12 Hydrology

12.1 Introduction

This chapter describes and assesses the potential impacts of the proposed Douglas Flood Relief Scheme (including Togher culvert), on hydrology. The receiving environment and the characteristics of the proposed scheme for construction and operation are described. The potential impacts of the scheme during the construction and operation phases are evaluated, and the mitigation measures for these potential impacts are presented. The chapter concludes with the predicted residual impacts of the proposed scheme.

12.2 Methodology

12.2.1 Guidance

This section of the EIS was prepared in accordance with the following guidance documents:

- Guidelines on the information to be contained in EIS (EPA, 2002);
- Advice Notes on Current Practice in the Preparation of EIS (EPA, 2003);
- Revised Guidelines on the Information to be contained in Environmental Impact Statements Draft September 2015 (EPA, 2015); and
- Advice Notes for Preparing Environmental Impact Statements Draft September 2015 (EPA, 2015).

Other reference documents used in the preparation of this section include the following:

- National Roads Authority (NRA) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Good practice guidelines on the control of water pollution from construction sites developed by the Construction Industry Research and Information Association (CIRIA);
- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters (Inland Fisheries Ireland, 2016); and
- Department of Environment, Heritage and Local Government, The Planning System and Flood Risk Management Guidelines for Planning Authorities (Department of Environment, Heritage and Local Government, 2009).

Background information on the local and regional surface water network was obtained from an array of documents and online resources including the following:

- South Western River Basin District (SWRBD) Catchment Characterisation Report (SWRBD, 2010);

- SWRBD River Basin Management Plan 2009 – 2015 (SWRBD, 2010);
- SWRBD Programmes of Measures 2009 – 2015 (SWRBD, 2008);
- SWRBD River Basin Management Plan and Programmes of Measures – Strategic Environmental Assessment (SWRBD, 2011);
- EPA online Water Quality Database and Envision Map Viewer (www.epa.ie);
- Maltby Land Services Ltd. Topographical Survey of the Tramore River, Ballybrack Stream and Moneygurney Stream (2007);
- Murphy Surveys Ltd. Topographical Survey of the Tramore River, Ballybrack Stream and Moneygurney Stream (2014);
- Cork County Council Topographical Survey of the Study Area (2015);
- Amelio Utilities Topographical Survey of the Study Area (2016);
- Douglas Flood Relief Scheme (Including Togher Culvert) Hydrology Report (Arup, 2016);
- Douglas Flood Relief Scheme (Including Togher Culvert) Hydraulics Report (Arup, 2016);
- Douglas Flood Relief Scheme (Including Togher Culvert) Togher Hydraulics Report (Arup, 2016);
- Douglas Flood Relief Scheme (Including Togher Culvert) Douglas Options Report (Arup, 2016);
- Douglas Flood Relief Scheme (Including Togher Culvert) Togher Options Report (Arup, 2016);
- OPW Preliminary Flood Risk Assessment mapping, www.cfram.ie/pfra;
- OPW Lee Catchment Flood Risk Assessment and Management (CFRAM) Study Reports and Maps, www.cfram.ie; and
- Geological Survey of Ireland (GSI) Online Mapping;

12.2.2 Site Visits

Site visits were conducted as part of the impact assessment process to ascertain specific areas which may be at risk of being impacted by the proposed works.

12.2.3 Water Quality Assessment

An assessment of the water quality in the study area was carried out which comprised a desk-top study examining water quality data gathered by the EPA.

Under current regulation the water quality of River Basin Districts is assessed biologically, physically and chemically. Assessment using surveys is predominately conducted by the EPA and local authorities, and complemented by other government bodies including the Inland Fisheries Ireland (IFI) and the Marine Institute. **Table 12.1** summarises the quality classes used to establish and monitor the condition of rivers and streams in Ireland.

Table 12.1: River and Stream Water Quality Classes (EPA, 2013)

Q Value[Note1]	WFD Status	Pollution Status	Condition[Note 2]
Q5, Q4-5	High	Unpolluted	Satisfactory
Q4	Good	Unpolluted	Satisfactory
Q3-4	Moderate	Slightly polluted	Unsatisfactory
Q3, Q2-3	Poor	Moderately polluted	Unsatisfactory
Q2, Q1-2, Q1	Bad	Seriously polluted	Unsatisfactory
where:	Biotic indices or Quality (Q) value indicates specified groups of macro-invertebrates sensitivity to pollution, with:		
	Q5 =	Mostly pollution sensitive, a few to numerous less pollution sensitive, a few pollution tolerant, and no very pollution tolerant or most pollution tolerant macro-invertebrate species.	
	Q4 =	At least one pollution sensitive, few to numerous less pollution sensitive, numerous pollution tolerant, and a few or no very pollution tolerant or mostly tolerant macro-invertebrate species.	
	Q3 =	No pollution sensitive, few or no less pollution sensitive, dominant in pollution tolerant, a few to common in very pollution tolerant, and few or no most pollution tolerant macro-invertebrate species.	
	Q2 =	No pollution sensitive or less sensitive, few or no pollution tolerant, dominant in very pollution tolerant, and few to common in most pollution tolerant macro-invertebrate species.	
	Q1 =	No pollution sensitive, less sensitive, and pollution tolerant, a few to no very pollution tolerant, and dominant in most pollution tolerant macro-invertebrate species.	

Note 1: These values are based primarily on the relative proportions of pollution sensitive to tolerant macroinvertebrates resident at a river site.

Note 2: "Condition" refers to the likelihood of interference with beneficial or potential beneficial uses.

Table 12.2 describes in detail the classification system combined with the Biological Quality Q-Ratings, basic physico-chemical water quality, the status of the ecosystem and the human value associated with surface water systems.

In summary, quality classes relate to the potential beneficial use of a water body, with:

- Class A = Highest water quality, suitable for abstraction, game fisheries, very high amenity value, orthophosphate ~ 0.015 mg P/L, dissolved oxygen close to 100%, maximum BOD is < 3mg/L.
- Class B = Variable water quality, potential problems for abstraction, game fish at risk, considerable amenity value, orthophosphate ~ 0.045 mg P/L, dissolved oxygen <80% to >120%, maximum BOD is occasionally elevated.
- Class C = Doubtful water quality, advanced treatment of abstracted water, coarse fisheries, reduced amenity value, orthophosphate ~ 0.070 mg P/L, dissolved oxygen is very unstable with potential fish kills, maximum BOD is high at times.
- Class D = Poor to bad water quality, low grade to limited abstraction, fish usually absent, low or no amenity, orthophosphate >0.1 mg P/L, dissolved oxygen is low to zero, maximum BOD is usually high to very high.

Existing pollution has an impact on the value of surface waters and this has been taken into account when characterising individual surface water systems in the following section. The existing adverse effects are reflected in the EPA Q-Value, which describes the biological status of the watercourse.

In general, the higher the level of pollution in a watercourse, the lower the Q-value. The Q-value reflects impacts from surface water run-off (including run-off from agricultural land which may contain nutrients and urban run-off from roads and buildings which may contain solids, hydrocarbons and heavy metals).

Table 12.2: General Characteristics of the various Biological Quality Classes (DRA, 2006)

Quality Classes	Class A		Class B	Class C	Class D	
Quality Ratings (Q)	Q5	Q4	Q3-4	Q3	Q2	Q1
Pollution Status	Pristine, unpolluted	Unpolluted	Slight Pollution	Moderate Pollution	Heavy Pollution	Gross Pollution
Organic Waste Load	None	None	Light	Considerable	Heavy	Excessive
Maximum B.O.D.	Low (< 3 mg/l)	Low (< 3 mg/l)	Often elevated	High at times	Usually high	Usually very high
Dissolved Oxygen	Close to 100%	80%-120%	<80% to >120%	Very unstable.	Low to zero	Very low or zero
Annual Median ortho-Phosphate	~0.015 mg P/l	~0.030 mg P/l	~0.045 mg P/l	~0.070 mg P/l	usually > 0.1 mg P/l	usually > 0.1 mg P/l
Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually v. heavy and anaerobic
'Sewage Fungus'	Never	Never	Never	May be some	Usually abundant	May be abundant
Filamentous Algae	Limited development	Diverse communities	Cladophora may be abundant	Cladophora may be excessive	May be abundant	Usually none
Macrophytes	Good diversity Limited growths	Considerable growths	Reduced diversity Luxuriant growths	Limited diversity Excessive growths	Tolerant species only. May be abundant.	Usually none or tolerant species only.
Macroinvertebrates (from shallow riffles)	Diverse communities. Normal density. Sensitive forms usually numerous.	High diversity. Increased density. Sensitive forms scarce or common.	Very high diversity. Very high density. Sensitive forms scarce.	Sensitive forms absent. Tolerant forms common. Low diversity.	Tolerant forms only. Very low diversity.	Most tolerant forms. Minimal diversity.
Water Quality	Highest quality	Fair quality	Variable quality	Doubtful quality	Poor quality	Bad quality
Abstraction Potential	Suitable for all	Suitable for all	Potential problems	Advanced treatment	Low grade abstractions	Extremely limited
Fishery Potential	Game fisheries	Good game fisheries	Game fish at risk	Coarse fisheries	Fish usually absent	Fish absent
Amenity value	Very high	High	Considerable	Reduced	Low	Zero
Condition	Satisfactory	Satisfactory	Transitional	Unsatisfactory	Unsatisfactory	Unsatisfactory

12.2.4 Existing Hydrological Environment Categorisation

Characterisation of surface water systems is based on the identification of features of the baseline hydrological environment that are relevant and can be assigned a functional value. The functional value of each of these features is compiled through the relevance of three factors: the importance of the feature, the sensitivity of the feature and the existing adverse pressures affecting the feature. The assignment of functional values is also cognisant of technical standards, regulations and relevant legislation.

Surface water systems act as resources for both aquatic and terrestrial ecosystems and are an essential factor to sustain human life. Surface water floodplains can also act as a reserve or store for floodwaters during times of significant flooding and this can prevent floodwaters from impacting farther downstream. Table 12.3 indicates how the importance of surface water resources is evaluated using specific criteria that have been defined for the purpose of this hydrological baseline assessment. Refer to Section 12.3.1 for the hydrology of the existing environment.

Table 12.3: Hydrological Baseline Categorisation

	Functional Value
• Surface Watercourses with Q-values of Q5 and/or Q4-5 or Q4, which are classified by the EPA as 'Class A - Unpolluted'. • Surface Watercourses with flood plains that have significant storage capacity for potential floodwaters.	Very High
• Surface Watercourses with Q-values of Q3-4, which are classified by the EPA as 'Class B -Slightly Polluted'. • Surface Watercourses with flood plains that have significant storage capacity for potential floodwaters.	High
• Surface Watercourses with Q-values of Q3 or Q2-3, which are classified by the EPA as 'Class C - Moderately Polluted'. • Surface Watercourses with flood plains that have significant storage capacity for potential floodwaters.	Medium
• Surface Watercourses with Q-values of Q2 or Q1-2 or Q1, which are classified by the EPA as 'Class D - Seriously Polluted'. • Surface Watercourses with flood plains that have no storage capacity for potential floodwaters.	Low
• Surface Watercourses that have been culverted. • Surface Water Features solely used for visual amenity.	Very Low

The functional value of the existing hydrological environment is evaluated through the assessment of surface water criteria and the importance and sensitivity of the surface water features. The surface water criteria are described below.

12.2.4.1 Sensitivity

Surface water features are highly sensitive to culverting, which can alter flow conditions and affect light penetration to the watercourse. Surface water features are also at risk from discharges of surface water run-off which may contain polluting substances that can have a significant adverse impact on the biological and physico-chemical status of a watercourse such as a salmonid river or stream.

Surface water features are also highly sensitive to morphological change through deepening, realignment or diversion of their natural channel which can also alter the hydrodynamic regime of the surface water feature. These factors were taken into account when defining the criteria to be used to assign a functional value to the baseline hydrological environment.

12.2.4.2 Existing Adverse Hydrological Pressures

Existing pollution has an adverse impact on the functional value of surface water features. Consequently the definition of the functional value for each individual watercourse has been cognisant of the pressures from pollution both upstream of the study area and within the study area. The existing hydrological pressures are reflected in the EPA Q-Value, which describes the biological status of the watercourse. The higher the pollution level in a watercourse, the lower the Q-value. The Q-value reflects impacts from surface water run-off (including run-off from agricultural land which may contain nutrients and run-off from roads and buildings which may contain solids, hydrocarbons and heavy metals). The existing pressures are also apparent in the physico-chemical status of the surface water feature with both organic and inorganic pollutants altering the physico-chemical status.

12.2.4.3 Significance Criteria / Impact Assessment

The source and type of all potential impacts is described in Section 12.4 and Section 12.5. The criteria and durations used to assess the different impacts associated with the project are shown in Table 12.4 and Table 12.5. The criteria have been defined in accordance with the aforementioned EPA and NRA Guidelines.

Table 12.4: Criteria for Assessment of Hydrological Impact Magnitude

Criteria	Impact Magnitude
• Long-term to permanent change to a designated conservation site or designated salmonid river. • Medium-term to permanent contamination of surface water over entire surface water catchment. • Medium-term to permanent potential changes in drainage patterns over entire catchment.	Profound
• Medium term change to a designated conservation site or a designated salmonid river. • Temporary to short-term contamination of surface water over entire surface water catchment. • Temporary to short-term potential changes in drainage patterns over entire catchment.	Significant
• Temporary to short-term change to a designated conservation site or a designated salmonid river. • Medium to long-term contamination of local surface water. • Medium to long-term potential changes in local drainage patterns.	Noticeable
• Short-term contamination of local surface water. • Short term potential changes in local drainage patterns.	Slight
• Temporary contamination of local surface water. • Temporary potential changes in local drainage patterns.	Imperceptible

Table 12.5: Definition of Duration Criteria

Impact Description	Definition
Permanent Impact	Impact lasting over sixty years
Long-Term Impact	Impact lasting fifteen to sixty years
Medium-Term Impact	Impact lasting seven to fifteen years
Short-Term Impact	Impact lasting one to seven years
Temporary	Impact lasting for one year or less

12.2.5 Flood Risk Information Collation

A detailed assessment of the fluvial and tidal flood risk, from the Tramore River and Ballybrack Stream and its tributaries, was undertaken to ascertain the extent of flood defence measures required as part of the scheme.

The risk of flooding from other sources, including pluvial flooding, flooding from groundwater and flooding from artificial sources such as surface water drainage systems, was not assessed in the Hydrology and Hydraulic assessment of the scheme. To determine the flood risk from these sources, a comprehensive desk-top study examining the available sources of information was undertaken.

12.3 Receiving Environment

12.3.1 Hydrology and Water Quality

The study area is located with Hydrometric Area 19 which is the EPA classification for the catchments flowing into the River Lee, Cork Harbour and Youghal Bay. Togher and Douglas are included in this hydrometric area. This Hydrometric Area falls within the South Western River Basin District which also included Togher and Douglas. Refer to **Figure 12.1**. Hydrometric Area 19 is 1,732km^2 in area with ground elevations ranging from sea level to over 500mOD. Agricultural land comprises the majority of the hydrometric area land use with the main centres of population being Cork City and its suburbs, Blarney, Midleton and Macroom.

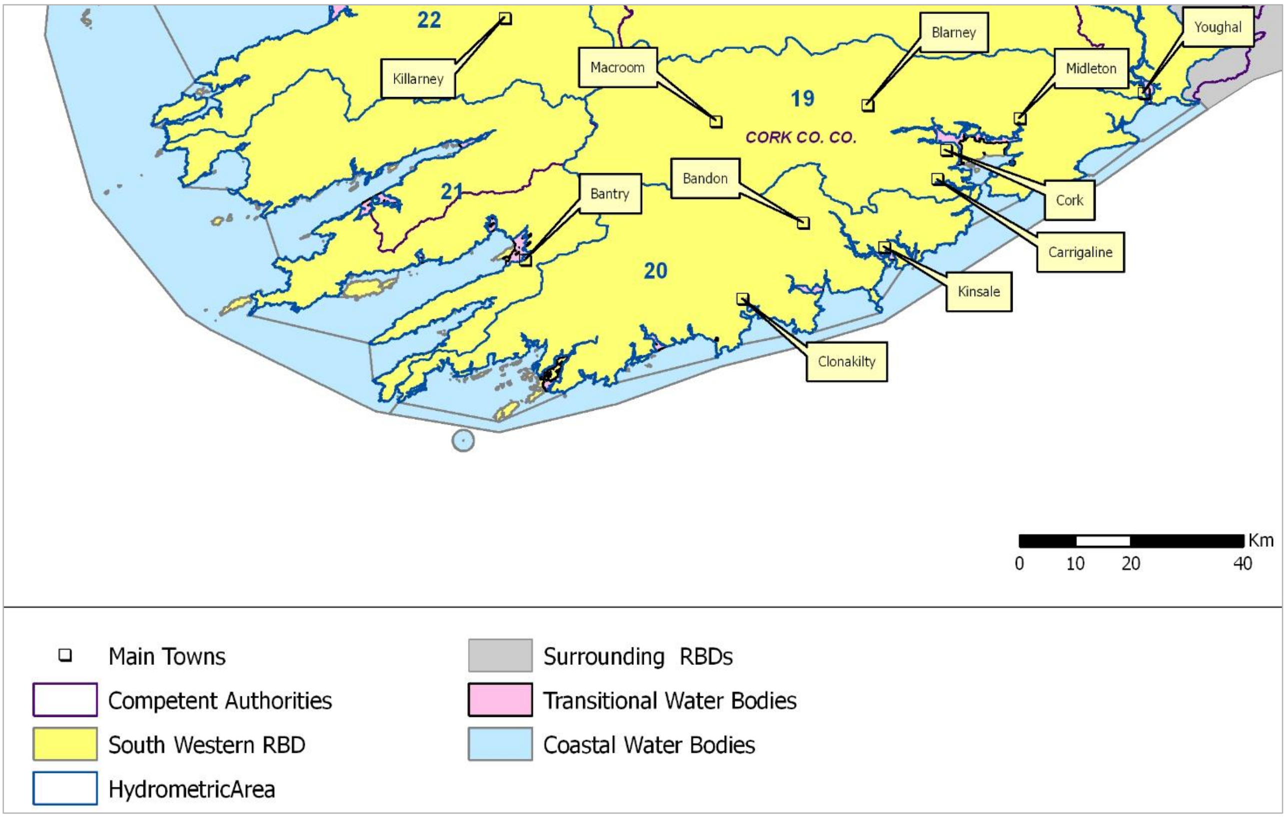

Figure 12.1 Hydrometric Area 19 as part of the South Western River Basin including Togher and Douglas (Water Framework Directive Ireland, 2005).

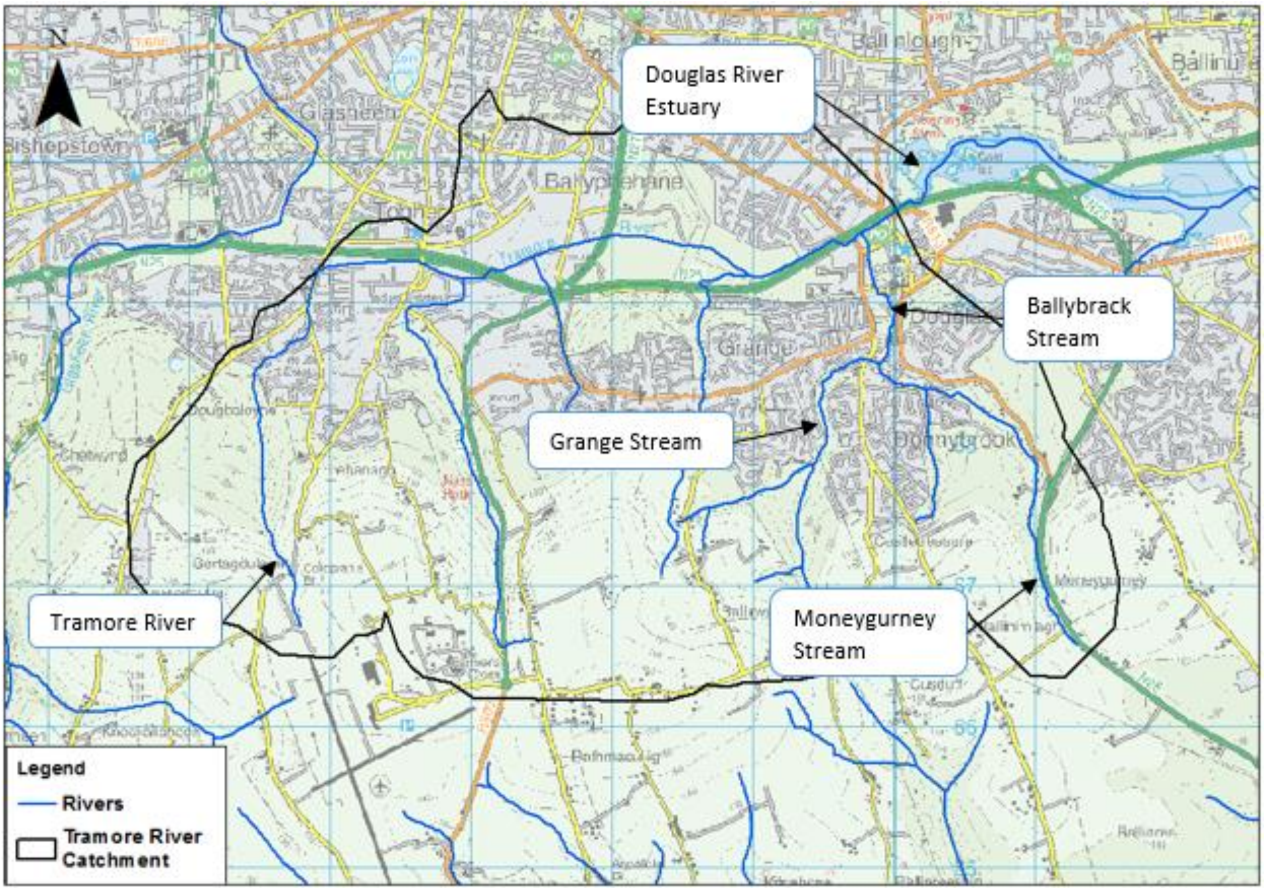

Figure 12.2: Hydrological Features

The following sub-sections outline the existing hydrological environment in the vicinity of the proposed scheme which includes the catchments of the Tramore River, Ballybrack Stream and their tributaries. Both of these river systems are discussed in the following sections and all hydrological features relevant to the project are indicated in **Figure 12.2**.

The South Western River Basin District (SWRBD) management plan was consulted during the preparation of this chapter. The main objectives of the management plan are to:

- Prevent deterioration;
- Restore good status, reduce chemical pollution in surface waters; and
- Achieve protected areas objective.

The programme of measures designed to achieve these objectives outlined in the management plan, include the following:

- "*control of urban waste water discharges,*
- *control of un-sewered wasted water discharges,*
- *control of agricultural sources of pollution,*
- *water pricing policy,*
- *sub-basin management plans and programmes of measures for the purpose of achieving environmental water quality objectives for Natura 2000 sites, designated for the protection of Freshwater Pearl Mussel populations,*
- *pollution reduction programmes for the purpose of achieving water quality standards for designated shellfish waters, and*
- *control of environmental impacts from forestry*."

Information on status, objectives and measures in the SWRBD has been compiled for smaller, more manageable geographical areas than river basin districts, termed water management unit action plans. There are twenty-eight water management units (WMUs) in the South Western RBD. The scheme is located within the Lower Lee/Owenboy WMU. The key measures to be implemented in the Lower Lee/Owenboy WMU are summarised in Table 5.1 of the River Basin Management Plan, and include measures for:

- *"Control of urban waste water discharges,*
- *treatment plants requiring capital works,*
- *Treatment plants requiring further investigation,*
- *Treatment plants requiring attention to meet Shellfish waters PRPs [Pollution Reduction Programmes],*
- *Treatment plants requiring improvements in operational performance,*
- *Urban agglomerations requiring investigation of CSOs [Combined Sewer Overflows],*
- *Agglomerations that require management of development,*
- *Properties that will be subject to performance, operational and maintenance standards for onsite waste water treatment systems,*

- *IPPC licences with discharges to waters that require review,*
- *Licences for discharges to waters under the Water Pollution Acts that require review,*
- *and River waterbodies assessed to be at risk from diffuse sources, including agriculture."*

In relation to Future Pressures and Developments, the WMU Action Plan states:

"*Throughout the river basin management cycle, future pressures and developments will need to be managed to ensure compliance with the objectives of the Water Framework Directive and the Programme of Measures will need to be developed to ensure issues associated with these new pressures are addressed."*

12.3.1.1 Tramore River

The Tramore River rises in the southwest of the study area and flows eastwards for approximately 7.5km before entering the Douglas River Estuary and subsequently Lough Mahon, approximately 200m east of Douglas. The catchment area of the Tramore River covers an area of 21km^2 with 41% of the catchment consisting of discontinuous urban fabric. The urban areas are concentrated in the north of the catchment with agricultural land making up the remainder of the land use.

The Tramore River (Coastal) (IE_SW_19_1717*) Water Matters Report*, available at www.wfdireland.ie, covers the catchment of the Tramore River upstream of its confluence with the Ballybrack Stream at Douglas Village. The report states that the watercourse is not heavily modified, however, the Tramore River is culverted over the majority of its length through Togher. The overall ecological status of the watercourse is classified as '*moderate*' with the watercourse classified as "*at risk of not achieving good status*" in accordance with the WFD. Refer to **Figure 12.3**. The watercourse is identified as being at risk from diffuse sources in the EPA diffuse model and point sources in the form of combined sewer overflows (CSOs).

The functional value of the Tramore River in Togher is considered '*very low*' as the watercourse is culverted for the majority of its length in this area. Refer to **Table 12.3**.

The WFD ecological status of Lough Mahon, the water body to which the Tramore River discharges, was classified as '*moderate*' in the Water Quality in Ireland 2010 – 2012 report. This status was a reduction from the 'Good' status achieved in the 2007 – 2009 report. The WFD Risk Score assigned to Lough Mahon is '*at risk of not achieving good status'.*

Lough Mahon is a transitional water body and the Water Quality in Ireland 2010 – 2012 report classifies the eutrophication of the water body as intermediate. Intermediate status is given to water bodies that breach one or two of the three assessment criteria, namely nutrient concentrations, accelerated growth of plants and undesirable water quality disturbance. Lough Mahon is also classified as a nutrient sensitive water body.

Tramore River Surface Water Quality

There are no EPA water quality monitoring stations located on the Tramore River, therefore, biological quality ratings (Q-values) are not available for the watercourse.

There is surface water quality information available for the Tramore River as reported in the Annual Environmental Report (AER) (2015) for the Kinsale Road Landfill which operates under an EPA waste licence (licence registration No. W0012-03). The site is a former landfill site operated by Cork City Council and no longer accepts waste. The Kinsale Road Landfill is located at the Tramore Valley Park, off the Kinsale Road and the Tramore River flows around the southern section of the site before flowing through Douglas. Refer to **Figure 12.4**. The site monitors the water quality of the Tramore River as part of the EPA licence conditions. This report is available online on the EPA website.

Biological oxygen demand (BOD) is one of the physico-chemical parameters used to assess water quality of rivers, refer to **Table 12.5**. **Table 12.2** summarises surface water quality results for three locations (labelled EM2, EM10 and EM11 in **Figure 12.2**) on the Tramore River as reported in the Kinsale Road Landfill AER (2015). All the reported BOD measurements are less than 3mg/l for all but one (EM11, **Table 12.4**). A BOD measurement less than 3mg/l would suggest a Q4/Q5 water quality rating according to the quality classes listed in **Table 12.5**.

Table 12.6: Surface water quality results (summarised) for sampling location EM 2, EM10 and EM11 as reported in the Kinsale Road Landfill AER (2015) under the EPA waste licence No. W0012-03.

Sampling Point	Sampling Date	pH	BOD (mg/l)
EM2	11/03/2015	7.67	1
	08/09/2015	8.06	1.7
	01/12/2015	7.71	1.2
EM10	11/03/2015	7.71	2.5
	08/09/2015	8.33	2.9
	01/12/2015	7.53	1.6
EM11	11/03/2015	7.22	4.3
	08/09/2015	8.41	1.1
	01/12/2015	8.11	1.2

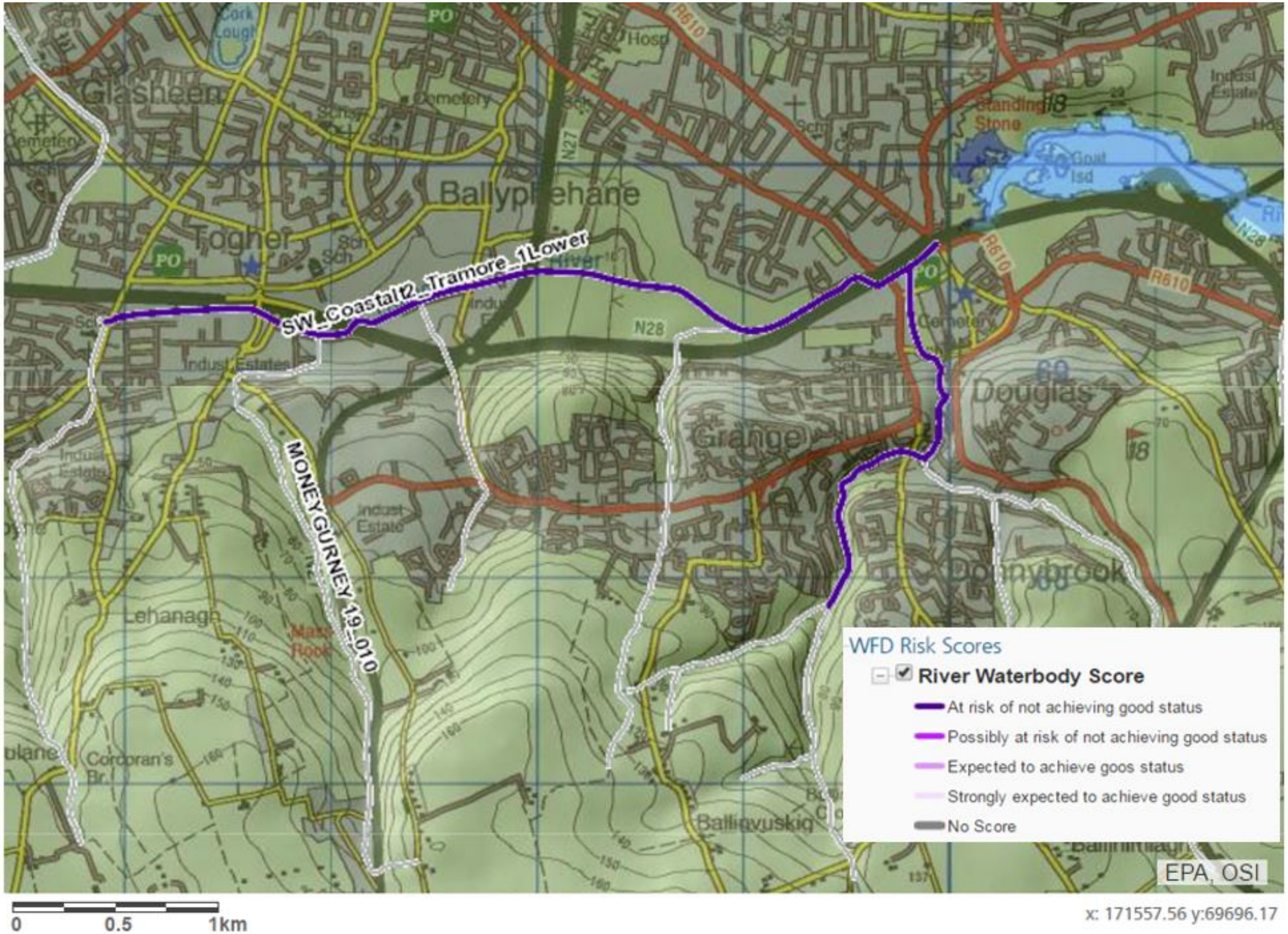

Figure 12.3: Water Framework Directive Risk Scores for the Tramore River Source: EPA Envision Mapping, 2016)

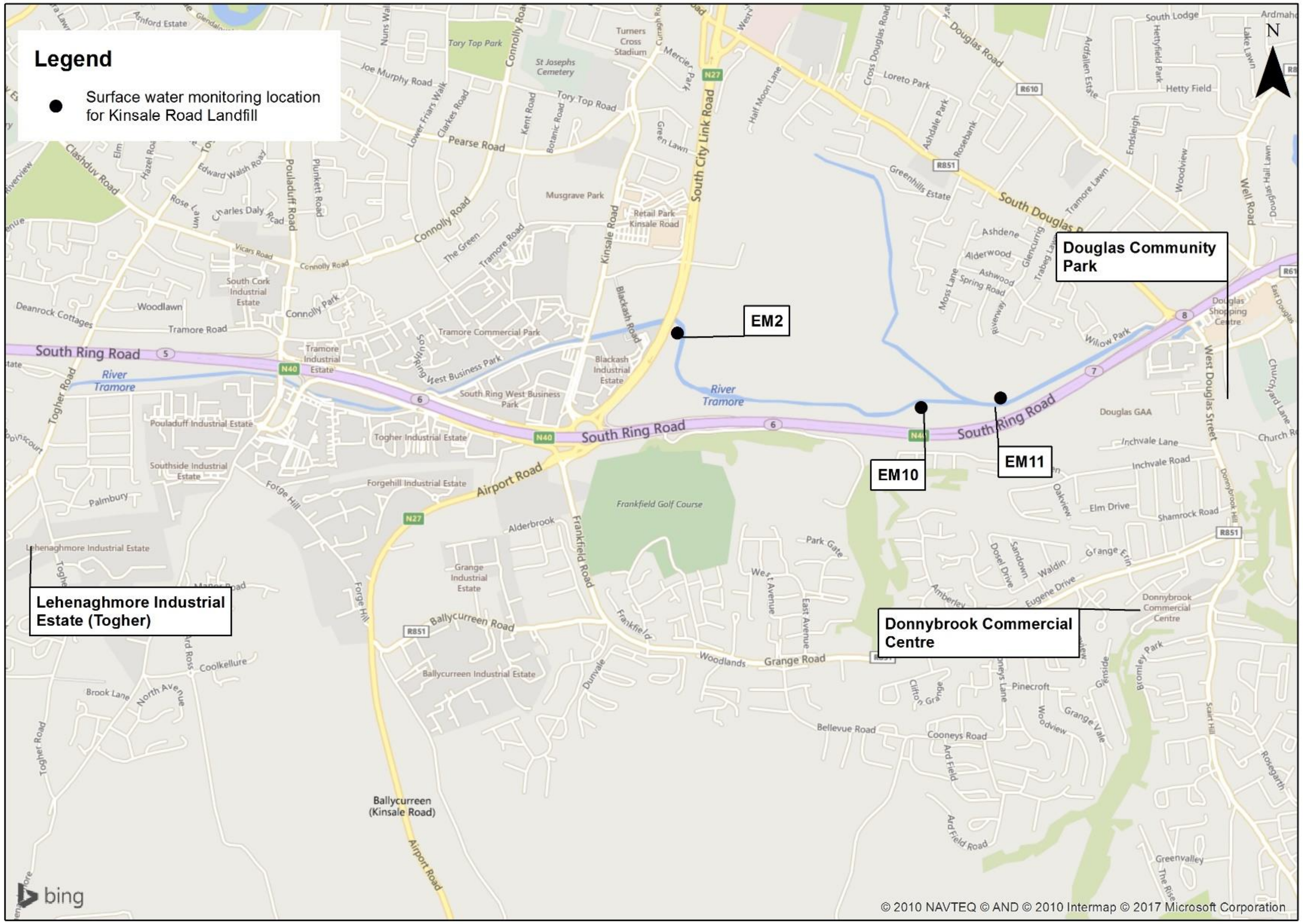

Figure 12.4: Surface water monitoring locations for Kinsale Road Landfill (EPA Licence Reg. No. W0012-03) Source: Kinsale Road Landfill Annual Environmental Report 2015, accessed from www.epa.ie.

12.3.1.2 Ballybrack Stream

The Ballybrack Stream is formed by the confluence of the Grange and Moneygurney Streams. The Grange Stream rises in Ballinvuskig approximately 2.5km south of the confluence with the Moneygurney Stream. The catchment area of the Grange Stream primarily consists of arable land in the south while the north of the catchment is urbanised.

The Moneygurney Stream rises in Moneygurney approximately 2km south of its confluence with the Grange Stream. Similar to the Grange Stream, the catchment of the Moneygurney Stream watercourse is primarily arable land in the south and urbanisation in the north. An unnamed watercourse joins the Moneygurney Stream approximately 420m upstream of its confluence with the Grange Stream.

The Ballybrack Stream catchment is primarily arable land in the south and is urbanised in the north. The Ballybrack Stream generally flows in a northerly direction through Ballybrack Woods, Ravensdale and Douglas Community Park. The stream is culverted under Douglas Village Shopping Centre before joining the Tramore River adjacent to the South Ring Road.

The Tramore River (Coastal) (IE_SW_19_1964) *Water Matters Report*, available at www.wfdireland.ie, covers the catchment of the Ballybrack Stream. Similar to the Tramore River upstream of Douglas Village, the overall ecological status of the Ballybrack Stream is classified as '*moderate*' with the watercourse classified as "*at risk of not achieving good status*". The watercourse is identified as being at risk of diffuse (EPA diffuse model, 2008) and point (CSOs) sources of pollution.

There are no EPA water quality monitoring stations located on the Ballybrack Stream, therefore, no biological quality ratings (Q-values) are available for the watercourse.

The functional value of the Ballybrack Stream and Grange Stream has been determined based on the available flood plain storage in accordance with **Table 12.3** as no Q values for the streams are available. Therefore, both watercourses in the area of the proposed works are considered to have low functional values as the floodplains have no storage capacity for potential floodwaters due to the urbanisation of the area.

12.3.2 Flood Risk

12.3.2.1 Fluvial Flood Risk

Togher

A detailed assessment of the fluvial flood risk in Togher was undertaken as part of the Lee CFRAM Study. The Tramore River is not tidally influenced in Togher. An extract from the flood mapping produced as part of this study is included in **Figure 12.5**.

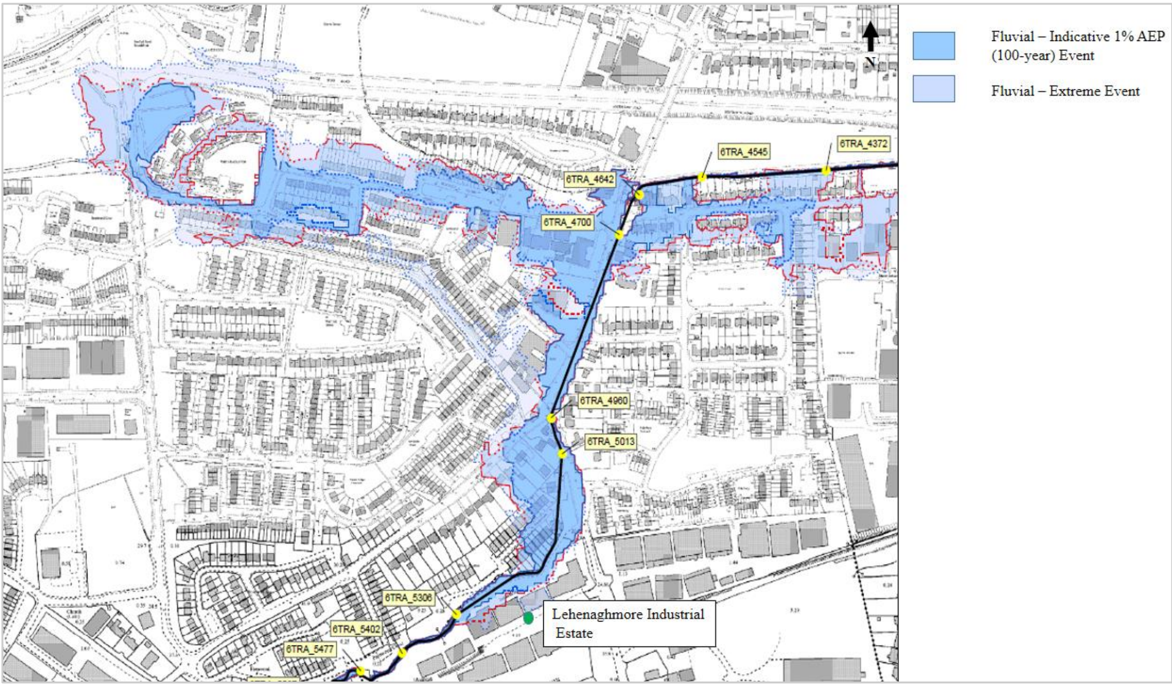

Figure 12.5: Extract from the Lee CFRAM Study Fluvial Flood Map for Togher

Figure 12.5 indicates that a number of residential and commercial properties in Togher are located within Flood Zone A, where the probability of flooding from rivers is highest (greater than 1% AEP or 1 in 100 for river flooding). Lehenaghmore Road and Togher Road also lie within Flood Zone A.

Douglas

To determine the extent of flood defences required in Douglas, detailed modelling the Ballybrack Stream and Tramore River in Douglas was undertaken as part of the Douglas Flood Relief Scheme (including Togher Culvert). The fluvial flood map for Douglas produced from the modelling is included in **Figure 12.6**. The flood extents shown on the map correspond to Flood Zone A (the 1 in 100 year fluvial flood extent). The fluvial flood map for Donnybrook Commercial Centre is included in **Figure 12.7**

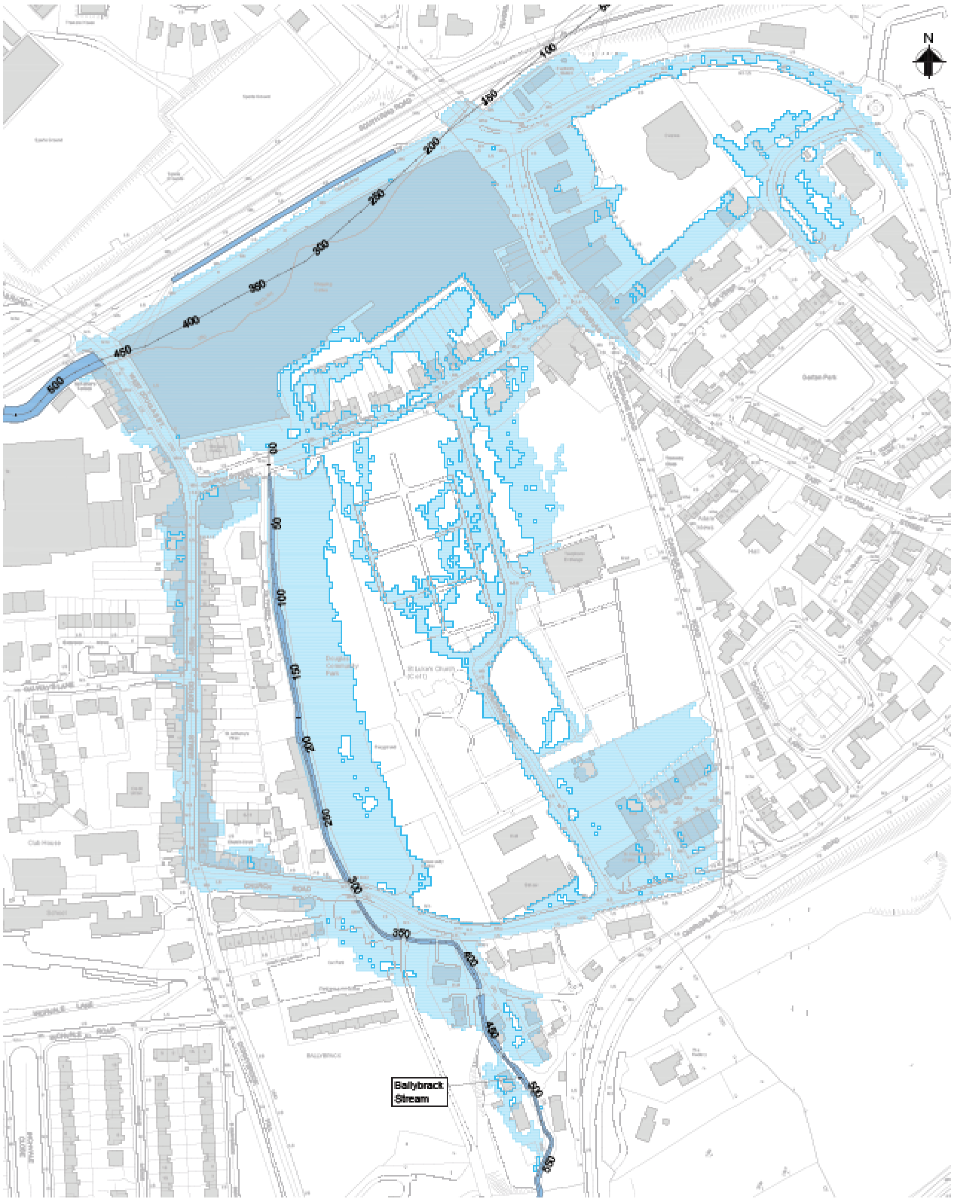

Figure 12.6: Extract from the Douglas FRS Flood Map showing the 1 in 100 year fluvial flood extent.

Figure 12.7: Extract from the Douglas FRS Flood Map showing the 1 in 100 year fluvial flood extent in Donnybrook Commercial Centre.

Figure 12.6 indicates that a number of residential and commercial properties are located within Flood Zone A. Douglas Community Park, Church Road and Church Street are also located within Flood Zone A as a result of fluvial flooding.

Figure 12.7 indicates that a number of commercial properties within Donnybrook Commercial centre are also located within Flood Zone A.

12.3.2.2 Tidal Flood Risk

Togher

There is no tidal flood risk in Togher.

Douglas

The risk of tidal flooding was considered as part of the Douglas Flood Relief Scheme (including Togher Culvert). The results of the hydraulic modelling indicated that the 0.5% AEP tidal flood event does not get out of bank in Douglas. Although the 0.5% AEP tidal flood event does not overtop the river bank in St Patrick’s Mills, a flood defence wall is proposed in this area to provide freeboard.

12.3.2.3 Pluvial Flood Risk

Pluvial flooding occurs when extreme rainfall overwhelms drainage systems or soil infiltration capacity, causing excess rainwater to pond above ground at low points in topography. In order to assess the risk of pluvial flooding in Togher and Douglas, the OPW Preliminary Flood Risk Assessment (PFRA) mapping has been reviewed. An extract from the PFRA pluvial flood map for Togher is included in **Figure 12.8**.

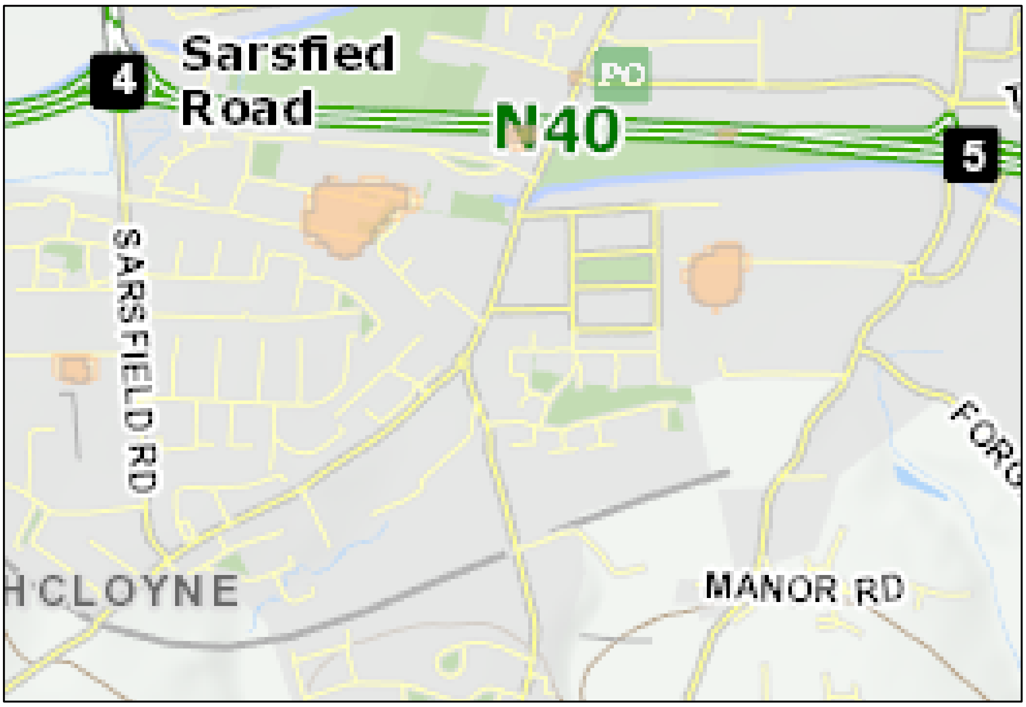

Figure 12.8: Extract from the OPW PFRA pluvial flood Map at Togher (highlighted in orange) | Source: www.myplan.ie

The pluvial flood map for Togher indicates that the two areas of Togher are at risk of pluvial flooding – within Elmvale Avenue and on Pouladuff Road. Anecdotal evidence from Cork County Council and residents in the area however suggests that significant overland flow occurs along Lehenaghmore Road and subsequently Togher Road during extreme rainfall events.

A 2D "direct rainfall" hydraulic model of the catchment was developed to identify the potential issues which lead to the observed flow on Lehenaghmore Road and estimate the peak flow and volume that might be expected to flow down the road during the 1 in 100 year rainfall event.

The pluvial flood map for Douglas indicates that the area is generally at low risk of pluvial flooding with the exception of Donnybrook Commercial Centre which is shown to lie within the indicative 1% AEP (100 year event) pluvial flood extent. An extract from the PFRA pluvial flood map for Douglas is included in **Figure 12.9** below.

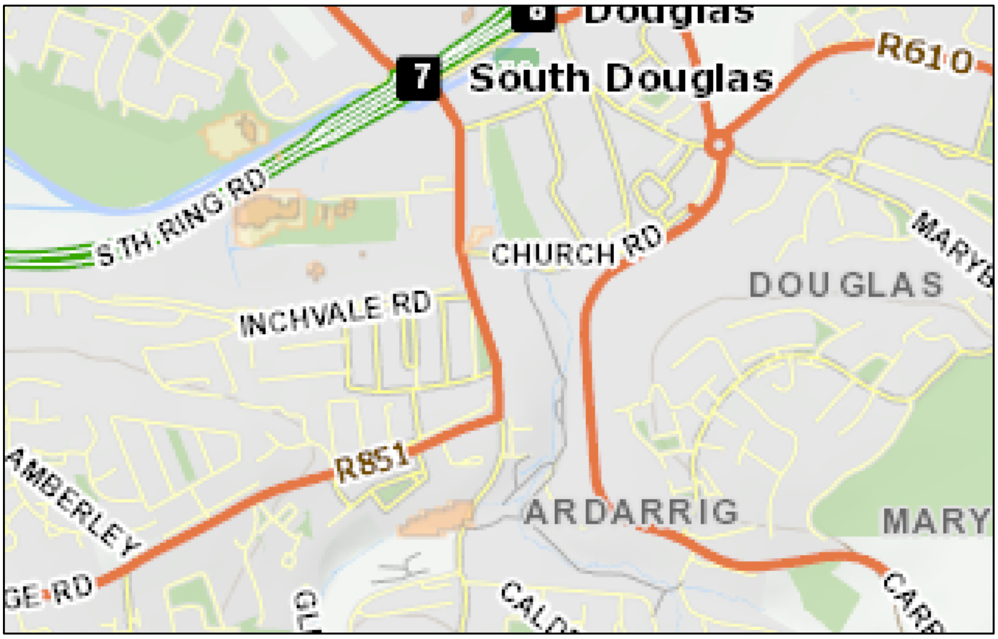

Figure 12.9 Extract from the OPW PFRA pluvial flood map at Douglas (highlighted in orange) | Source: www.myplan.ie

12.3.2.4 Groundwater Flood Risk

Groundwater flooding can occur during lengthy periods of heavy rainfall, typically during late winter / early spring when the groundwater table is already high. If the groundwater rises above ground level, it can pond at local low points and can cause periods of flooding. In order to assess the risk of groundwater flooding to the subject site, the PFRA mapping undertaken by the OPW has been reviewed. This does not indicate any areas in the vicinity of the works as being at risk of groundwater flooding.

12.3.2.5 Historical Flood Events

The National Flood Hazard Mapping website operated by the OPW (www.floodmaps.ie) has collated records of historic flooding events throughout Ireland. The website shows numerous historical flood events in both Togher and Douglas Village, primarily related to the 2012, 2009 and 2002 events.

Copies of summary reports for flooding events at Togher and Douglas by the OPW can be found on the National Flood Hazard Mapping website (www.floodmaps.ie). An extract from the reports is included in **Figure 12.10**.

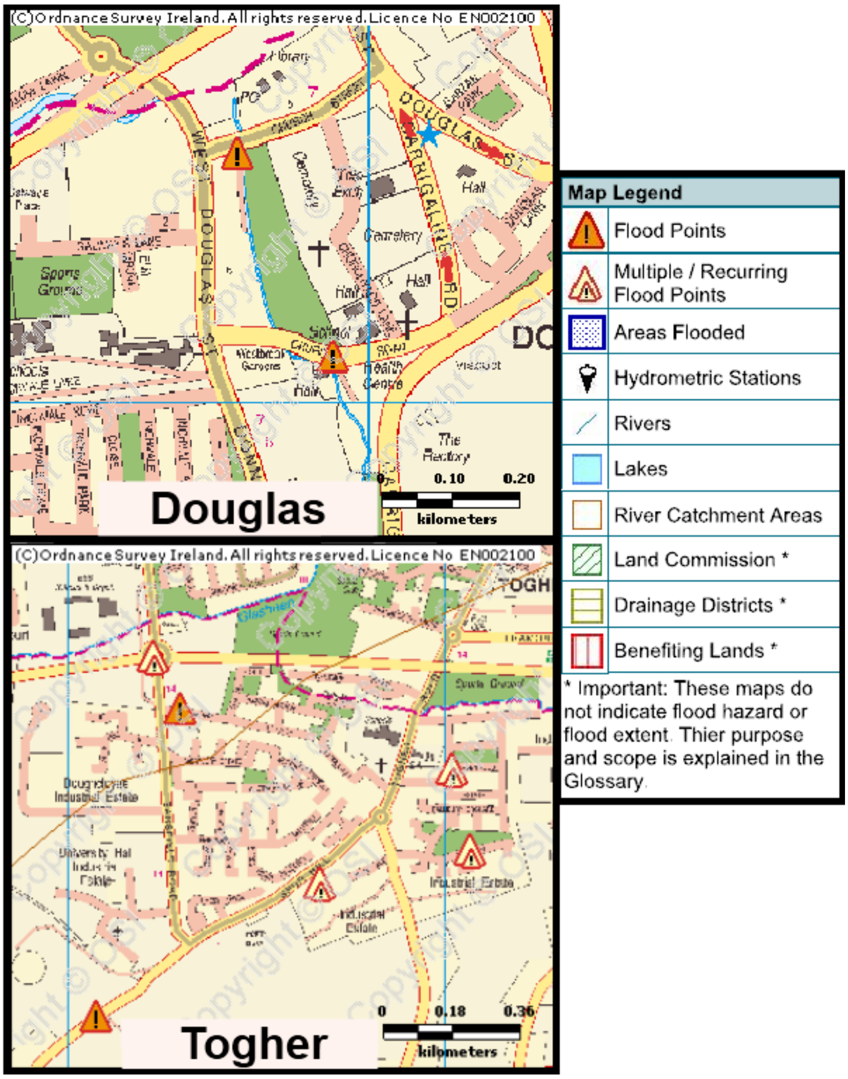

Figure 12.10 Extract from the National Flood Hazard Mapping reports.

Historic mapping was examined and found to contain evidence of historical flooding in the study areas. The Ordnance Survey 6” map contains a reasonably detailed “extent of inundation” line along the Tramore River as far as the former Kinsale Road Landfill. The line indicates a wide floodplain upstream, which narrowed through Douglas before widening again as the Tramore River entered the Douglas River estuary.

The Ordnance Survey 25” map shows an area of marshy ground along the left bank of the Ballybrack Stream that was once a pond which fed a mill at the corner of Church Street and West Douglas Street. Extracts from the historic maps showing the above features are included in **Figure 12.11**.

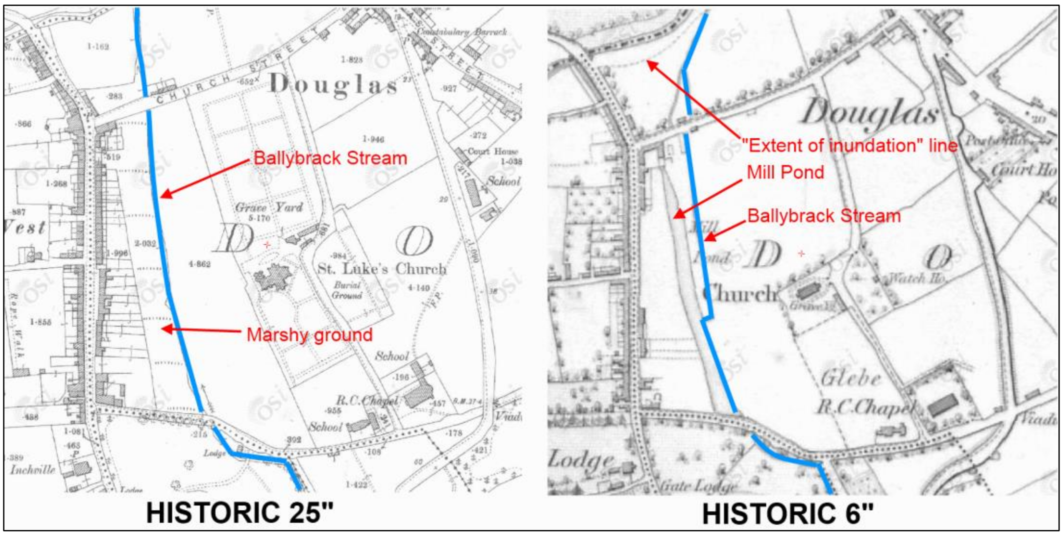

Figure 12.11: Extract from Historic 25" (1888-1913) and 6" (1837-1842) maps for Douglas. Source Ordnance Survey Ireland (2006) via www.geohive.ie

Reports and other information on past flooding in the study areas were supplied by Cork County Council (CCC) and the Office of Public Works (OPW). Anecdotal evidence from CCC staff suggests that Douglas experienced infrequent minor flooding in the past from backing-up/blockage at the entrance to the old Ballybrack culvert at Church Street.

Based on the above review, a timeline of flood events in Togher and Douglas has been created and summarised in **Table 12.7**.

Table 12.7: Timeline of major fluvial and tidal flood events in Togher and Douglas

Date of Flood Event	Mechanism	Areas Affected
December 2015	Fluvial	Douglas village
28 June 2012	Fluvial	Togher, Douglas village
December 2009	Fluvial	Tramore River (Kinsale Road roundabout area only)
27 November 2002	Fluvial	Togher
21 November 2002	Fluvial	Togher, Douglas village
3 December 2001	Fluvial	Togher
30 November 2000	Fluvial	Togher
5 November 2000	Fluvial	Togher, Douglas
1998	Fluvial	Togher
27 November 1953 (Date unconfirmed)	Fluvial	Douglas
17 March 1947	Fluvial	Togher, Douglas
24 December 1895	Fluvial	Douglas
19 November 1892	Fluvial	Douglas
Historic recurring	Fluvial / Tidal	Tramore River downstream of the former Kinsale Road Landfill, Douglas

12.4 Characteristics of the Proposed Scheme

As discussed in **Chapter 2 Need for the Proposed Scheme and Alternatives Considered**, due to past flooding events in Togher and Douglas the need to increase flood defences has been identified in these areas. A summary of the flooding history in Togher and Douglas is presented in this chapter in **Section 12.3.2.5**.

A detailed description of the proposed scheme is included in **Chapter 3 Description of the Proposed Scheme** of this EIS. In summary, the scheme will consist of the construction of flood defences along the Tramore River, Ballybrack Stream and Grange Stream. The works to be carried out on site are summarised below:

- Construction of new flood defence walls and/or replacement of existing walls with new flood defence walls
- Replacement of and/or extension of existing culverts
- Removal of and/or replacement of bridges
- New underground surface water pumping stations
- Removal of existing trash screens and construction of new coarse screens
- Local channel widening, deepening, realignment and re-grading of river channel
- Construction of new earthen flood defence embankments
- Provision of civil works such as road/footpath re-grading at a number of locations;
- Removal of vegetation and trees to facilitate construction works
- Protecting drainage outlets along the line of flood defence works
- Once construction is completed, ongoing maintenance of the river channel, trash screens etc.

12.4.1 Hydrology and Water Quality

Hydrological impacts arise from the quality of water discharged to surface water during construction and operation, therefore, management of such risks are of relevance to the proposed development.

12.4.2 Flood Risk

The proposed scheme lies within an area at high risk of fluvial flooding. There is also a significant risk of pluvial flooding in the vicinity of the scheme. Therefore, consideration of flood risk management is relevant to the proposed scheme.

12.5 Evaluation of Impacts

The impacts of the Scheme are evaluated for both the construction and operation phases of the scheme. Refer to **Table 12.4** and **12.5** for the description of impacts magnitude given in the following sections.

12.5.1 Construction Impacts

12.5.1.1 Hydrology and Water Quality

Construction activities pose a potentially significant temporary risk to all watercourses as these sites will be exposed to rainfall which has the potential to produce run-off during the construction phase. Surface water run-off from construction activities has the potential to be mildly contaminated. Due to the nature of the proposed scheme, construction works within watercourse channels will be required which exacerbates the risk of contamination. The main contaminants arising from surface construction activities include:

- Suspended solids: arising from ground disturbance and excavation;
- Hydrocarbons: accidental spillage from construction plant and storage depots;
- Faecal coliforms: contamination from coliforms can arise if there is inadequate containment and treatment of on-site toilet and washing facilities;
- Concrete / cementitious products: arising from construction materials.

These pollutants pose a significant temporary risk to surface water quality for the duration of construction if not properly contained and managed. Suspended solids, which can include significant quantities of silt, influence water turbidity and are considered to be the most significant risk to surface water quality from construction activities. Suspended solids can also reduce light penetration, visually impact the receiving water and damage the ecosystem. These suspended solids are likely to occur in:

- Water removed from surface excavations as a result of rainfall or groundwater seepage;
- Water in contact with exposed excavations within the watercourse channel;
- Vehicle wheel wash water;
- Runoff from exposed works areas and excavated material storage areas; and
- Cement wash-down areas: The potential for cement to increase the pH of water above a natural range, that is typically pH 6 to 9, can pose a threat to aquatic species living in a watercourse.

Contamination of surface water systems by the above pollutants may potentially occur due to:

- Inappropriate handling and storage;
- Leakage of temporary foul water sources; and
- Solid (municipal) wastes being disposed or blown into watercourses or drainage systems.

12.5.1.2 Flood Risk

The construction phase of the scheme poses a temporary increase to the risk of fluvial from the Tramore River, Ballybrack Stream and Grange Stream. During the construction phase, it will be necessary to temporarily divert the existing watercourses to facilitate the construction of replacement culverts. There is a risk that flooding could be exacerbated if the temporary diversions do not have sufficient conveyance capacity or if adequate overflow arrangements are not put in place. Over pumping of the watercourses, if used, may also increase the risk of flooding.

The construction of the scheme will require in channel works in a number of areas. These include:

- Togher;
- Donnybrook Commercial Centre;
- Ravensdale; and
- Douglas Community Park.

The construction phase also poses a temporary increase to the risk of pluvial flooding in Togher and Douglas. The construction of the scheme will generate debris, including silt, which if not handled correctly could result in blockage of the existing surface water drainage networks in the vicinity of the scheme. This will reduce the capacity of these networks to drain the surrounding areas during rainfall events and therefore increase the risk of pluvial flooding.

12.5.2 Operational Impacts

12.5.2.1 Hydrology and Water Quality

The impacts on hydrology as a result of maintenance of the proposed flood defence works will be temporary and minimal. Maintenance of the permanent defences will be carried out periodically and the impact will be similar in nature to the construction impacts. The main contaminants arising from maintenance activities include:

- Hydrocarbons: accidental spillage from construction plant and storage depots;
- Faecal coliforms: contamination from coliforms can arise if there is inadequate containment and treatment of on-site toilet and washing facilities; and
- Concrete / cementitious products: arising from construction materials.

Contamination of surface water systems by the above pollutants may potentially occur due to:

- Inappropriate handling and storage;
- Leakage of temporary foul water sources; and
- Solid (municipal) wastes being disposed or blown into watercourses or drainage systems.

12.5.2.2 Flood Risk

The proposed scheme will considerably reduce the fluvial and tidal flood risk in Togher and Douglas by providing a flood defence standard equal to the 1 in 100 year fluvial flood level plus the 1 in 200 year tidal flood level including freeboard. Therefore the risk of fluvial and tidal flooding in the areas to be protected by the scheme will be greatly reduced. The risk of fluvial flooding downstream of the flood defences due to the increased volume of water being conveyed in the channel is considered to be imperceptible.

The operational phase of the scheme poses a permanent and slight risk of pluvial flooding in the vicinity of the flood defences. The construction of the flood defences will result in increased water levels in the watercourse channel during flood events which could result in surcharging of surface water drainage outfalls. As a result, water may back up through the surface water drainage network and cause flooding behind the flood defences. Surcharging of the surface water outfalls could also prevent surface water runoff from entering the watercourse which will result in flooding behind the defences.

The flood defences may also block existing overland flow routes, where surface water run-off flows overland into the watercourses. This could result in an increased risk of pluvial flooding if adequate surface water drainage networks are not constructed to collect these flows.

12.5.2.3 Geomorphology

A baseline geomorphological survey was carried out as part of the design process. The information gathered has been used to assess the impact of the proposed scheme on the geomorphological processes within the catchment. The key aspects considered in the assessment are the likely impact of the scheme on the erosion and deposition of sediment in the catchment and how the functioning of the scheme may be adversely impacted by it. It is noted that as the works are being constructed in urban areas, it is considered that the impact of the scheme on the overall catchment geomorphology, or any high-quality physical river habitat, will likely be limited.

The key considerations of the scheme are:

- The scheme should not alter the morphological typology (i.e. the ‘type of river morphology’) of the various watercourses in the catchment and should improve the hydromorphological conditions in general. This statement is made in the context of the scheme increasing channel capacity in general, which will help partially restore / improve natural processes in comparison to the existing more confined state;

Togher

The primary flood relief option for Togher involves the removal of the existing multiple undersized culverts/drainage pipes that convey the Tramore flow from upstream of Lehenaghmore Industrial Estate to downstream of Greenwood Estate, and replacing it with a single larger culvert with increased capacity. The two existing open channel sections along the existing route are to be included as part of the proposed single culvert. As these two sections are relatively short (circa 45m and 15m) the reduction in open channel river habitat will be very minor.

This is unlikely to have any significant negative impact on the geomorphological conditions within the wider catchment as the proposed upgraded culvert will not influence sediment delivery processes from the upper catchment.

However, there is potential for localised sediment accumulation within the culvert during low flow conditions due to the upgraded culvert being wider than the existing culvert, leading to a reduction in velocities. This is unlikely to compromise the functioning of the culvert as a flood relief measure in Togher as 'morphologically-effective' flows should still move sediments through the culvert during high flow events. However, it is recommended that this localised change to sediment transport conditions be monitored by inspecting the culvert at least once a year and/or after every significant flood event as part of the scheme's maintenance regime.

Donnybrook Commercial Centre

The proposed design for Donnybrook Commercial Centre involves the upgrade of the lower section of the existing 190m long culvert that runs underneath the centre and the re-grading of certain sections of the reach. Additionally, this design involves the removal of two screens that currently trap sediment and artificially raise bed levels in the channel immediately upstream as a result.

Removing both coarse screens will benefit the geomorphological systems as it will facilitate more natural sediment storage and transport locally, and provide more favourable fish passage conditions through the reach.

Removal of the screens is unlikely to increase the overall sediment delivery into long culvert than runs underneath the centre when compared to the existing situation (i.e. when the screens are storing a maximum amount of sediment upstream, coarse sediment is delivered over the top of the screens). The volumes of stored sediments will be removed as part of the local screen removal works and be taken from the site.

As with the culvert in Togher, there is potential for localised sediment accumulation within the culvert during low flow conditions. A benched low flow channel will however be incorporated into the culvert which will mitigate the risk of sedimentation. Again, it may be the case that local higher magnitude and longer duration morphologically-effective flows have the effect of flushing sediments through the culvert if and when sediment transport exceeds supply from upstream.

It is recommended however that this localised change to sediment transport conditions be monitored at Donnybrook by inspecting the culvert at least once a year and/or after every significant flood event as part of the scheme's maintenance regime.

Douglas – Ballybrack stream

The flood relief option for Douglas along the Ballybrack stream are direct flood alleviation structures combined with channel conveyance improvement works.

The proposed works will have a minimal impact on the sediment delivery to the watercourse as the proposed direct defences only cover a relatively short reach of the channel (circa 240m).

The proposed works have the potential to mobilise a greater amount of sediment during high flow events as all the flow will be kept in channel, as opposed to spilling over a wider floodplain as it does in the existing scenario. There is therefore the potential for an increase in sedimentation downstream of the works in areas of reduced velocities. This however is not likely to have an adverse impact on conveyance through the reach as these events are infrequent and will be mitigated by the flows in normal conditions.

The proposed works are unlikely to have an adverse impact at low flows as the existing channel width will be maintained for low flows through the reach.

St Patricks Mills

The proposed design at St Patricks Mills are direct defences along the right bank of the Tramore River within St Patricks Mills. These flood alleviation structures are not likely to have any adverse impact on the geomorphology of the Tramore river due to their localised nature and size in comparison to the wider channel.

12.6 Mitigation Measures

12.6.1 Construction Mitigation Measures

12.6.1.1 Hydrology

The following precautionary measures will be implemented as part of the project design.

Prior to construction, the Contractor will be required to develop a Construction Environmental Management Plan (CEMP) which will incorporate the precautionary measures detailed below. These precautionary measures apply for the prevention of pollution to all waters during construction. These measures are implemented as standard for construction projects of this type. No impediments to the effective implementation of these measures have been identified. **Chapter 4 Construction Activities** outlines the recommended Construction Industry Research and Information Association (CIRIA) guidance in relation to minimising the risk of spills and contamination of surface waters.

The following construction precautionary measures will be utilised to minimise the risk of surface water contamination during in channel works:

- Where cast-in-place concrete is required, all work must be carried out in the dry and effectively isolated from any flowing water (or water that may enter streams and rivers) for a period sufficient to ensure no leachate from the concrete;
- Waterproofing and other chemical treatment to structures in close proximity to watercourses shall be applied by hand; and
- All pumps used for dewatering excavations shall be located in sump to minimise the sediment generation.

The following construction precautionary measures will be utilised to control the interaction of wash down water from concrete and cementitious material, vehicle wash down areas and run-off from fuelling areas with surface water:

- All batching and mixing activities will be located in areas away from watercourses and drains;

- Surface water drainage around the batching plant will be controlled;
- There will be no hosing into surface water drains of spills of concrete, cement, grout or similar materials;
- Washout from mixing plant or concrete trucks will be carried out in a designated, contained impermeable area;
- All oils and fuels shall be stored in secure bunded areas and care and attention taken during refuelling and maintenance operations. Particular attention shall be paid to the gradient and ground conditions which could increase the risk of discharge to waters; and
- Vehicle wash down areas shall be bunded and run-off channelled to a treatment area, such as a settlement pond, prior to discharge.

As per the above listed guidelines, protection measures will be put in place to ensure that all materials used during the construction phase are appropriately handled, stored and disposed of in accordance with recognised standards and manufacturer's guidance.

Process water used during construction will be disposed of appropriately.

12.6.1.2 Flood Risk

To mitigate the increased risk of fluvial flooding during the construction of the scheme, the Contractor will be required to ensure all temporary watercourse diversions have adequate hydraulic capacity and do not increase the risk of flooding during high fluvial flows or tidal water levels. Adequate overflow arrangements will be required to ensure high flows can be conveyed downstream without increasing the risk of fluvial flooding.

To mitigate the risk of pluvial flooding during the construction stage the Contractor will be required to ensure all surface water drainage networks in the vicinity of the works remain clear and free flowing. The Contractor will also be required to ensure that all surface water drainage outfalls to existing watercourses are maintained or alternative outfalls are constructed.

12.6.2 Operational Mitigation Measures

12.6.2.1 Hydrology

No mitigation measures are required.

12.6.2.2 Flood Risk

The proposed scheme will reduce the risk of fluvial and tidal flooding by providing a standard of protection equal to the 1 in 100 year fluvial flood level and 1 in 200 year tidal level including freeboard. Therefore no mitigation measures are required in relation to fluvial and tidal flood risk.

To mitigate the risk of increased pluvial flooding following the construction of the scheme, a non-return valve will be constructed on all surface water drainage outfalls due to the risk of surcharge during the 1 in 100 year fluvial flood including freeboard.

New surface water drainage networks will be constructed to drain areas where overland flow routes will be severed by the construction of the flood defences.

These drainage networks will outfall to the watercourses through non-return valves or will be pumped to the outfall as required.

12.6.2.3 Geomorphology

It is recommended that the localised change to sediment transport conditions be monitored at Togher and Donnybrook by inspecting the culvert at least once a year and/or after every significant flood event as part of the scheme's maintenance regime.

12.7 Residual Impacts

A wide range of mitigation measures have been specified for the construction and operational phase of the project. These mitigation measures seek to ensure that construction and operational discharges are controlled to prevent potential pollution impacts to all receiving surface water systems, groundwater bodies and their downstream catchment areas. The mitigation measures also seek to ensure the risk of flooding from all sources is not exacerbated during the construction and operational phases.

No negative residual impacts to flood risk are anticipated with the implementation of the construction and operational mitigation measures described above. The risk of flooding will be considerably reduced due to the proposed flood relief scheme.

12.8 References

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