheries) traversed by the proposed road development are minor in flow requirements and therefore can be culverted using a standard nominal 1200mm or 900mm diameter concrete pipe or equivalent.

All of these culverts have been designed for the 100year flood and climate change allowance such that the impact on flood risk is rated at slight with a moderate residual flood risk associated with potential blockage by debris of the culvert barrel, inlet or outlet structures. The proposed regular maintenance and inspection program of the road drainage infrastructure minimises this residual flood risk impact reducing the flood risk to slight.

Under Section 50 of the Arterial Drainage Acts 1945 and 1995, culverting of streams by either new, upgraded or extended culverts/bridges requires approval from the OPW. This enables the OPW who are responsible for Flood Risk Management and Arterial Drainage to assess the implications of the proposed works. The minimum culvert size to be used in relation to the natural drainage is a 1200mm diameter pipe culvert which facilitates burying of the pipe by 150mm. From a hydraulic capacity, blockage potential and maintenance point of view, this minimum culvert size is acceptable and easily meets the OPW requirements. Section 50 approval has been obtained from the OPW in respect to all proposed watercourse culvert crossings described in **Table 11.20** above.

All culverts are designed to prevent permanent impact to the river morphology. A short term temporary impact may occur whilst on-line culverts are put in place. These impacts will be minimised through the incorporation of strict control procedures – refer to the Construction Environmental Management Plan (CEMP) in **Appendix A.7.5**. Permanent impacts on river morphology will be prevented by ensuring the river width is not exceeded or contracted by the proposed culvert or bridge and that reasonable transitions to and from the bridge or culvert is provided where approach and exit channels are skewed to the culvert alignment. In all fishery sensitive watercourses, the proposed culvert will be embedded into the channel to a depth of 300mm for box sections and a minimum of 150mm for pipe culverts (depending on hydraulic size requirements). Suitable local granular material will be placed to back fill the embedded culvert and sizing will be designed based on scour resistance requirements and in consultation with Inland Fisheries Ireland. In all fishery potential streams low flow channels through the culverts will be provided using appropriately sized natural sediments and baffles to assist the formation of such. The design of such measures must take into account the potential for scour.

All Culverts are designed with inlet and outlet structures that include headwall, wing walls and a buried concrete apron or armour stone to resist local scour of the stream bed at the inlet and outlet.

All crossings identified as potential salmonid rivers/streams and important for mammalian (otter) migration have been be designed to maintain the existing migratory routes as far as possible, in accordance with Guidelines for the crossing of Watercourses during the Construction of National Road Schemes, NRA 2008.

The culverts with mammal ledges have been identified and the effect of these ledges has been take into account in the Section 50 assessment.

Channel transitions are required to and from the culvert structure and this may require slight channel realignments to achieve a smooth transition and avoid local erosion and deposition sites due to the culvert.

River Corrib Bridge

The proposed road development crosses the River Corrib to the southwest of Menlo Castle on the eastern side and crosses through NUIG Sporting Campus at Dangan on the western side of the river. The proposed structure is a balanced cantilevered structure spanning over the river banks and provides a clear span between support piers of 153m. This clear span is sufficient to allow the support piers to be set back from the channel bank and thereby substantially reduces any potential encroachment of the River Corrib channel and its flood banks and allows for continuous access along the river bank edge on both banks. On the eastern bank the minimum setback distance from the pier face to channel edge is 5m and on the western bank the minimum setback is slightly more than 10m. Such setbacks meet IFI Fisheries requirements.

The bridge soffit level above the River Corrib Median flood level of 6.26m AOD is 14.1m AOD on the eastern bank edge, 17.8m AOD at the midspan of the channel and 15.5m OD on the western river bank edge. This ensures navigation requirements are easily met and such clearance reduces shadowing effects of the bridge structure.

A detailed hydraulic assessment of the River Corrib and the proposed bridge structure was carried out as part of the Section 50 application for the proposed bridge. This assessment involved development of a detailed 2-dimensional hydraulic model of the River Corrib reach from Menlough to the Salmon Weir and included the Jordan’s Island Channel and the Coolagh Lakes to predict flood levels and allow testing of various bridge configurations as part of the preliminary design and bridge options study. A summary of the predicted design flows and predicted design flood levels are presented in **Table 11.21** below.

Table 11.21: Estimated Design Flood Flows and Flood Levels at the Proposed River Corrib Bridge Crossing

Return Period years	**QT Flood Flow cumec**	**Computed Upstream Flood Level m OD**
2year (Median)	274.5	6.26
10year	389.3	6.72
100year	519.5	7.20
1000year	647.9	7.62
100year+CC	623.4	7.54

11.4.1.3 Proposed Road Drainage Features

There are 16 proposed mainline surface water outfalls discharging directly to surface watercourses, located primarily in the western section of the study area (over the western 10.15km of the mainline for the proposed road development). The remaining surface water outfalls from the 7.35km, to the east of the River Corrib will be discharged to groundwater or to existing public storm and foul sewer systems in the absence of surface water drainage features. The realigned N84 Headford Road and slip roads for the N84 Headford Road Junction will discharge to a small ditch that inflows to Ballindooley Lough. The two short sections of tunnel in the eastern section will discharge to the public foul sewer via pumping. Details of the overall breakdown of the proposed drainage network sections are shown on **Figures 11.6.101** to **11.6.115**.

The total surface drainage area for the proposed road development is estimated to be 94.85ha and the hard-paved area is 61.21ha. This gives the average percentage impervious area for the road of 64.5%. The total drainage area discharging to surface water outfalls is 55.96ha with hard paved area of 32.5ha and the total drainage area discharging to groundwater is 35.5ha with hard paved area of 19.2ha.

The proposed tunnelled sections are relatively short closed systems and the surface drainage from inside the tunnel is gravitated to a sump where it will be collected and discharged by pumping into the nearby public foul drainage system, which eventually arrives at the Mutton Island Waste Water treatment facility, where it is treated and disposed to sea. The tunnelled section will not receive any direct rainfall. An impounding sump of 25m^3, to collect accidental spillages from inside the tunnel is provided for both the Lackagh Tunnel and Galway Racecourse Tunnel.

The paved area contributing to the proposed road development drainage outfalls has an average pavement area of 1.2ha, which represents a reasonably small ratio of pavement area to outfall. The largest surface water outfall serves a paved area of 2.45ha and the largest groundwater outfall serves a paved area of 4.82ha. A summary of the proposed road development drainage outfalls discharging to surface watercourses is presented here in **Table 11.22** and those storm outfalls discharging to groundwater are presented in **Table 11.23**.

Table 11.22: Proposed Road Development Drainage Outfalls to Watercourses

Drainage Network Ref. No.	Approx. Chainage	Total Road Drainage Area (ha)	Road Pavement Area (ha)	Watercourse
S1	0+0000 to 0+700	2.05	1.29	Sruthán na Líbeirtí
S2	0+ 700 to 1+000	0.55	0.38	Sruthán na Líbeirtí
S3	1+000 to 1+475	2.31	1.28	Sruthán na Líbeirtí
S4A	1+475 to 1+900	0.96	0.62	Trusky Tributary
S5A	1+900 to 2+850	2.45	1.53	Trusky Stream
S7A	2+850 to 3+050	0.30	0.24	Bearna Stream
S7B	3+050 to 3+910	2.94	1.07	Bearna Stream
S8	3+910 to 4+125	0.42	0.26	Bearna Stream

Drainage Network Ref. No.	Approx. Chainage	Total Road Drainage Area (ha)	Road Pavement Area (ha)	Watercourse
S9	4+125 to 4+900	1.75	1.19	Bearna Stream
S10	4+900 to 5+640	2.19	1.22	Bearna Tributary
S12	6+325 to 7+300	3.15	2.45	Knocknacarra Tributary
S13	7+300 to 7+525	0.91	0.63	Knocknacarra Tributary
S14A	7+525 to 8+250	5.66	2.199	Discharging to culvert on River Corrib Tributary West Bank
S14B	8+250 to 8+525	0.85	0.65	River Corrib Tributary
S18A	8+525 to 9+250	1.75	1.58	River Corrib Tributary West Bank
S18B	9+250 to 10+150	2.27	1.95	River Corrib Tributary East Bank
S21A	11+850 to 12+450	3.31	1.36	Ballindooley Lough Tributary
S4B	1+500	0.12	0.07	Trusky Tributary
S15	+ N59 Link Road North Chainage 0+000 to 0+625	1.89	0.73	River Corrib Tributary West Bank
S5B	2+800	0.24	0.14	Trusky Stream
S36A	3+350	0.24	0.17	Bearna Tributary
S36B	3+350	0.10	0.08	Trusky Stream
S31A	7+250	0.09	0.06	Knocknacarra Tributary
S31B	7+250	0.15	0.12	Knocknacarra Tributary
S44	9+150	0	0	River Corrib Tributary West Bank

Table 11.23: Proposed Road Development Drainage Outfalls to Infiltration Basins

Drainage Network Ref. No.	Approx. Chainage	Total Drainage Area (ha)	Pavement Area (ha)
S19A	10+150 to 10+730	1.95	1.66
S19B	10+730 to 11+150	2.22	1.68
S20	11+420 to 12+020	4.26	2.23
S21B	12+020 to 13+630	8.28	4.82
S22A	13+360 to 14+350	5.68	3.94
S22B	14+350 to 14+950	3.06	2.76

Drainage Network Ref. No.	Approx. Chainage	Total Drainage Area (ha)	Pavement Area (ha)
S27	16+750 to 17+535	5.47	3.20
S22E	14+400	0.79	0.69
S22C2	14+400	0.83	0.76
S40	10+475	0.16	0.12

The remaining drainage areas discharge to the existing public storm drainage infrastructure. The permissible discharge rates have been set based on consideration of natural greenfield runoff rates and the current capacity in the receiving storm drainage system. All of the proposed discharge rates to public storm sewers have been agreed with Galway City Council. A summary of the outfalls to the public sewer is provided in **Table 11.24** below.

Table 11.24: Proposed Road Development Outfalls to Public Storm Sewers

Drainage Network Ref. No.	Approx. Chainage	Total Drainage Area (ha)	Pavement Area (ha)	Receiving Sewer Size (mm)	Peak discharge rate 1 in 100 (l/s)
S11	5+640 to 6+325	2.02	1.57	300	7.8
S14A	7+525 to 8+250	5.66	2.199	1200	21
S26	15+750 to 16+750	5.12	3.47	900	4.5
S29	16+500	2.73	2.07	900	5.0
S30	15+200 to 15+700 Junction - Coolagh Junction to Lynch Junction	6.33	4.58	900	5.7
S16A	N59 Link Road South 0+625 to 1+625	4.16	2.15	450	16.1
S17A	N59 Link Road South 1+625 to 2+210	1.08	0.98	1500	5.7
S22C1	14+400	1.46	1.36	900	5.0
S37	4+450	0.21	0.19	450	5.4
S32	6+300	0.80	0.40	375	5.6
S16B	N59 Link Road South 1+625	0.12	0.10	450	4.7
S17B	N59 Link Road South 2+210	0.34	0.27	1500	5.2
S31C	7+250	0.25	0.16	450	4.9
S38	5+650	0.14	0.10	300	46.7

Drainage Network Ref. No.	Approx. Chainage	Total Drainage Area (ha)	Pavement Area (ha)	Receiving Sewer Size (mm)	Peak discharge rate 1 in 100 (l/s)
S41	13+150	0.24	0.23	225	66.7
S39	7+575	0.22	0.15	225	68.6
S33	1+500	0.56	0.54	600	5
S45	15+200	1.736	1.44	750	241

Proper management and regular inspection and maintenance of these drainage discharge facilities will be undertaken as part of the operation and maintenance schedule during the operational phase of the proposed road development.

All rainfall runoff will be prevented from discharging directly to the receiving surface waters by the proposed road sustainable drainage system. Road runoff will only outfall to receiving surface waters at specified outfall locations. Catchment sizes are conserved as far as practicable by minimising diversion of run-off between sub-catchments. Attenuation ponds, treatment wetlands oil / petrol interceptors and silt traps will be installed at all major outfalls, to prevent pollutants from entering the receiving watercourses. The installation of emergency spill containment facilities with a minimum volume of $25m^3$ will mitigate against any potential adverse impacts to the receiving surface waters arising from an accidental spillage associated with road haulage.

Attenuation storage and flow control have been provided for all mainline and new link road drainage areas so that the design flood discharge in the case of surface discharges achieves predetermined greenfield flood runoff rates. This prevents potential impacts to river morphology and surface water flow hydraulics of the receiving watercourses. In the case of groundwater, the storm water disposal rates meet the infiltration capacity of the infiltration basin. The proposed attenuation storage volumes are sized accordingly to accommodate any potential increase in surface water runoff rates up to the 100year return period storm event with climate change allowance. This ensures that there will be no increase to flood risk up to and including the 1 in 100year storm event as per TII drainage publications Clause 7.5 of DN-DNG-03022 Drainage Systems for National Roads. A departure from this standard applies to the two River Corrib outfalls (S18A and S18B) located on either bank, where flood attenuation is not necessary due to the significant difference in drainage catchment scale (with the River Corrib catchment over 70,000 times bigger) and timing of flood response (hours versus days). All outfall structures will be designed with an outlet structure that includes headwall, wing walls and a bed apron to prevent local scouring of the banks and the channel bed. All culverts are designed to allow for both aquatic species and mammal migration, and to maintain the existing river bed as far as possible, in accordance with “Guidelines for the Crossing of Watercourses During the Construction of National Road Schemes,” NRA, 2008. All culverts upstream and downstream of protected ecological areas (NHAs, SACs or SPAs) are designed to retain natural riverbed forms. **Section 11.4.1.1** discusses in greater detail the requirements of culverting for the protection of local ecology.

All culverts and the River Corrib Bridge are designed accordingly to prevent impact to watercourse morphology and to prevent impoundment or alteration of surface water flow hydrodynamics. All watercourse culverts and the River Corrib Bridge have obtained Section 50 approval from the OPW and therefore satisfy the OPW Flood Risk and impact requirements. For further details, refer to the Flood Risk Assessment Report in **Appendix A.11.1**.

The proposed River Corrib Bridge crossing is designed to prevent impact to the hydrodynamics of the river and its associated floodplain. It has been designed so as not to have any piers located within the effective floodplain area, within the channel, or within 5m of the river banks. The bridge is located in a stable, straight, reach section of the river (as evidenced by bankside vegetation), so it is expected to neither be sensitive to, nor impact on, local channel morphology.

No major river realignment work will be necessary as part of the proposed road development. Some minor stream and ditch realignment is required. The minor drain and stream diversions proposed for the proposed road development are summarised in **Table 11.25** below.

Table 11.25: Minor Watercourse Diversions

Stream	**Approx. Chainage**	**Diversion Channel Length (m)**	**Location**
Sruthan na Liberiti	0+700	35	Na Foraí Maola
Truskey Stream	2+800	50	Bearna to Moycullen Road
Tributary to Bearna Stream	3+375 to 3+900	525	Aille
Tonabrocky Stream	4+960 to 5+200	240	Keeraun
Drain	7+200 to 7+350	320	Letteragh Road

The proposed stream and drain realignments have been assessed as part of the culvert design. Localised design measures are included to prevent potential bank erosion at sites of bends which were found to coincide with a number of the proposed road culverts. This protection may be in the form of large boulders or rip-rap along the outer bank with a suitable filter material or geotextile placed inside the armouring to protect the native soil bank. All diversion channels will include fishery friendly requirements where they are identified as having fishery potential.

This may require the incorporation of meanders, riffles/shoals and pools within the channel bed and suitable sediment size provided within the new channel to resist scour under flood flow conditions. The flood capacity will be enhanced while importantly preserving the low flow channel characteristics. The inclusion of shoals and pools in the channel will assist the rehabilitation of the low flow channel at crossing and diversion/realignment sites. All stream re-alignment work shall create new channels that will achieve maximum ecological benefits and maintain or improve on the existing hydrological environment. The design of stream re-alignments was conducted in consultation with Inland Fisheries Ireland to ascertain their desired stream morphology to adequately address fishery habitats and passage. The principle aim of stream re-alignment is to promote ecology and ensure a more suitable stretch of stream for fisheries. Stream realignment will be conducted using the principles and guidance laid out by the Central Fisheries Board for the enhancement of rivers (O'Grady, 2006).

The use of persistent herbicides, pesticides or artificial fertilisers in any landscaping or subsequent maintenance within 2m of a watercourse is not permitted. Applications of herbicides or pesticides within a zone of 2m to 10m from any watercourse will be in accordance with manufacturer's recommendations and confined to periods when the vegetation is not wet from rainfall or dew.

11.4.1.4 Pollution Control Measures

The proposed drainage system design incorporates a range of pollution control features to limit the water quality impact to receiving waters. These include combined filter drains, detention ponds, grassed surface water channels, petrol and oil interceptors, wetlands and infiltration basins. The use of filter drains and grassed surface water channels are proposed in non-sensitive groundwater areas (granite bedrock areas west of N59 Moycullen Road) and closed (sealed) drainage systems are proposed in the highly vulnerable Karst Aquifer region east of the N59 Moycullen Road. A Treatment wetland will also be provided upstream or in combination with the attenuation pond at all proposed surface outfalls from the proposed mainline and new link road catchments and upstream of all infiltration basins, to provide primary treatment of road runoff. These wetlands systems will be suitably planted with aquatic plants for uptake of solutes including dissolved heavy metals and nutrients and will have a permanent pond depth of at least 500mm. A summary of the pollution control measures provided at each drainage outfall is summarised in **Table 11.26** below.

Table 11.26: Pollution Control Summary

Drainage Network Ref. No.	Outfalling to	Pollution Control Measure Provided
S1	Watercourse	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S2	Watercourse	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S3	Watercourse	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S4A	Watercourse	Spillage Containment Area, Oil and petrol interceptor, Wetland, Attenuation Pond
S5A	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S7A	Watercourse	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S7B	Watercourse	Spillage containment Area, Oil and petrol interceptor, Wetland, Attenuation Pond
S8	Watercourse	Spillage containment Area, Oil and petrol interceptor, Wetland, Attenuation Pond

Drainage Network Ref. No.	Outfalling to	Pollution Control Measure Provided
S9	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S10	Watercourse	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S11	Existing Sewer	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S12	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S13	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S14A	Existing Culvert	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S14B	Watercourse	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S18A	Watercourse	Spillage Containment Pipes, Oil and Petrol Interceptor, Wetland
S18B	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland
S19A	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
S19B	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
F19	Foul Sewer	Spillage Containment Area, Oil and Petrol Interceptor discharging to Foul Sewer. Discharge to be treated at Mutton Island Waste Water Treatment Works.
S20	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
S21B	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
S22A	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
S22B	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
F24	Foul Sewer	Spillage Containment Area, Oil and Petrol Interceptor discharging to Foul Sewer. Discharge to be treated at Mutton Island Waste Water Treatment Works.
S26	Existing Sewer	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S27	Existing M6 Infiltration Basin	Existing M6 Infiltration Pond
S21A	Attenuation Basin	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond

Drainage Network Ref. No.	Outfalling to	Pollution Control Measure Provided
S22E	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Infiltration Basin
S29	Existing Sewer	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S30	Existing Sewer	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S4B	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S15	Watercourse	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S16A	Existing Sewer	Spillage Containment Area, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S17A	Existing Sewer	Spillage Containment Pipe, Oil and Petrol Interceptor, Wetland, Attenuation Pond
S22C1	Existing Sewer	Spillage Containment Pipe, Oil and Petrol Interceptor, Attenuation Pond
S22C2	Infiltration Basin	Spillage Containment Pipe, Oil and Petrol Interceptor, Infiltration Basin
S5B	Watercourse	None Required, overlay of existing local road
S16B	Existing Sewer	Online Attenuation – Flow Control and Oversized Pipes
S17B	Existing Sewer	Online Attenuation – Flow Control and Oversized Pipes
S31A	Watercourse	None Required, overlay of existing local road
S31B	Watercourse	None Required, overlay of existing local road
S31C	Existing Sewer	Online Attenuation – Flow Control and Oversized Pipes
S32	Existing Sewer	Attenuation Pond
S33	Existing Sewer	Attenuation Tank
S36A	Watercourse	None Required, upgrade of existing local road
S36B	Existing Ditch	None Required, overlay of existing local road
S37	Existing Sewer	Online Attenuation – Oversized Pipes
S38	Existing Sewer	None Required, overlay of existing local road
S39	Existing Sewer	None Required, overlay of existing local road
S40	Infiltration Basin	Spillage Containment Area, Oil and Petrol Interceptor, Infiltration Basin
S41	Existing Sewer	None Required, overlay of existing local road
S44	Watercourse	None Required, synthetic playing pitch development only
S45	Existing Sewer	None Required, brown field development

Each of the mainline and new link road catchment attenuation ponds either includes or have immediately upstream a wetland treatment system which has been sized to cater for the first flush volume from the proposed road pavement (15mm rainfall event).

The attenuation ponds are sized to cater for the 100year storm event with 20% climate change allowance and discharge at the permissible greenfield flood outflow rate subject to a minimum discharge rate of 5l/s. These storages provide large detention times that allow effective settlement of sediments within the pond systems.

Spillage containment will be achieved using oil and petrol interceptors sized for the individual drainage catchment and located upstream of the wetland and attenuation ponds / infiltration basins to prevent any contamination from hydrocarbons entering the surface and groundwater systems. A minimum emergency spill containment volume of 25m^3 will be provided at all outfall locations where runoff can be diverted in the event of a spillage from a HGV.

To facilitate emergency response to serious spillages all pond and storage systems will be fitted with a manual penstock to close off the outfall and contain the spillage water within the pond/storage system for pumping out and appropriate treatment and disposal. Access will be provided to these facilities to enable ongoing inspection, maintenance and emergency response.

11.4.1.5 Material Deposition Areas

A total of 40 site areas have been identified as potential material deposition areas for the excess soft and unacceptable material along the route of the proposed road development. These sites are all within easy haulage distances from the location of large soft ground deposits and are detailed in the **Table 11.27** below. These sites provide a storage capacity in excess of the anticipated 370 thousand cubic metres of potentially excess unacceptable material which may be encountered along the proposed road development. Each area has been assessed, however they will not be fully utilised as there is excess capacity.

Table 11.27: Location of Potential Material Deposition Areas

Location	Approx. Chainage	Catchment Reference	Area (ha)	Approximate Capacity (m^3)
R336 Coast Road	0+050	Sruthán na Líbeirtí	0.089	1,200
An Baile Nua	0+300	Sruthán na Líbeirtí	0.232	3,200
Cnoc na Gréine	0+350	Sruthán na Líbeirtí	0.248	2,700
Na Foraí Maola Thiar	1+050	Sruthán na Líbeirtí	0.098	<1,000
Na Foraí Maola Thoir	1+450	Sruthán na Líbeirtí / Trusky Stream	1.051	<1,000
Troscaigh Thiar	1+800	Trusky Stream	0.483	7,800
Bearna to Moycullen Road	2+900	Trusky Stream	0.065	<1,000

Location	Approx. Chainage	Catchment Reference	Area (ha)	Approximate Capacity (m^3)
Bearna to Moycullen Road	2+950	Trusky Stream	0.602	11,400
An Chloch Scoilte	3+250	Trusky Stream	0.239	4,000
An Chloch Scoilte	3+375	Bearna Stream	0.154	<1,000
An Chloch Scoilte	3+950	Bearna Stream	0.349	10,000
An Chloch Scoilte	4+050	Bearna Stream	0.468	10,000 2,100
Cappagh	4+850	Bearna Stream	0.121	
Ballymoneen	5+250	Bearna Stream	0.811	10,700
Keeraun	5+950	Knocknacarra Stream	0.484	2,500
Letteragh	7+450	Knocknacarra Stream	0.308	5,000
Bushypark	0+050	River Corrib Catchment incl. Terryland River Valley	0.079	<1,000
Bushypark	0+075	River Corrib Catchment incl. Terryland River Valley	0.393	2,200
Bushypark	0+200	River Corrib Catchment incl. Terryland River Valley	0.353	6,000
Dangan	8+100	River Corrib Catchment incl. Terryland River Valley	0.149	<1,000
Dangan	8+200	River Corrib Catchment incl. Terryland River Valley	0.069	<1,000
Coolough	10+675	River Corrib Catchment incl. Terryland River Valley	0.142	<1,000
Lackagh Quarry	11+000	River Corrib Catchment incl. Terryland River Valley	1.727	45,000
Lackagh Quarry	11+350	River Corrib Catchment incl.	2.936	200,000

Location	Approx. Chainage	Catchment Reference	Area (ha)	Approximate Capacity (m^3)
		Terryland River Valley		
Lackagh Quarry	11+450	River Corrib Catchment incl. Terryland River Valley	0.148	<1,000
Lackagh Quarry	11+500	River Corrib Catchment incl. Terryland River Valley	0.160	<1,000
Lackagh Quarry	11+550	River Corrib Catchment incl. Terryland River Valley	0.346	
Lackagh Quarry	11+650	River Corrib Catchment incl. Terryland River Valley	1.180	250,000
Ballinfoyle	12+200	River Corrib Catchment incl. Terryland River Valley	0.208	5,700
Ballinfoyle	12+225	River Corrib Catchment incl. Terryland River Valley	0.359	7,300
Twomileditch	14+000	River Corrib Catchment incl. Terryland River Valley	3.024	25,000
Parkmore	13+950	River Corrib Catchment incl. Terryland River Valley	0.315	<1,000
Parkmore	13+950	River Corrib Catchment incl. Terryland River Valley	0.195	<1,000
Coolagh	16+000	Doughiska	0.395	7,000
Coolagh	16+400	Doughiska	0.853	10,000
Coolagh	16+550	Doughiska	1.789	11,500
Coolagh	16+350	Doughiska	1.941	63,000
Coolagh	16+450	Doughiska	0.440	18,000
Coolagh	16+500	Doughiska	0.782	35,000

These material deposition areas will be bunded or excavated sites and will have double erosion control fencing (silt fence) and a sediment settlement pond at the outlet which will be constructed in advance of their use as deposition areas. In addition, wheel wash facilities, will be provided at the entrance/exit as outlined in the CEMP – see **Appendix A.7.5**.

A 2.5m wide permanent maintenance access track will extend around the external perimeter of the peat restoration areas and combined with the foundation to the perimeter berm for access. Materials will initially be delivered to the working area for access roads and perimeter berm construction by low ground pressure vehicles such as tracked dumpers and light weight, wide track excavators.

Any local drains within these areas will be either diverted around the site or truncated to minimise the volume of water entering such areas to that of direct rainfall and the soil moisture of the material itself.

11.4.2 Construction Phase

The construction phase of the proposed road development involves temporary and permanent works in the vicinity of and within watercourses, generally associated with the construction of culverts and outfalls, realignment of drainage channels. The aspects of the construction phase that are relevant to hydrology are summarise below.

- Construction of 17 new culverts on watercourse crossings, refer to **Table 11.20** above
- Construction of all 25 road drainage outfalls discharging to surface water outfalls refer to **Table 11.22** above
- Construction of 10 road drainage outfalls discharging to groundwater via infiltration basins, refer to **Table 11.23** above
- Construction of 17 outfalls discharging to existing Public Storm sewer, refer to **Table 11.24** above
- Construction of 5 minor watercourse diversions, refer to **Table 11.25** (ranging in length from 35m to 525m)
- Construction of a new bridge over the River Corrib
- Construction of two tunnel sections at Lackagh Quarry and at Galway Racecourse
- General construction earthworks adjacent to watercourses including the construction of a replacement 3G all weather pitch and training pitch at NUIG Sporting Campus at Dangan
- Construction of wetland treatment systems, attenuation ponds and infiltration basins upstream of the proposed road drainage outfall
- Construction of permanent interceptor drains
- Construction of the proposed road drainage network including carrier drains, filter drains, grassed surface water channels
- Construction of retaining walls along route of the proposed road development

- Construction of flood relief mitigation measures at the N83 Tuam Road crossing location
- Construction of 13 site compounds within the proposed development boundary as set out in **Table 7.9** and shown on **Figures 7.101** to **7.123**
- Construction of material deposition areas - the provision of 40 material deposition sites along the route for surplus topsoil, U1 material (material that does not comply with the requirements outlined in TII Series 600 Cl. 601.1) and peat encountered during construction with the majority of peat material encountered on the west side of the River Corrib. Such material is not suitable as construction material and is excess material
- Construction of temporary drainage works such as sedimentation ponds and silt traps as required to treat soiled construction water. Temporary diversions and interceptor drains will be constructed to reduce the potential for soiled water runoff from the construction site. For further details of control of sediment and erosion refer to the CEMP in **Appendix A.7.5**

11.5 Evaluation of Impacts

11.5.1 Introduction

Given the scale and nature of the proposed road development there are potential significant impacts to the hydrological regime both during their construction and on-going operation. Consequently, detailed measures have been designed and incorporated to ensure that all potential significant impacts are avoided or mitigated.

The principal potential hydrological impacts to the character of the receiving waters are associated with the proposed crossing points and the potential for sediment loading and associated road drainage pollutants entering such watercourses during both construction and operational phases.

There is also potential for impacts to surface water hydrology from other sources which include:

- Impact to surface watercourses crossed by the proposed road development involving culvert and bridge structures and associated realignment of the watercourse channel
- Impact to surface watercourses discharged to via proposed road drainage outfalls and downstream impacts
- Impact to potential morphological changes to watercourses at channel crossings and proposed road development outfall discharge locations
- Impact to flooding and flood risk, upstream and downstream of proposed crossing points and floodplain encroachment at proposed crossing points, at material deposition areas and downstream impacts from storm outfall locations
- Impacts on sites of ecological importance in proximity to surface watercourses namely the River Corrib, Coolagh Lakes and Ballindooley Lough

- Impacts on Galway City public drinking water abstraction from the River Corrib at Jordan's Island, which is located in the downstream reach from the proposed road development crossing of the River Corrib

11.5.2 Do Nothing Impact

In the event of the proposed road development not being constructed there would be no resulting impacts on the hydrology along the route of the proposed road development. The traffic will remain on the existing road network, which for many of the existing outfalls do not include a sustainable urban drainage system to protect surface and groundwater bodies from pollution and flood runoff.

11.5.3 Potential Impacts to Hydrological Receptors

Construction activities pose a significant risk to watercourses particularly from contaminated surface water runoff from construction activities entering nearby watercourses.

Construction activities within and alongside surface waters associated with bridge and culvert construction, outfalls and channel diversions can contribute to the deterioration of water quality and can physically alter the stream/river bed and bank morphology with the potential to alter erosion and deposition rates locally and downstream. Activities within or close to the watercourse channels can lead to increased turbidity through re-suspension of bed sediments and release of new sediments from earthworks. Consequently, in-stream works can potentially represent a severe disruption to aquatic ecology.

The main contaminants arising from construction runoff include:

- Elevated silt/sediment loading in construction site runoff. Elevated silt loading can lead to long-term damage to aquatic ecosystems by smothering spawning grounds and gravel beds and clogging the gills of fish. Increased silt load in receiving watercourses stunts aquatic plant growth, limits dissolved oxygen capacity and overall reduces the ecological quality with the most critical period associated with low flow conditions. Chemical contaminants in the watercourse can bind to silt which can lead to increased bioavailability of these contaminants
- Spillage of concrete, grout and other cement based products. These cement based products are highly alkaline (releasing fine highly alkaline silt) and extremely corrosive and can result in significant impact to watercourses altering the pH, smothering the stream bed and physically damaging fish through burning and clogging by the fine silt of gills
- Accidental spillage of hydrocarbons from construction plant and at storage depots / construction compounds
- Faecal contamination arising from inadequate treatment of on-site toilets and washing facilities

11.5.3.1 Hydraulic Structures

This sub-section considers the hydraulic impact of the proposed watercourse structures and stream realignments along the proposed road development.

Culvert Crossings

Table 11.19 presents a summary of the primary culvert crossings including upstream contributing catchment area and **Table 11.20** presents the proposed culvert sizes.

The majority of the streams intercepted have relatively small catchment areas and the recommended barrel dimension size provided is generally an increase over existing structures and stream channel dimensions and will not result in any significant contraction of the stream flow velocity or creation of upstream afflux. In a lot of cases the culvert dimensions have been increased to facilitate bat passage and mammal ledges. The Section 50 assessments show that all culverts provided are suitably sized to prevent any potential flood impacts both under present day statistics and in the short to medium term climate change conditions.

These structures can also have a negative impact on the flow regime in watercourses particularly those with fishery potential as often the wider dimension or increased channel gradients can locally result in insufficient water depth during mean and low flow conditions and such structures if not appropriately designed can lead to undesirable changes in channel morphology and thus potentially impact fish migration and sedimentation. The construction of these structures in watercourses, if not carefully managed, can lead to pollution of the watercourse both locally and in its downstream reaches through the potential for spillages from construction plant and equipment and potential release of cement based products, wood preservative from roadway timber fencing and the disturbance of bed and channel banks resulting in suspended sediment releases.

Without appropriate design measures the potential operational impact on hydrology and channel morphology is classified as slight for Local Low fishery watercourses and moderate for Local High watercourses. This is based on the fact that most of the streams are to be culverted are classified as locally higher value for fish in their downstream reaches. It is noted that all of the watercourses are valued as having Local High ecological value.

The potential constructional impacts without mitigation through potential release of sediments by disturbance of the channel bed and bank represent a short term local moderate to significant impact on water quality and bed sediment deposition rates that could impact fishery habitat potential of the downstream reach. As a result all construction works are to be carried out in accordance with OPW, EPA and IFI guidelines at appropriate times of the year and are to implement all necessary measures to limit the potential impact of the works on all stream/river ecology.

A summary of both operational and construction impact due to watercourse crossings is provided in **Table 11.28** below.

Table 11.28: Impact Assessment of Proposed Watercourse Culvert crossings

Ref.	Watercourse	Construction Phase Impact magnitude	Operational Phase Impact Magnitude
C00/01	Sruthán na Libeirtí	Short-term potential moderate impact on water quality and siltation locally and downstream reach	moderate local impact on channel flow regime and morphology
C00/02	Sruthán na Libeirtí	Short-term potential moderate impact on water quality and siltation locally and downstream reach	moderate local impact on channel flow regime and morphology
C01/01	Small coastal stream	Sort-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology
C02/01a	Trusky Stream	Short-term potential moderate impact on water quality and siltation in its downstream reach	moderate local impact on channel flow regime and morphology
C02/01b	Trusky Stream	Short-term potential moderate impact on water quality and siltation in its downstream reach	moderate local impact on channel flow regime and morphology
C03/01	Trusky minor drain	Short-term potential moderate impact on water quality and siltation in its downstream reach	slight local impact on channel flow regime and morphology
C03/02	Trusky minor drain	Short-term potential moderate impact on water quality and siltation in its downstream reach	slight local impact on channel flow regime and morphology
C03/03	Bearna Tributary	Short-term potential moderate impact on water quality and siltation locally and downstream reach	slight local impact on channel flow regime and morphology
C03/04	Bearna Tributary	Short-term potential moderate impact on water quality and siltation locally and downstream reach	slight local impact on channel flow regime and morphology
C04/01	Bearna Stream	Short-term potential significant impact on water quality and siltation locally and downstream reach	moderate local impact on channel flow regime and morphology
C04/02	Tonabrocky	Short-term potential moderate impact on water quality and siltation locally and downstream reach	moderate local impact on channel flow regime and morphology
C06/01	Knocknacarra Drain	Short-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology
C07/02B	Knocknacarra Drain	Short-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology

Ref.	**Watercourse**	**Construction Phase Impact magnitude**	**Operational Phase Impact Magnitude**
C07/02A	Knocknacarra Drain	Short-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology
C08/01	Minor Drain Dangan	Short-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology
C10/01	Minor Drain Coolagh	Short-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology
C07/01	Knocknacarra Drain	Short-term potential slight impact on water quality and siltation	slight local impact on channel flow regime and morphology

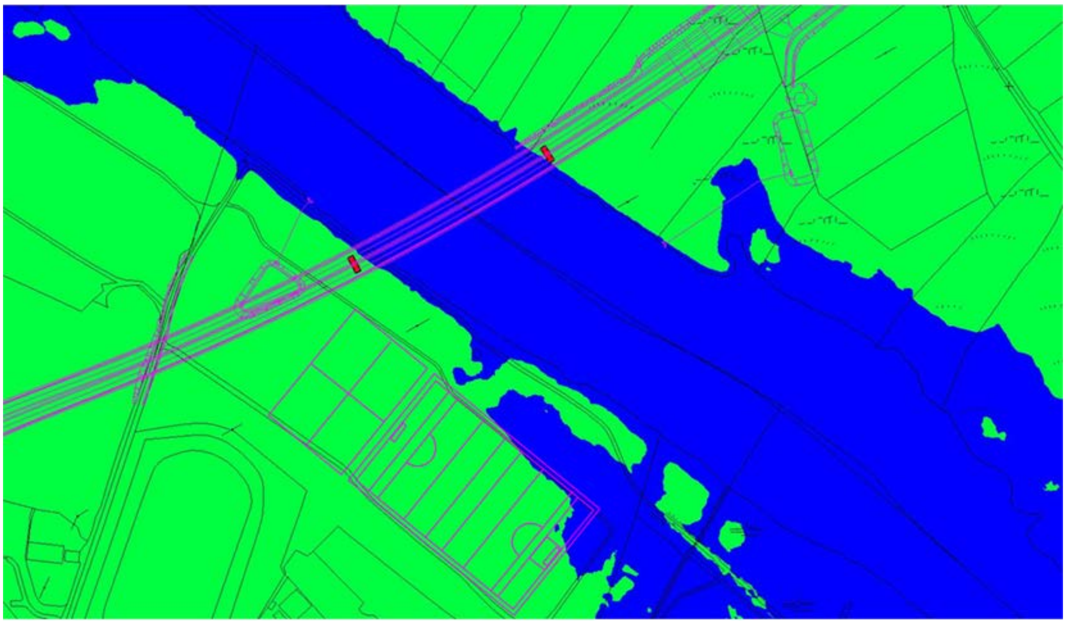
River Corrib Bridge Crossing

For the operational phase, the hydraulic modelling of return period flood flows (with inclusion for statistical error) provided estimates of flood levels at the proposed bridge site. Refer to **Table 11.26** above. This clearly demonstrates that the proposed bridge structure has no discernible impact on flood levels either upstream or downstream nor is there any flood risk issues for the proposed road development with the proposed bridge deck and the storm drainage system sufficiently elevated.

Hydraulic analysis shows no discernible impact on flood levels at the design flood event which is the 100year with inclusion of a climate change allowance of 20%. The predicted flood level for this design flood condition (100yr +CC) is 7.54m OD. At such a flood level, both river bank piers will be located just outside of the flood risk area. At the estimated 1000year flood level of 7.62m OD associated with a peak flood flow of 648cumec, the proposed bridge piers remain outside floodplain area in Flood Zone C, refer to **Plate 11.1** below and therefore no encroachment of the floodplain area will occur at the bridge crossing. The water quality / attenuation ponds remain outside the flood zone also.

There is little potential for bank erosion at the proposed River Corrib crossing location as the river channel is straight, regular and cut into bedrock.

Plate 11.1: 1 in 1,000 year return period flood inundation map of proposed bridge crossing with pier locations shown in red outside of the flood zone



During the construction phase, in order to avoid any potential scour risk associated with the construction of these bridge structures, abutments for bridges are sufficiently set back from the channel bank edge with foundations located at depth. This will protect the river channel from changes in morphology whereby the channel over time would naturally migrate towards one of the abutments. The proposed construction method for the River Corrib bridge crossing will essentially avoid works within the river channel, temporary or otherwise except for the installation of drainage outfalls 18A and 18B. The main risk will be associated with the construction of the support piers adjacent to the channel bank edge which are setback at least 10m on the western bank and 5m on the eastern bank. The River Corrib is sensitive as a salmonid river, major water supply source, European site designation and an important amenity, both locally and downstream through the city and canals. Potential construction accidental spillages of hydrocarbons from plant and spillage of concrete and associated chemicals with constructing the river side piers, bridge deck and storms outfalls represents a potential temporary impact to the waterbody and places risk to the water supply of Galway City, particularly activities on the eastern (left) bank and therefore is categorised as a potential moderate to significant impact in the absence of mitigation measures to protect the River Corrib from construction related pollution in the form of accidental spillages and soiled construction water runoff.

Construction sediment releases from construction activities associated with the bridge crossing represents a potential temporary impact on the River Corrib water quality both locally and downstream. The potential sediment plume will generally hug the river bank edge for quite a distance downstream (approximately 1 to 2km) before fully mixing across the channel width. There is generally good dilution in the River Corrib throughout the year to minimise the wider impact of sediment releases on fisheries, benthos and on the public water supply source. The low velocities associated with the River Corrib and particularly along its river edge provides the opportunity for released construction sediment to settle out rapidly along the bank edge giving rise to the potential for local smothering of the benthos.

Extensive earthworks will be associated with the development of the NUIG pitches at Dangan and given their close proximity to the River Corrib bank edge and to a local drain that discharges to the River Corrib a short distance downstream and the potential for partial flood inundation at the 100year flood a potential for construction runoff pollution of the River Corrib exists. Construction phase mitigation measures are required to protect the sensitive River Corrib waters.

There is a potential for construction impacts on the Coolagh Lakes and supporting habitat from construction site sediment runoff and construction spillages. The natural wetland habitat in the riparian zone of the lakes provides a good buffer between the construction area and the lakes. Notwithstanding this buffer zone, construction phase mitigation measures in the form of sediment and pollution control measures are required to protect this sensitive waterbody.

Mitigation which is outlined in the **Section 11.6** addresses these potential construction impacts through the proposed implementation of good construction practice procedures and environmental controls so as to minimise the opportunity for contaminated releases of construction water to the River Corrib, refer to the CEMP in **Appendix A.7.5**.

11.5.3.2 Stream Diversions and Realignments

The construction of watercourse crossings for the proposed road development will necessitate in some cases the localised diversion/realignment of the existing watercourses. Where feasible, these minor watercourse diversions/realignments will be carried out in the dry and when the channel has established, the watercourse will be diverted into them. The principal impact on a watercourse by a diversion is the change in the watercourse morphology. The general potential impacts can be:

- Slacker gradients: Slower flow velocities with resulting increased flow area and deposition, siltation promoting vegetation and weeds to grow in channels during periods of low flow
- Steeper gradients: Faster flow velocities, increased local bed erosion, shallower low flow depth
- Sharp bends and change in direction: Erosion and deposition with subsequent changes to the river channel morphology
- Lack of natural flood plains: Increase in upstream flood levels

Other potential impacts of watercourse diversions include:

- Change to natural low flow channels: Impact on fisheries and other animals
- Change to existing foliage and vegetation: Impact on fisheries and other species (otters, badgers etc.)

Stream diversions/realignments are not proposed on any locally sensitive salmonid streams. Details of the proposed stream diversions and realignments are presented in **Table 11.23** above. None of these realignments/diversions represent a transfer of stream flow between basins and are only local realignments to facilitate the proposed road development.

It is likely that all the proposed culverts will require some slight local channel realignment and regrading to facilitate the proposed road culvert barrel and to ensure gentle transition to and from the culvert and such transitions have been assessed as part of the culvert crossing assessment in **Table 11.28**.

The principal impact of these channel realignments is associated with the construction stage and the potential for soil erosion associated with the initial excavation works and the initial establishment of the flow channel. This soil erosion may give rise to potential water quality impacts and sedimentation downstream in the receiving waters, most of which are salmonid and of a local higher ecological value in their lower reaches. Therefore, in the unmitigated case, the potential impact of the constructional phase on salmonid potential downstream reaches with locally higher ecological value will represent a temporary moderate to significant water quality impact with potential for elevated suspended solids concentrations and potential for short-term sediment deposition.

The operational impact of the proposed watercourse realignments/diversions will be very localised to morphology changes in the stream channel during large floods and which will stabilise over time. The potential impact is rated to be a locally minor impact which can be further minimised through engineering design (trapezoidal channel with side slopes 1 in 2) of the channel and transitions including provision of culvert wing-walls and armoured bed and channel banks at such transitions. The significant realignment works to the Tonabrocky Stream represent a permanent moderate impact as the realignment diverts the stream channel in a relatively straight artificial channel that has relatively steep channel banks.

The drainage design has also identified that a number of minor drains/watercourses are intercepted by the proposed road development, principally in the western section of the proposed road development (i.e. west of the River Corrib). A number of the smaller field and roadside drains can, from a hydraulic and fisheries perspective, be truncated and the upstream portion diverted either to another existing drain close by or be connected into the road embankment drainage.

The relatively high density of the proposed road drainage outfalls will result in a very minor potential for significant diversion of drainage and recharge waters between neighbouring sub-catchments. The disturbance of field drainage systems represents a direct impact to the existing drainage regime. Following the detailed design this impact is considered to represent a residual slight to imperceptible and permanent in nature impact on the hydrology of adjacent wetland features, conservation areas and flood risk areas.

11.5.3.3 Flow Regime Impact from Drainage Outfalls

The drainage outfall discharges to surface watercourses represent point discharges. Therefore, locally, the discharges will change the flow rate, the flow depth and velocity in the receiving watercourse and generally cause an increase locally, but elsewhere it may cause a reduction. In general, there is not a significant transfer of catchment runoff between streams and tributaries and therefore the water balance is not negatively impacted. It is found that the impact to existing watercourses from the road storm discharge varies depending on the size of the natural catchment. The greater the natural catchment the lower the potential impact as the channels are better developed. Another reason for lower potential flow impact on the larger catchments is due to the smaller stormwater discharge volume relative to the natural stream and river volumes. The potential increase in the ambient water levels arising in larger catchment sizes therefore is reduced.

The impact to flood regime in the receiving watercourse represents potentially the more significant impact as road drainage can increase the rate and volume of flood runoff and cause potential flooding and scouring of the receiving watercourse locally. The design includes the provision of attenuation ponds and flow control to restrict the outfall discharge to a more natural greenfield flood runoff rate, thereby avoiding potential significant impacts to channel morphology and flow regime at the local scale. The potential impact magnitude is presented in **Table 11.29**.

Table 11.29: Impact Assessment of Storm Drainage on Receiving Waters in Respect to flow regime and Morphological Changes

Network Drainage Ref. No.	Outfall Chainage	Total Road Drainage Area (ha)	Receiving Water Catchment Area (ha)	Channel / Lake Capacity	Greenfield Mean Annual Maximum Flood Runoff Rate in Receiving Stream (m^3/s)	Potential Impact
S1	0+000	2.05	147	Narrow vegetated channel Low flood capacity constricted downstream by R336 culvert	1.132	Slight Local
S2	0+625	0.55	79	Narrow vegetated channel Low flood capacity	0.608	Slight Local
S3	0+900	2.31	32	Narrow vegetated channel Low flood capacity	0.246	Slight Local
S4A	1+550	0.96	5	Narrow vegetated channel Poor channel capacity	0.019	Slight Local
S5A	2+750	2.45	50	Narrow vegetated channel Low flood capacity	0.19	Slight Local
S7A	3+000	0.30	6	Narrow vegetated channel Low flood capacity	0.02	Slight Local
S7B	3+950	2.94	582	moderate capacity wide flat gravelly base	2.150	Slight Local
S8	4+000	0.42	85	moderate capacity channel	0.314	Slight Local
S9	4+150	1.75	494	moderate capacity wide flat gravelly base	1.828	Slight Local
S10	4+850	2.19	190	moderate capacity channel narrow	0.703	Slight Local
S11	6+000	2.02	16	Discharge to Storm Sewer – limited capacity	0.103	Slight Local

Network Drainage Ref. No.	Outfall Chainage	Total Road Drainage Area (ha)	Receiving Water Catchment Area (ha)	Channel / Lake Capacity	Greenfield Mean Annual Maximum Flood Runoff Rate in Receiving Stream (m^3/s)	Potential Impact
S12	6+850	3.15	177	Narrow vegetated channel Low flood capacity culverted downstream	1.140	Slight Local
S13	7+350	0.91	32	Narrow vegetated channel Low flood capacity culverted downstream	0.206	Slight Local
S14A	8+300	5.66	14	Moderate channel capacity discharge to large storm culvert pipe and culvert under N59	0.090	Slight Local
S14B	8+550	0.85	26	Moderate to Low channel capacity	0.167	Slight Local
S15	east of N59 link	1.89	5	Good capacity channel	0.032	Slight Local
S18A	9+250	1.75	313,600	Good capacity channel	265.0	Imperceptible
S18B	9+425	2.27	313,600	Good capacity channel	265.0	Imperceptible
S21A	12+250	3.31	225	Good capacity as channel part of the permanent Lake area	0.621	Imperceptible
S36A	3+380	0.24	10	Minor Stream at Aille that is diverted into PED drain which discharges to Bearna Stream	0.064	Slight Local
S36B	3+380	0.10	14	Boundary Ditch	0.090	Slight Local
S31A	7+230	0.09	32	Narrow vegetated channel Low flood capacity culverted downstream	0.206	Slight Local
S31B	7+230	0.15	32	Narrow vegetated channel Low flood capacity culverted downstream	0.206	Slight Local

Network Drainage Ref. No.	Outfall Chainage	Total Road Drainage Area (ha)	Receiving Water Catchment Area (ha)	Channel / Lake Capacity	Greenfield Mean Annual Maximum Flood Runoff Rate in Receiving Stream (m^3/s)	Potential Impact
S44	9+150	0	10	Good capacity channel	0.064	Slight Local

11.5.4 Potential Impact to Water Quality

During the operational phase, the storm outfalls outlined in **Section 11.4.1.3** have a potential to adversely impact water quality in the receiving watercourse and groundwater from routine contaminants that are contained in road drainage waters. The water quality and ecological status of the receiving waters are also potentially threatened by contamination arising from large liquid spillages as a result of an accident on the proposed road development. These impacts are assessed by using the guidelines provided in the appropriate TII publications document DN-DNG-03065 (HD45) Road Drainage and the Water Environment. The outfalls discharging via infiltration basins to groundwater are assessed in **Chapter 10, Hydrogeology**. A summary of the paved area contributing from the proposed road drainage outfalls to the receiving surface watercourses are presented in **Table 11.30**.

The surface water storm outfalls also have the potential to impact the general flow and morphological regime of a receiving watercourse by increasing the volume and rate of runoff during storm events. The morphology of the stream is significantly influenced by ambient flow and flooding conditions in the stream. The potential increase in flow volume to the stream arises from an increased impervious area from the proposed road pavement area, the provision of road and embankment drainage with a direct pathway via the road drainage system to the receiving watercourse and potential interception of groundwater and diversion of drainage waters that would not otherwise have reached the outfall point. The hard-paved areas and the road drainage system reduces the time of concentration for rainwater to arrive at the outfall and thus increases the rate of runoff over the natural greenfield condition.

It is anticipated that the proposed road development will remove traffic from the existing road network which will provide some benefit as most these existing roads do not have sustainable urban drainage systems to protect surface and groundwater bodies from drainage water quality impacts.

Most of the surface watercourses being outfalled to by the proposed road drainage networks are only of high local value, but do eventually discharge to the European sites of the Lough Corrib cSAC and the Galway Bay Complex cSAC and Inner Galway Bay SPA. The N59 Link Road North outfall S15 eventually discharges to Lough Corrib cSAC and Lough Corrib SPA via an open drain at Dangan. Such watercourses provide a good buffer for attenuation and provide natural wetland treatment before reaching any of the European sites. Outfalls S18A and S18B discharge directly to the River Corrib channel, which is of high sensitivity being a salmonid river, European designated site and major public water supply source (Terryland Galway City water supply intake). All of the receiving watercourses have local higher attribute value further downstream in their lower reaches and all the outfalls to the Bearna, Knocknacarra and River Corrib Systems eventually discharge into the Galway Bay Complex cSAC and Inner Galway Bay SPA. Waters in the Sruthán na Libeirtí and the Trusky Stream at Bearna have the potential after mixing with the coastal waters to reach the tidal waters of the Galway Bay Complex cSAC and Inner Galway Bay SPA.

Outfalls S18A and S18B are located on the banks of River Corrib bank edge and represent very limited disturbance with the construction works to be carried out from the banks. Therefore water quality risks are significantly reduced. Construction works for outfalls S14A, S14B and S15 located at Dangan/Bushypark on its western bank discharge to the River Corrib via drainage ditches over distances of c.300 to 800m. These ditches provide an excellent wetland and settlement buffer to protect the River Corrib from construction runoff. Notwithstanding this buffer, the construction erosion and Sediment, Erosion and Pollution Control Plan, in the CEMP contained in **Appendix A.7.5** will apply to these watercourses designed to minimise the direct construction runoff to watercourses and minimise disturbance of sediment from in-stream and river bank works.

Table 11.30: Summary of Proposed Road Drainage Outfalls to Receiving Watercourses

Drainage Reference	Approx. Ch. Of Outfall	Road Section Ch. Start – Ch. End	Total Impervious Road Area (ha)	Receiving Catchment Area (km^2)	Mean Flow (cumec)	95% Low Flow (cumec)	Catchment	Comment and Fisheries Value
S1	0+000	0+000 – 0+700	1.29	1.47	0.03	0.05	Sruthán na Libeirtí	Local Lower at Site and downstream
S2	0+625	0+700 – 1+000	0.38	0.79	0.02	0.002	Sruthán na Libeirtí	Local Lower at Site and downstream
S3	0+900	1+000 – 1+475	1.28	0.32	0.01	0.0006	Sruthán na Libeirtí	Local Lower at Site and downstream
S4A	1+550	1+475 – 1+900	0.62	0.05	0.001	0.0001	Trusky Tributary	Minor drain Local Higher downstream
S4B	1+560	L-580 – 680	0.07	0.05	0.001	0.0001	Trusky Tributary	Minor drain Local Higher downstream
S5A	2+750	1+900 – 2+850	1.53	0.50	0.011	0.0010	Trusky	Small Stream Local Higher downstream
S5B	2+750	L- 000 – 300	0.14	0.07	0.0012	010001	Trusky Ditch	Minor drain Local Higher downstream
S7A	3+000	2+850 – 3+050	0.24	0.06	0.001	0.0001	Bearna Tributary	Minor drain Local Higher downstream
S7B	3+950	3+050 – 3+900	1.07	5.82	0.129	0.0116	Bearna	Small Stream Local Higher downstream
S8	4+000	3+910 – 4+125	0.26	0.85	0.019	0.0017	Bearna Tributary	Minor drain Local Higher downstream
S9	4+150	4+125 – 4+900	1.19	4.94	0.110	0.0099	Bearna	Bearna Stream Local Higher downstream

Drainage Reference	Approx. Ch. Of Outfall	Road Section Ch. Start – Ch. End	Total Impervious Road Area (ha)	Receiving Catchment Area (km^2)	Mean Flow (cumec)	95% Low Flow (cumec)	Catchment	Comment and Fisheries Value
S10	4+850	4+900 – 5+640	1.22	1.90	0.042	0.0038	Bearna Tributary. Tonabrocky	Small Hill side stream Local Higher downstream
S12	6+850	6+325 – 7+300	2.45	1.77	0.039	0.0035	Knocknacarra Tributary	Minor drain Local Higher downstream
S13	7+350	7+300 – 7+525	0.63	0.32	0.007	0.0006	Knocknacarra Tributary	Minor drain Local Higher downstream
S14A	8+300	7+525 – 8+250	2.20	0.14	0.003	0.0003	Corrib Tributary	Minor hillside drain Corrib SAC downstream
S14B	8+550	8+250 – 8+525	0.65	0.26	0.006	0.0005	Corrib Tributary	Minor hillside drain Corrib SAC downstream
S15	East of N59 Link	0 – 625 N59 Link	0.73	0.050	0.001	0.0001	Local Ditch to Corrib	Minor drain Lough Corrib cSAC
S18A	9+250	8+525 – 9+250	1.58	3136	82.000	14.000	Corrib River West Bank	Extremely Important Lough Corrib cSAC
S18B	9+425	9+250 – 10+150	1.95	3136	82.000	14.000	Corrib River East Bank	Extremely Important Lough Corrib cSAC
S21A	12+250	11+850 – 12+450	1.36	< 0.05	< 0.001	< 0.0001	Ballindooley Lough Tributary	Minor drain Local Higher downstream
S36A	3+380	3+350	0.17	0.10	0.0022	0.0002	Bearna Stream Tributary	Minor drain (Tributary of Bearna stream) Local Higher downstream
S36B	3+380	3+350	0.08	0.14	0.0028	0.0003	Trusky Stream Tributary	Minor drain (Tributary of Trusky stream) Local Higher downstream
S31A	7+230	7+250	0.06	0.26	0.006	0.0005	Knocknacarra Tributary	Minor drain (Tributary of Rahoon stream) Local Higher downstream

Drainage Reference	Approx. Ch. Of Outfall	Road Section Ch. Start – Ch. End	Total Impervious Road Area (ha)	Receiving Catchment Area (km^2)	Mean Flow (cumec)	95% Low Flow (cumec)	Catchment	Comment and Fisheries Value
S31B	7+230	7+250	0.12	0.27	0.006	0.0005	Knocknacarra Tributary	Minor drain (Tributary of Rahoon stream) Local Higher downstream
S44	9+150	N/A	N/A	0.17	0.003	0.0003	River Corrib Tributary	Minor drain Lough Corrib cSAC

11.5.4.1 Accidental Spillages

During the operational phase of the proposed road development, the risk of pollution to both surface and groundwater resulting from accidental spillage is an issue to be considered. Trying to predict the occurrence of a spill with any degree of certainty is difficult. The risk is influenced by the type of roadway, length of road, the traffic volume, and proportion and type of heavy goods vehicles (HGV's), design speed and visibility. A spillage risk assessment of the proposed road development has been carried out in accordance with the TII publications document DN-DNG-03065 (HD45) – see **Table 11.31**.

The spillage assessment shows the proposed road development will have a very low magnitude of risk for individual outfalls or grouped catchment outfalls, and as such specific mitigation measures to lower this risk are not required under the TII publications road design standards.

The overall combined probability of a serious HGV spillage entering a watercourse from the proposed road development is low at 0.09%. This spillage risk analysis was based on the medium growth AADT Traffic figures, presented in **Chapter 6, Traffic Assessment and Route Cross-Section**, which indicate that HGV numbers are only 3 to 6% of the AADT number.

A similar assessment was carried out for the proposed outfalls to groundwater via infiltration basins and is presented in **Table 11.32** and similarly show very low probabilities.

Notwithstanding the very low spillage risk for this proposed road development, all storm outfalls will include pollution control facilities at their outfalls. All of the mainline drainage network outflows will pass through a suitably sized oil and petrol interceptor and then through a constructed wetland with a permanent pool followed by an attenuation pond or infiltration basin, depending on the design prior to discharging through its outfall. A penstock or similar online control restriction will be installed upstream of the petrol interceptor. In the event of a serious spill these controls can be put in place to block the outflow of contaminants allowing time for clean up to take place.

Table 11.31: Serious Spillage Pollution Risk Assessment at Proposed Outfalls to Surface Watercourses

Drainage Reference	Approx. Chainage	Watercourse	Outfall Risk (%)	Combined Risk (%)
S1	0+000 - 0+700	Sruthán na Libeirtí	0.0066	
S2	0+700 - 1+000	Sruthán na Libeirtí	0.0005	
S3	1+000 - 1+475	Sruthán na Libeirtí	0.0025	0.0096
S4A	1+475 - 1+900	Trusky Tributary	0.0023	
S4B	Link Road 0+580 - 0+680	Trusky Tributary	0.0001	
S5A	1+900 - 2+850	Trusky Stream	0.0068	

Drainage Reference	Approx. Chainage	Watercourse	Outfall Risk (%)	Combined Risk (%)
S5B	Link Road	Ditch Trusky Tributary	0.0001	
S7A	2+850 - 3+050	Ditch Trusky Tributary	0.0004	0.0097
S7B	3+050 - 3+910	Bearna	0.0015	
S8	3+910 - 4+125	Bearna	0.0004	
S9	4+125 - 4+900	Bearna	0.0029	
S10	4+900 - 5+640	Bearna Tributary.	0.0028	0.0080
S12	6+325 - 7+300	Knocknacarra Tributary	0.0031	
S13	7+300 - 7+525	Knocknacarra Tributary	0.0008	0.0073
S14A	7+525 - 8+250	Corrib Tributary	0.0062	
S14B	8+250 - 8+525	Corrib Tributary	0.0029	
S15	0 - 625 N59 link	Existing Ditch to Corrib	0.0062	
S18A	8+525 - 9+250	Corrib River West Bank	0.0054	
S18B	9+250 - 10+150	Corrib River East Bank	0.0067	0.042
S21A	Sliproads and N84 interchange	Ballindooley Lough	0.0138	
S36A	Aille Road North	Bearna Stream Tributary	0.0000	
S36B	Aille Road South	Trusky Stream Tributary	0.0000	
S31A	Letteragh Road	Knocknacarra Tributary	0.0000	
S31B	Letteragh Road	Knocknacarra Tributary	0.0000	
S44	9+150	Corrib Tributary	0.0000	

Table 11.32: Serious Spillage Pollution Risk Assessment at Proposed Outfalls to Groundwater Infiltration

Drainage Network Ref. No.	Approx. Chainage	Outfall Risk (%)
S19A	10+150 to 10+730	0.00286
S19B	10+730 to 11+150	0.00207
S20	11+414 to 12+017	0.00320
S21B	12+017 to 13+700	0.01361
S22A	13+700 to 13+920	0.01557
S22B	13+920 to 14580	0.0038
S22C2	13+650 to 14+160	0.00045
S22E	N83 Tuam Road Junction	0.00006
S40	10+450	0.0000

11.5.4.2 Routine Road Runoff

Research has found that a broad band of potential pollutants are associated with routine runoff from road schemes arising from road traffic and road maintenance. These contaminants are generally associated with the particulate phase and are principally heavy metals, hydrocarbons and suspended solids and de-icing agents (salt and grit) and to a lesser extent nutrients, organics and faecal contamination. In terms of the potential impact to receiving watercourses research has found the first flush runoff (10 to 15mm rainfall runoff following an extended dry period) can produce elevated concentrations locally in the receiving waters. The impact of contaminants within routine road runoff depends on the loading (associated with traffic numbers) and the available dilution in the receiving watercourse.

The high density of outfall discharge points along the mainline of the proposed road development, disperses and reduces the potential pollutant point load from the proposed road drainage system. The design traffic volume in conjunction with the relatively small contributing road areas will not give rise to any potential significant hydraulic or pollutant loads on the receiving waters. The potential impact of routine runoff in the absence of storm drainage pollutant removal represents a localised impact on water quality of the receiving environment. The overall loading of heavy metals, sediments, hydrocarbons and other waste products on the receiving waters will be significantly reduced through the provision of various drainage design elements such as, petrol and oils interceptors, filter drains, grassed surface water channels, wetlands, infiltration area and storm attenuation ponds upstream of the outfalls designed to capture and treat the first flush rainfall runoff events.

TII publications document DN-DNG-03065 (HD45) gives guidance and assessment tools for the impact of road projects on the water environment, including the effects of runoff on surface waters. The Highways Agency Water Risk Assessment Tool (HAWRAT) is the tool used to assess the effects of road runoff on surface water quality and uses toxicity thresholds based on UK field research programmes which are consistent with the requirements of the Water Framework Directive (WFD) and appropriate for assessment of National Road Schemes in Ireland. The UK research programme has shown that pollution impacts from routine runoff on receiving waters are broadly correlated with Annual Average Daily Traffic (AADT) numbers.

A HAWRAT assessment has been carried out for all proposed mainline drainage outfalls directly discharging to surface watercourses along the proposed road development, including realigned and upgraded link roads and junctions, see **Table 11.33** below. The HAWRAT assessment tool uses the AADT category of 10,000 to 40,000 in the assessment process which is appropriate for the Design Year AADT numbers. Further to the west, as ADDT numbers reduce, this category is likely to be precautionary in terms of its water quality predictions as the ADDT numbers are much closer to 10,000 than 40,000. Anticipated traffic volumes on each section of the proposed road development are detailed in **Chapter 6, Traffic Assessment and Route Cross Section**.

It is also important to note that the HAWRAT assessment presented here is based on direct discharges to watercourses in the absence of proposed drainage design measures, that include petrol interceptors, water quality treatment ponds and wetlands and storm attenuation ponds, and therefore the predictions are worst case not including any treatment performance which have been designed to achieve well in excess of 60% reduction in suspended sediments and associated heavy metal contamination. The HAWRAT analysis was carried out on all of the proposed outfalls in the absence of proposed water quality and attenuation measures and the required level of treatment quantified, refer to **Table 11.33** below.

In cases where the road drainage outfall discharges to a drainage ditch with very limited drainage catchment, resulting in potentially dry / stagnant conditions during low flows, the local HAWRAT assessment will produce a FAIL result, as there is no dilution available for solutes nor flow velocities to disperse sediment away from the outfall. These failures in the HAWRAT analysis are not considered to represent an impact as such minor ditches are only serving as conduits to the larger stream and river channels. In these cases, the potential impact on watercourses is also assessed further downstream where it joins the larger stream channel, refer to outfall locations on **Figures 11.6.101** to **11.6.115**.

In general, HAWRAT is considered to provide a precautionary means to assess those proposed road outfall discharges in respect to soluble and sediment-bound pollutants. The screening parameters are sediment and the dissolved heavy metals of zinc and copper concentrations. These represent the primary waste constituents in the road drainage discharges and used as screening parameters for other pollutant substances such as de-icing agents of salt and grit, hydrocarbons, Cadmium, Pyrene, PAHs, nutrients and organics. The required treatment performance in terms of percentage reduction of soluble and sediment contaminants is also presented in **Table 11.33**.

Table 11.33: Results of the HAWRAT Road Outfall Water Quality Assessment of Receiving Surface Waters

Outfall No. Refer to Figures 11.6.101 to 11.6.115	Water Hardness (mg/l $CaCO_3$)	Dissolved Copper (ug/l)	Dissolved Zinc (ug/l)	Sediment Deposition Index	Comment
S1	Low < 50	0.31	0.93	174	Pass Solubles, Fail Sediment (Settlement required 43%)
S2	Low < 50	0.20	0.62	84	Pass Solubles, Pass Sediment accumulates but not extensive
S3	Low < 50	1.07	3.27	248	Fail Solubles, Fail Sediment (Required Treatment Solubles 30% reduction Settlement 76%
S4A	Low < 50	2.01	6.27	250	Fail Solubles, Fail Sediment

Outfall No. **Refer to Figures 11.6.101 to 11.6.115**	**Water Hardness (mg/l $CaCO_3$)**	**Dissolved Copper (ug/l)**	**Dissolved Zinc (ug/l)**	**Sediment Deposition Index**	**Comment**
					(Required Treatment 61% settlement and 56% soluble reduction)
S5A	Low < 50	0.87	2.65	299	Fail Solubles, Fail Sediment (Required Treatment 67% settlement and 25% soluble reduction)
S7A	Low < 50	1.39	4.27	122	Fail Solubles, Fail Sediment (Required Treatment 18% settlement and 44% soluble reduction)
S7B	Low < 50	0.09	0.27	41	Pass Solubles, Pass Sediment
S8	Low < 50	0.16	0.50	44	Pass Solubles, Pass Sediment
S9	Low < 50	0.13	0.40	50	Pass Solubles, Pass Sediment
S10	Low < 50	0.31	0.96	87	Pass Solubles, Pass Sediment
S12	Low < 50	0.60	1.87	191	Pass Solubles, Fail Sediment (Required Treatment 48% settlement)
S13	Low < 50	0.82	2.55	178	Fail Solubles, Fail Sediment (Required Treatment 44% settlement and 3% soluble reduction)
S14A	Med 50 – 200	2.39	7.38	725	Fail Solubles, Fail Sediment (Required Treatment 87% settlement and 35% solubles reduction)
S14B	Med 50 – 200	1.11	3.46	365	Fail Solubles, Fail Sediment (Required Treatment 49% settlement and 10% solubles reduction)

Outfall No. **Refer to Figures 11.6.101 to 11.6.115**	**Water Hardness (mg/l $CaCO_3$)**	**Dissolved Copper (ug/l)**	**Dissolved Zinc (ug/l)**	**Sediment Deposition Index**	**Comment**
S15	Med 50 – 200	2.42	7.49	175	Fail Solubles, Fail Sediment (Required Treatment 61% settlement and 25% solubles reduction)
S18a	Med 50 – 200	<0.00	<0.00	1	Pass Solubles, Pass Sediment
S18b	Med 50 – 200	<0. 00	<0.00	2	Pass Solubles, Pass Sediment

A HAWRAT water quality toxicity analysis of the proposed road development discharges to the River Corrib was also carried out modelling the soluble heavy metal pollutants of copper and zinc from combined outfall sources. In this analysis the 95 percentile low river flow was specified, an AADT Class of >10,000 and < 40,000 and the combined load of all five outfalls having a total road impervious area of 7.08ha and a permeable (Grassed) area of 5.43ha. The annual rainfall catchment was taken as 1250mm, the base flow index as 0.5 the water hardness as medium (50 to 200 CaCO3 mg/l). A cumulated load from all of the outfall discharges (S14A, S14B, S15, S18A and S18B, ref **Figures 11.6.101** and **11.6.114**) was also specified in the HAWRAT assessment water quality toxicity analysis so as to include for the combined effects on the Dangan reach section of the River Corrib. Note that the outfall from the proposed NUIG pitches S44 was not assessed in this combination as this catchment is not a road, therefore routine road runoff water quality characteristics from traffic at this location is not applicable. This combined load simulation showed no discernible acute or chronic impacts on the water quality of River Corrib due to the high dilutions rates available in the River Corrib. The event statistics for the untreated effluent in the drainage runoff give the following event statistics, refer to **Tables 11.34** and **11.35**. These loadings are used as the mean concentration in the two-dimensional modelling of the River Corrib receiving waters presented latter in this section.

Table 11.34: Event Statistics for soluble heavy metal pollutants in untreated Road Drainage Runoff

	Dissolved Copper Cu (µg/l)	**Dissolved Zinc Zn (µg/l)**
Mean	24.00	67.53
90%	45.95	144.85
95%	57.54	191.09
99%	90.93	346.16

Table 11.35: Event Statistics for soluble heavy metal pollutants in River Corrib at 95% low flow

	Dissolved Copper Cu (µg/l)	Dissolved Zinc Zn (µg/l)
Mean	0.00	0.01
90%	0.00	0.01
95%	0.01	0.02
99%	0.03	0.08

The event statistics for this grouped discharge give a mean event concentration in the River Corrib of that is negligible (<0.00 (µg/l)) for copper and (<0.01 (µg/l)) for zinc and 99-percentile event statistics of 0.03 (µg/l) dissolved copper and 0.08 (µg/l) dissolved zinc which are considered to represent only trace concentrations and well below the maximum allowable concentrations of 30 and 100 µg/l as set out in the Surface Water Regulations. In the HAWRAT manual the runoff specific thresholds for short term exposure of organisms gives the following short-term exposure threshold values for dissolved copper and zinc.

Table 11.36: Maximum Short-term exposure threshold limits for dissolved copper and zinc (WRc 2007)

Exposure Duration	Copper (µg/l)	Zinc (µg/l)		
		Harness		
		Low (< 50mg/l CaCO3)	Medium (50 to 200 mg/l CaCO3)	High (>200mg/l CaCO3)
24 hour	21	60	92	385
6 hour	42	120	184	770

This assessment clearly shows that the dilution available in the River Corrib even at 95-percentile low flow conditions ensures that the potential toxicity impact from road runoff contaminants on this salmonid river will be negligible and well below allowable levels for dissolved copper and zinc set out in the Salmonid Waters Directive and in the Surface Waters Regulations and also well below the recommended short-term exposure thresholds presented in **Table 11.36** above.

It should be noted that the above assessment is carried out in the absence of proposed road drainage water quality and attenuation treatment and therefore the potential impact will be considerably lower after the designed treatment.

The provision of first flush treatment in a wetland system and the storage in the attenuation pond provides residence time for the sediment to settle out before being discharged to the watercourse. This storage also reduces the outfall discharge rate with the contaminated first flush event being stored and released gradually.

This grouped assessment was also carried out on Sruthán na Libeirtí, the Knocknacarra, Bearna and Trusky Streams and were found to satisfy the HAWRAT water quality assessment in the downstream fishery reaches. The impact on water chemistry downstream in the coastal waters will be negligible due to the significant mixing available in the downstream reaches of the watercourses and within the tidally flushed estuarine reaches.

For the various individual outfalls discharging to small drains and streams with limited upstream catchment, it is found that the majority of these outfalls fail the HAWRAT assessment (in absence of pollution control measures), simply because there is negligible flow for dilution during 95-percentile low flow design conditions. At these locations, these failures are not considered significant as locally these smaller drains are not fishery sensitive and further downstream in the receiving streams the flow rate and contributing catchment area increases which lessens any potential impact.

The proposed storm drainage design for all proposed new surface water outfalls discharging to watercourses includes a spillage containment area (25m^3), a petrol and oil interceptor, a surface flow (SF) wetland with a permanent pond depth of 0.6m (to take first flush volume 15mm) and an attenuation pond (typically having a storage volume of a further 70mm rainfall over the paved area). Such facilities will achieve a long hydraulic residence time for first flush pollutant events ensuring good settlement performance. Flood attenuation will not be provided at the direct outfalls to the River Corrib S18A and S18B as attenuation of the proposed road storm flow is not warranted given the immense scale of the River Corrib catchment and capacity of the channel relative to the proposed road drainage direct discharges at S18A and S18B. The other pollution control elements including spillage containment, wetland first flush treatment and petrol and oil interceptors will be provided to achieve storm water treatment and accidental spillage protection for these outfalls.

The expected performance of the designed pollution control measures is expected to achieve in excess of 60% settlement performance of particulate matter but for soluble substances unlikely to achieve above 30% reduction and lower performances during the non-growing season, refer to **Table 11.37** below. The design ensures no significant water quality impact on receiving designated waters of the Lough Corrib cSAC and Lough Corrib SPA and the downstream Galway Bay Complex cSAC and Inner Galway Bay SPA.

Table 11.37: Expected Pollutant Removal Performance of Vegetated systems extracted from TII DN-DNG-03063

Runoff Constituent	Stormwater treatment system Performance					
	Swales	Infiltration Basins	SF Wetlands	SSF ** Wetlands	Detention / Retention Ponds	Sedimentation Ponds
Sus Solids & associated heavy metals	Good	Good	Good	Good	Moderate	Good
Heavy Metals in solution *	Moderate - Good	Moderate - Good	Moderate - Good	Good	Poor	Poor - moderate
Oil and grease	Good	Moderate - Good	Good	Good	Moderate	Moderate
Nutrients	Poor	Poor	Moderate - Good	Good	Poor	Poor - moderate

Notes:

Poor represents < 30% removal efficiencies, Moderate represents 30 to 60% removal efficiency and Good represents > 60% removal efficiency

* applicable to Growing Season

** very limited operational life of SSF Wetlands due to clogging of substratum

In general, the most likely impact of untreated road runoff from the proposed road development is the increased total suspended solids loading to receiving waters and associated trace amounts of heavy metals (Cu, Zn) and hydrocarbons. At all proposed surface drainage outfalls, water quality treatment of the sediment load is provided for, which will reduce local impacts from sediment deposition accumulation and potential toxicity levels in the stream/drain channel immediately close to the outfall.

The two tunnel sections of the proposed road development do not receive direct surface water runoff, however small volumes of water could potentially be carried into the tunnel on tyres and bodies of wet vehicles. These volumes will be picked up by the internal sealed tunnel drainage and pumped to the foul sewer. This volume for treatment is miniscule (fraction of a percent) in comparison to the overall sewage and combined storm volume treated at the Mutton Island Plant and discharged to the Galway Bay via the Mutton Island marine outfall and therefore will have no perceptible effect of treatment performance of the Mutton Island Treatment Plant and the Galway Bay receiving waters.

The Water Quality Impact Assessment is presented in **Table 11.38** below:

Table 11.38: Water Quality Impact Assessment

Network Drainage Ref. No.	Outfall Chainage	Dilution Characteristics	Receiving Water Details	Water Quality Impact
S1	0+000	Low summer dilution available	Sruthán na Libeirtí	Slight Permanent Local Slight downstream
S2	0+625	Low summer dilution available	Sruthán na Libeirtí	Slight Permanent Local Slight downstream
S3	0+900	Low summer dilution available	Sruthán na Libeirtí	Moderate Permanent Local Slight downstream
S4A	1+550	Very Low summer dilution available	Trusky Tributary	Moderate Permanent Local Slight downstream
S5A	2+750	Low summer dilution available	Trusky Tributary	Slight Permanent Local Slight downstream
S7A	3+950	Very Low summer dilution available	Bearna Tributary	Moderate Permanent Local Slight downstream
S7B	3+950	Moderate summer dilution available	Bearna Stream	Slight Permanent Local Slight downstream
S8	4+000	Low summer dilution available	Bearna Tributary	Slight Permanent Local Slight downstream
S9	4+150	Moderate summer dilution available	Bearna Stream	Slight Permanent Local Slight downstream
S10	4+850	Low summer dilution available	Bearna Tributary Tonabrocky	Slight Permanent Local Slight downstream
S11	6+000	Very low summer low flow dilution available	Storm Sewer to Knocknacarra	Slight Permanent Local Slight downstream
S12	6+850	Low summer low flow dilution available	Knocknacarra Tributary	Moderate Permanent Local Slight downstream
S13	7+350	Very low summer low flow dilution available	Knocknacarra Tributary	Slight Permanent Local Slight downstream
S14A	8+300	Very low summer low flow dilution available	Minor River Corrib Stream	Moderate Permanent Local and imperceptible in downstream receiving Corrib waters
S14B	8+550	Very low summer low flow dilution	Minor River Corrib Stream	Slight Permanent Local and imperceptible in downstream receiving Corrib waters
S15	east of N59 link	Very Low summer dilution	Local drainage Ditch to River Corrib	Moderate Permanent Local and imperceptible in downstream receiving Corrib waters
S18A	9+250	Very High Summer low flow dilution	River Corrib	Slight Permanent Local

Network Drainage Ref. No.	Outfall Chainage	Dilution Characteristics	Receiving Water Details	Water Quality Impact
S18B	9+425	Very High Summer low flow dilution	River Corrib	Slight Permanent Local
S21A	12+250	Low Summer dilution Eventually drains to groundwater	Ballindooley Lough	Moderate Permanent Local

Detailed Assessment of River Corrib

<u>River Corrib Channel</u>

Two-dimensional transport and dispersion modelling of the outfall discharges in the River Corrib was carried out so as to assess the local impact effects of the plume near the inflow points and downstream, where full mixing with the receiving flow will not have fully occurred. Simulations were carried out modelling the two principal soluble heavy metal pollutants in the drainage effluent, namely copper and zinc and included the proposed first flush stormwater treatment in the wetland and attenuation ponds, which are designed to capture the first flush event of 15mm rainfall runoff and release slowly back to the River Corrib system so that a high percentage of the sediment is removed through settlement. Low flow conditions were modelled in the River Corrib with the river discharge rate set at the 95-percentile low flow of 14cumec (note median river flow is 82cumec) and the downstream water level upstream of the Salmon Weir barrage set at 5.7m OD (median 5.9mOD).

The event mean runoff concentrations from the HAWRAT model was specified as the storm effluent concentration at the outfalls of 24 µg/l Cu and 67.53 µg/l Zn. The simulation was run for combined outfall discharges on the western side of the River Corrib (outfalls 14A, 14B, 15 and 18A). An independent simulation for outfall S18B on the eastern bank of the River Corrib was also run and results combined with the western outfall simulations to predict the overall impact of the proposed road drainage discharge on the River Corrib. Note that the outfall from the proposed NUIG pitches S44 was not assessed as part of this analysis as this catchment is not a road, therefore routine road runoff water quality characteristics from traffic at this location is not applicable.

The drainage discharge plume in the River Corrib migrates with the flowing river downstream towards Galway Bay and therefore exposure duration is limited to hours as opposed to days. The maximum predicted concentrations throughout the model domain are presented below in **Plates 11.2** to **11.7** which show that the plume hugs the near bank side of the river for quite a distance downstream before fully mixing across the river channel. The simulations show that during the River Corrib low flow conditions the stormwater plume does not enter via the small channel east of Jordan’s Island and therefore has very limited effect on the Terryland Galway City water supply intake. It is also noted that the plume does not travel up in the Coolagh Lakes system under these conditions. The large dispersion provided by the River Corrib result in rapid dilution and low trace level pollutant concentrations in the receiving water. The potential impacts on water quality in Lough Corrib cSAC and Lough Corrib SPA arising from the plume are imperceptible.

The analysis shows that the potential soluble toxicity levels of copper and zinc in the receiving waters are negligible in terms of the threshold levels for 24-hour and 6-hour exposure periods. The available dilution in the River Corrib at low flow conditions is still very large and therefore the combined discharge from the various outfalls to the reach is very well diluted and does not impact the water quality or quantity in the receiving waters.

These simulations predict very low far-field concentrations of heavy metal pollutants under the River Corrib 95-percentile low flows of less than 0.05µg/l dissolved copper and less than 0.1µg/l dissolved zinc in the river channel near Jordan's Island. More elevated concentrations are predicted close to the outfalls of S18A and S18B on both River Corrib banks with predicted concentrations with a maximum local concentration of 1.75µg/l dissolved copper and 4.92µg/l dissolved zinc. These locally elevated concentrations are well below any potential exposure threshold levels for heavy metals (refer to **Table 11.36**) and easily satisfy the surface water and Salmonid Waters Regulations. At mean river flow the concentration both locally at the outfall and fully mixed downstream are significantly lower at almost six times lower than the River Corrib low-flow scenarios described above.

The potential impact of de-icing agents such as sodium chloride on the receiving water quality of the River Corrib will not result in a water quality impact as the dilution is large and particularly so during winter months, which is the high flow period with river flows generally above the median flow which dilutes and rapidly transports the salt load through the lower reaches of the River Corrib out to sea where they are imperceptible and have no effect.

The water quality impact of the proposed stormwater discharge on the River Corrib, given its high dilution and assimilative capacity, represents only a slight impact immediately local to the outfalls. The high water quality status of the River Corrib will not be affected by the proposed road development and its road drainage discharges.

The dispersion analyses show only trace pollutant concentrations reaching Jordan's Island channel and the Terryland Galway City water supply intake from the proposed road drainage discharges and can be concluded that the first flush impact of road drainage runoff on the water quality of the intake flow will be imperceptible.

Plate 11.2: Maximum Dissolved Copper Concentrations for First Flush Storm Water Event and 95% River Corrib Low Flow for Outfall 18B at Menlough

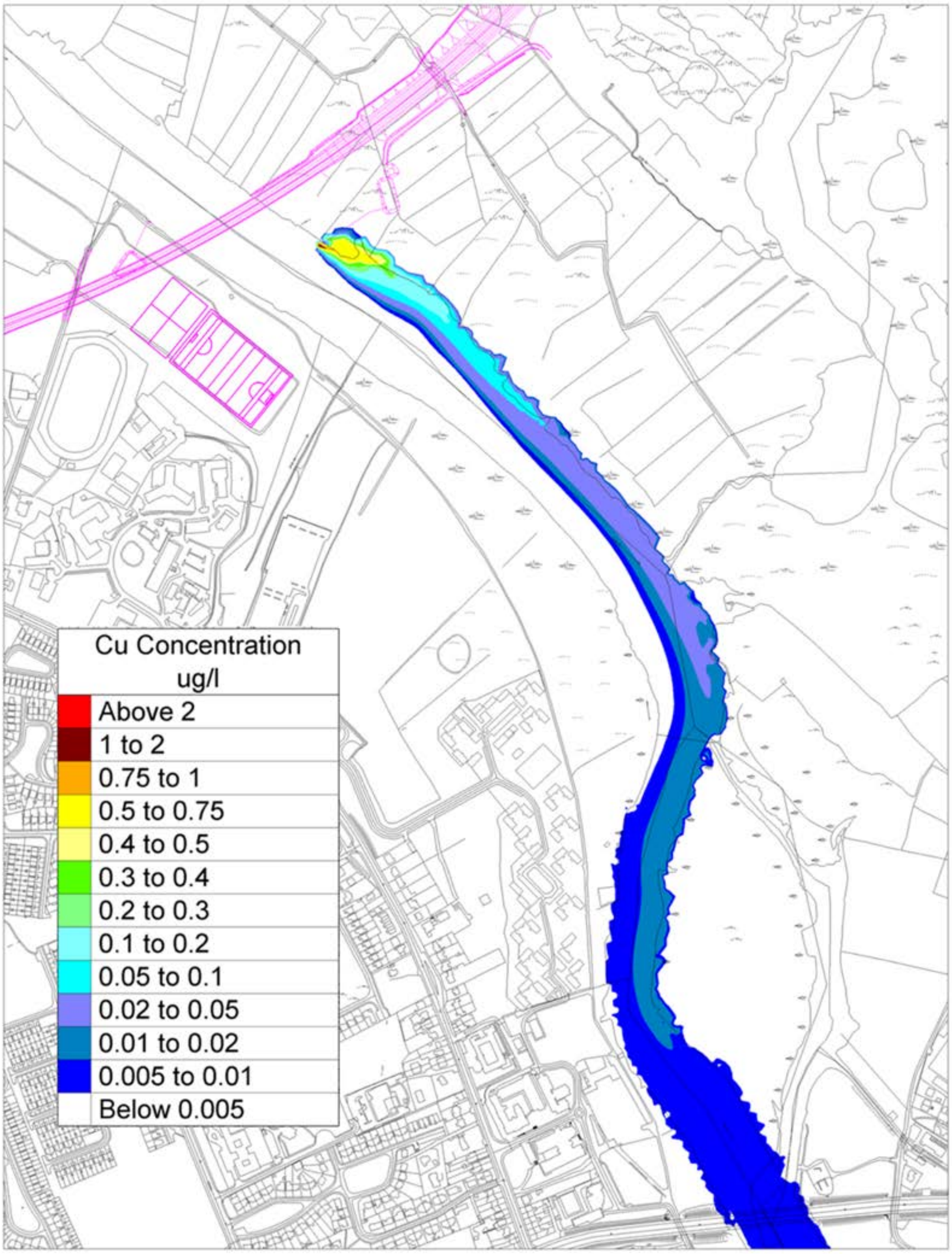


Plate 11.3: Maximum Dissolved Copper Concentrations for First Flush Storm Water Event and 95% River Corrib Low Flow for Dangan Outfalls (14A, 14B, 15 and 18A)

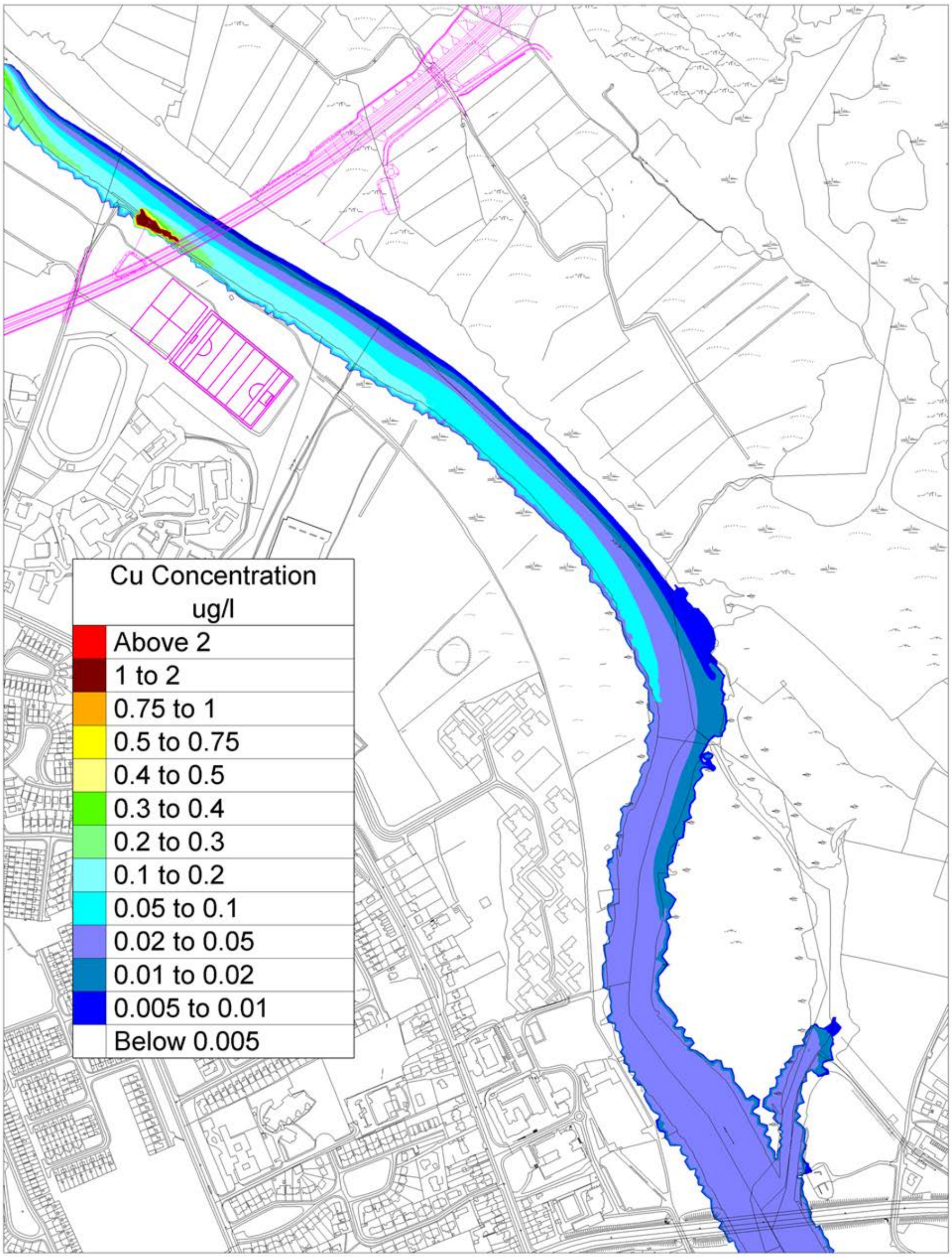


Plate 11.4: Maximum Dissolved Copper Concentrations for First Flush Storm Water Event and 95% River Corrib Low Flow for all combined Outfalls (14A, 14B, 15, 18A and 18B)

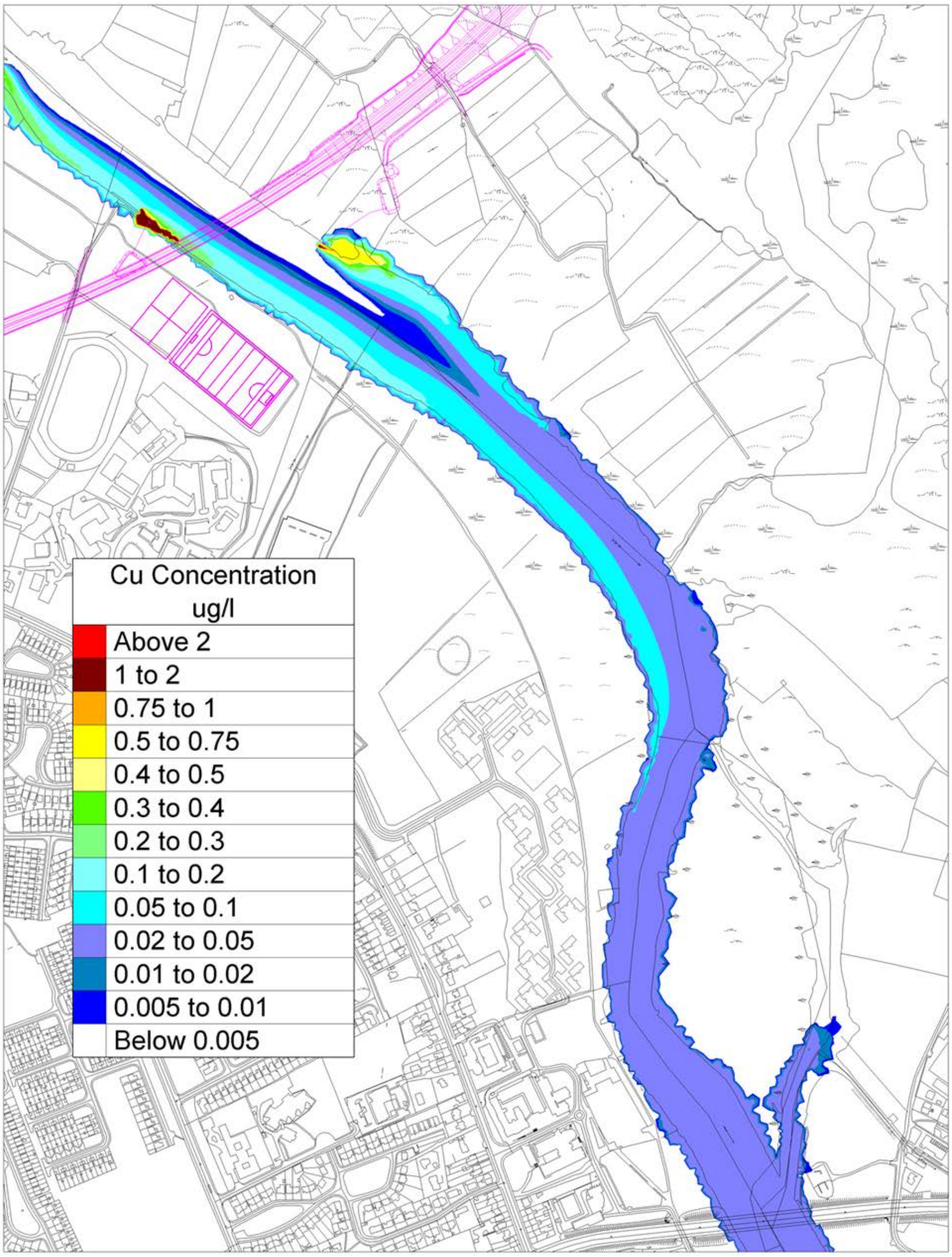


Plate 11.5: Maximum Dissolved Copper Concentrations for First Flush Rain Storm Event and median River Corrib Flow (82cumec) for all combined Outfalls (14A, 14B, 15, 18A and 18B)

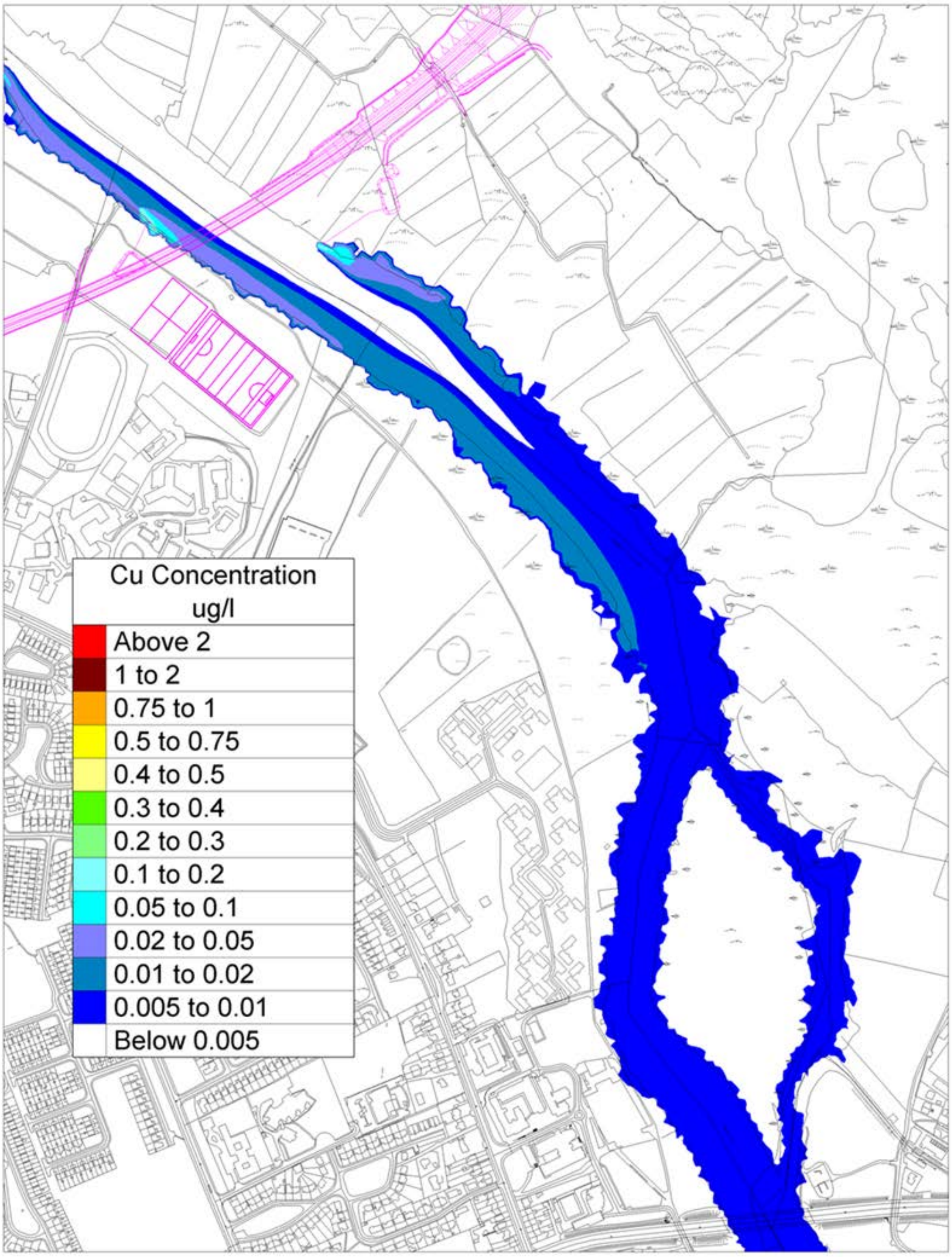


Plate 11.6: Maximum Dissolved Zinc Concentration for First Flush Rain Storm Event and 95% River Corrib Low Flow (14cumec) for all combined Outfalls (14A, 14B, 15, 18A and 18B)

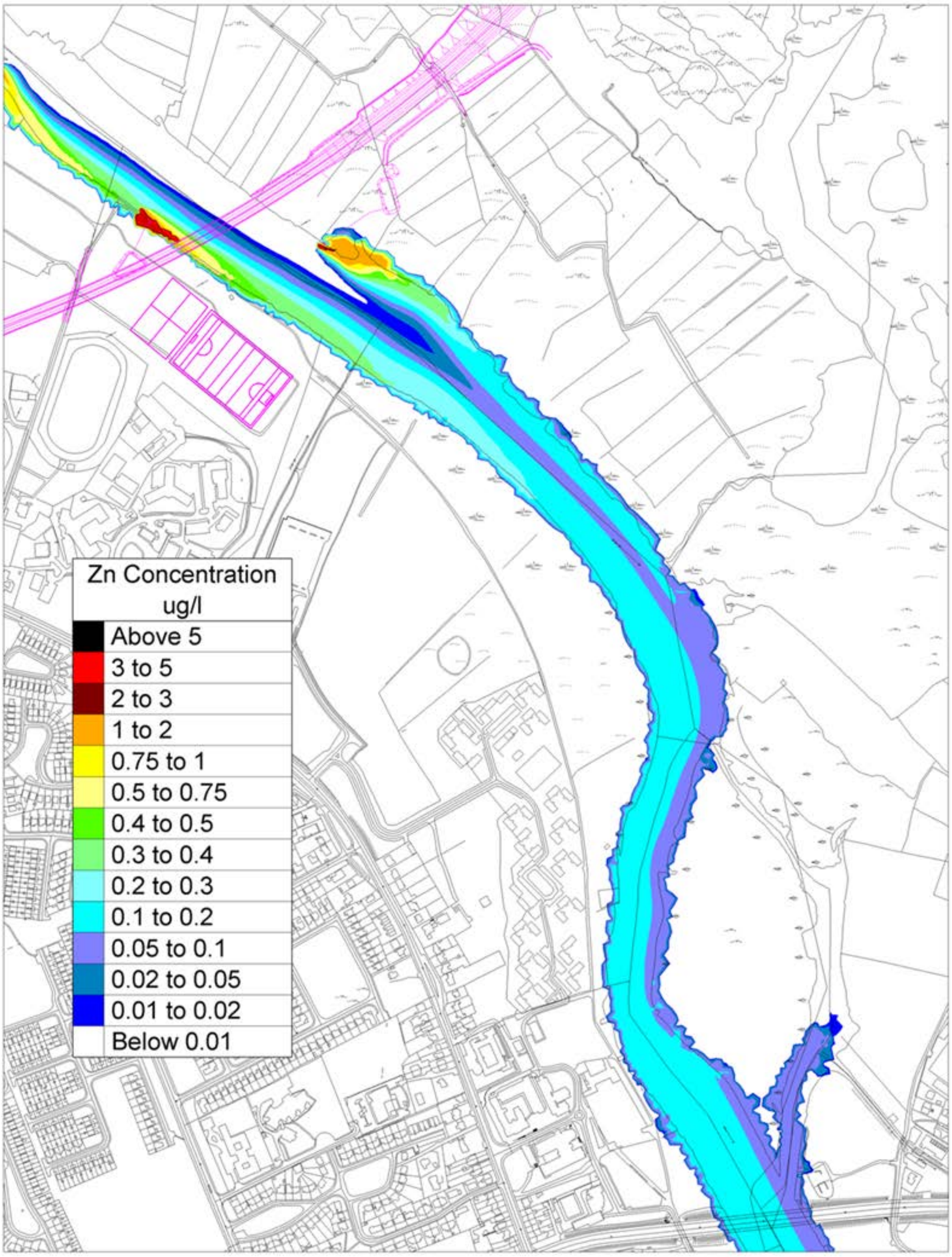
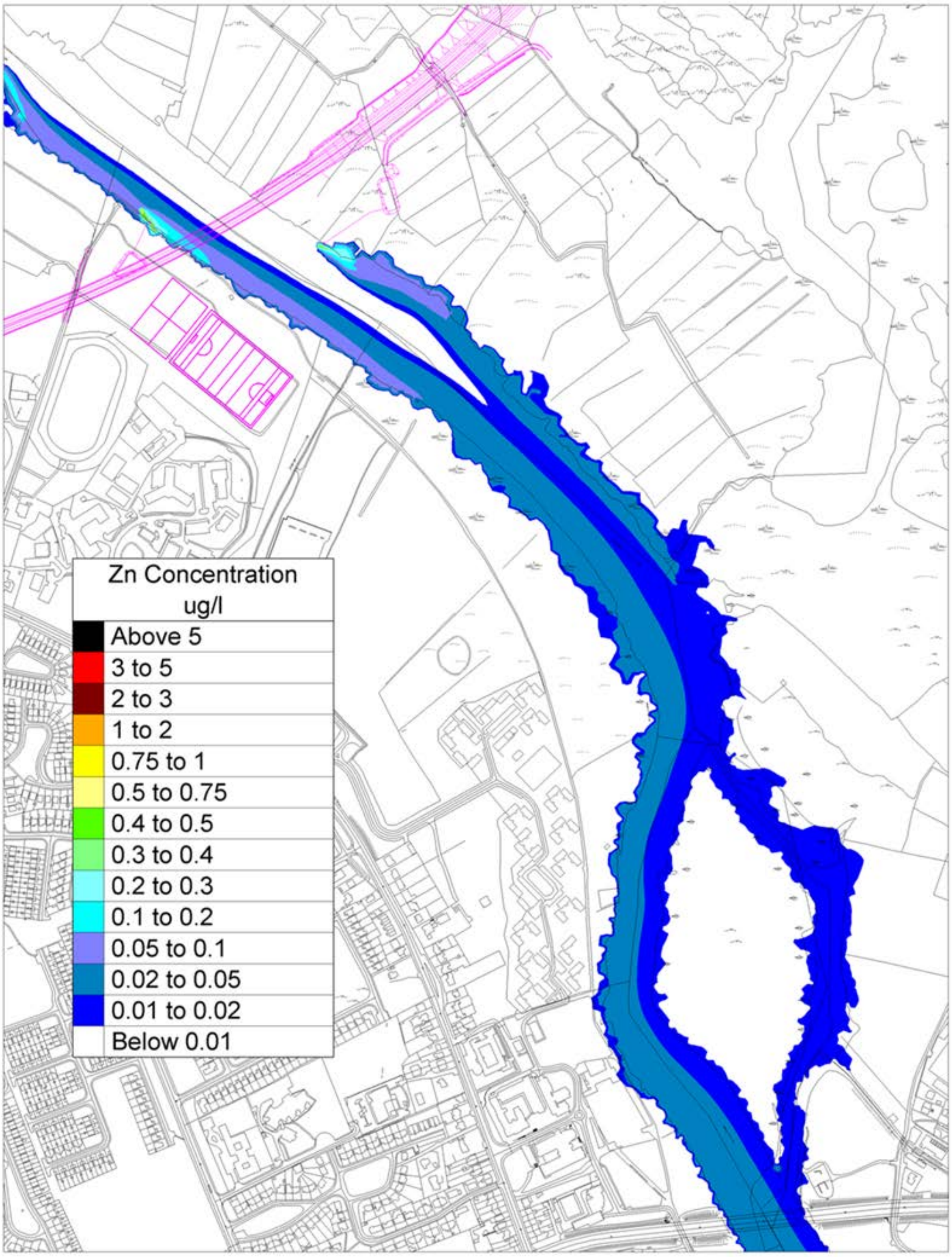


Plate 11.7: Maximum Dissolved Zinc Concentrations for First Flush Rain Storm Event and median River Corrib Flow (82cumec) for all combined Outfalls (14A, 14B, 15, 18A and 18B)



Detailed Assessment of Coolagh Lakes

The Coolagh Lakes and surrounding riparian lands form part of the Lough Corrib cSAC. The proposed road development traverses the Coolagh Lakes catchment from Ch. 9+700 to Ch. 11+800. There are no proposed direct storm water discharges to the Coolagh Lakes with all proposed road drainage discharges to groundwater via engineered infiltration basins. This runoff water drains into the limestone bedrock aquifer and ultimately some of this drainage water potentially recharges the Coolagh Lakes system. The protection of the groundwater quality is dealt with in detail in **Chapter 10, Hydrogeology**, with the infiltration basin and wetlands systems at each of these groundwater outfalls designed to remove pollutants and protect the highly vulnerable, regionally important, groundwater aquifer from adverse impacts by the proposed road drainage runoff. These groundwater quality design measures will also prevent impact to the hydrochemistry of the Coolagh Lakes through removal of pollutants via provision of a deep soil filter and generous infiltration areas at the relevant outfalls S19A and S19B and S20. The impact on the Coolagh Lakes water quality is rated as an imperceptible impact.

Detailed Assessment of Ballindooley Lough

The mainline section of the proposed road development from N84 Headford Road Junction to N83 Tuam Road Junction will be serviced by outfall S21B which is designed to discharge to groundwater in the vicinity of Ballindooley Lough where the groundwater flow gradient is southwards away from the lough. As a consequence, there will be no water quality or flow regime impacts on the lough from the mainline carriageway of proposed road development during the operational phase.

A single outfall S21A servicing the on-off slip roads and 250m of the existing N84 Headford Road at the N84 Headford Road Junction will discharge via a ditch to Ballindooley Lough system, entering the small lough to the southwest first which is connected to the bigger lough by a wide, straight c.200m long drainage channel. The total drainage area for this section is 3.31ha and the impervious road area is 1.36ha. This represents an average inflow rate of 0.3l/s and the annual average catchment drainage inflow is 20l/s from its 225ha catchment area presenting an average dilution of 67. Ballindooley Lough potentially represents a sink for sediment with the lake rising and falling with the groundwater table and in dry weather periods its water level remains perched above the receding groundwater table.

This proposed outfall is designed with pollution control measures that include a spillage containment volume, a petrol-oil interceptor, a wetland and an attenuation pond. These measures will reduce the potential sediment load on Ballindooley Lough by well over 60%. Circa 1.4km of the existing N84 Headford Road carriageway discharges untreated and uncontrolled surface water into Ballindooley Lough via road side trenches and storm pipes.

An assessment of the predicted loads and concentrations from road runoff from this outfall are presented in **Table 11.39** below. The annual mean concentrations of dissolved copper and zinc will rise by 0.399 and 1.417 µg/l respectively based on Event Mean concentrations and loads for significant road drainage pollutants in accordance with Table 3.1 of the TII publications DNS-03065. All other parameters considered below in **Table 11.39** represent minor increases and will not affect the water quality status of Ballindooley Lough.

Table 11.39: Predicted mean load of Stormwater Pollutants from Outfall S21A and predicted mean increase in pollutant concentration within Ballindooley Lough from S21A

Main Road Drainage Pollutants	Road Runoff Load	Road Runoff Event Mean Concentration	Pollution Control Performance	Lake mean storm Inflow Concentration	Mean Lake Concentration increase
	kg/yr	µg/l	%reduction	µg/l	µg/l
Total Copper	863	91.2	60%	36.48	0.547
Dissolved CU	296	31.3	15%	26.605	0.399
Total Zinc	3336	352.6	60%	141.04	2.116
Dissolved ZN	1051	111.1	15%	94.435	1.417
Total Cadmium	5.96	0.63	60%	0.252	0.004
Total Fluoranthene	9.65	1.02	60%	0.408	0.006
Total Pyrene	9.74	1.03	60%	0.412	0.006
Total PAH	71.1	7.52	60%	3.008	0.045

Please note the predicted lake concentrations in **Table 11.39** above do not take reducing factors such as filtration and absorption and settlement within the lake, or of plant uptake and natural biodegradation.

The proposed road development will have a negligible impact on the flow regime within the lake from the proposed road drainage outfall and the slight encroachment of the proposed road development into an extreme winter flood area. The overall water quality impact on the lake is classified as slight permanent impact and particularly as circa 1.4km of the N84 Headford Road already discharges uncontrolled and untreated to the lake catchment. The proposed road discharge is treated and the remaining sediment is likely to settle out locally within the small lake and this represents a potential moderate local impact on the lake sediments. The overall hydrological impact rating of the proposed road development on Ballindooley is classified as a local slight permanent impact.

11.5.5 Surface Water Supply Sources

There are two very large public surface water abstractions in proximity to the proposed road development. These are the Luimnagh regional water abstraction from Lough Corrib located over 15km upstream (north) of the proposed crossing point of the proposed road development of the River Corrib and the Terryland Galway City water supply abstraction from the River Corrib at Jordan's Island located 1.7km downstream of the crossing point on the eastern side of the river. The proposed road is not within the zone of contribution to the Luimnagh supply being located well downstream, whereas, the proposed road development is in close proximity to the Terryland Galway City supply intake having a travel time of potentially only 30 minutes to 2 hours to this abstraction point depending on the flow magnitude of the River Corrib. By virtue of the Luimnagh Lough Corrib abstraction being located over 15km upstream there will be no potential water quality impact from the proposed road development either during construction or operation phases.

The proposed road development will not have any perceptible impact on River Corrib flows and therefore will not impact the Terryland abstraction in terms of quantity of supply.

The close proximity of the proposed road development to the Terryland Galway City water supply intake, located within the immediate source contribution area, any pollution of the River Corrib by the proposed road development either during construction (construction runoff, construction accidental spillages (concrete, hydrocarbons), etc.) or during operation (spillages from road accident and routine road runoff) from the various contributing road drainage outfalls S14A, S14B, S15, S18A and S18B) has a high potential of reaching and contaminating the abstraction point at Jordan's Island. This is particularly so for activities on or near the eastern bank. The abstraction is less sensitive to activities and discharges on the western bank but can still potentially be impacted given the right flow and meteorological conditions (southerly and westerly winds). The Terryland Galway City water supply is a fully treated water supply with tertiary treatment which provides some protection against significant impact by the proposed road development in the event of worst case spillage incident.

The dispersion analyses modelling of the River Corrib storm outfalls for the operational phase drainage discharges shows only trace pollutant concentrations reaching Jordan's Island channel and the Terryland Galway City water supply intake under the critical first flush design conditions and can be concluded that the impact of routine road drainage runoff on the water quality of the Terryland Galway City water supply abstraction will be imperceptible.

The outfall spillage risk assessment indicates very low potential for serious accidental spillage and by the provision of outfall control facilities in the design, the potential impact from the operational phase of the proposed road development is rated as slight. Construction activities without adequate construction management mitigation measures, particularly on the eastern river bank have the potential to impact on this important abstraction which has a regionally important attribute value. Taking account of the good dilution available in the River Corrib, the avoidance of any major instream works in the channel, and the water treatment process available at the Terryland Galway City water supply treatment works to purify the water for public consumption, this construction impact is rated as a potential slight to moderate temporary impact. Notwithstanding this, a serious spillage has significant consequences and therefore mitigation measures to prevent construction based activities polluting the River Corrib are necessary.

Other water rights downstream are associated with the canals and various headraces both immediately to the east and west of the River Corrib channel through Galway City. The proposed road development will have an imperceptible impact on the flow regime and water quality of the River Corrib through Galway City and therefore will not impact flows and water quality in the various canals and main river channel.

11.5.6 Flood Risk

A Flood Risk Assessment (FRA) of the proposed road development in accordance with the Planning System and Flood Risk Management Guidelines (2009) was carried out and the FRA Report can be found in **Appendix A.11.1**. This assessment investigated the potential flood risk to the proposed road development itself and the potential flood impact arising from the proposed road development. A summary of the findings of the FRA is presented below.

Road developments by their nature traverse watercourses and flood risk areas along their selected route. The proposed road development will involve the crossing of 17 small watercourse channels requiring culverting, the local diversion/realignment of a number of these watercourses and road drainage outfall discharges to these watercourses at a proposed 23 number outfalls. The proposed road development involves a major bridge crossing over the River Corrib at Dangan, the encroachment of a number of small pluvial flood risk areas, wet grassland areas, the very slight encroachment of the River Corrib Floodplain adjacent to the Coolagh Lakes and the Ballindooley Lough floodplain. The proposed reconfiguration/redevelopment of the NUIG pitches at Dangan is shown to slightly encroach the River Corrib floodplain area. The most significant flood risk area that is encroached by the proposed road development is a large pluvial flood risk area adjacent to the N83 Tuam Road Junction at Twomileditch.

The vertical alignment of the proposed road development has been assessed against predicted fluvial, pluvial and groundwater flood levels and found to be sufficiently clear of flooding under both present day and future climate change scenarios. The proposed road development is not subject to any coastal flood risk being sufficient elevation naturally even with high range sea level rise of 1m.

The proposed bridge structure over the River Corrib is a 153m bridge span and avoids any instream piers and avoids the River Corrib floodplain width at the predicted 100year and 1000year flood levels. The potential impact of the proposed River Corrib bridge structure on flooding and flood risk has been shown through detailed modelling presented in the FRA Report in **Appendix A.11.1** to have no discernible impact on flood levels. The River Corrib Bridge crossing is considered not to present a residual flood risk as structure completely spans the floodplain width, no instream weirs and a soffit to flood level clearance of over 10m giving no opportunity of blockage by floating debris. Section 50 (1945 Arterial Drainage Act) approval has been granted by the OPW, who are the competent authority in respect to Flood Risk Management in Ireland, for the proposed River Corrib Bridge.

There is minor encroachment by the embankment of the proposed road development on the River Corrib floodplain near the Coolagh Lakes section at Ch. 9+890. This represents a very minor encroachment and will not result in a perceptible impact on flooding or on the active flow regime of the River Corrib and the Coolagh Lakes themselves and therefore such impact is rated as an imperceptible flood impact.

The proposed redevelopment of the NUIG pitches at Dangan represents a slight encroachment of the River Corrib's 100-year and 1000-year flood zones at Dangan. 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 potential loss of floodplain storage is miniscule in comparison to the available flood storage in the River Corrib catchment and will not impact the flow regime in the River Corrib or affect flood risk elsewhere. Recreational/sports pitches are considered to be a suitable type of development within high and moderate flood zones A and B under the flood risk management planning guidelines.

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 associated with these watercourses ensures that the associated flood zones for these streams is very localised having relatively narrow floodplain widths along these streams. The proposed culvert sizes are very generous and will not result in any constriction to flow and therefore any impact on flooding and flood risk is categorised as a slight permanent negative impact. Section 50 approval has been obtained from the OPW concerning flooding and flood capacity of all proposed culverts. The impact of all of the proposed culvert and bridge structures on flood water level and flood risk to properties is rated as imperceptible. All new culverts represent a residual flood risk in that serious blockage could cause local flooding.

A slight encroachment on the Ballindooley Lough flood zone by the embankment of the proposed road development is predicted and the effect of this has been assessed as minor and the impact on flooding assessed as a slight permanent impact.

There is a potential flood risk to the proposed Lackagh Tunnel from elevated groundwater table combined with pluvial flooding within the quarry. This risk is associated with the potential for elevated flood levels within the quarry floor, under extreme 1000-year flood events and climate change conditions, to potentially enter the tunnel from the eastern portal entrance on the quarry side. As the proposed road development traverses through the quarry, it will reduce the available storage for rainfall and increase pluvial ponding depths contained within the lower bench of the quarry. This could potentially increase flood levels local to the quarry. The potential risk is significant but has been reduced to slight by design, through raising the minimum road level at the tunnel portal entrance by 1m above the recorded historical worst flooding event (highest recorded winter groundwater level is 15.7m OD. and lowest design road level is 16.735m OD). Such a clearance, given the limited drainage catchment area, is considered sufficient to minimise flood risk. Topographically the quarry area is self-contained and the proposed infilling as a result of the proposed road development will not result in flood waters spilling from the quarry and causing flooding elsewhere with flood waters retained and receding with the groundwater table. Permeable infill material is recommended for use within the quarry so as to maintain the drainage route to groundwater through it limestone base and sides.

Road drainage outfalls discharging to limited capacity (flow and infiltration capacity) surface and groundwaters sources are provided with suitably sized flow control and attenuation and infiltration basins. The flow controls are designed to achieve greenfield flood runoff rates in the case of surface water outfalls, and soil infiltration capacity in respect to groundwater outfalls. Flood attenuation for the River Corrib outfalls from S18A and S18B is not required due to the large scale of the River Corrib catchment and its flood response time relative to the proposed storm discharge. The potential impact rating of the storm drainage outfalls on the receiving waters with respect to flow regime and morphological changes, and as such flood risk is presented in **Table 11.29**. This generally represents slight to imperceptible permanent impacts. The provision of infiltration basins and attenuation ponds represents a residual flood risk in respect to the continued design performance in respect to preventing local flooding and flood impact.

The provision of infiltration basins and attenuation pond facilities throughout the proposed road development represent a potential new source of flood risk as by their nature they temporarily impound road drainage waters and release slowly to the receiving waters. These are engineered structures designed to deal with 1 in 100-year storm event with allowance for climate change and freeboard. Proposed design water depths vary from 1 to 1.85m and therefore represent a relatively low flood risk under normal operating conditions. In addition, infiltration basins are sized such that half of the basins volume will empty in 24 hours or less which facilitates space for consecutive storm events. However, such facilities may be subject to potential blockage and therefore overtop giving rise to potential local flooding. Flow control devices which have small orifice sizes in order to restrict flows to greenfield runoff rates can be prone to blockage.

The residual flood risk is minimised in the design as the following maintenance schedule for the proposed road development drainage infrastructure:

- Regular inspections of all drainage facilities that include, culverts, flow control devices, outfalls, attenuation ponds and infiltration basins and the road drainage network to ensure that the drainage system is in proper working order and performing as designed

Several small pluvial flood sources are encountered along the proposed road development associated with small local depressions which will be either fully or partially removed and are highlighted in the FRA Report in **Appendix A.11.1**. The assessment indicates that these pluvial flood sources are very minor in respect to contributing drainage area and the extent of the flood area and the infilling of these will not result in significant impact on flooding, with the potential impact assessed as slight to imperceptible.

A large pluvial flood risk area near the existing N83 Tuam Road at Twomileditch is encroached by the proposed road development. This area has a significant flood risk with up to seven dwellings and the existing carriageway of the N83 Tuam Road at high risk of flooding (currently). The existing road and a number of dwellings have experienced flooding in the recent past. The critical flood levels for flooding on the N83 Tuam Road and adjacent dwellings is 18.0m to 18.5m OD. The local authority regularly deploy pumps to clear flooding from the existing road in this area. The proposed road development potentially encroaches the pluvial Flood Zone A (high probability of flooding zone) with the potential for 21.2% to 22.4% loss in available flood storage within these pluvial flood prone lands at a flood level of 18m and 18.5m OD respectively. Without suitable mitigation, the proposed road development has a potential at this location to remove flood storage and potentially worsen the flood risk at this location. This loss of flood storage represents a significant permanent impact on flooding and flood risk and therefore requires specific flood mitigation. In addition to the loss of storage, the proposed road development will also introduce a significant additional paved area to the contributing catchment of this flood zone. However, the drainage of this paved runoff area is designed to dispose separately to groundwater via a number of appropriately located and sized infiltration basins which minimises the contribution of the road pavement runoff to flooding at this location. The specific flood mitigation measures are dealt with in detail below in Section 11.6.

The proposed N59 Link Road South from Ch. 1+550 to 2+200 and the proposed upgrade / 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 (30 September 2015) and the OPW pFRA mapping. Both the Galway City Council SFRA and the OPW pFRA mapping are very coarse and did not include details of the stream channel or its various culverts. The 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 land development initiative. This flood risk mapping only allowed for overland flow based on poor resolution DTM lidar data and did not include for channel / storm pipe conveyance. 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 the 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 the various nodal points of the storm sewer model and the micro-drainage program ran. The model results showed ample capacity within the storm pipe at both the 100 and 1000-year flood events not to result in flooding in the vicinity of the proposed N59 Link Road South 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 Knocknacarra Stream will be attenuated to the natural greenfield runoff rates and therefore will not impact flood flows and flooding.

11.5.7 European Sites

Lough Corrib cSAC and Lough Corrib SPA

A summary of the potential hydrological impacts on the Lough Corrib cSAC are provided in in **Table 11.39**. The proposed road development via its drainage outfalls will provide a pathway for road runoff pollutants to enter the Lough Corrib cSAC and Lough Corrib SPA during construction and operational phases. Only one outfall S15 from the N59 Link Road North has a potential pathway via a drainage ditch that discharges to the River Corrib in the vicinity of the southern extent of the Lough Corrib SPA. The potential impacts from the operational phase have been reduced in the design process to minor and imperceptible both in respect to flow regime changes and water quality impact.

The potential impact of the proposed road development on the surface hydrology of the Coolagh Lakes system will be imperceptible. The proposed road development represents a potential pollution hazard and has a residual risk of pollution via contamination of the groundwater at its proposed infiltration basin. Proper management and regular inspection and maintenance of these drainage discharge facilities will significantly reduce the risk of pollution impact on the groundwater and the Coolagh Lakes system.

Galway Bay Complex cSAC and Inner Galway Bay SPA

A summary of the potential hydrological impacts on the Lough Corrib cSAC are provided in in **Table 11.40**.

The proposed road drainage treatment, the good natural buffering from the receiving watercourses before reaching the Galway Bay Complex cSAC and Inner Galway Bay SPA and the natural high dilution within the coastal and transitional waters of these European sites ensures that the residual impact on flow and water quality within the Galway Bay Complex cSAC and Inner Galway Bay SPA both locally and regionally will be negligible.

Construction impacts arising from the proposed road development represent a low risk to water quality within the Galway Bay Complex cSAC and Inner Galway Bay SPA due to the available buffering by the watercourses and by the high dilution within these European sites.

11.5.8 Water dependent habitats outside of a European site

The proposed road development traverses through and adjacent to the various water dependent habitats located outside of the European site. These habitats types encountered which have been mapped and described in **Chapter 8, Biodiversity** are summarised below in **Table 11.40**.

Table 11.40: Summary of water dependent habitats

Habitat Code	Habitat Name	Status
Fossitt Code PF1	Rich Fen and Flush	Non-Annex
Fossitt Code PF2	Poor Fen and Flush	Non-Annex
Annex Code 4010	Wet Heath	Annex I
Annex Code 6410	Molina Meadows	Annex I
Annex Code 7130	Blanket Bog (active)	Annex I
Annex Code 7140	Transition Mire	Annex I
Annex Code 7150	Rhynchosporion Depression	Annex I

The proposed road development has the potential to impact the water balance of water dependent wetland habitats through the potential diversion of overland and interflow that supplies these wetlands either through interception in the embankment toe drains, the subsurface filter drains, interceptor drain and by drainage in the road formation layer. **Table 11.41** presents an assessment of the impact to adjacent wetland habitats.

Table 11.41: Hydrological Impact Assessment on Water dependent habitats outside of a European site

Wetland Code	Habitat	Approx. Chainage	Location	Potential Impact
4030/4010	Mosaic of dry and Wet heath	0+700	Within proposed development boundary and to northwest	A toe drain of the proposed road development will drain a small section of this habitat, the potential hydrological impact will not extend beyond the hydrogeology ZOI
4010	Wet heath	0+700	Extends to within 30m north of the proposed development boundary	Wet heath located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically
PF2/GS4	Poor Fen and Flush and wet grassland	0+750	Extends to within 20m north of the proposed development boundary	Located up gradient of the proposed road surface drainage. This habitat will not be impacted
4010	Wet heath	0+950	Within proposed development boundary	Habitat removed / lost. Refer to **Chapter 8, Biodiversity** for full details on habitat loss or removal
6410	Molinia Meadows	0+900	North of road	Located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically
4010	Wet heath	1+250	Within proposed development boundary	Habitat removed / lost. Refer to **Chapter 8, Biodiversity** for full details on habitat loss or removal
4010	Wet heath	1+350	Within proposed development boundary	Slight encroachment and local drainage impact. The surface drainage impact will not extend beyond the hydrogeology ZOI
4010	Wet heath	1+450	Extends to within 30m Southwest of Road proposed development boundary	Located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically
4010	Wet heath	1+400 - Na Foraí Maola to Troscaigh Link Road	Extends to within 8m north of Road proposed development boundary	Located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically

Wetland Code	Habitat	Approx. Chainage	Location	Potential Impact
4010	Wet heath	1+750 to 2+400	Extends typically to within 50m north of Road proposed development boundary	Located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically
4010	Wet heath	1+850 to 2+100	Located within and immediately north and south of proposed development boundary. Topography generally flat.	Habitat removed and local drainage effect both north and south of the proposed road toe drains. The surface drainage impact will not extend beyond the hydrogeology ZOI
4010	Wet heath	2+700	South(60m) and 40m west of Bearna-Moycullen Road	Located up gradient of the proposed road surface drainage. This habitat will not be impacted
6410	Molinia Meadows	2+850 to 2+950	130m south	Surface drainage at this habitat will not be impact by the proposed road development
4010	Wet heath	3+450 to 3+700	Extends to within 50m southeast of Road proposed development boundary. Habitat located downgradient and within the ZOI of the road	A small local drain that runs along the downstream boundary of this habitat will be diverted. The proposed road drainage and formation layer will capture and divert contributing overland and interflow away from this habitat. Potential Moderate Impact on the surface hydrology of this habitat. The groundwater ZoI does not extend downstream to this habitat and therefore it is likely that this habitat will not be lost
6410	Molinia Meadows	3+600	west of proposed development boundary	Located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically
6410	Molinia Meadows	3+600	30m east of proposed development boundary	Habitat located downgradient with potential drying effect through interception of overland and interflow by road drainage and road construction. The hydrogeological ZoI does

Wetland Code	Habitat	Approx. Chainage	Location	Potential Impact
				not extend downstream to this habitat and therefore it is likely that this habitat will not be lost. Potential Slight Impact on the surface hydrology of this habitat
4010	Wet heath	3+650 to 3+800	Habitat within proposed development boundary	Habitat removed / lost. Refer to **Chapter 8, Biodiversity** for full details on habitat loss or removal
4030/4010	Mosaic and dry and Wet heath	3+750	Habitat generally Northwest and slightly within proposed development boundary	The proposed road development is in a cutting with drainage effect by interceptor drains and road filter drains. The surface drainage impact will not extend beyond the hydrogeology ZOI
4030/4010	Mosaic and dry and Wet heath	4+925	Habitat Northwest and slightly within proposed development boundary	The effect of the proposed road development drainage will not extend beyond the hydrogeology ZOI at this location
4010	Wet heath	5+075	located South and slightly within proposed development boundary	Slight local surface drainage effect on habitat by the proposed road development. The effect of the proposed road development drainage will not extend beyond the hydrogeology ZOI
4010	Wet heath	5+200	Extends to within 60m North of Road proposed development boundary	Located up gradient of the proposed road surface drainage. This habitat will not be impacted hydrologically
4030/4010	Mosaic and dry and Wet heath	5+250	Slight encroachment of Habitat within Fence Line	The effect of the proposed road development drainage will not extend beyond the hydrogeology ZOI
4010	Wet heath	5+850	Extends to within 110m North of proposed development boundary	No hydrological impact as habitat not within ZoI of road and surface drainage in area serviced by existing storm sewer

Wetland Code	Habitat	Approx. Chainage	Location	Potential Impact
7140	Transition Mire	7+450 and N59 0+700	80m NW of proposed development boundary and proposed construction compound area	No hydrological impact as habitat not within ZoI of Road being fed from the Northwest and North
7130	Blanket Bog (active)	7+550 and N59 0+650	10m NW of proposed development boundary and proposed construction compound area	No hydrological impact as habitat not within ZoI of Road being fed from the Northwest and North
PF2	Poor Fen and Flush	7+850	north and within proposed development boundary	The effect of the proposed road development drainage will not extend beyond the hydrogeology ZoI
6410	Molina Meadows	12+250	within and downstream near Ballindooley Lough	The effect of the proposed road development drainage will not extend beyond the hydrogeology ZoI
PF1	Rich Fen and Flush	12+350	Extends to within 70m NW of proposed development boundary	The surface drainage of this Habitat will not be impacted by the proposed road development

Local impacts to the local water chemistry in terms of changing the pH may apply where limestone derived alkaline material is placed over granite bedrock. Surface water run-off, interflow or groundwater movements through such material has the potential to impact local areas of peatland habitats by changing the pH of the recharge water particularly where this alkaline material is saturated (below the groundwater table). This potential impact will only apply to adjacent wetland habitats within hydrogeological Zone of Influence of the proposed road development. The use of limestone based road material for the pavement and capping layers is permitted as such layers will be protected from direct surface water and groundwater infiltration and located in the unsaturated zone above the groundwater table. This capping protection is provided by the road bitumen surface and the use of native topsoil capping along the grass verge and embankment section of the road construction. Restriction on the use of limestone derived formation material will apply locally to road sections in the vicinity of water dependent habitats within the granite bedrock area (west of the existing N59 Moycullen Road), refer to **Chapter 9, Soils and Geology** for details of mitigation.

A summary of the potential impacts on the Lough Corrib cSAC and Lough Corrib SPA is provided in **Table 11.42** below.

Table 11.42: Hydrological Impacts on Lough Corrib cSAC and Lough Corrib SPA

Attribute	Impact Stage	Nature of Impact	Impact description	Potential Impact Magnitude
Lough Corrib cSAC (00297), and Lough Corrib SPA (004042) River Corrib	Construction	Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	A major bridge construction is proposed across the River Corrib and associated with the bridge deck and the bridge piers will be the pouring of concrete and the use of chemical and grouting agents in close proximity to an internationally important waterbody. Due to the major public water abstraction located only 1.7km downstream on the east bank makes it highly sensitive to construction pollution and potential accidental spillages.	Moderate to Significant Temporary Impact requiring mitigation
Lough Corrib cSAC (000297), Lough Corrib SPA (004042) River Corrib Coolagh Lakes	Construction	Silts and sediments arising from works adjacent to watercourses and construction site runoff	Within the River Corrib Catchment, the various streams/drains encountered provide a pathway for silts and sediment laden runoff water from the construction site to reach the Lough Corrib cSAC and cause local increase in suspended solids and turbidity. These activities adjacent to the River Corrib and its floodplain provide a significant source and pathway for sediment laden runoff to enter the River Corrib with little buffer time available for natural filtering and settlement. The River Corrib Bridge crossing of the Lough Corrib cSAC at Menlo/Dangan will not involve any in-stream works but bridge piers are to be located on either bank close to the river edge which can give rise to site runoff entering the river during works. Two bank side drainage outfalls are to be constructed which given their proximity the river flow make it difficult to prevent local disturbance of sediments. Good dilution in the River Corrib significantly lessens the potential impact on the receiving waters The proposed construction of the NUIG pitches as part of the accommodation works for the Road has the potential during construction to pollute given their proximity of the pitches to the Corrib river bank and to a local drainage ditch to the southeast that discharges directly into the River Corrib. A section of the	Moderate to Significant Temporary Impact requiring mitigation

Attribute	Impact Stage	Nature of Impact	Impact description	Potential Impact Magnitude
			Pitch is shown to be within the 1 in 100year flood contour and therefore there is a small risk of flood inundation during construction which could further exacerbate sediment runoff to the Corrib There is potential for construction impact in the form sediment runoff and pollution associated with the road construction in vicinity of the Coolagh/Corrib Floodplain at Ch. 9+850.	
Lough Corrib cSAC (000297), Lough Corrib SPA (004042) River Corrib Coolagh Lakes	Operational	Changes to Flow regime within the River Corrib	The proposed road development slightly encroaches the River Corrib floodplain near Menlo / Coolagh Lakes at Ch. 9+850 to Ch. 9+900. The area of encroachment at the 1000year flood level is 0.27ha and at the 100year it is 0.11ha. The proposed encroachment will not have any perceptible impact on flooding or on the hydrological flow regime. Potential encroachment of the 100year flood extents will also occur at Dangan associated with the redevelopment of the NUIG pitches. The Pitches infill this floodplain area to achieve a free draining pitch These encroachments are very small and the potential flood storage loss from infilling will be miniscule in relation to the Corrib Flood area and flood volume and will no perceptible impact on flooding or flow regime in the Corrib and the Corrib cSAC and Corrib SPA. A number of road outfalls discharge directly and indirectly to the Corrib cSAC (outfalls S14A, S14B, S15, S18A, S18B) and Corrib SPA (outfall S15). These outfalls relatively to the Corrib drain a miniscule area and will have no perceptible effect on the flow rate and water depth of the Corrib River.	Slight to imperceptible permanent impact

Attribute	Impact Stage	Nature of Impact	Impact description	Potential Impact Magnitude
Lough Corrib cSAC (000297), Lough Corrib SPA (004042) River Corrib Coolagh Lakes	Operational	Impact on Receiving Water Quality of Corrib from Road Drainage at proposed road drainage outfalls	Within the River Corrib Catchment, the various streams/drains encountered provide a permanent pathway for pollutants from the road drainage waters to enter the River Corrib. The potential impact by the road drainage outfalls on the Lough Corrib cSAC and SPA have been assessed as local minor to imperceptible impact and will not affect the "Good" water quality status of the Corrib River. The potential risk of impact to the River Corrib by serious accidental road spillage has been assessed as extremely low risk and further reduced in the design process through the provision of containment facilities in the form of petrol and oil interceptors and wetland area upstream of the drainage outfalls	Slight permanent impact

A summary of the potential impacts on the Galway Bay Complex cSAC and Inner Galway Bay SPA is provided in **Table 11.43** below.

Table 11.43: Hydrological Impacts on Galway Bay Complex cSAC and Inner Galway Bay SPA

Attribute	Phase	Source	Impact description	Potential Impact Magnitude
Galway Bay Complex cSAC (00268) Inner Galway Bay SPA (04031)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff.	The various streams encountered all along the proposed road development provide a pathway for silts and sediments runoff from the construction site to reach the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City which is typically located 1 to 2km downstream of the proposed road development and therefore at risk of indirect water quality impacts.	Slight Temporary Impact
	Construction	Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages similar to silts and sediments can reach the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City via surface runoff and via groundwater.	Slight Temporary Impact

Attribute	Phase	Source	Impact description	Potential Impact Magnitude
	Construction	Disturbance due to construction machinery and carrying out of temporary works (cofferdams, culverts, channel diversions, sediment ponds, silt fences etc.).	There is no direct encroachment of the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City by the proposed road development.	None
	Operational	Road drainage and outfalls impacting on the water quality Regime: - Routine road runoff discharges - Accidental fuel spills from road	There are no direct discharges from road drainage outfalls to the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City but most the road outfalls discharge to watercourses and groundwater aquifer that outfall to this cSAC/SPA and therefore provide a pathway for contaminants to reach the cSAC/SPA. The probability of accidental road accident spillages is shown to be very low and sufficient dilution available to minimise the impact of routine runoff on the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City.	None
	Operational	Changes to watercourse channel morphology because of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition and morphological changes.	The proposed road development will not impact on morphological processes in the Galway Bay Complex cSAC and Inner Galway Bay SPA and particularly so as outfall discharges will be attenuated which will limit any local increase in flood runoff rates that could cause increased channel erosion. The sediment yield to the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City will not be perceptibly changed given the proposed works involved and the scale of the overall contributing catchments to the Galway Bay Complex cSAC and Inner Galway Bay SPA at Galway City relative to the footprint of the proposed road development.	None

11.5.9 Material Deposition Areas

A total of 40 site areas have been identified as potential material deposition areas for the excess soft and unacceptable material along the route of the proposed road development, refer to **Table 11.27**.

These potential material deposition areas if not correctly constructed, could represent a serious source of pollution to an adjacent watercourse should untreated runoff waters containing high concentration of sediment from these facilities enter the watercourse.

These material deposition areas will be bunded or excavated sites and will have double erosion control fencing (silt fence) and a sediment settlement pond at the outlet which will be constructed in advance of their use as deposition areas. In addition, wheel wash facilities will be provided at the entrance/exit as outlined in the CEMP – see **Appendix A.7.5**.

Runoff from the material deposition areas will be treated in temporary settlement ponds which will be provided upstream of the outfall to the receiving watercourse or sewer. These ponds will be maintained until the material deposition areas have stabilised and become adequately vegetated. In addition, the specific construction sequence for these areas (described below) will allow for settlement of sediment prior to discharge to the receiving watercourse. The construction sequence of each of the material deposition areas is such that the area allocated for material deposition is compartmentalised to allow a deposition area to be first established in one compartment, while the runoff water from this compartment flows into and is contained within an adjacent compartment. This will allow settlement of sediment to take place. Once settlement of the sediments has occurred, this settlement area is then itself filled with peat and the adjacent compartment acts as the settlement area for the runoff from this section. This process is repeated as the works advance.

The construction sequencing and design of the material deposition areas will ensure that there will be negligible impact on adjacent watercourses. As part of the CEMP a plan for erosion and sediment control has been developed which deals specifically with the potential impacts of the material deposition areas and this is attached in **Appendix A.7.5**.

11.6 Mitigation Measures

11.6.1 Introduction

This section outlines the proposed mitigation measures for hydrology. Mitigation measures follow the principles of avoidance, reduction and remedy. The most effective measure of avoidance is dealt with during the route selection and design stage, by moving the proposed road development either laterally or vertically within the Emerging Preferred Route Corridor, to ensure that it does not traverse or pass near to sensitive hydrological attributes. As set out throughout **Section 11.4**, appropriate measures have been incorporated into the design of the proposed road development to avoid impacts where possible.

Where avoidance of the feature has not been possible, consideration has been given to locally modifying the proposed road development so as to reduce / minimise the extent of the impact. If any modifications are proposed to reduce hydrological impacts, it is necessary to also consider any associated impacts to the hydrogeological and ecological regimes.

11.6.2 Construction Phase

As is normal practice the Construction Environmental Management Plan (CEMP) included in **Appendix A.7.5** will be finalised by the Contractor in advance of the commencement of construction and the following will be implemented as part this plan:

- An Incident Response Plan detailing the procedures to be undertaken in the event of spillage of chemical, fuel or other hazardous wastes, logging of non-compliance incidents and any such risks that could lead to a pollution incident, including flood risks (Refer to Section 10 of the CEMP in **Appendix A.7.5**)
- A Sediment Erosion and Pollution Control Plan (Refer to Section 8 of the CEMP in **Appendix A.7.5**). This shall include water quality monitoring and method statements to ensure compliance with environmental quality standards specified in the relevant legislation (i.e. surface water regulations and Salmonid Regulations 1988)
- All necessary permits and licenses for instream construction works associated with the provision of culverts, bridges and outfalls. OPW Section 50 consent has been received for all culverts and bridges proposed in the EIAR. Changes to these structures as part of the detailed design and construction stage will require new Section 50 consent to be obtained
- Inform and consult with OPW Western Arterial Drainage Section who have responsibility for the Corrib-Mask Arterial Drainage scheme and the ongoing control of river and lake levels at the Salmon Weir Barrage in Galway City
- Continue to Inform and consult with Inland Fisheries Ireland (IFI)
- Continue to Inform and consult with National Parks and Wildlife Service (NPWS)

Construction activities will be required to take cognisance of the following guidance documents for construction work on, over or near water:

- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters (Inland Fisheries Ireland, 2016)
- Shannon Regional Fisheries Board – Protection and Conservation of Fisheries Habitat with particular reference to Road Construction
- Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites (Eastern Regional Fisheries Board)
- Central Fisheries Board Channels and Challenges – The Enhancement of Salmonid Rivers
- CIRIA C793 The SuDS Manual
- CIRIA C624 Development and Flood Risk – guidance for the construction industry
- CIRIA C532 Control of Water Pollution from Construction Sites Guidance for Consultants and Contractors
- CIRIA C648 Control of Water Pollution from Linear Construction Projects, technical guidance
- CIRIA C649 Control of Water Pollution from Linear Construction Projects, site guide
- Guidelines for the Crossing of Watercourses during the Construction of National Road schemes (NRA, 2006)
- Road Drainage and the Water Environment DN-DNG-03065 (TII, June 2015)
- Vegetated Drainage Systems for Road Runoff DN-DNG-03063 (TII, June 2015)

Based on the above guidance documents concerning control of construction impacts on the water environment, the following outlines the principal mitigation measures that will be prescribed for the construction phase in order to protect all catchment, watercourse and ecologically protected areas from direct and indirect impacts:

- All constructional compound areas will be required to be located on dry land and set back from river and stream channels and out of floodplain areas. Floodplain areas include the Flood Risk Zones A and B (i.e. outside of the present day 100year and 1000year flood extents)
- The storage of oils, fuel, chemicals, hydraulic fluids, etc. will not occur within 100m of the River Corrib or within the Floodplain Area as defined above
- Surface water flowing onto the construction area will be minimised through the provision of temporary berms, diversion channels and cut-off ditches, where appropriate
- Management of excess material stockpiles to prevent siltation of watercourse systems through runoff during rainstorms will be undertaken. This may involve allowing the establishment of vegetation on the exposed soil and the diversion of runoff water off these stockpiles to the construction settlement ponds and avoiding stockpiling of material in vicinity of sensitive watercourses

- Where construction works are carried out adjacent to turloughs, fens, stream and river channels and lakes, protection of such waterbodies from silt load shall be carried out through use of reserved grassed buffer areas, timber fencing with silt fences or earthen berms. These measures will provide adequate treatment of constructional site runoff waters before reaching the watercourses
- Use of settlement ponds, silt traps and bunds and minimising construction activities within watercourses. Where pumping of water is to be carried out, filters will be used at intake points and discharge will be through a sediment trap or sedi-mat
- All watercourses that occur in areas of land that will be used for site compound/storage facilities will be fenced off at a minimum distance of 5m. In addition, measures will be implemented to ensure that silt laden or contaminated surface water runoff from the compound site does not discharge directly to the watercourse. Compounds shall not be constructed on lands designated as Flood Zone A or B in accordance with the OPW's The Planning System and Flood Risk Management Guidelines (November 2009). Site compounds will not be permitted in a European Sites (i.e. Lough Corrib cSAC)
- Protection measures will be put in place to ensure that all hydrocarbons used during the construction phase are appropriately handled, stored and disposed of in accordance with the TII document "Guidelines for the crossing of watercourses during the construction of National Road Schemes". All chemical and fuel filling locations will be contained within bunded areas and set back a minimum of 10m from watercourses
- Foul drainage from all site offices and construction facilities will be contained and disposed of in an appropriate manner to prevent pollution
- The construction discharge will be treated such that it will not reduce the environmental quality standard of the receiving watercourses
- Riparian vegetation along the identified sensitive watercourses will be fenced off to provide a buffer zone for its protection to a minimum distance of 5m except for proposed crossing points
- The use and management of concrete (which has a deleterious effect on water chemistry and aquatic habitats and species) in or close to watercourses will be carefully controlled to avoid spillage. Where on-site batching is proposed, this activity will be carried out well away from watercourses. Washout from such mixing plants will be carried out only in a designated contained impermeable area
- All material deposition areas must be adequately bunded and compartmentalised such that the rainwater outflow from these facilities is adequately controlled and treated prior to reaching the receiving surface watercourses. The sediment control requirements are set out in the in the Sediment, Erosion and Pollution Control Construction Management Plan section of the CEMP (refer to **Appendix A.7.5**).

The potential for constructional phase impacts on water quality in receiving streams and lakes has been reduced to slight and imperceptible through the implementation of a Sediment Erosion and Pollution Control Management Plan included in the CEMP in **Appendix A.7.5**.

The potential for constructional phase impacts on water quality in the Lough Corrib cSAC has been reduced to slight and imperceptible through the implementation of a Sediment Erosion and Pollution Control Management Plan., included in the CEMP in **Appendix A.7.5**.

To minimise the risk of contamination to the Galway Bay Complex cSAC a detailed Sediment, Erosion and Pollution Control Management Plan for the construction phase has been developed and included in the CEMP in **Appendix A.7.5**, which provides for avoidance, reduction, mitigation and monitoring. Construction hydrological and water quality impacts on the Galway Bay Complex cSAC and Inner Galway Bay SPA will be avoided.

11.6.3 Operational Phase

11.6.3.1 Flood Risk Mitigation

A single flood risk area adjacent to the N83 Tuam Road at Twomileditch is identified as being significantly impacted by the proposed road development with a potential loss of 21% of the available flood storage. This potential impact is identified as significant as the loss of flood storage will increase the extreme flood levels and increase the probability of flooding within an existing flood risk area where seven houses and the N83 Tuam Road are identified to be at high flood risk.

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 100-year return period flood event with a 20% allowance for climate change design flood level for the proposed flood relief measures is 17.5m OD Malin which will prevent flooding of the driveways to the dwellings and the N83 Tuam Road.

The flood relief mitigation measures to eliminate the flood impact of the proposed road development and reduce the existing flood risk in this area are described as follows (refer also to Drawing GCOB-500-D-600):

- Prevent the upgraded portion of the N83 Tuam Road from spilling laterally northwards into the driveways of existing flood risk houses by:
  - Upgrade and provide effective road drainage network along the existing N83 Tuam Road. The proposed upgraded road drainage for the N83 portion is extends for a length of 780m
  - Provide interceptor drain to capture rapid hill slope runoff from the southeast reaching the N83 Tuam Road
  - Provide for infiltration of this interceptor drain for the less severe rain storm events
  - Connect this interceptor drain to the proposed flood compensation storage

- Compensate flood storage lost by providing compensation storage of 8,030m^3 in the form of an excavated rectangular engineered storage pond. The base elevation of 16m OD and a top design water level elevation of 17.5m OD
- Connect this compensation storage to the remaining low-lying natural flood storage area located to the northwest of the proposed road development so that both storage areas are hydraulically linked via culverts
- Provide for permanent a pumping station and rising mains from the proposed compensation flood storage facility to discharge to the existing storm sewer with maximum pumping capacity of 250l/s

Table 11.44 Outlines the required storage volumes required for the catchment for a range of return periods and durations events. The critical volumes for each return period are shown in bold text.

Table 11.44: Flood Mitigation Storage Volumes

Duration	**Pumping**	**Storage Volume Required**		
hours	**250 l/s**	**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 of 0.25cumec is 20,700m^3 for the 100year event and including 20% climate change the storage required is 24,800m^3.

The available storage at a top water level of 17.5m OD is compensation storage of 8,030m^3 and remaining (with proposed road development) natural storage of 18,470m^3 giving a total available flood storage of 26,500m^3, which is sufficient to achieve that design standards.

Overall the proposed road development with this mitigation will provided a significant positive impact on flooding and flood risk in N83 Tuam Road in the Twomileditch flood risk area.

To minimise the residual flood risk associated with the blockage of flood relief culverts and associated drainage assets, the following operational mitigation measure is recommended:

- Regular (monthly) inspection of N83 Flood Relief facilities be carried out to ensure that the system is in proper working order and performing as designed.

11.7 Residual Impacts

The residual hydrological impacts associated with the proposed road development can be grouped as follows:

- Drainage and flood risk
- Water quality
- Channel morphology
- Potential impacts on key ecological receptors

11.7.1 Drainage and Flood Risk

There is a potential to increase peak flow rates and runoff volumes due to the increased impermeable area associated with the proposed road development and the collecting drainage system which discharges at outfall points. The implementation of SuDS through the incorporation of engineered wetlands, attenuation ponds, infiltration basins and controlled discharges at all outfalls will control storm runoff rates to greenfield flood runoff rates and will not exacerbate flooding and flood risk in the receiving watercourses. As part of the proposed drainage design attenuation storage has been sized to accommodate the 100-year storm event with 20% climate change allowance.

In the karst aquifer section east of the River Corrib, where surface drainage watercourse features are non-existent, the proposed road drainage system will convey rainfall from the impervious road pavement as drainage runoff to discharge, virtually a point source, to groundwater via engineered infiltration basins. Sizing of these basins, with facility for surcharging within the basin, has been designed to cater for the 100year flood event with 20% climate change allowance.

The provision of infiltration basins and attenuation pond facilities throughout the proposed road development represent a potential new source of flood risk as they by their nature impound road drainage waters and release slowly to the receiving waters. Such facilities may be subject to potential blockage and therefore overtop giving rise to potential for local flooding. The residual risk is low due to the standard regular inspections of such facilities, that include, culverts, flow control devices, outfalls, attenuation ponds and infiltration basins to ensure that system is in proper working order and performing as designed. Such facilities are considered to represent a slight magnitude permanent impact to flooding and flood risk.

With the relatively high density of drainage outfalls along the proposed road development there is limited opportunity for significant diversion of drainage flows between catchments and sub-catchments with the overall residual impact on flow regime categorised as local slight to imperceptible as only very minor land drains and recharge from the road pavement are potentially diverted.

The disturbance of field drainage systems represents a direct impact to the existing drainage regime. The drainage has been designed sympathetic to the natural drainage pathways maintaining where feasible existing drainage runs by culverting or slightly realigning the local drains across the proposed road development. The overall impact on surface drainage along the proposed road development is a slight to imperceptible residual impact.

No negative residual impacts on flood risk due to loss of conveyance are anticipated at the River Corrib and the various culverted watercourse crossings. All culvert design flows include large factors for uncertainty associated with flood estimation in small ungauged catchments and thus the proposed culvert sizes are conservatively large and in all cases substantially exceed the existing culvert sizes on such streams and therefore avoid any conveyance capacity issues. There will be no residual impact from the proposed road development.

The loss of floodplain storage where the proposed road development crosses such areas is minor relative to the catchment flood flows and existing flood storage volumes within the floodplain. The assessment identifies a slight reduction of flood storage at the River Corrib crossing adjacent to the Coolagh Lakes and at Ballindooley Lough both of which are considered to represent an imperceptible impact on flood risk and flow regime of the Coolagh Lakes and Ballindooley Lough.

The proposed flood mitigation measure for the N83 Tuam Road Junction to mitigate loss of flood storage from a pluvial flood risk area will provide a moderate to significant positive residual impact on flooding and flood risk at N83 Tuam Road Twomileditch area, as the proposed mitigation measure will reduce the flood risk to the existing road and to the six remaining houses.

However negative residual flood impacts associated with the N83 flood relief measures will remain:

- Discharge of flood water into the Terryland Basin at 250 l/s resulting in slight increase in flood levels within the Terryland River channel. The impact of this discharge on flood levels in the Terryland Basin is minor representing a slight permanent residual impact on flood levels
- Reduction of available capacity within the existing storm sewer located to immediately south in the City North Business Park (the full bore capacity in the pipe is estimated to be 900l/s and therefore the proposed maximum discharge of 250l/s will reduce the available capacity by 27% This is considered a slight impact
- Residual flood risk at the N83 Tuam Road associated with potential breakdown of the storm water pumping station, and blockage of storage area and associated drains and outfalls. This is considered slight in light of regular monthly inspections proposed

11.7.2 Water Quality

The proposed road drainage will be collected and discharged to watercourses resulting in localised water quality impact at the outfall sites. This impact is minimised by utilising best practice design using sustainable drainage systems (SuDS). These include filter drains and grassed surface water channels where permitted, vegetated lined wetlands, attenuation ponds and infiltration basins. The vegetated wetlands, are sized to cater for the potentially contaminated first flush volume 15mm effective rainfall. Further detention storage of runoff water, provided within the attenuation pond systems and infiltration basins, will permit further settlement of suspended pollutants. The impacts of reduction of water quality in streams receiving routine runoff is considered to represent slight and imperceptible permanent residual impacts.

All pollution control facilities and attenuation areas will be fitted with oil and petrol interceptor and a penstock or similar restriction at the outfall to the receiving channel and groundwater basin. The overall risk assessment to quantify the likelihood of a serious accidental spillage indicates a cumulative risk for the entire road length discharging to surface water courses as 0.07% which represents a very low risk of serious contamination. For most watercourse receptors, this potential spillage risk for individual outfalls is much smaller and therefore represents an imperceptible risk. The risk decreases westward along the route of the proposed road development.

The impact from an accidental spillage should it occur on all stream outfalls will be reduced using oil and petrol interceptors upstream of the ponds and outfall. A penstock control and spillage containment area which can be closed off in the event of a serious pollution incident arising will be provided for all mainline and new link road catchments. As a consequence of the design there will be an imperceptible residual impact from accidental spillages along the proposed road development.

The proposed road development discharges to the River Corrib near the bridge crossing a short distance 1.7m upstream of the Terryland Intake from the River Corrib at Jordan’s Island. 2.625km of proposed road development mainline and 0.625km of N59 Link Road North representing 7.1ha of road pavement area contributes to the proposed River Corrib outfalls at (S14A, S14B, S18A, S18B and S15) at the location of the intake. Routine road drainage discharges will have imperceptible impact on water quality of the Terryland Galway City water supply abstraction. A risk assessment of serious spillage for this section of the proposed road development indicated very low risk of spillage (0.042%). The provision of oil petrol interceptor, wetland treatment system and outflow control further reduces the risk of impact to the water supply to imperceptible.

11.7.3 Morphology

No significant local impacts to stream and river morphology are anticipated, as all practicable design measures for bridges, culverts, channel realignments and drainage outfalls are to be implemented which are designed to minimise the potential for local scouring and flow regime changes. The residual impact on river and stream channel morphology is classed as local slight permanent impact at the various culvert crossing and outfalls and classed as an imperceptible impact the

River Corrib crossing as there are no in-stream piers or in-stream works to be carried out.

11.7.4 Key Ecological Receptors

The key ecological receptors sensitive to surface hydrology impacts are Ballindooley Lough, Lough Corrib cSAC including the Coolagh Lakes and River Corrib channel, the various salmonid potential streams (including downstream reaches of the Bearna, Trusky and Knocknacarra Streams) and the coastal/transitional waters of the Galway Bay Complex cSAC. The key water dependent wetland receptors sensitive to surface hydrology include Blanket bogs, Transitional mires, Wet heath, Rich fen and flush, and Molinia Meadows.

The rating of these receptors varies from locally high for the watercourses and Ballindooley Lough and extremely high for the Lough Corrib cSAC including Coolagh Lakes and the River Corrib channel and Galway Bay Complex cSAC. The hydrological residual impact on these receptors is rated as imperceptible for the Coolagh Lakes, Ballindooley Lough and Galway Bay Complex cSAC.

The hydrological residual impact represents a slight local magnitude impact on the River Corrib channel. The impact is associated with the outfall discharges and the construction of two river bank drainage outfalls. There is a slight residual impact for the salmonid potential in local higher value streams associated with flooding, flow regime change, water quality and morphology changes all of which are localised and minor. The overall residual impact from the proposed road development and its drainage system on the Lough Corrib cSAC and Lough Corrib SPA is rated as an imperceptible residual impact. This rating is achieved through design of appropriate pollution control measures at the proposed road drainage outfalls and at appropriate design of the proposed bridge and culvert crossings.

The proposed road development and its drainage system will have an imperceptible residual hydrological impact on Galway Bay Complex cSAC and Inner Galway Bay SPA. This is achieved through design of appropriate pollution control measures at its road drainage outfalls.

Surface drainage impacts to water dependent wetland habitats have been identified where the proposed road development traverses through such a habitat or passes in close proximity upstream of such habitats. Overall the zone of influence (ZoI) on surface drainage by the proposed road development on these habitats does not exceed the hydrogeological ZOI. The exception to this is the potential impact to a downstream Wet Heath (4010) located 50m southeast of the proposed development boundary between Ch. 3+450 to Ch. 3+700 and Molinia Meadows (6410) located 30m east of the proposed development boundary at Ch. 3+800. In both cases, the proposed road development which is in a large cutting will intercept the local surface drainage partially supplying these wetlands and divert into the proposed road drainage to outfall elsewhere resulting in a potential reduction in the surface water supplying these wetlands. The hydrogeological ZOI from the proposed road development does not extend to these wetland features and therefore the groundwater table and flow is unlikely to be altered. The residual hydrological impact on these two wetland habitats represents moderate and slight permanent impact respectively.

11.7.5 Cumulative Impacts

Cumulative impacts are defined as the combination of many minor impacts creating one, larger, more significant impact (NRA, 2009 and EPA 2017). Cumulative impacts consider existing stresses on the natural environment as well as developments that are underway and in planning.

The baseline hydrology has identified that the surface water features in the study area have a number of existing stresses in the form of discharges from surface water drainage systems, road runoff and agricultural activities and loss of natural flood plains. These sources have the potential to impact the existing hydrological environment in the form of reducing water quality by increased contaminants or by increasing flood risk. On the basis that the design and mitigation measures employed for the proposed road development to maintain or improve water quality in existing catchments, there are no significant hydrological residual impacts associated with the proposed road development.

The Galway County Development Plan 2015-2021, Galway City Development Plan 2017-2023, Bearna Local Area Plan 2007-2017, Gaeltacht Local Area Plan 2008–2018 and Ardaun Local Area Plan 2018–2024 set out a series of objectives for appropriate management of surface water and water quality of the existing environment. This will ensure that future planning applications are developed using design criteria to ensure that no there is no hydrological impact on receiving watercourses or surface water sewers associated with planned developments. This will typically be achieved in terms of flood risk and stream morphology by utilising sustainable drainage systems (SUDS) and restricting surface water runoff discharge rates to meet that of greenfield runoff rates and volumes. Therefore, the residual impact associated with future proposed or planned developments on the hydrological environment is imperceptible.

The residual impacts associated with the following major projects and plans that are currently underway or in planning have also been assessed in more detail. These projects include:

- M17 Galway to Tuam Road Project (operational)
- N18 Oranmore to Gort Road Project (operational)
- N17 Tuam Bypass (operational)
- N59 Maam Cross to Oughterard Road Project (consented and pre-construction)
- N59 Maigh Cuilinn (Moycullen) Bypass Road Project (consented and pre-construction)
- Proposed Galway Harbour Port Extension (planning stage)
- Galway Transport Strategy (GTS)

The M17/M18 Tuam to Gort Motorway Project has recently completed construction. The portion of the M17 and Tuam Bypass (circa 26km) that lies north of the existing R339 Galway to Caltra Road, lies within the catchment of the River Corrib. The portion of the M17 M18 to the south of the R339 lies within the catchment of Galway Bay for the Oranmore River, Clarin River, Kilcolgan River, Gort River and Lough Coole turlough system. This M17/M18 scheme has been designed with a modern road drainage system and construction methods that reduce the potential impact on the receiving environment. Where residual local impacts arise at various road outfalls, culvert crossings and displacement of flood storage, the impacts do not translate downstream in the River Corrib or to Galway Bay as perceptible impacts that would combine with residual impacts from the proposed road development, given the very large dilution available and the travel distances involved.

There will be no perceptible hydrological cumulative impact between the M17/M18 Tuam to Gort Motorway Scheme and the proposed road development.

The N59 Oughterard to Maam Cross Road Scheme and N59 Moycullen Road Scheme also lie within the catchment of the River Corrib upstream of the proposed road development. Both N59 road schemes have been designed with modern road drainage systems and construction methods that reduce the potential impact on the receiving environment. Where local impacts arise at various road outfalls and culvert crossings and displacement of flood storage and changes to river and stream morphology, these impacts do not translate downstream in the River Corrib (given the very large dilution available and the travel distances involved) as perceptible impacts that would combine with residual impacts from the proposed road development. There will be no perceptible hydrological cumulative impact between the N59 Oughterard to Maam Cross Road Scheme and the N59 Moycullen Road Scheme with the proposed road development.

The proposed Galway Harbour Expansion Project is located in the Galway City Coastal catchment and at the mouth of the River Corrib Estuary downstream of the proposed road development. The following hydrological residual impacts have been extracted from the summary of residual impacts from the Galway Harbour Company, Galway Harbour Extension Environmental Impact Statement:

- *Alteration of salinity levels in vicinity of the River Corrib outflow during construction as a result of increased current velocities or changes in current direction due to the construction of the proposed development – Permanent Slight Positive Impact*
- *Alteration to current velocities at the proposed development site will impact the sedimentary environment resulting in a shift of existing scouring and deposition sites and subsequent alteration of benthic habitat resulting from construction of the proposed development in the intertidal and subtidal zone in proximity to the River Corrib outflow – Permanent Slight Negative Impact*
- *Alteration to current directions at the proposed development site will impact the sedimentary environment resulting in a shift of existing scouring and deposition sites and a subsequent alteration of benthic habitat types as a result of construction of proposed development in the intertidal and subtidal zone in proximity to the River Corrib outflow – Permanent Imperceptible Impact*
- *Release of grey water from construction site as a result of construction activities – Temporary Slight Negative Impact*
- *Release of sewage from construction site resulting from leakage from construction site and vessels – Temporary Slight Negative*

- *Release of diesel from construction site resulting from leakage from construction site – Temporary Slight Negative*
- *Oil Spills and other accidental release of fluids/solids during loading/off-loading of vessels as a result of accidental spillage – Temporary High Negative Impact*
- *Impacts from maintenance dredging as a result of sedimentation and smothering arising from dredging and disposal – Short Term Serial Localised Negative Impacts*
- *Changes in wave climate as a result of increases and decreases due to new structure – Permanent Low Impact*

The proposed road development will have no noticeable effect on the flow regime, salinity, sedimentation process or water quality downstream in the River Corrib Estuary and Inner Galway Bay, both during construction and operation stages. Therefore, no cumulative hydrological impacts will occur between the Galway Harbour Expansion project and the proposed road development, even if the construction phases for both projects were to coincide.

There are a number of elements of the Galway Transport Strategy (GTS) located within the same hydrological catchments as the proposed road development.

The relevant elements of the Galway Transport Strategy that could have an impact on hydrology include:

- the upgrading of pedestrian network
- the upgrading of cycle network which includes the Bearna Greenway, the Galway to Dublin Cycleway (Galway City to Oranmore)[1], the Galway to Oughterard Greenway[2] and non-greenway elements
- Expansion of Public Bike Hire Scheme (currently under construction)
- The upgrading of public transport network including increased frequency of buses and a new cross city access link (including the N83 Tuam Bus Corridor Scheme)
- the upgrading of road network which includes modifications to the existing road infrastructure and the proposed road development

The GTS is at the plan stage so each individual project element of the design will be subject to further detail design. The detailed design shall be in compliance with the surface water management and water quality objectives set out in the various development plans. Therefore, there should be no cumulative impacts associated with this development.

[1] The GTS includes that portion of the Galway to Dublin Cycleway between Galway City and Oranmore.
[2] The GTS includes that portion of the Galway to Oughterard Greenway between Galway City and Moycullen.

11.8 Summary

The proposed road development, passes through three hydrometric areas 29 - Galway Bay South East, 30 - Corrib and 31 - Galway Bay North along its 17.4km length. Within the study area there are two distinct regions of hydrological response, with the area to the west of the N59 Moycullen Road associated with the granite bedrock having high surface run-off characteristics and the area to the east of the N59 Moycullen Road having low surface run-off associated with karst permeable limestone bedrock. This results in a reasonably dense network of surface drains in the western section and a very sparse non-existent surface drain network in the eastern section. Consequently, the drainage solution for the proposed road development is challenging in the eastern section requiring infiltration to groundwater for safe disposal of road drainage waters.

The proposed road development traverses only one major watercourse, namely the River Corrib which is of international importance being part of the Lough Corrib cSAC and Lough Corrib SPA. The remaining watercourses encountered, principally to the west are minor, the majority of which are intersected close to their upstream watersheds. Therefore, these watercourses have limited contributing catchment areas, and consequently are of low capacity. They are poorly established stream channels and generally not maintained. The attribute rating of these small watercourses, which include the Trusky Stream, Bearna Stream and Knocknacarra Stream is one of local higher and of fishery interest/potential in their downstream reaches closer to the coast. Other watercourses/drains encountered are of limited fisheries importance but are also classified as local higher ecological value which include the Sruthán na Libertí.

The proposed road development will involve 17 culvert crossings and one major bridge crossing. All of the 17 culvert crossings are crossing small watercourses, with the largest catchment being less than 5 km^2, which is the Bearna Stream. A number of local diversion and realignments are associated with the various culvert crossings so as to facilitate channel transition to and from the new culverts. These have a potential for constructional impact and more permanent local morphological changes. A realignment is proposed for the Tonabrocky Stream to facilitate the proposed road development and to avoid a significant length of culvert beneath the proposed road development. Mitigation for this realignment is to incorporate fish friendly design incorporating shoals, pools and meanders.

The drainage system for the proposed road development will include 54 road drainage outfalls, which comprise the following:

- 25 to surface watercourses at new storm outfalls
- 9 to groundwater via new infiltration basins
- 17 to existing public surface water sewers
- 2 (tunnel sections) to be pumped to the public foul sewer
- 1 to an existing N6 road infiltration basin

The proposed surface water outfalls and culvert crossings represent a potential for local flood impact, morphological changes and water quality impacts both during construction and operation phases. This is described further below.

The major bridge crossing of the River Corrib from Dangan to Menlough is designed to clear span the main river channel and provide as a minimum 5m setback from the river edge for its two banksides piers. The clear spanning of River Corrib avoids the need for in-stream works at the construction stage which lessens the potential for constructional and operational (permanent piers) impacts. The River Corrib is the source to a major public drinking water abstraction that supplies Galway City, located downstream at Terryland, off Jordan's Island. The abstraction point is only 1.7km downstream of the proposed road development. There is therefore, a high pollution risk (in the absence of mitigation measures) from the proposed road development to water quality, particularly during the construction phase.

Stringent mitigation and control of potential polluting activities associated with construction activities is proposed which will significantly reduce this pollution risk. Stringent controls are proposed to limit the risk of untreated sediment run-off entering the water body and to minimise the risk of construction spillages of concrete and hydrocarbons into these waters. Refer to the CEMP in **Appendix A.7.5**. Specifically, there will be no in-stream works at the River Corrib channel associated with the construction of the river bridge crossing that fully spans the River Corrib channel, so as to protect both the Lough Corrib cSAC and SPA and the major downstream drinking water abstraction to the Galway City Water Treatment Plant at Terryland.

The operational phase also presents a pollution risk to the Terryland water supply both from accidental spillages and from routine road run-off discharges. However, design pollution control measures have been put in place to significantly reduce the risk.

In conclusion, residual construction and operational pollution impacts on the River Corrib will be slight to imperceptible. Elsewhere, construction impacts on water quality are reduced from having potentially moderate and significant temporary impacts to having slight and imperceptible temporary impacts through mitigation with the implementation of the CEMP in **Appendix A.7.5**.

During the operational phase, water quality in the receiving streams (which have been identified as of generally good quality status) will be protected from proposed road drainage discharges. Oil and petrol interceptors along with wetland treatment systems will be placed upstream of all surface water outfalls and groundwater infiltration basins. These are designed to capture first flush rainfall events and provide protection against both minor or large road spillages. An operational spillage assessment for the proposed road development was carried out for all outfalls, both surface and groundwater, and the results show low risk of impact from serious accidental spillage involving a HGV. In conclusion, residual water quality impacts on these watercourses will be slight during the operational phase.

The proposed road development passes close to the Coolagh Lakes and Ballindooley Lough. There is only a very slight encroachment by the proposed road embankment of the extreme floodplain area of these lakes and there will be no direct surface water discharge to the Coolagh Lakes. There is a single small treated surface discharge from the N84 Headford Road to Ballindooley Lough. The overall hydrological impact on these features is rated as slight to imperceptible with the construction phase representing the greater risk to the lakes. Similar to other sensitive aquatic locations, such as the River Corrib crossing, stringent mitigation and control of potential polluting activities associated with construction activities is proposed which will significantly reduce the risk of impact to a slight temporary impact.

The proposed road development as part of the EIAR has undergone a detailed Flood Risk Assessment in accordance with the DoEHLG Planning System and Flood Risk Management Guidelines for Planning Authorities. The assessment identified the sources of flood risk to the proposed road development from fluvial, pluvial and groundwater sources, but not from a coastal source as the proposed road development is sufficiently set back and elevated above the coastal zone. Overall the assessment has concluded that the proposed road development design minimises flood risk to the development itself and is rated as having a low probability of flooding.

A potential significant flood risk impact has been identified in the vicinity of the N83 Tuam Road Junction resulting in the permanent encroachment and loss of flood storage from this flood risk area. Flood relief mitigation measures involving improved land and road drainage, provision of compensation storage and storm water pumping to the Terryland Basin have been designed which when implemented will result in providing a residual moderate to significant positive benefit by reducing the risk of serious flooding in this area.

At all other locations along the proposed road development, there will only be slight to imperceptible impacts on flood risk as very minimal encroachment of floodplains occur and design measures in the form of large culverts and stormwater attenuation ponds are proposed. Residual flood risks exist at the drainage outfalls and their associated attenuation ponds and at the various culverts from potential blockages. This impact through the design of the proposed road development has been assessed as a slight residual flood risk achieved by the proposed program of regular inspections and maintenance of these assets and for the ponds the inclusion of controlled overflow systems in the event of a blockage. The culverts are all generously sized and blockage potential is minimised.

The proposed road development satisfies the requirements of the Water Framework Directive in terms of maintain, protecting and enhancing the water quality status of the receiving watercourses and groundwater. Protection is achieved through the provision of storm water treatment and controlled discharge at the proposed road drainage outfalls and enhancement is achieved by taking road traffic from unprotected roads where uncontrolled road runoff enters adjacent watercourses and the groundwater aquifers.

Potential hydrological impacts from the proposed road development have been identified and assessed. Appropriate design and mitigation measures have been incorporated to remove any risk of significant hydrological impact on the receiving environment. There are no significant negative residual hydrological effects due to the proposed road development.

The overall residual hydrological impact from the proposed road development on the Lough Corrib cSAC and SPA and the Galway Bay Complex cSAC and Inner Galway Bay SPA is rated as imperceptible. This is achieved through design of appropriate pollution control measures at the proposed road drainage outfalls, the proposed full spanning bridge structure of the River Corrib channel and effective floodplain area and the proposed implementation of the CEMP during construction. Refer to **Appendix A.7.5**.

There are no significant cumulative hydrological impacts associated with this proposed road development in combination with other projects either granted or in planning.

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