14 Water

14.1 Introduction

This chapter describes the likely significant effects associated with the construction, operation and maintenance of the proposed scheme (also referred to as proposed development in other sections of the EIAR) on surface water quality and the existing hydrological regime. Groundwater features of relevance and hydrogeology have been considered separately in **Chapter 13**, *Land and Soils*. **Chapter 4**, *Description of the Proposed Scheme* provides a full description of the proposed scheme whilst **Chapter 5**, *Construction Strategy* describes the construction strategy. The following aspects of those chapters are particularly relevant to the water assessment.

- Design:
  - Bridge underpinning, remedial works and scour protection at Arklow Bridge in the Avoca River;
  - Channel dredging;
  - Debris and gravel trap;
  - Flood defence walls and storm water drainage on the south bank;
  - Flood defence earth embankment and flood defence wall in Arklow Town Marsh and on the north bank;
  - Flood protection from 1% AEP fluvial flood events and 0.5% AEP coastal flood events.
- Construction:
  - Flood risk due to construction of permanent works;
  - Flood risk due to temporary works;
  - Dewatering activities;
  - Working within waterbodies;
  - Unplanned discharges to surface waters.
- Operation and Maintenance:
  - Performance of the storm water drainage network (pipes and pump stations);
  - Maintenance of gravel trap, debris trap and river channel.

14.2 Assessment Methodology

14.2.1 General

The Avoca River and its many tributaries drain a relatively steep catchment of 652km^2 extending from just north of the Sally Gap and flowing southwards, discharging to the Irish Sea at Arklow Town. The catchment is illustrated in **Figure 14.1** overleaf.

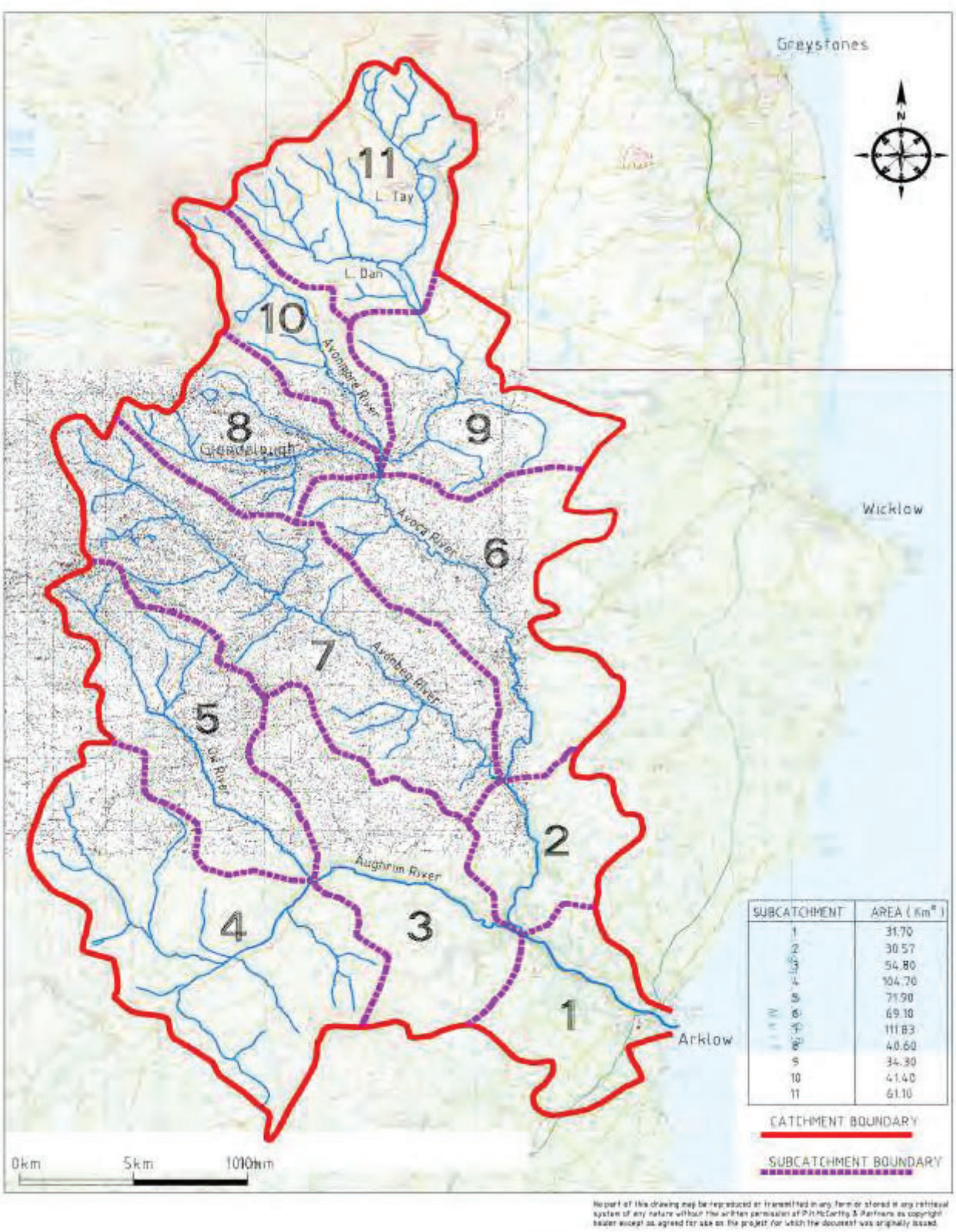

Figure 14.1: Avoca River Catchment

The hydrological study area comprises all surface water features that could potentially impact on and/or could potentially be impacted by the proposed scheme. These include the Avoca River and Estuary, the Irish Sea and Arklow Town Marsh proposed Natural Heritage Area (pNHA) (site code 001931) – refer to **Chapter 10**, *Biodiversity***,** for further information on the status of the pNHA.

The study area relating to hydrology and water quality is generally the estuary of the Avoca River, shown yellow in **Figure 14.2** below.

Figure 14.2: Hydrology and Water Quality Study - Site Boundary. Not to scale.

The hydrological assessment has considered the likely significant impacts of the proposed scheme on surface watercourses and hydrological features within and in proximity to the proposed scheme during construction and operation.

The hydrological assessment also considers the impact of flooding (flood risk) from the river and from transitional waters on the adjacent lands. The flood risk assessment has been considered for the likely significant impacts of the proposed scheme on sources of flooding and the pathways which flood waters might reach receptors during construction.

The water quality assessment has been based on the potential likely significant impacts of the proposed scheme during construction and operation on the receptors located within the study area indicated in **Figure 14.2** above.

14.2.2 Guidance and Legislation

This assessment has been undertaken with due regard to the overarching EIA guidance (described in **Section 1.3.1** of **Chapter 1**).

The following provides the statutory framework for the protection and control of rivers and/or transitional waters:

- The European Union Water Framework Directive (WFD) (2000/60/EC) that established a framework for the protection of groundwater, surface water and transitional waters;
- The EU Floods Directive (2007/60/EC);
- Groundwater Directive (2006/118/EC);
- The EU Environmental Impact Assessment Directive (2014/52/EU) amending the EIA Directive (2011/92/EU);
- The European Communities Environmental Objectives (Surface Water) Regulations 2019 as amended (S.I. No. 77 of 2019);
- The European Communities (Water Policy) Regulations (S.I. No. 350 of 2014);
- European Communities (Quality of Salmonid Waters) Regulations 1998 (S.I. No. 293 of 1988);
- The River Basin Management Plan for Ireland (2018-2021);

Each of these are described in detail under **Section 14.2.2.1 to 14.2.2.3** below.

Regard was also given to the following guidance documentation and legislation in this assessment:

- National Roads Authority (NRA)[1] 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Scheme' by the National Roads Authority (2008);
- Inland Fisheries Ireland (2016) Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters.
- Office of Public Works (OPW) Environmental guidance: Drainage Maintenance and Construction (2019);
- The Planning System and Flood Risk Management; Guidelines for Planning Authorities (2009);

[1] Transport Infrastructure Ireland (TII)

14.2.2.1 Water Framework Directive (WFD)

The WFD aims at improving the water environment in the EU and requires all Member States to protect and improve water quality in all waters so that they achieve good ecological status at a minimum by 2015 or, at the latest, by 2027.

The WFD has been transposed into Irish law by means of the following main Regulations.

- European Communities (Water Policy) Regulations, 2014 (S.I. No. 350 of 2014)
- European Communities (Drinking Water) Regulations 2014 (S.I. No. 122 of 2014);
- European Communities Environmental Objectives (Surface Waters) (amendments) Regulations, 2019 (S.I. No. 77 of 2019)
- European Communities Environmental Objectives (Groundwater) (Amendments) Regulations, 2016 (S.I. No. 366 of 2016)
- European Communities (Good Agricultural Practice for Protection of Waters) (Amendments) Regulations, 2020 (S.I. No. 40 of 2020)
- European Communities (Technical Specifications for the Chemical Analysis and Monitoring of Water Status) Regulations, 2011 (S.I. No. 489 of 2011)

The WFD applies to all waters including rivers, lakes, estuaries, coastal waters and groundwater, and their dependent wildlife/habitats under one piece of environmental legislation. It requires that management plans are prepared on a river basin basis through the specified structured method.

The River Basin Management Plans (RBMPs) have been prepared to protect and improve Ireland's water environment. They are reviewed and updated every six years. The first RBMPs covered the period 2009 to 2014 and identified the waterbodies that may not meet the environmental objectives of the WFD by 2015. The second RBMPs (for 2018 to 2021) were published in April 2018 and these set out the actions to improve water quality and achieve 'good' ecological status in water bodies (rivers, lakes, estuaries and coastal waters) by 2027. Ireland's third River Basin Management Plan is due to be published in December 2021 and it will run until 2027.

14.2.2.2 The European Union Environmental Objectives (Surface Water) (Amendment) Regulations, 2019

The European Union Environmental Objectives (Surface Water) (Amendments) Regulations 2019, provide a more complete and stringent set of surface water quality regulations which address the requirements of the WFD and Council Directive 2006/11/EC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community.

These regulations specify the conditions and physio-chemical concentrations that should be considered in the assessment of surface water quality. See **Table 14.1.1** to **Table 14.1.5** in **Appendix 14.1** for Physio-Chemical Conditions supporting Biological Elements considered for assessment.

These regulations also give effect to Council Directive 2008/105/EC on environmental quality standards in the field of water policy.

14.2.2.3 European Communities (Quality of Salmonid Waters) Regulations, 1988

Legislation for salmonid waters was first established under Council Directive 78/659/EEC on the quality of freshwaters needing protection or improvement in order to support fish life (the Freshwater Fish Directive). The Directive was given effect in Ireland through the S.I. No. 293/1988 - European Communities (Quality of Salmonid Waters) Regulations, 1988.

The Freshwater Fish Directive was subsequently superseded by Water Framework Directive but the Irish Regulations remain in force.

The Regulations defined freshwaters as being waters capable of supporting Salmon *(Salmo Salar),* Trout *(Salmo trutta),* Char *(Salvelinus)* and whitefish *(Coregonus)* and are designated as Salmonid waters.

The surface water quality standards specified across a range of relevant legislation are outlined in **Table 14.1.1** and **Table 14.1.2** in **Appendix 14.1**.

The assessment of coastal processes examines the existing coastal processes in the area and assesses the likely significant effects of the proposed in-stream works in WP1 (Arklow Bridge), WP2 (dredging works), WP3 (debris and gravel traps) and WP4 (flood defence walls founded within the river channel).

The assessment includes of a desktop study of the site conditions (including metocean, tidal levels, extreme sea level, currents, wind and wave data, as well as any other relevant historical information and aerial photographs.

14.2.3 Site Visits

A number of site visits to the study area were conducted in the period from 2005 to 2020. Site walkovers and intrusive site investigation surveys were conducted where access was possible. Site specific details were recorded and included logging of springs, drainage details and surface water levels.

14.2.4 Consultation

The EPA were contacted to obtain relevant biological and physio-chemical water quality data for the Avoca River and Estuary.

The project team met Inland Fisheries Ireland (IFI) on 16 March 2018 to discuss the proposed scheme (in conjunction with representatives from the proposed Arklow Wastewater Treatment Plant project who were also present to discuss their proposal given the physical overlap of the two schemes within the river

channel). An overview of the proposed scheme was provided. A further meeting was held with IFI on 18th November 2020 to provide an update on the scheme and obtain any additional feedback. Comments raised from discussions were addressed in this chapter.

A meeting with NPWS on the 5th November 2020 was held with the project team to discuss the proposed scheme. Comments raised from discussions were addressed in this chapter.

The physio-chemical water quality information for the period 2011-2020 and the biological water quality (Q Values) information for the period 1981 to 2019 for the Avoca river was provided by the EPA in February 2021 (See **Table 14.1.1** to **Table 14.1.6** in **Appendix 14.1).** This includes river/transitional water (biological) quality elements for the Avoca Estuary.

14.2.5 Categorisation of the Baseline Environment

14.2.5.1 Hydrological Regime and Flood Risk

A hydrological analysis of the study area was carried out through a desktop study, gauging data and catchment characteristics to establish the design fluvial flood flows and coastal water levels for the scheme.

A hydraulic model was constructed using computer software and utilising existing bathymetric, topographical and property surveys to establish flow routes, storage areas and water levels for various annual exceedance probabilities (AEP), also referred to as return periods.

Flood maps were produced showing the flood extents and depths for both fluvial and coastal flood events for the various AEPs. **Figure 14.5** below indicates the flood extent undefended design event.

14.2.5.2 Water Quality

A desktop study of relevant existing and target water quality data has been undertaken to obtain information on the existing surface water quality within the study area. The following documentation and sources were reviewed as part of this desktop study:

- Survey information from the EPA on the water quality of the study area was obtained on the 24th February 2021. Specifically, water quality data was collected from the EPA's monitoring stations on the Avoca River (River water quality status of the Avoca River is recorded at the EPA's river water quality monitoring station [RSA10A031140] located upstream of the Arklow Bridge). The water quality status of the Avoca Estuary is recorded at the EPA's transitional water quality monitoring stations (AV010, AV020 (previously RSA10A031200), AV030 and AV040). **Figure 14.3** below shows the locations of the EPA monitoring locations;

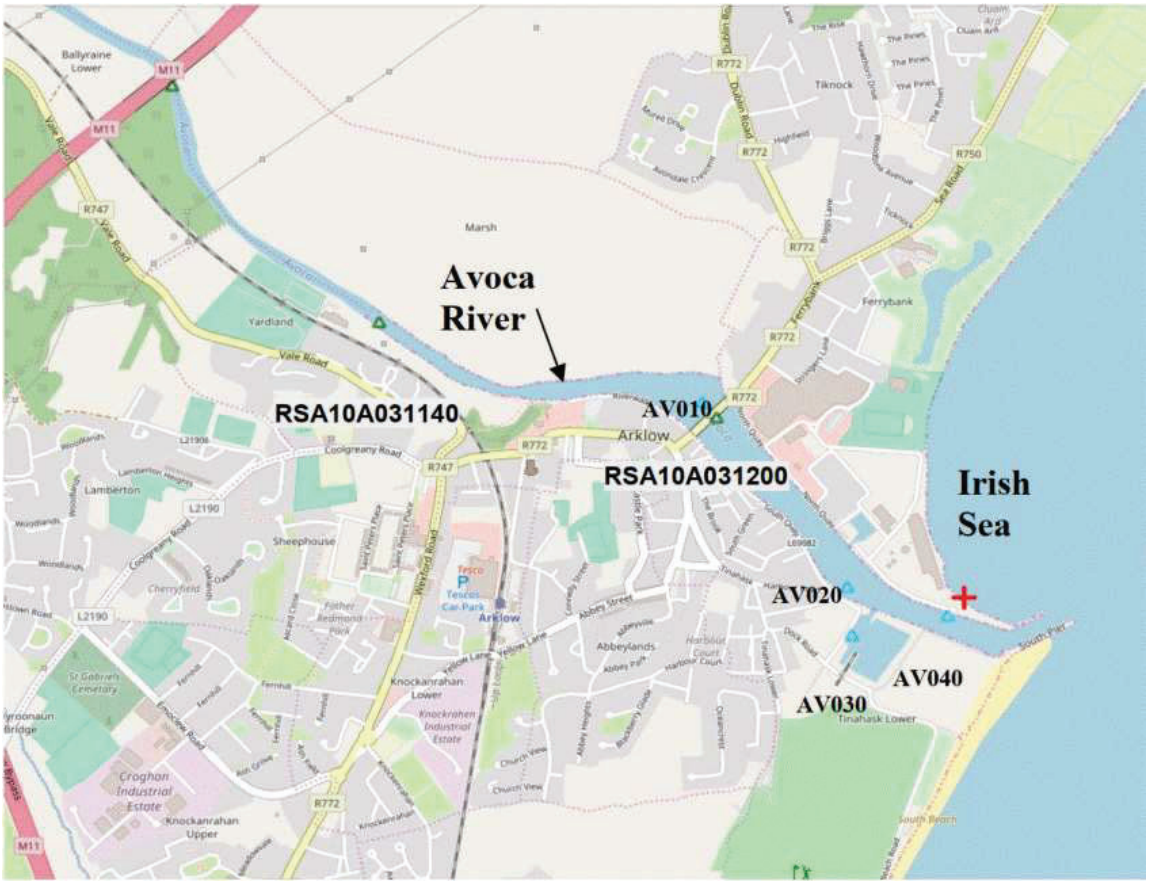

Figure 14.3: Water quality monitoring stations in Avoca River (extracted from EPA). Not to scale

- There is now a national RBMP based on a single national River Basin District for 2018 – 2021 which was published in April 2018 and which sets out the actions that Ireland will take to improve water quality and achieve 'good' ecological status in water bodies (rivers, lakes, estuaries and coastal waters) by 2027. The information contained in the RBMP was reviewed in relation to water quality;
- European Communities Environmental Objectives (Surface Water) (Amendments) Regulations 2019 require biological monitoring of macroalgae, angiosperms, phytoplankton, fish and benthic invertebrate fauna in transitional waters. However, it is understood from consultation with the EPA that phytoplankton biomass (chlorophyll) and phytoplankton count only are used to determine the biological quality element in Arklow transitional waters. (refer **Tables 14.1.4 and 14.1.5** in **Appendix 14.1** for further details). Biological water quality rating information was obtained from EPA in the form of Q values at Arklow Bridge (Station No.: RSA10A030700). The rating for the Q values is shown in **Table 14.1.6** in **Appendix 14.1**;
- Information on the WFD Risk status in relation to the Avoca Estuary was also obtained from EPA website (https://gis.epa.ie/EPAMaps/).

14.2.6 Impact Assessment Methodology

14.2.6.1 Overview

The likely significant effects have been assessed by classifying the importance of hydrology, flood risk and water quality, and quantifying magnitudes of any likely significant effects on these attributes. It should be noted that for the purpose of this assessment, likely significant effects and potential impacts are used interchangeably as this assessment methodology has been undertaken in accordance with:

i. National Road Authority (NRA) 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes' by the National Roads Authority (2008);

ii. The EPA 'Guidelines on the Information to be contained in Environmental Impact Assessment Reports (2017);

iii. The EU Environmental Impact Assessment of Projects, Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU);

The assessment of the potential impacts of the proposed development will involve a description of and assessment of the impacts that are planned to take place. This will include assessment of do-nothing scenario, assessment of effects during construction and during operations.

The methodology considered for rating impacts on hydrology and water quality is based on the criteria presented in **Table 14.1** and **Table 14.2** below, which takes account of the quality, significance, duration and type of impact characteristic identified in accordance with criteria provided in the EPA draft Guidelines (2017).

Table 14.1: Description of significance of Impacts

Magnitude of Impact	Criteria
Imperceptible	i. Temporary/ brief contamination of local surface water. ii. Temporary/ brief changes in local drainage patterns. iii. Temporary/brief change in local channel conveyance capacity
Slight	i. Temporary/ Short-term contamination of local surface water. ii. Temporary/ Short-term potential changes in local drainage patterns. iii. Temporary/ Short-term change in local channel conveyance capacity
Moderate	i. Temporary to short-term change to a designate conservation site, river, or estuary. i. Medium to long-term contamination of local surface water. ii. Medium to long term potential changes in local drainage pattern. iii. Medium to long-term change in local channel conveyance capacity
Significant	ii. Medium term change to a designate conservation site, river, or estuary. iii. Temporary to short term contamination of surface water over entire surface water catchment.

Magnitude of Impact	Criteria
	iv. Temporary to short-term potential changes in drainage patterns over entire catchment. v. Temporary to short -term potential change in channel conveyance capacity
Profound	i. Long-term to permanent change to a designated conservation site, river, or estuary. ii. Medium-term to permanent contamination of surface water over entire surface water catchment. iii. Medium-term to permanent potential changes in drainage patterns over entire catchment. iv. Medium to permanent change to channel conveyance capacity

Definition of duration criteria is provided in **Table 14.2** below.

Table 14.2: Definition of Duration Criteria

Impact Description	Impact Description
Permanent	Impact lasting for over sixty (60) years
Long-Term	Impact lasting fifteen (15) to sixty (60) years
Medium-Term	Impact lasting seven (7) to fifteen (15) years
Short-Term	Impact lasting one (1) to seven (7) years
Temporary	Impact lasting one (1) year or less
Brief	Impact lasting less than a day
Momentary	Impact lasting from a second to minutes

14.2.6.2 Hydrological Regime and Flood Risk

The assessment considers the proposed scheme and how relevant aspects have the potential to change the physical characteristics and thus the flood characteristics of the study area. The assessment specifically considers how any change will interact with the hydrological regime and how significant the change will be in the context of the relevant legislation. The baseline information (particularly the river flows, coastal water levels, bathymetric and topographical data) have been used to establish hydrodynamic regime within the study area.

Impacts on hydrological regime and flood risk considers changes to surface water bodies and adjacent receptors described in **Section 14.2.6.3** below.

Surface water bodies can act as both aquatic and terrestrial ecosystems and are an essential factor to sustain human life. During flood events, flood plains also act as a reserve or store for flood waters and this can prevent flood waters from impacting further downstream.

14.2.6.3 Water Quality Standard

Surface water quality has been assessed by determining the baseline status as described in **Section 14.3.4** below, reviewing the data and establishing the impacts as a result of the proposed scheme based on the parameters outlined in the legislation (referred to in **Section 14.2.2** above).

To achieve this, the proposed scheme has been reviewed in detail and considered to assess the impacts on surface water quality. The assessment specifically considers how any change interacts with the receiving waters and how significant is the change in the context of the relevant legislation.

The target water quality standards for various environments are listed in **Table 14.3** below. Under the European Union Environmental Objectives (Surface Water) (Amendment) Regulations 2019 (S.I No. 77 of 2019), the DIN target must be achieved at the edge of the mixing zone. A regulatory method for determining the extent of the mixing zone is not defined. It is required to be restricted to the proximity of the discharge and be proportionate.

Table 14.3: Target water quality standards for surface water (SI 77/2019)

Parameter	Transitional Waters	Coastal Waters
BOD (mg O2/l)	<4.0 (Good Status, 95%ile)	Not Specified
Dissolved Oxygen lower limit (DO) (% Sat)	Summer Good Status (0-17 psu) 95%ile >70% saturation	Summer Good Status (>17-35 psu) 95%ile >70%-80% saturation
Dissolved Oxygen upper limit (DO) (% Sat)	Summer Good Status (0-17 psu) 95%ile >130% saturation	Summer Good Status (>17-35 psu) 95%ile >120%-130% saturation
Suspended Solids (SS) (mg/l)	Not Specified	Not Specified
Total Ammonia (mg N/l)	Not Specified	Not Specified
PO4 (mg P/l)	0.06mg/l (0-17psu) median 0.04mg/l (34psu) median	Not Specified
Dissolved Inorganic Nitrogen DIN (mg N/l)	Good Status <2.6mg/l(0psu) median Good Status <0.25mg/l(34.5psu) median High Status <0.17mg/l(34.5psu) median	

Characterisation of surface water is based on the identification of features of the baseline hydrological environment that are relevant and can be assigned a biotic index (Q Values). River Q Values reflect average water quality at any surface water feature and the Q values of these features can be compiled through three factors namely, importance of the feature, the sensitivity of the feature and existing adverse pressures affecting the feature. **Table 14.1.3** in **Appendix 14.1** indicates the classification of the surface water body biological quality rating applicable to the Avoca River Estuary.

Various non-binding guidelines for the assessment of discharge have been developed under the EC Common Implementation Strategy for the Water Framework Directive. The general approaches for identifying mixing zones are followed. The design objective of '*High Status'* is used to delineate the mixing zone extent. The water quality of surface water bodies is also highly sensitive to the following:

i. Culverting, which can alter flow conditions and affect light penetration to the watercourse.

ii. Discharge of surface water run-off which may contain polluting substances that can have a significant adverse impact on the biological and physio-chemical status of a watercourse such as a salmonid river or stream.

iii. Morphological change through deepening, realignment or diversions of their natural channel which can also alter the hydrodynamic regime of the surface water feature.

River Q Values of surface water bodies can be adversely impacted by existing pollution upstream of the study area. As indicated in **Table 14.1.3** in **Appendix 14.1**, the higher 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 can contain solids, hydrocarbons and heavy metals). The existing adverse hydrological pressures are also apparent in the physio-chemical status of surface water bodies with both organic and inorganic pollutants altering the physio-chemical status.

14.3 Baseline Conditions

14.3.1 Introduction

The study area is located in the Arklow catchment, in Arklow town, which is located at the mouth of the Avoca River.

The key water features in the study area include:

- Avoca River;
- Arklow Estuary;
- Arklow Town Marsh pNHA; and
- Irish Sea

Arklow Ponds lie outside the FRS planning boundary but are also considered in this assessment in terms of potential for indirect impacts.

14.3.2 Hydrology Regime

The main hydrological features within the study area are shown on **Figure 14.1** above. The Avoca River is the longest river in County Wicklow and its catchment covers an area of approximately 650km^2 on the eastern flanks of the Wicklow mountains. The Avoca River discharges into the Irish Sea in Arklow town. The main tributaries of the Avoca River, that join the river upstream of Arklow, include the Aughrim, Avonbeg and Avonmore Rivers as shown in **Figure 14.4** below.

Figure 14.4: Main Tributaries of the Avoca River

The study area drains directly into the Avoca River as overland flow and also via manmade drains and/or surface water outfalls within the Avoca catchment. The construction of major motorways and significant residential development throughout Arklow and Aughrim towns has modified the natural drainage characteristics of the catchment of the Avoca River.

Arklow Town is divided by the Avoca River, which is crossed by the Arklow Bridge, a stone arch bridge linking the southern part of the town with the northern part, called Ferrybank. The Avoca River and part of its riverbanks and the Arklow Town Marsh lie within a proposed pNHA, (Site Code 001931).

Arklow Town Marsh is located on the northern side of the Avoca River and upstream of Arklow Bridge. The marsh is the principal wetland habitat in the area, providing an important flood control role and supporting a variety of plant and animal life, in particular reed species and bird life. The marsh acts as a natural flood plain during peak flood periods.

The marsh extends northwards from the Avoca River for c. 500-700m, and its eastern extent is defined by the rear of private properties along the western side of Ferrybank and the Dublin Road. The marsh is traversed by an elevated pathway leading from Ferrybank to Shelton Abbey over 3.0km to the west. A drainage canal runs along the southern side of the pathway, and continues along the rear property boundaries at Ferrybank, discharging to the Avoca River just upstream of the Arklow Bridge. This canal forms part of the Shelton Abbey Canal. Due to the waterlogged conditions of Arklow Town Marsh, its amenity and recreational use for people is extremely limited. The Marsh primarily consists of wetland habitat however, some services are also located within the marsh.

Part of the surface water run-off from Avoca River Business Park (formerly IFI fertilizer plant) flows through the canal from the west to the east through Arklow Town Marsh and discharges into the Avoca river upstream of Arklow Bridge.

The marsh is waterlogged for significant periods of the year due to the impermeable nature of the underlying peats, silts and clays. It is influenced through tidal contribution and surface water run-off from upstream catchments. Surface water from rainfall is typically dissipated through infiltration, evaporation, transpiration, and run-off which under excessive rainfall conditions can lead to flooding in the Marsh. River flow also influences groundwater levels in the Marsh. These flood periods occur irregularly and have a short-term effect on the marsh. Groundwater levels in the marsh are described **Chapter 13***, Land and Soils.* The hydraulic gradient of the groundwater in the marsh is generally from north to south, towards the river. It is considered that the groundwater regime in the Marsh is linked to the Avoca river.

In the north-east corner of Arklow Town adjacent to the Irish Sea lies Arklow 'Duck' Pond (also known as "Arklow Ponds"). The pond was constructed in 1958 and is reported to lie on the original course of the river. The small lake consists of lightly saline water behind raised dunes and coastal defence structures which are made up of diverse habitats (source: https://heritage.wicklowheritage.org/).

There is no direct surface water pathway from the Arklow River to Arklow Ponds. Between Arklow Town Marsh and Arklow Ponds lies roads and urban development (such as residential properties, shopping centres and recreational facilities) with no evidence of any surface water features connecting the bodies.

Groundwater regime is discussed in **Chapter 13**, *Land and Soils*. There is no groundwater pathway between Arklow Town Marsh or Arklow River to Arklow Ponds. Impacts of Arklow Ponds from surface water and groundwater from the scheme is hence ruled out.

The Avoca Estuary is a relatively small, narrow estuary that runs from Pease Park yard located near the Alps (900m upstream of Arklow bridge) to Arklow Bay (See **Figure 14.2** above). The river channel (which is part of the Avoca Estuary) is within the boundary of the Arklow Town Marsh pNHA upstream of Arklow Bridge. The banks of the estuary primarily consist of quay walls, boat moorings and piers. The estuary upstream of the Arklow Bridge has steep banks and is heavily wooded with large trees on both banks. Upstream of the Arklow Bridge, the river channel flows in an easterly direction and is typically c.50m wide. The river widens to c.150m at the Arklow Bridge, and changes course to a south easterly direction. Upstream of Arklow Bridge, the river channel is defined by River Walk on the southern side, and by the wooded edge of the Arklow Town Marsh on northern side. The river is shallow immediately upstream of the bridge. Discrete small-scale gravel beds (islands) have built up on the riverbed immediately upriver of Arklow Bridge. The shape and size of these features change over time, mainly due to increased river flow, on a seasonal/ annual duration as sediment particles collect upriver of the bridge. The estuary covers an area of 0.17km^2. The area downstream of Arklow Bridge (along the North Quay and South Quay) experiences periodic flooding from significant tidal events.

Due to the presence of a tidal node or amphidromic point in the part of the Irish Sea, tidal variations at Arklow are low and the predicted range is given as 0.73m during spring tides. However, under storm surge events this is typically greater. The river is tidal to ca 0.5 km upstream of the Arklow Bridge but again under storm surge events, this would be extended westwards. Low salinity sea water (< 5 practical salinity units) will penetrate the upper *ca* 10 cms of the riverbed.

14.3.3 Flood Risk Management

As outlined in **Section 2.2** of **Chapter 2**, *Background and Need for the Scheme*, Arklow has experienced recurring flooding events in the past, some of which have resulted in damage to property. The largest flood event recorded in the study area was in August 1986 resulting from extreme meteorological conditions commonly referred to as 'Hurricane Charlie'. Further recent flooding events occurred in December 1989, November 2000, February 2002, October 2004, October 2005, January 2010, January 2013 and December 2015.

Figure 2.1 of **Chapter 2**, *Background and Need for the Scheme*, illustrates the historic flood events in the Arklow area, according to 'www.floodmaps.ie.' **Figure 2.2** illustrates predicted flood levels in Arklow, according to the Strategic Flood Risk Assessment of the Arklow Local Area Plan 2018-2024.

As noted in **Section 2.2** of **Chapter 2**, *Background and Need for the Scheme*, the following areas are considered the most at risk of flooding in Arklow:

- Upstream (west) of Arklow Bridge along the south bank of the Avoca River is a promenade (River Walk) which includes residential and commercial properties, car parking, green space and public amenity facilities. This is connected to Main Street by Bridge Street and Condren's Lane Upper. This is a low-lying urban area built on the narrow floodplain and is affected primarily by fluvial flooding.
- The Ferrybank area, located north of the Avoca River, which is predominantly residential in character, is impacted by fluvial rather than tidal flooding. Flood waters flow from the Avoca River through Arklow Town Marsh and on to Ferrybank.
- Downstream (east) of the Arklow Bridge (along the South and part of the North Quays, towards the dock area) is prone to tidal flooding. This area experiences periodic flooding from significant tidal events. This flooding is more frequent but less extreme than fluvial flooding events and generally coincides with spring tides.

Figure 14.5 below presents the flood extent for the undefended design event in Arklow.

In the future, the risk of flooding in Arklow may also increase. Future changes which have the potential to affect the risk of flooding include:

- Climate change resulting in higher rainfall, increased river flows and higher tide levels:
- Isostatic land movement.

- Geomorphological processes, such as sediment transport, which affects the area of conveyance of the river channel, and erosion.
- Development within the catchment of the Avoca River and its tributaries, which does not conform to the principles of sustainable drainage, and which adversely affects the response of the catchment to rainfall; *and*
- Changes in land use, including forestation and land drainage

Details are set out in **Section 4.3.4** of **Chapter 4 – Proposed Scheme.**

The design flow rates have been derived following an extensive review of hydrological flow estimation methodologies. The design flood event was based on a joint probability taking a combination of the 1% AEP (1 in 100-year) fluvial flood event and the 0.5% AEP (1 in 200-year) coastal flood event. The design flow includes the OPW factors of safety in respect to factorial errors of the Flood Study estimation method. **Table 14.4** below provides the estimated design flood flows in the Avoca River with and without climate change allowance.

Table 14.4: Summary of design flood flows with and without climate change

Annual Exceedance Probability	Design Flow m³/s (no climate change allowance)	Design Flow m³/s (with climate change allowance)**	Design Flow with SFE* m³/s (no climate change allowance)
50%	231	277	340
20%	322	386	473
10%	381	457	560
4%	457	548	672
2%	512	614	753
1%	568	682	835
1%	627	752	922
0.1%	698	838	1026

*SFE is the standard factorial error of the regression equation used (SFE = 1.47)

** Climate Change Allowance – 20% increase in Flow rate

14.3.4 Water Quality

The quality of surface water in Ireland is examined regularly by the EPA to monitor performance against a number of biological parameters. The EPA's trophic status assessment compares the compliance of individual parameters against a set of criteria indicatives of trophic state.

These criteria fall into three different categories which broadly capture the cause-effect relationship of the eutrophication process, namely nutrient enrichment, accelerated plant growth, and disturbance to the level of dissolved oxygen normally present. Each water body assessed is categorised as either eutrophic, potentially eutrophic, intermediate or unpolluted with respect to nutrient enrichment.

The Avoca River/Estuary falls under 'Transitional Waters' and was given 'Moderately Polluted' water quality status by the EPA in the last reporting period July 2019.

The Q values (i.e., biological quality rating as described in detail in **Section 14.2.6.3**) for the Avoca River within the study area are summarised in **Table 14.1.6** in **Appendix 14.1**:

- The Q value for the Avoca River was '1' in 1990 at Arklow Bridge River Monitoring Station (Station No. RS10A031200) which indicates serious pollution of the river. There has not been a biological water quality survey undertaken since 1990 at this monitoring station.
- The only monitoring station that has been regularly surveyed is at the Avoca Bridge (Station No. RS10A030700) which is approximately 10.5km upstream of the Arklow Bridge and 2.6km downstream of the Avoca Mines. A Q value of 2-3 was determined during the latest survey in 2019. This Q value indicates that the Avoca River is moderately polluted at this location.

Section 10.4.10 of **Chapter 10**, *Biodiversity* notes that because of the acid mine drainage impacts and untreated wastewater discharges, the intertidal and estuarine habitats of the study area are depressed in species numbers and this in turn decreases the species richness and therefore these waters are of low ecological value. With regard to Q values, **Section 10.4.10** of **Chapter 10**, *Biodiversity* notes that the most recent review (EPA 2020) noted that the lack of pollution sensitive taxa and the low abundances of pollution tolerant species continued to indicate significant ecological disruption at Avoca Bridge in July 2019. Despite the above impacts, the river and estuary continue to provide a migration corridor for the Habitats Directive Annex II listed diadromous fish species Atlantic Salmon *Salmo salar*, River Lamprey *Lampetra fluviatilis* and Sea Lamprey *Petromyzon marinus.*

The latest Biological Status (physio-chemical conditions) Survey (https://www.catchments.ie/data/#/waterbody/IE_EA_150_0100?_k=5jug9q) indicates '*failure to achieve good status'* for chemical surface water parameters for specific pollutants, in particular Cadmium, Copper and Zinc, in July 2018. The Avoca Varty Catchment Assessment Report indicates groundwater bodies being at risk due to historic mines. The main issues raised are the elevated concentrations of heavy metals due to the acid mine drainage from lead-zinc mines. These historic mines are situated upstream of the study area and adversely impact surface water quality.

The biological surface water quality of the Avoca River within the study area was found to have a Q value of less than 4 which is classed as 'polluted' and determined as 'unsatisfactory' condition by the EPA. This indicates significant interferences with beneficial or potential beneficial uses of the Avoca River due to the pollution, in part, caused by discharge of untreated wastewater into the Avoca River within Arklow town via the existing 19 SWOs and /outfalls. It is noted that the proposed construction of the proposed Arklow WwTP (which received planning consent in 2019) will remove the practice of discharging of untreated water into the Avoca River.

In contrast, the main tributaries to the Avoca River – the Aughrim, Avonbeg and Avonmore Rivers, which lie outside the study area, were given Q values of 4-5 indicating that these rivers are mostly 'unpolluted' and generally in 'satisfactory' conditions with respect to beneficial uses.

As noted in **Section 14.2.5.2**, chlorophyll (phytoplankton biomass) and phytoplankton counts have been used to determine the Phytoplankton Biological Quality Element.

The EPA has indicated that the last assessment (2013-2018) for the Avoca / Arklow Estuary the Phytoplankton Biological Quality Element was assessed as 'High'. This indicates that the estimated values in Avoca Estuary for Biological Quality elements can generally be designated as high ecological status (Refer to **Section 10.4.10** of **Chapter 10**, *Biodiversity* for further details on aquatic ecology).

The EPA's physio-chemical data from the 2013-2015 sampling periods for monitoring points immediately upstream and within the study area as shown in **Table 14.1.7 – 14.1.11** in **Appendix 14.1**. The locations of all stations where water quality is monitored are shown in **Figure 14.3** above. In summary, the majority of the parameters are in compliance with the surface water quality standards. Parameters that are outside the standards are highlighted in bold **Tables 14.1.7 – 14.1.11** in **Appendix 14.1**.

Overall, the physio-chemical parameters indicate compliance with the European Communities Environmental Objectives (Surface Water) (Amendment) Regulations 2019, with the exception of BOD_5 and Ammonia Total values which were found to be above the limits outlined in these regulations.

WFD Status and Risk

The study area is located within the national river basin district under the RBMP 2018 – 2021.

The most recent water quality status report on the Avoca Estuary indicated the following (Refer to **Table 14.1.6** in **Appendix 14.1** for further detail):

- The overall WFD status of the Avoca River within the study area was 'Poor' (Refer to Table 14.1.6 in Appendix 14.1);
- The Avoca Estuary was given 'At risk' status;
- Ecological status for the Avoca Estuary was classed as 'moderate'; and
- Chemical surface water status was specified as 'Failing to achieve good', due to cadmium failure for chemical status and copper and zinc failure for specific pollutants'; EPA (2013-2018)

Whilst the ecological status was determined by the EPA as 'moderate', the Avoca Estuary has been assigned a draft ecological status classification of 'good' (EQR=0.88) based on the fish populations present during a 2015 fish stock survey carried out at sites on the Avoca Estuary by IFI and the Eastern Regional Fisheries Board.

The risk report for the Avoca River identified that the surface water quality is at risk from diffuse contamination, particularly pollutants from road washing activities and elevated concentrations of heavy metals due to acid mine drainage from lead-zinc mines upstream. The report also specified that at present hydrological risk or morphological risk is 'bad' for the Avoca River. **Table 14.5** outlines the WFD's water quality data for the Avoca Estuary.

Table 14.5: WFD Status of the Avoca Estuary 2013 - 2018 (Source: EPA date?)

European Code	**IE_EA_150_0100**	**Comment**
Name	Avoca Estuary	-
Ecological Status	Moderate	-
Period for WFD Status	SW 2013-2018	This data is from the period of 2013 – 2018
Biological Status	Good	Good status indicates that macro invertebrate and fish quality elements assessed were in compliance with WFD standards
Chemical SW Status	Failing to Achieve good	Chemical status is assessed by compliance with environmental standards for priority substances and priority hazardous substances such as metals, pesticides etc. Avoca Estuary is one of the two transitional water bodies that failed to achieve their chemical status objective during this period.
Dissolved Oxygen Saturation	Good	Low DO effects aquatic life & organisms that live in the sediments. A good status of DO in Avoca River indicates it support aquatic life.
Fish Status	Good	Good Fish status indicates that fish species composition and abundance correspond with little anthropogenic disturbance.
General Conditions	Good	Good status of general conditions includes oxygenation & nutrient conditions, thermal conditions, transparency salinity
Hydro morphological Conditions	Bad	Good hydro morphological conditions support aquatic ecosystems (i.e hydro morphological elements such as water flow and substrate provide physical habitat for biota such as fish, invertebrates and aquatic macrophytes). However, it was classed as Bad for Avoca River which indicates that water flow and substrate provided are not adequate.
Nutrient Conditions	Good	Monitoring of phosphorus (P) and nitrogen (N) nutrients causing eutrophication, is undertaken by the EPA. A good nutrient condition indicates there is no eutrophication of Avoca River.
Other Nutrient Conditions	Good	Nutrients other than phosphorus (ortho Phosphate) and nitrogen (Nitrate & Ammonia) were found to be within reference conditions values

European Code	IE_EA_150_0100	Comment
Other Oxygenation Conditions	Moderate	Oxygenation conditions other than BOD and DO were found to be meet reference conditions values to be classed as Moderate
Phytoplankton Status	High	Measure of phytoplankton biomass as concentration of chlorophyll in µg/l. Degradation in ecological status measure by increase in chlorophyll concentrations assessed against a salinity related threshold.
Specific Pollutant Conditions	Fail	All priority substances plus other pollutants substances discharged in significant quantities are measured. An assessment of dangerous substances in Water Framework Directive Transitional and Coastal Water indicates that face value comparison against standards set out in Schedule 5, Table 10 of SI 272 of 2009 is not met by Avoca Estuary.

In terms of background transitional/ coastal water quality, the available data for the Avoca estuary is provided in **Table 14.6** below.

Table 14.6: Avoca Estuary background water quality data (Station AV010) (2014 - 2020)

Depth	TON	DO	NH4	BOD	Chlorophyll	ortho-P
0	1.82	97.9	0.055	0.5	1.4	0.026
0	1.02	97.3	0.095	0.5	3.2	0.016
0	1.49	92.7	0.129	0.5	2.9	0.028
0	1.5	99.6	0.132	0.5	3.3	0.018
0	1.36	98.2	0.196	1.2	4	0.07
0	1.43	101.9	0.245	1.4	4.8	0.04
0	1.4	94	0.42	2.4	1.9	0.014
0	0.82	94	0.13	0	0.5	0.006
0	0.79	84	0	6.3	1.1	0.091
0	1.6	97	0.061	0.5	0.5	0.0025
0	1.5	97	0.32	2	1.6	0.009
0	1.3	89	0.21	5.3	2.6	0.014
0	0.55	88	0.13	1.6	4.7	0.012
0	0.9	101	0.052	0.5	1.1	0.005
0	1.6	98	0.092	6.1	0.5	0
0	1.6	102	1.1	0.5	0.5	0
0	1.4	92	0.11	0.5	0.5	0
0	0.45	103	0.47	5.6	3	0
0	2	99	0.12	0.5	0.5	0
0	1.8	96	0.15	0.5	2.3	0
Average	**1.3165**	**96.08**	**0.221947**	**1.942105**	**2.045**	**0.025107**
Median	**1.4**	**97**	**0.131**	**0.85**	**1.9**	**0.016**

Background coastal water quality in the vicinity is provided in **Table 14.7** below.

Table 14.7: Coastal background water quality data (2007 – 2016)

Station No	Sample Depth	Salinity	TON mg/l N	NH_3 mg/l N	DIN mg/l N	BOD mg/l	Season
AV110	0.0	33.22	0.16	0.014	0.174	1.0	Winter
AV110	9.7	33.25	0.15	0.022	0.172	1.0	Winter
AV110	0.0	34.14	0.01	0.016	0.026	1.0	Summer
AV110	9.7	34.17	0.01	0.021	0.031	1.0	Summer
AV120	0.0	28.87	0.21	0.122	0.332	1.0	Summer
AV120	9.8	34.15	0.01	0.023	0.033	1.0	Summer
AV130	0.0	32.93	0.19	0.016	0.206	1.0	Winter
AV130	10.1	33.20	0.15	0.018	0.168	1.0	Winter
AV130	0.0	30.78	0.02	0.017	0.037	1.0	Summer
AV130	6.4	34.12	0.02	0.050	0.07	1.0	Summer
AV150	0.0	33.38	0.14	0.014	0.154	1.0	Winter
AV150	18.0	33.39	0.14	0.022	0.162	1.0	Winter
AV150	0.0	34.14	0.02	0.014	0.034		Summer
AV150	15.0	34.19	0.02	0.012	0.032		Summer
AV160	0.0	33.25	0.14	0.022	0.162		Winter
AV160	13.5	33.36	0.14	0.014	0.154		Winter
Average			**0.10**	**0.026**	**0.122**	**1.0**	
Median		**33.37**	**0.14**	**0.017**	**0.154**	**1.0**	

14.4 Likely Significant Effects

14.4.1 Do-Nothing Scenario

The do-nothing scenario refers to what would happen if the proposed scheme was not implemented, and appropriate flood risk management measures were not provided in Arklow town. As outlined in **Chapter 1,** *Introduction* and **Chapter 2,** *Background and Need for the Scheme*, the need for flood risk management measures in Arklow Town has been well documented in national, regional and local policy as well as legal cases. Without intervention, Arklow faces the continued onset of a range of issues associated with flooding which are described below.

The flood extent for the design flood event i.e. the combined 1% AEP fluvial food event and the 0.5% coastal flood event, in the absence of any flood risk management measures is shown in **Figure 14.5** overleaf.

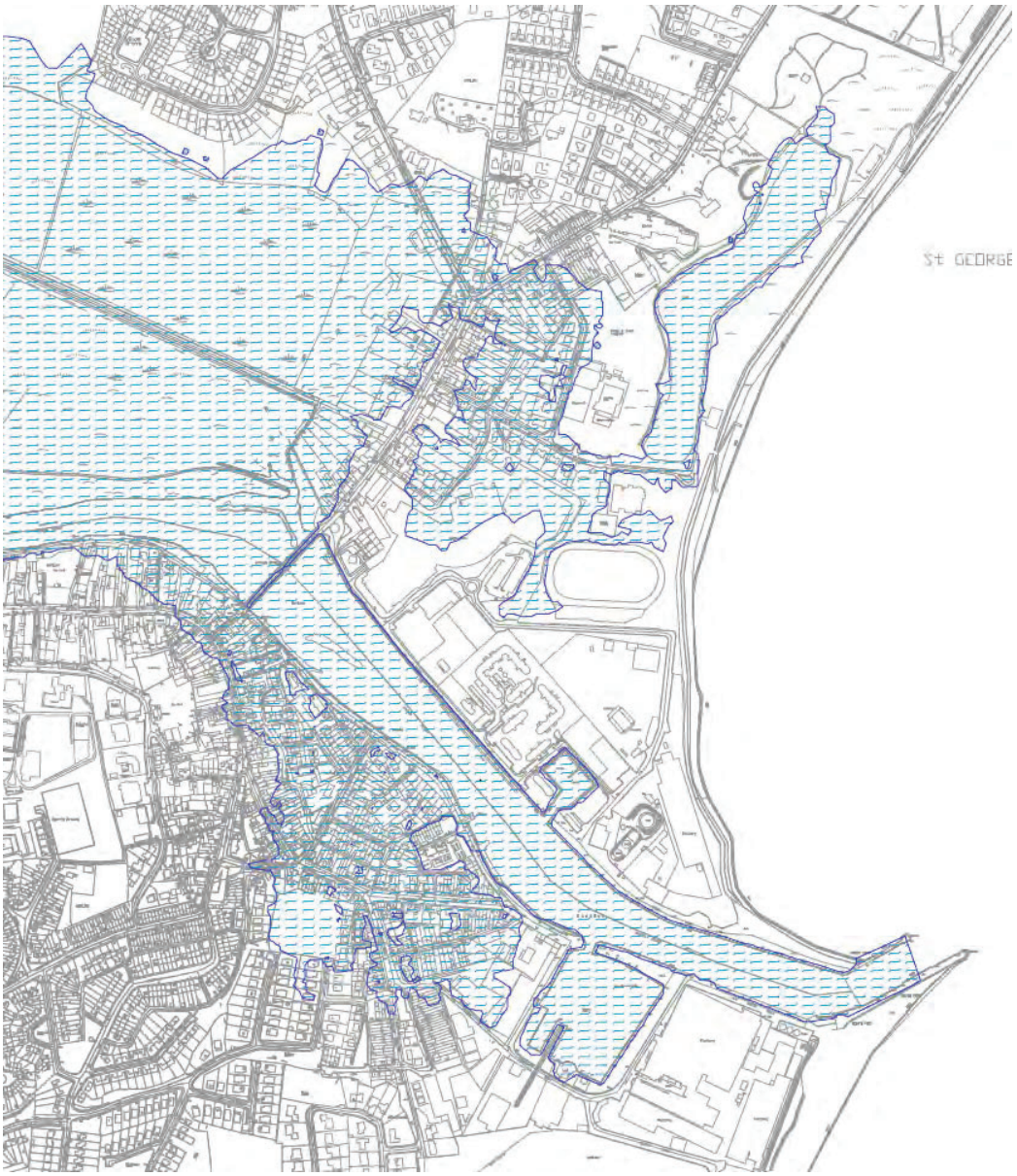

Figure 14.5: Flood Extent for Undefended Design Event. Not to scale.

The extent of a flood event represented in **Figure 14.5** above indicates that it has the potential to wash significant quantities of pollutants which may arise from affected properties and public amenities (including filling stations and fuel depots) into the estuary and onwards to the Irish Sea. For these reasons, the 'do-nothing' scenario arising from a flood event is considered likely to have a significant negative effect with regards to water quality. See **Section 16.4.1.2** of **Chapter 16**, *Population and Human Health* for human health impact for 'do-nothing scenario'.

Therefore, the condition of water quality in the Avoca Estuary will be unsatisfactory and at risk of being prevented from attaining the EU surface water environmental objectives. This will be a significant negative effect.

14.4.2 Assessment of Effects During Construction

14.4.2.1 Hydrology and Flood Risk due to Temporary Works

The construction activities associated with the enabling works (as described in detail in **Chapter 5,** *Construction Strategy*), including the construction of bunds and temporary haul roads in the Avoca River, diversion of the channel in the marsh and diversion of drainage pipework, could have a potential impact on the river flow and drainage characteristics of the study area. These are described in detail per work package below:

Work Package 1 - Bridge Underpinning, Bridge Remedial Works and Scour Protection

The working area associated with the bridge works is shown in **Figure 5.8** which is part of **Appendix 5.2** *Chapter 5 Figures.* In-channel access roads and temporary bunds will be constructed around the bridge piers and southern abutment to form working areas in the Avoca river. The bunds will be high enough to prevent overtopping during high spring tides. The work will be carried out over three summers when river flows are typically lower so that it is expected that the contractor will work on a third of the bridge each summer. During the first construction period, the southern section of the bridge will be enclosed by a bund and river flow will continue through the remaining northern section of the bridge. Similarly, during the second and third construction periods when work will be carried out on the middle and northern sections of the bridge and access will be from the north bank, river flow will continue through the available southern sections. During these works, the contractor will the monitor water levels in the river and maintain the in-channel access roads. Flow through the bridge arches will be maintained, and the contractor will remove any restrictions and /or debris encountered.

With the reduced conveyance capacity through the bridge during these work periods, the risk of flooding upstream of the bridge is increased. This will have a potential slight temporary negative effect on hydrology in the Avoca River.

Work Package 2 - Channel Dredging

Construction of temporary haul roads (minimum 4m wide) within the river channel will be formed adjacent to both riverbanks along the extent of channel to be dredged and also across the channel by the debris trap as indicated in **Figure 5.24** *of* **Appendix 5.2** *Chapter 5 Figures,* hence slightly reducing the channel width over this river extent. The temporary haul road will extend across the channel from north bank to south bank, with steel pipes installed in the haul road to convey river flow downstream. The haul roads will have a more significant impact along the narrow stretches of river channel, identified in red in **Figure 14.6** overleaf. The reduced channel width will impact river conveyance and increase flood risk upstream of the affected part of the channel. It is anticipated that the works will be carried out over 5 months over a summer when river flows are typically lower and be completed withing one summer period; hence a potential moderate temporary to short term negative effect on hydrology will be experienced.

A section of the riverbank will be extended into the river on north bank upstream of Arklow Bridge for habitat creation.

Figure 14.6: Impacts sections of river channel (shown red)

Work Package 3 – Debris Trap and Gravel Trap

The construction work will be carried out in two sections, these being the north and south sides of the river channel. The working area is shown in **Figure 5.26** which forms part of **Appendix 5.2** *Chapter 5 Figures.*

A temporary construction road will be constructed in the riverbed from River Access 4 (RA4) downstream to the location of the debris trap and then across the river towards the north bank (see **Figure 5.28** in **Chapter 5** *Construction Strategy*). The southern half of the construction road will incorporate suitably sized steel pipes to allow conveyance of river summer flow. Excess flow in the river will flow over the southern half of the road. A bund will be formed around the northern half of the debris trap to facilitate construction. On completion of the northern half of the debris trap, the bund will be removed and used to form a bund around the southern half of the debris trap. Dewatering of the bunded area will follow. On completion of the southern half of the debris trap, the material from the bund will be removed. Finally, the construction road will be removed from the gravel trap upstream to RA4. Construction works are expected to be carried out over one summer (May to September inclusive) when river flows are typically lower. The works will reduce conveyance capacity in the channel which will result in a potential moderate temporary to short-term negative effect on hydrology.

Work Package 4 – Flood Defence Walls and Drainage along South Bank

The working area and access locations are shown on **Figure 5.29** *in* **Appendix 5.2** *Chapter 5 Figures*. To facilitate construction of the sheet piled wall along River Walk and South Quay, a temporary causeway will be required to provide a working platform for piling activities. The temporary causeway will include a sufficient working area of up to approximately 10m wide for installing manholes, drainage and sheet pile walls. Construction of the proposed interceptor sewer for Arklow WwTP will be included as part of the works.

The temporary causeway will be constructed from clean, suitable engineered fill (coarse granular material free from fines with a maximum particle size of 200mm). It will be required from approximately 120m upstream of Arklow Bridge to approximately 300m downstream of the bridge. This will reduce the channel width and potentially reduce conveyance capacity with a consequent increase in flood risk upstream of the affected channel sections.

Following completion of the construction of the river-based flood defences and drainage (i.e. when the causeway is no longer required) along River Walk, the causeway material will be removed from the river side of the new sheet piled wall by excavator and used as fill where required on the land side of the wall. Excess material will be removed by excavator and dump truck and used for the construction of the causeway along South Quay.

Construction activity is anticipated to be carried out over 18 months with the in-stream works schedule for the summer periods (May to September inclusive) when river flows are typically lower. This will have a potential slight temporary negative effect on hydrology.

Work Package 5 – Flood Defence Walls, Embankment and Drainage along North Bank

The working area and site compounds for work package 5 is shown on **Figure 5.33** of **Appendix 5.2** *Chapter 5 Figures.*

A temporary haul road will be constructed along both sides of the proposed earthen embankment (541m long) from Ferrybank to the rear of the Arklow Presbyterian Church on Dublin road. These enabling works will restrict surface water flow from the working area to Arklow Town Marsh. It is anticipated that works will be carried out over one summer period which could result in a potential imperceptible temporary negative effect on hydrology.

Other construction activities

Other construction activities to be carried out at site compounds and river access locations have the potential to impact the hydrological regime. These include:

- Temporary stockpiling of material at site compounds could impact pathways for surface water run-off.
- The erection of hoarding around all working area and at all site compounds.

The construction activities outlined above have the potential to negatively impact hydrology and flood risk slightly on a temporary basis.

Existing Drainage Infrastructure

The construction activities, associated with the enabling works (as described in detail in **Chapter 5**), include temporary diversions and extensions of existing combined and/or surface water sewers that currently discharge via outfalls into the Avoca River at the locations of the proposed flood defence walls on the north and south banks. All of these outfalls will be reinstated as part of the scheme and extended to outside the proposed walls. These temporary sewer diversions could have an imperceptible temporary negative effect on the drainage characteristics by blocking or interfering with the existing drainage system.

Arklow Marsh

The marsh is regularly inundated with flood flows both from fluvial and coastal flood events. In fact, a large portion of the marsh is waterlogged for months of the year at a time. As such, any potential slight increase in river levels is considered to have an imperceptible impact on the marsh.

14.4.2.2 Water Quality

There are numerous substances used on construction sites that are potential pollutants to water bodies and could impact negatively on surface water quality. Runoff from the working areas during construction may contain increased sediment and suspended solid loads and contaminants. Fuels, oils, etc from accidental spills and leakage from machinery, plant or storage containers could enter the River or Marsh. Temporary and permanent construction activities within the river could result in increased sediment and suspended solids entering the Avoca River either directly, or through the existing drainage network or through overground flow. This is typical on construction sites and working areas for projects of this nature.

The assessment of the effects of construction activities is provided per work package below. The assessment of water quality effects during preparatory works such as advance contract site investigations, surveys and the preparation of site compounds is also provided. All in-stream works will be carried out during the summer periods (May to September inclusive).

Further site investigations and surveys

Section 5.4.1 of **Chapter 5** *Construction Strategy* provides details on the further site investigations which will be procured during the detailed design stage in addition to an advance archaeological site investigation for Arklow Town Marsh and Avoca River. In the absence of mitigation measures, these advance site investigation activities have potential to cause slight temporary negative water quality impacts in the Marsh and river due an increased risk of sediment and suspended solid loads and contaminants in runoff.

Advance treatment of invasive alien plant species may be required in some areas. An Invasive Alien Plant Species Management Plan is presented in the CEMP in **Appendix 5.1** of **Chapter 5** *Construction Strategy.* In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality arising from accidental spillages of herbicide.

Preparation of site compounds and temporary stockpiling of dredge materials for archaeological investigation or reuse

The construction compounds (site compounds) are illustrated in **Figure 5.3** of **Appendix 5.2** *Chapter 5 Figures.* The purpose of each site compound such as archaeological examination of dredge material, temporary stockpiling of material for re-use, welfare facilities, site offices etc is outlined in **Section 5.3.2** of **Chapter 5** *Construction Strategy.* **Section 5.4.3** of **Chapter 5** *Construction Strategy* provides details of the sequencing, site preparation and enabling works that will typically be required at each of the working areas. The activities most relevant to water quality impacts at the site compounds are summarised below as part of the impact assessment.

SC1 - Dredge material will be archaeologically investigated at SC1 before transportation offsite. Some dredge material consisting of slightly elevated chloride concentrations and inert material will be temporarily stockpiled for reuse in the construction of the embankment (WP5).

As noted in Chapter 5 Construction Activities, some of the dredged material sampled downstream of Arklow Bridge had natural slightly elevated chloride concentrations, likely due to saline intrusion given the tidal influence on this section of river. Temporary stockpiling of this material is likely to allow natural reduction in chloride concentrations sufficiently so this material could be deemed to be inert (subject to verification testing).

The level of chlorides found in the slightly elevated chloride dredge material is approximately 0.06ppt. Runoff from this material is also likely to contain slightly elevated levels. However, chloride levels in the Avoca River have been recorded at 1.5ppt and salinity levels in sea water in the Irish Sea are approximately 35ppt. The groundwater in the marsh is in constant connection with the estuary and the marsh is regularly inundated by coastal flooding. Therefore, any the runoff from the high slightly elevated chloride material will potentially have an imperceptible temporary negative impact on surface water or groundwater in Arklow Marsh.

Topsoil will be stripped and stockpiled on site for reuse during reinstatement following completion of the permanent works. A suitable geotextile membrane will be placed over the ground and hardcore material will be placed over the geotextile to form a trafficable surface for construction plant. Arklow Marsh pNHA will be protected by a temporary low bund constructed of impermeable material. It will be situated along the western boundary and will redirect surface water run off towards siltation traps prior to discharge.

Dredge material will be managed in an area situated on the south eastern portion of SC1 behind Circle K filling station. A low bund will be installed around the area on top of a geotextile membrane and hardcore material.

A localised stormwater drainage system will be constructed within the area to convey runoff to a sedimentation collection system before percolating into the ground. The collection system will be periodically monitored during material testing. Dust control measures will be installed around stockpiled material. Upon completion of works, SC1 will be re-vegetated as detailed in **Appendix 4.2**, *Public Realm Drawings* (No.: 305 and 306).

SC2 – Dredge material including hazardous and non-hazardous material will be archaeologically tested at SC2 before transportation offsite. A suitable geotextile membrane will be placed over the existing ground and suitable hardcore material will be placed over the geotextile to form a trafficable surface. A low bund, comprising precast concrete traffic barriers or similar wrapped in an impermeable membrane, will be constructed around the perimeter of the site to retain the temporary surface and the dredged material. The temporary surface will be graded to allow any water from dredged material to flow to a shallow drain around the perimeter by which it will flow to a sump from where it will be pumped to a storage tank for collection by tanker for disposal. Silt fences will be installed around stockpiled material. SC2 will be returned to its current condition by levelling and reseeding the grass area.

SC3 –This compound will be primarily used for river access and as a laydown area including dewatering of dredge material prior to trucks traveling on local roads. The ground will be levelled to form an even surface. A suitable geotextile membrane will be placed over areas of soft ground and hardcore material will be placed over the site to form a trafficable surface. SC3 will be reinstated in accordance with the landscape drawings – refer to **Appendix 4.2.**

SC4 – Site offices and storage units will be placed on the carparking area. SC4 will be reinstated to its existing condition on completion of the permanent works.

SC5 – This compound will include stockpiling of materials with slightly elevated chloride levels for archaeological testing and onward off-site transportation. This compound is located at the eastern end of North Pier at the furthest extent of North Quay as the Avoca river enters the sea. A low bund, comprising precast concrete traffic barriers or similar, will be constructed around the perimeter of the site to retain the dredged material. Suitable dust control measures will be installed around stockpiled material. SC5 will be reinstated to its existing condition on completion of the permanent works.

SC6 – Inert dredge material will be archaeologically tested at SC6 before transportation offsite. This compound is located between South Beach Road and the South Beach. Archaeological examination of dredge material will be on the southern half of the site compound. Topsoil will be stripped from the grass area and stockpiled on site for reuse during reinstatement following completion of the works. A suitable geotextile membrane will be placed over the ground and suitable hardcore material will be placed over the geotextile to form a working surface for the archaeological metal detecting of the dredged material. A low bund, comprising precast concrete traffic barriers or similar, will be constructed around the perimeter of the site to retain the dredged material. Silt fences will be installed around stockpiled material.

A drainage channel will be constructed around the perimeter of the storage area to collect any water draining from dredged material. Any runoff will be discharged through a suitable sediment removal system to ground.

In the absence of mitigation measures, runoff from the site compounds to the Avoca River, Irish Sea and Arklow Town Marsh may contain increased sediment and suspended solid loads and contaminants due in particular to the temporary stockpiling and testing of dredge material. Accidental fuel/oil spills and leakages from machinery, plant or storage containers at the compounds may also enter the runoff. The potential water quality impact, in the absence of mitigation measures is predicted to be slight temporary negative impact.

Work Package 1 - Bridge Underpinning, Bridge Remedial Works and Scour Protection

As described in **Section 5.5.1** of **Chapter 5** *Construction Strategy,* the bridge underpinning and new scour protection slab will require river access ramps and temporary bunds to be constructed around sections of the bridge to provide dry working areas. The bunds will generally be formed from impermeable natural material or permeable material with an impermeable liner such as heavy-duty polythene. 1 tonne sandbags could also be used to form the core of the bund.

As described in **Section 5.5.1.4** of **Chapter 5** *Construction Strategy,* bunds will be installed on a suitable formation. The water within the bund will be electro-fished to ensure all fish are removed and released into the Avoca River in advance of dewatering. Dewatering will typically be achieved by using a series of sumps and submersible pumps. Discharge from the dewatering process will be passed to a suitably sized propriety sediment removal system located within the bund before discharge to the Avoca River. The pumps and settlement tanks will be relocated within bunded areas as and when required. Refer to **Figure 5.13** of **Chapter 5** for a typical sediment removal system.

Construction access roads within the river channel will be formed to run from the river access points to the bridge work areas. These may be located wholly or partially on top of the bunds to reduce the impact on the work area. Access roads will be approximately 4m wide where it meets the public road with suitable protection/ containment of the road edge. This will allow sufficient space for trucks to stop and allow water to drain from excavated material. The access roads will be located so as to allow sufficient working space around the permanent works and will be 500mm above high spring tide level. Refer to **Figure 5.14-5.16** of **Chapter 5** *Construction Strategy* which show the in-channel bund and access roads.

Existing inert river gravels from within the footprint of the designated work area will be used where available to form the in-channel access roads. This will be supplemented with imported clean hardcore when required. All machinery required for in-channel works will be inspected for condition and use prior to river access.

The toe of the access roads will be constructed with a silt trap system to be maintained during construction.

All temporary works will be removed by excavator and dump truck at the end of each summer work period and re-established where necessary at the commencement of the following summer work period. Water quality will be monitored on an on-going basis upstream and downstream of Arklow Bridge as described in **Section 14.7.2** below.

The establishment and removal of the temporary works during WP1 will disturb the riverbed, resulting in sediment plumes in the river. The imported materials for the construction of the access ramps and bunds could contain sediment which would increase the suspended solids content in the river. There will be a slight temporary negative impact on water quality in the river during WP1 arising from increased siltation.

As noted in **Chapter 5** *Construction Strategy* estuarine material will be brought to site compound 1 (SC1) for archaeological testing (metal detection and visual inspection) prior to transportation off site. See details above.

Underpinning will be constructed using a number of possible techniques as described in **Section 5.5.1.5** of **Chapter 5** *Construction Strategy*. All will require grouting of the bridge piers and abutments, both from bridge deck level and from riverbed level. There is a potential of grout leakage into the Avoca River during grouting from bridge deck level when working areas are not isolated. The cement-based grout could be toxic to aquatic life in the river. **Drawing 1006** in **Appendix 4.1** illustrates proposed grouting works at bridge piers.

Runoff from the working areas during WP1 construction may contain contaminants. Fuels, oils, etc from accidental spills and leakage from machinery, plant or storage containers may enter the river.

There is potential for moderate temporary negative impact on water quality in the river arising from accidental spillages and leakages and grout leakages.

Remedial works will also be carried out on Arklow Bridge. This will include the application of suitable herbicide injected into deeply embedded roots where to remove them mechanically would prove destructive to the integrity of the masonry. There is potential for imperceptible temporary negative impact on water quality in the river arising from accidental spillages of herbicide.

Work Package 2 - Channel Dredging

The dredging process is described in detail under **Section 5.5.2 of Chapter 5,** *Construction Strategy*.

As noted in **Section 5.5.2 of Chapter 5,** *Construction Strategy*, River water quality monitoring will be carried out for a period of twelve months in advance of the commencement of the river dredging works to establish a baseline for water quality. Parameters to be monitored will include suspended solids, dissolved oxygen, temperature, pH, turbidity and BOD_5. During the course of the dredging works, monitoring will be continued, and any significant changes will be investigated. Construction practices will be adjusted if found to be having an unacceptable negative impact on water quality.

The estimated duration of the dredging works is 5 months during the summer season).

The enabling works will comprise the construction of river access points and construction haul roads in the river channel. These will result in sediment on the riverbed being disturbed and possible sediment issues arising from any materials used for the temporary works. This will also occur during removal of the temporary works.

As noted in **Section 5.5.2** of **Chapter 5,** *Construction Strategy*, the dredging works upstream of Arklow Bridge will typically involve the use of draglines for the wider sections of the river, long reach tracked hydraulic excavators, standard excavators and dump trucks.

Some of the riverbed materials have been identified as being contaminated and comprise both hazardous and non-hazardous materials. The dredged face of areas where these materials are present could result in contaminants being released into the river. Therefore, a specific construction methodology has been designed to address this potential impact. Trucks carrying this contaminated material will be sealed so that there is no loss of water from the truck when transporting the material to SC2.

As the dredging adjacent to the riverbanks is completed, the geotextile membrane and riprap will be placed along the excavated face by a tracked excavator using the temporary haul road.

A portion of inert dredged material will be utilised for the extension of the riverbank along the northern bank. The material will be clean and not contaminated. Riprap will be placed around the perimeter of the area to be filled, dredged material will be placed inside the rip-rap to the required level and soil filled geotextile sacks will be placed over the dredged material. The area will then be planted in accordance with the landscape design. This will have a slight temporary negative impact on water quality in the Avoca River.

A section of in-fill along north banks will be carried out after completion of channel dredging. Material imported will be clean and not contaminated. This will have no negative impact on water quality along the northern bank.

Dredging downstream of Arklow Bridge is expected to be carried out by a dragline excavator for the wider sections of river channel and by a long reach excavator sitting on a jack-up or spud barge for other areas and where careful excavation of materials with slightly elevated chloride levels is required. The barge will typically be manoeuvred by means of a tugboat. The dredged material will be loaded onto adjacent dump trucks stationed on the haul road in the river adjacent to the north and south banks of the river.

The dump trucks will require a location to park to allow water to drain from the dredged material. The dump trucks will be parked on a steep slope for a short duration to allow the dredged material to drain, which will be collected in a sump and discharged to a sediment removal system before discharge to the river.

As noted above and in **Section 5.5.2, Chapter 5** *Construction Strategy* some of the dredge material will be sent to designated site compounds (SC2, SC5, SC6 and SC1) for archaeological examination and subsequently transport for reuse/disposal offsite. Some of the dredge material will also be sent to SC1 for reuse in the construction of the embankment (WP5).

The dredging process will disturb the sediment in the riverbed and thus increase the suspended solids concentrations in the Avoca river. Excessive suspended sediment loads can negatively impact riverine and estuarine flora and fauna. Water quality impacts due to suspended sediments on flora and fauna are addressed in more detail below with cross references to **Chapter 10** *Biodiversity*, as appropriate.

As noted in **Section 10.5.4** of **Chapter 10** *Biodiversity*, as the Avoca River will for the great majority of the tidal cycle be flowing in an easterly direction (*ca* 10 hours), sediment laden water will be washed downstream and out to sea and as this section of the river is poor in fauna, the impact of this sediment laden water on biota is considered to be low. **Section 10.5.4** of **Chapter 10** *Biodiversity* also notes that species such as Lamprey, Salmon and Seatrout evolved over geological time to migrate through estuaries on their way to spawning grounds and as many estuaries are naturally high in turbidity, these species evolved mechanisms to deal with high suspended sediment loads. **Section 10.5.4** of **Chapter 10** *Biodiversity* notes that it is also considered that when tidal forcing is affecting the Avoca River upstream of the bridge, due to the low tidal exchange rate brought about by the near-by tidal node, velocities will be very weak and will not transport sediment particles far from the dredge site and that they will fall out to the river bed within a short distance. Furthermore, it is planned that the dredging activity will last on average 10 hours per day after which it will stop. This will allow the sediment laden water to be effectively flushed out of the river completely.

Section 10.5.4 of **Chapter 10** *Biodiversity* also notes that background levels of suspended solids vary considerably from river to river and **Figure 14.7** below shows the sediment plume from the Avoca River dispersing northwards into the Irish Sea. This image suggests that the Avoca River is naturally quite turbid.

However, **Section 10.5.4** of **Chapter 10** *Biodiversity* notes that while the Avoca experiences naturally turbid conditions, there remains potential that dredging activity may result in effects to Lamprey, Salmon in the absence of mitigation measures. Finally, **Section 10.5.4** of **Chapter 10** *Biodiversity* notes that the effect of increased turbidity, if realised, will be short lived. In addition, any effects are not likely to be significant for local sedimentary habitats and fauna, as the area is naturally turbid (see above) and hydrodynamically active and likely experiences a high degree of natural suspended solids due to the current tidal regime and sedimentary nature of the area. Consequently, there is no risk of significant effects to benthic habitats.

In conclusion, there will be a moderate temporary negative impact on water quality in the river during WP2 arising from increased siltation.

Runoff from the working areas during WP2 construction may contain contaminants. Fuels, oils, etc from accidental spills and leakage from machinery, plant or storage containers may arise. There is potential for slight temporary negative impact on water quality in the river arising from accidental spillages and leakages. Pollution events have the potential to effect flora and fauna and also those who use the river for amenities etc.

Figure 14.7: Sediment Plume at Mouth of Avoca River Estuary (January 2019)

Work Package 3

The debris trap and gravel trap construction is detailed under **Section 5.5.3. of Chapter 5,** *Construction Strategy*.

Construction and removal of the temporary haul road and in-channel bunds will temporarily disturb the riverbed and thus cause a sediment plume in the Avoca Estuary. Sediment from the temporary materials for the haul road and bunds may also impact on water quality. Dewatering of the working area will involve pumping from sumps over the bund to the river.

The impacts of water quality impacts due to suspended sediments on flora and fauna during WP3 will be similar in nature to those described in WP1 and WP4. The dredging during WP2 is likely to be the most impactful in terms of suspended solids as previously described. In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality in the river arising suspended sediments during WP3.

Concrete works for the construction of the debris trap may result in unintended release of concrete into the river channel which would result in an initial localised area of cementitious material into the water. This could be toxic to aquatic life in the river. In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality in the river arising from accidental concrete releases and fuel.

Work Package 4

The proposed scheme will require construction of permanent sheet pile walls with reinforced concrete (RC) capping in the river channel to form the flood defence walls, reinforced concrete retaining walls on the riverbanks and around the dock area and the storm water drainage network (Refer to **Section 5.5.4** of **Chapter 5** for further detail). A temporary causeway will be required to facilitate the driving of the sheet piles which will disturb the riverbed and cause an increase in suspended solids. The imported materials for the construction of the causeway could contain sediment which would increase the suspended solids content in the river.

Dewatering of the excavations for foundations of walls and the drainage system will involve pumping from sumps to the river, potentially causing an increase in suspended solids in the river.

The impacts on flora and fauna due to suspended sediments impacting water quality during WP4 will be similar in nature to those described in WP1 and WP3. The dredging during WP2 is likely to be the most impactful in terms of suspended solids as previously described. In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality in the river arising suspended sediments during WP4.

There is a potential of concrete leakage to the Avoca River during concrete works. The cement-based concrete could be toxic to aquatic life in the river. In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality in the river arising from accidental concrete releases and fuel.

Work Package 5

As described in detail in **Section 5.5.5** of **Chapter 5**, *Construction Strategy*, the flood defence earthen embankment will be constructed by importing fill material to form the embankment. The flood defence wall by Ferrybank will be constructed using a combination of sheet piling and reinforce concrete techniques.

Surface water in Arklow Town Marsh could be impacted during construction of WP5, primarily during enabling work including construction of temporary haul roads, diversion of ESB utilities, excavations for the foundation for the embankment, the trench for the French drain and the permanent maintenance track, the dewatering of excavations has the potential to release sediments into the marsh. In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality in the river arising suspended sediments during WP5.

Spillage of concrete adjacent to the marsh and the riverbank has the potential to release toxic cementitious product into the river. In the absence of mitigation measures, there is potential for slight temporary negative impact on water quality in the river arising from accidental concrete releases and fuel.

Other Construction activities:

A summary of construction activities and associated potential pollutants of relevance to water quality is provided below:

- Potential sources of pollution from site drainage include runoff and erosion from site excavation, earthworks from construction of the temporary causeway and construction of RC flood defence walls, open cut construction of the storm water drainage network etc and associated stockpile;
- The release of concrete washings and other cementitious materials via the discharge of construction runoff;
- The washing of construction vehicles and equipment also pose a pollution risk to watercourses in the area if undertaken in inappropriate locations and in the absences of effective management and mitigation.
- In addition, surface water run-off from surface construction activities has the potential to be contaminated and pose a significant risk to all watercourses as these sites will be exposed to rainfall which has the potential to produce silt laden run-off.
- Wash water from dust suppression sprays;
- Sediment plume will be experienced during dredging, in-channel construction works such as construction of bunds, temporary haul roads and causeway when machinery disturbs the riverbed. Water quality will experience a short term significant negative effect.
- Impacts on coastal waters during the construction of the proposed scheme relate primarily to the excavation and potential dispersion of sediments.
- Dredged material collected by dump trucks will dock at discharge bays at river access location where excess water collected on truck beds will be allowed to drain into sediment removal tanks.
- Spillage of fuel and lubricants from maintenance of construction vehicles and mechanical equipment.
- Any accidental spillage of fuel and/or discharge of oil from leaks in vehicles and fuel tanks.
- Dewatering during installation of bunds or within working area will be carried out in all work packages.
- Site compounds (SC1, SC2,SC5 and SC6) where dredge material archaeological monitoring will temporarily stored, spread for inspection and reloaded for disposal. See section above on construction compounds;

- Site Compound (SC3 and SC4) will serve only as contractors' compounds. Surface water run-off at SC3, which is likely to contain sediment due to the movement of construction traffic through it to the river and to WP5 works, will be prevented from running into the adjacent Avoca River by the construction of a low bund along the river edge and the diversion of any runoff to a sump from where it can be discharged through a sedimentation tank. Surface water run-off at SC4 will not contain sediment as SC4 is located in a carpark surfaced with tarmacadam.

The generation of silt-laden run-off during construction may result in slight temporary negative impact associated with the following:

- There is the potential for silt-laden surface run-off during the enabling works, site clearance and ground works that would be undertaken throughout the works areas. This potential of silt-laden surface runoff is likely to continue throughout construction until the ground has been completely consolidated and reinstatement of the working area has been completed.

14.4.3 Assessment of Effects During Operation

14.4.3.1 Hydrology and Flood Risk Management

The proposed flood relief measures including lowering of the floor of Arklow Bridge and the upstream and downstream channel dredging will result in a more uniform flow from upstream to downstream along the river channel and through Arklow Bridge. This will improve the flow regime towards the Avoca Estuary. In summary, the proposed scheme will result in a moderate long-term positive impact on the hydrological regime.

The permanent works associated with the gravel trap will have a positive impact on fluvial flood risk by reducing the quantity of gravels that will be carried downstream and reduce the conveyance capacity through Arklow Bridge and therefore there will be an overall moderate long-term positive impact on reduction in flood risk upstream of Arklow Bridge.

The permanent works associated with the debris trap will reduce the risk of flooding upstream of Arklow Bridge by reducing the risk of blockage of the bridge by floating debris and therefore there will be a moderate long-term positive impact.

The proposed scheme will provide protection from the 1% AEP fluvial flood event and the 0.5% coastal flood event. This will result in significant long-term positive impact due to a reduction in tangible and intangible flood damages, financial loss, extensive community disruption, health and safety issues and development restrictions.

Maintenance works at the debris and grave trap, along the channel and earth embankment is described in **Chapter 4**, *Proposed Scheme.* The implementation of the maintenance works will be essential throughout the life span of the scheme and contribute to a moderate positive long-term effect on hydrology and flood risk through removal of blockages within the regime.

14.4.3.2 Water Quality

The proposed flood defence walls and embankment will prevent flood waters flowing through properties and roads and washing contaminants into the river. This will significantly improve the Avoca River water quality and is thus considered a moderate long-term positive impact.

Runoff from the historic lead-zinc mines upstream of study area will continue to impact on water quality in the Avoca Estuary and the proposed flood relief scheme will not influence the levels of heavy metals either in the water or in the sediment carried downstream. It is noted that the current levels of heavy metals in the estuarine materials to be dredged are not at levels that warrant special disposal facilities. It is considered therefore that the annual maintenance of the gravel trap will result in an imperceptible temporary negative effect.

14.5 Mitigation Measures

14.5.1 Mitigation During Construction

14.5.1.1 Hydrology and Flood Risk Management

Sequencing of Works

The planned construction sequence of the work packages has been selected to ensure that there is no increase in the current flood risk from fluvial and coastal sources during construction. WP1 which includes the bridge underpinning and lowering of the floor of Arklow Bridge, is due to be carried out at the beginning of the scheme and will result in a reduced flood risk, once it has been completed.

The completion of the first section of the bridge works will provide sufficient benefit to allow the commencement of WP4, the construction of flood defence walls along the south bank, ensuring that there will be no increase in flood risk due to the construction of the WP4 works.

WP3 includes the construction of the gravel and debris traps and is planned for the first summer. These works will reduce the risk of blockage of Arklow Bridge and so, reduce flood risk further. WP5, the construction of the flood defence embankment and wall on the north bank will follow the completion of WP1, WP3 and WP4 and though it will increase flood levels, it will result in an overall reduction in the current flood risk. WP2, the dredging works, will be carried out at the same time as WP5 and will reduce the flood risk further.

Work Package 1: Bridge Underpinning, remedial and scour protection

There will be an increase in flood risk during the first stage of the bridge works due the temporary bunds in the river channel. The proposed mitigation measures to manage this increased flood risk are:

- Works will be carried out in the summer months when river flows and wave action are typically lower.

- Bund heights will be set at a level so that they will be effective during the expected range of river flows and tide levels for the summer months but will be overtopped if exceptional large events occur.
- A flood monitoring and warning system will be implemented so that all plant and equipment will be removed from the work areas in the event of an imminent large river flow or exceptional high tide.
- In the event of a warning of an extreme flood event, the temporary bund will be reduced in height or removed in part or entirely if time allows to further reduce any flood risk.
- The Works Contractor will be required to take measures to mitigate any increase in flood risk arising from his activities. This will include measures to safely evacuate the working area, monitoring of water levels (see also **Section 14.6.1.1** below) and weather patterns.

After the first section of works are completed, the increased capacity of the bridge arches in this section will provide additional conveyance capacity and offset any impact on conveyance due to the temporary bunds for the middle and northern sections of the bridge.

The increase in flooding risk due to the construction of WP1 following the above mitigation measures is considered to be imperceptible temporary.

Work Package 2: Channel Dredging

The proposed dredging works upstream and downstream of Arklow Bridge have the potential to increase flood risk due to the construction of haul roads within the river channel, parallel to the banks and across the channel. These haul roads may impact on the conveyance capacity at the narrower sections of the channel. Factors for the mitigation of flood risk are as follows.

- The dredging works will be carried out in the summer months when river flows and wave action are typically lower.
- The haul roads will be set at a level so that they will be effective during the expected range of river flows and tide levels for the summer months but will be overtopped if exceptional large events occur.
- Flood levels from coastal processes will not be impacted by the proposed temporary works.
- The bridge underpinning works will be completed thereby increasing the conveyance capacity through the bridge and offsetting and increase in flood levels upstream of Arklow Bridge.
- An increase in flood levels upstream of the proposed dredge works will not impact properties due to the high ground levels on the south bank and the marsh on the north bank upstream of the haul roads. Flood flows will be able to flow through the marsh if levels are sufficiently high and bypass the narrower section of river channel at the upstream extent of the dredging works.

- The Works Contractor will be required to safely evacuate working area, during monitoring of water levels and when extreme weather patterns occur.

The potential increase in flooding risk due to the construction of WP2, following the above mitigation measures, is considered to be imperceptible temporary.

Work Package 3: Debris and Gravel Trap

The construction of these works will impact on flood levels upstream of the proposed location for the traps due to the construction of the haul road and bund within the river. The following mitigation measures will be implemented:

- Construction of the debris and gravel traps will not impact on flood risk as the increase in flood levels will only occur upstream of the works area and flood flows will be retained by the high ground levels on the south bank. Flood flows will be able to flow through the marsh if levels are sufficiently high and bypass the works.
- The works will be carried out in the summer months when river flows are typically lower.
- The haul road and bund will be set at a level so that they will be effective during the expected range of river flows for the summer months but will be overtopped if exceptional large events occur.
- A flood monitoring and warning system will be implemented so that all plant and equipment will be removed from the work areas in the event of an imminent large river flow.
- In the event of a warning off an extreme flood event, the temporary bunds can be reduced in height or removed in part or entirely if time allows to further reduce any flood risk.
- The Works Contractor will be required to safely evacuate working area, during monitoring of water levels when extreme weather patterns occur.

It should be noted that an increase in flood levels upstream of the proposed debris trap works will not impact properties due to the high ground levels on the south bank and the marsh on the north bank upstream of the proposed works. Flood flows will be able to flow through the marsh and bypass the work area if levels are sufficiently high.

The potential increase in flooding risk due to the construction of WP3 following the above mitigation measures is considered to be imperceptible temporary.

Work Package 4: Flood Defences and storm water drainage works on South Bank

The construction of the temporary causeway for approximately 300m within the river channel to facilitate the construction of the sheet-piled wall downstream of Arklow Bridge will increase flood risk from a fluvial flood event. It will not change the flood risk from a coastal flood event. The proposed causeway will not be constructed until the first section of the bridge underpinning, and associated lowering of the floor of Arklow Bridge, is completed. Consequently, the temporary causeway will not increase flood risk over the current level.

A temporary causeway will also be constructed within the river channel for approximately 120m upstream from Arklow Bridge to facilitate construction of the sheet-piled wall along River Walk. The temporary causeway will be contained on the river side by either gabions or sheet piles, with these raised to the height of the causeway, to be effective. The proposed elevation of the temporary causeway is c. 0.8m OD which accounts for highwater mean spring tide of 0.5m OD plus 0.3m freeboard.

As the causeway will be constructed within the wider section of the river channel, it will not impact on fluvial flood flows. The proposed causeway will not be constructed until the first section of the bridge underpinning, and associated lowering of the floor of Arklow Bridge, is completed. Consequently, the temporary causeway will not increase flood risk over the current level.

The Works Contractor will be required to safely evacuate from river channel during flood risk arising from his activities.

The potential increase in flooding risk due to the construction of WP4 following the above mitigation measures is considered to be imperceptible temporary.

Work Package 5: Flood earth embankment and flood defence wall along North bank

The construction of the proposed flood defence embankment and wall will not commence until the bridge underpinning and associated lowering of the floor of Arklow Bridge is fully completed. As such, the proposed embankment and wall will not increase flood risk over the current level.

The Works Contractor will be required to safely evacuate from river channel during flood risk arising from his activities.

Existing Drainage Infrastructure

Where the existing drainage system requires diversion or alteration during construction, the contractor responsible will be required to have alternative drainage facilities in place. These may include temporary diversions if a suitable route for gravity flow is available or over-pumping where a gravity solution cannot be identified.

14.5.1.2 Water Quality

In order to further reduce any potential effect of the dredging on migrating fish species *e.g.* Lamprey and Salmon, dredging will not be carried out between October and April.

The standard best practice measures in the CEMP (Refer to **Appendix 5.1**) for the proposed scheme will mitigate significant negative effects on surface water quality during construction. A range of site-specific measures are presented below:

- During construction, contaminated surface water runoff in working areas will be collected by the temporary drainage systems installed by the contractor and then treated or desilted on-site before discharge to the Avoca River or stored and removed off site if not suitable for discharge to the Avoca.
- Site compound SC1, where archaeological testing of the dredged material including material with slightly elevated chloride concentrations will be conducted, will be prepared with the installation of a geotextile membrane with suitable hardcore placed over it to provide a trafficable surface. Arklow Marsh pNHA will be protected by a temporary low bund constructed of impermeable material. The bund will be situated along the western boundary and will redirect surface water run off towards siltation traps. Dredge material will be managed in an area situated on the south eastern portion of SC1 behind Circle K filling station. A low bund will be installed around the area on top of geotextile membrane and hardcore material. A localised stormwater drainage system will be constructed within the area to convey runoff to a sedimentation collection system before percolating into the ground. The collection system will be periodically monitored during material testing. Silt fences will be installed around stockpiled material.
- Site compound SC2, where archaeological testing of the contaminated dredged material will be conducted, will be prepared with the installation of a geotextile membrane and an impermeable membrane with suitable hardcore placed over these to provide a trafficable surface. A low bund, comprising precast concrete traffic barriers or similar wrapped in an impermeable membrane, will be constructed around the perimeter of the site to retain the temporary surface and the dredged material.
- A drainage channel with sumps will be constructed around the perimeter of the storage area to collect any water draining from the dredged material. Water draining from contaminated material stored at SC2 and will be collected in a suitable tanker to be taken to a suitable waste disposal facility. Groundworks operations will be carried out such that the surfaces are provided with adequate slope to promote safe runoff and prevent flooding.
- Site compound SC5, where archaeological testing of the dredged material with slightly elevated chloride concentrations will be conducted, will be prepared with the installation of a geotextile membrane with suitable hardcore placed over it to provide a trafficable surface. A suitable bund will be constructed around the storage area.
- Water draining from the material at SC5 will be allowed to drain by overland flow to the sea. Groundworks operations shall be carried out such that the surfaces are designed with adequate falls to promote safe runoff and prevent flooding.
- Site compound SC6, where archaeological testing of the inert dredged material will be conducted, will be prepared with the installation of a geotextile membrane with suitable hardcore placed over it to provide a trafficable surface. A suitable bund will be constructed around the storage area. A drainage channel with sumps will be constructed around the perimeter of the storage area to collect any water draining from the dredged material.

Any runoff will be discharged through a suitable sediment removal system for discharge.

- Good housekeeping such as site clean ups, use of disposal bins etc will be adopted in construction areas.
- In order to prevent accidental release of hazardous materials such as fuels, lubricants, cleaning agents, hazardous construction materials, etc. into surface water during construction, all hazardous materials will be stored within appropriately bunded containment areas designed to retain spillages.
- Dewatering will be achieved using a series of sump and submersible pumps and discharging through a suitably sized propriety sediment removal system. The contractor will regularly maintain the sedimentation tank to ensure that it is not full of sediment. This is aims to prevent pollution of the Avoca River through the release of sediments.
- Locations where contaminated material are anticipated, as identified in Chapter 15, Resources and Waste Management, will be isolated at low tide level. A temporary bund made up of impermeable material, approximately 500mm above high spring tide level will be constructed around the location. Dewatering for visibility of the riverbed and to enable the contractor to carry out the excavation process will be undertaken. A conventional excavator will be used to remove any layers of contaminated material. The excavation will extend approximately 300mm below the proposed dredge level and will be back filled with clean dredged material. The finished excavated surface will be trimmed to the required line and level at the channel edge. This will have an imperceptible temporary negative impact on water quality.
- The grouting process at Arklow Bridge will be preceded by water flushing to determine if there are any paths through to the face of the historic masonry. Any routes found will be plugged with mortar appropriate to the historic masonry. The grouting material will consist of cement only or a mixture of cement and bentonite, depending on the purpose of the grouting and the permeability of the material to be grouted.
- Dredging works in the river will be confined to either the northern half or the southern half of the channel at any one time to minimise the impact of suspended sediment in the water.
- Dredging works in the river will be limited to 10 hours per day to allow 14 hours for the water to clear and any migratory aquatic species to travel past the work area.
- Restricting the dredging hours, as described above, will also limit the impact on coastal waters off the mouth of the estuary. As noted in section 14.4.2 above, sediment plumes emanating from the Avoca River estuary are an existing feature of high flows in the Avoca River.
- Refer also to specific pollution prevention mitigation measures detailed in **Section 10.6.8** of **Chapter 10** *Biodiversity* and summarised below:

    i. Appropriate sediment control measures will be employed.

ii. Any chemical, fuel and oil stores will be located on an impermeable base within a secured bund with a storage capacity 110% of the stored volume.

iii. Biodegradable oils and fuels will be used where possible.

iv. Drip trays will be placed underneath any standing machinery to prevent pollution by oil/fuel leaks. Where practicable, refuelling of vehicles and machinery will be carried out on an impermeable surface in one designated area well away from any watercourse or drainage (at least 10m).

v. Emergency spill kits will be available on site and staff trained in their use.

vi. Operators will check their vehicles on a daily basis before starting work to confirm the absence of leakages. Any leakages will be reported immediately.

vii. Daily checks will be carried out and records kept on a weekly basis and any items that have been repaired/replaced/rejected noted and recorded.

viii. Any items of plant machinery found to be defective will be removed from site immediately or positioned in a place of safety until such time that it can be removed. All items of plant will be checked prior to use before each shift for signs of wear/damage.

- All washing out of grout pumps will be carried out in designated areas away from the river, such as in the lined compound area. At no point will grout pumps be washed out at the worksite.
- Specific mitigation measures regarding the careful application of herbicide to treat Invasive Alien Plant are presented the Invasive Alien Plant Species Management Plan in the CEMP in **Appendix 5.1** of **Chapter 5** *Construction Strategy.*
- Specific mitigation measures regarding the careful application of herbicide to remove woody vegetation in the joints in the masonry of the bridge during WP1 are presented the CORA report in **Appendix 11.8** of **Chapter 11** *Archaeological, Architectural and Cultural Heritage.*

Silt Management Procedures

Silt management onsite will be carried out in accordance with OPW Guidance as described below. This mitigation procedure will be adopted across all site compounds and working areas.

i. A suitably qualified Environmental Clerk of Works shall be appointed to oversee and monitor all measures taken to protect the aquatic environment;

ii. Ensure works area within waterbody does not become dry in an unmanaged fashion, killing fish or other aquatic species;

iii. Monitor the effectiveness of any installed silt control measures,

iv. Minimise increase silt levels, when removing control measures,

v. Manage site compounds and work area runoff effectively including wheel washing of transport;

vi. Minimise in-channel works and design temporary haul roads and crossing points effectively, to allow fish transition at all times;

vii. Management excavated spoil and dredge material effectively;

viii. Consider allowing river to return to background silt levels when required, use turbidity monitoring or other data manage effectively

ix. Ensure reporting procedure in place in the event of a pollution event;

14.5.2 Mitigation During Operation

14.5.2.1 Hydrology and Flood Risk Managements

No mitigation will be required during the operation of the scheme as the proposed scheme will improve the flow regime in the Avoca River towards the Irish Sea and the net impact is moderate medium-term significantly positive effect.

14.5.2.2 Water Quality

The proposed scheme will moderate medium-term positive impact on water quality in the Avoca River preventing flood waters from washing contaminants from land-based activities into the river and out to sea. Channel maintenance will be carried out within the river channel, sediment plume development will occur during this period. Accidental spills and leakages will be mitigated by measures already described above.

Provision of localised location for the removal of gravel and debris and carrying out the works during summer are positive mitigation measures. Gravel removal from the gravel trap will be limited to a maximum of 10 hours in a 24 hour period, as and when required. This will lead to a positive medium-term effect on water quality in the Avoca Estuary.

14.6 Monitoring

14.6.1 Monitoring During Construction

14.6.1.1 Hydrology and Flood Risk Management

The following monitoring will be carried out during the construction stages:

- Visual monitoring of river levels during instream work will be carried out in the morning, during midday and in the evening by observing the staff gauges at Arklow Bridge and the Dock. In the event that the Arklow Bridge gauge has to be removed temporarily to facilitate construction works, a temporary gauge will be established at the opposite (north) end of the bridge.

- Monitoring the weather forecast for heavy rainfall events and river water levels will be carried out twice daily.
- Monitoring of the tide forecast will be carried out twice daily.
- Advance monitoring of extreme weather conditions will also be carried out;

14.6.1.2 Water Quality

River water quality monitoring will be carried out for a period of twelve months in advance of the works to establish a baseline for water quality. Parameters to be monitored will include suspended solids, dissolved oxygen, temperature, pH, turbidity and BOD_5. During the course of the works, monitoring will be continued, and any significant changes will be investigated. Construction practices will be adjusted if found to be having an unacceptable negative impact on water quality.

Monitoring will be carried out both upstream of the proposed works and downstream to ensure that any changes in the levels of these parameters do not create an unacceptable condition for aquatic life in the river (Refer to **Section 14.3** for baseline water quality parameters). Monitoring will be carried out in the morning, midday, and mid-afternoon.

14.6.2 Monitoring During Operation

14.6.2.1 Hydrology and Flood Risk Management

There will be on-going recording of water levels in the Avoca river, to monitor any immediate change in flood risk and to provide a long-term assessment of any change in flood risk due to changes in climatic conditions and/or catchment characteristics.

14.6.2.2 Water Quality

On-going monitoring of water quality is proposed during the operation. It is envisaged that WCC and EPA will continue to monitor the water quality under the River Basin Management Plan in compliance with the Water Framework Directive after completion of the scheme.

During the maintenance operations which will involve works in the river and adjacent to it such as the channel maintenance dredging, debris and gravel trap maintenance, water quality monitoring will be carried out as described in Section 14.6.1 above.

14.7 Cumulative Effects

An assessment is presented in this section of the potential for likely significant direct and indirect cumulative effects of projects listed in **Table 20.1** in **Chapter 20**, *Cumulative and Interactive Effects* in combination with the proposed scheme.

The cumulative effects assessment is based on potential impacts on the hydrology regime, flood risk and water quality.

Circle K Safeway Service Station (20426)

This project relates to the demolition of the existing, and construction of a new, fuel forecourt at the existing Circle K service station, which is located immediately adjacent to Arklow Town Marsh and SC1 of the proposed flood relief scheme. Due to the nature of this scheme, there is potential for a cumulative water quality effect during the construction of the proposed scheme. Should the construction of this project proceed in parallel or overlap with the construction of the proposed scheme, this could give rise to short term, slight negative effects on water quality due accidental leak or spills which could be conveyed to Arklow Town Marsh via surface water run-off. However, the implementation of mitigation measures as described above will reduce these impacts to imperceptible temporary negative impacts.

Having regard to the imperceptible effect on water quality of the proposed scheme during both operation, no potential negative significant cumulative effect on water quality is identified during the operational and decommissioning phases of the proposed scheme and the Circle K project.

Irish Water Arklow, Co. Wicklow (SI201801)

This project relates to the development of a new Wastewater Treatment Plant at Ferrybank, Arklow. Due to the nature of this development, there is potential for a cumulative effect on hydrology, flood risk and water quality during the construction of the proposed scheme.

Based on the current programmes for the Arklow Wastewater Treatment Project (WwTP) and the Arklow Flood Relief Scheme (FRS), it is expected that the some of the construction works for both projects will take place in parallel. These are set out in **Table 14.8** below.

Table 14.8: Common Work Areas

Location	FRS Works	WWTP Works
River Walk	Flood defence walls Gravel & debris trap	Interceptor sewer
South Quay	Bridge Underpinning	Sheet-piled wall; Interceptor sewer
Ferrybank (site of WP1)	Bridge underpinning	Northern interceptor sewer; Tunnel shaft

The contemporaneous construction of both developments could exacerbate effects on the hydrological regime and flooding. However, a number of the construction activities which could impact on the hydrological regime and flooding are common to both developments and will be constructed either through the WwTP project or through the FRS project.

These include underpinning of the two southern arches of Arklow Bridge and the construction of the sheet piled wall and the associated temporary causeway in the river channel along River Walk and South Quay.

Also, the interceptor sewer on River Walk and South Quay will be constructed as part of the FRS if the scheme proceeds in advance of the WwTP.

Similarly, the water quality impacts associated with the works described above will arise through either the Wastewater Treatment Plant (WwTP) Project or the Flood Relief Scheme (FRS).

A memorandum of understanding agreement has been developed by both parties to manage construction activities for both WwTP and FRS.

The bridge underpinning works and the construction of the flood defences walls and stormwater drainage system along River Walk and South Quay will have a cumulative impact with the proposed sewer construction works for the Arklow WwTP and may generate the potential for direct and indirect slight temporary negative effects on hydrology and water quality of the Avoca River during construction. If FRS proceeds to carry out common works, the existing sewer outfalls will be maintained. This will have a short-term negative effect on water quality.

Other Projects listed

Other projects are listed in **Table 20.1** in **Chapter 20**, *Cumulative and Interactive Effects*. The development of these individual schemes will not result in a negative, likely significant, direct, indirect or cumulative effect when assessed in relation to the proposed works necessary during the construction and operational phases to deliver the Arklow Flood Relief Scheme from a hydrology, flood risk and water quality perspective. This is due to the nature of the proposed scheme and the proximity to all other permitted projects.

14.8 Residual Effects

14.8.1 Residual effects during construction

14.8.1.1 Hydrology and Flood Risk Management

With the implementation of the mitigation measures, a imperceptible temporary negative impact will occur during the construction of the first section of the bridge underpinning and new scour slab.

With the implementation of mitigation measures described in **Section 14.6.1,** it is expected that this residual risk can be effectively managed.

There will be no significant residual effect on hydrology and flood risk during construction.

14.8.1.1.1 Drainage

There will be no significant residual effect on drainage during construction.

14.8.1.2 Water Quality

With the implementation of the mitigation measures and monitoring measures described in **Section 14.5.1 and 14.6.1,** the residual effects on water quality will be imperceptible temporary negative during the construction of the proposed scheme and not cause any deterioration in the overall status of the water quality once the works are completed.

14.8.2 Residual effects during operation

14.8.2.1 Hydrology and Flood Risk Management

The hydraulic modelling of the proposed flood defences indicates an improved flow regime through Arklow Bridge by restricting flooding along Ferrybank and Dublin Road and along River Walk and South Quay and adjoining streets.

All 19 arches of Arklow Bridge will be underpinned and lowered by 1m which will mitigate against rise in flood levels upstream of the Avoca Bridge. Channel dredging for 560m upstream and 360m downstream of Arklow Bridge by 1m will also improve the flow regime. Flood defences along North Quay within the Arklow Town Marsh will mitigate flooding of properties along Ferrybank and Dublin Road. Therefore, there will be an overall significant reduction in the existing flood risk following construction of the proposed scheme which will be a moderate medium to long term positive effect.

During operation, river flow will be confined in-channel with a freeboard allowance of 300mm to 600mm above the design flood level for flood defences along River Walk and South Quay on the south bank and along the marsh on the north bank. Therefore, a significant positive residual impact on flood risk is expected during operation of the proposed scheme.

14.8.2.2 Water Quality

During operation, the proposed scheme will convey fluvial flow (including surface water run-off) in-channel towards the Irish Sea. Through reducing flood risk along north and south bank, pollutants from adjacent properties will not be conveyed to the Avoca River thereby providing a slight short-term positive impact. The collection of sediment at the gravel trap upstream of the Arklow Bridge will allow sediment to be removed at a single controlled location which will have a slight short-term negative impact. Maintenance dredging of the channel will be occasionally required. It is expected that this activity will have a short-term negative impact.

It should be noted that the sheet pile wall constructed as part of the proposed scheme will also serve as advance works for the interceptor sewers to be built as part of the proposed Arklow WwTP Project.

It is recognised that once constructed, the proposed Arklow Wastewater Treatment Plant Project would bring about further positive, cumulative effects on water quality.

Overall:

- the residual effect on surface water quality of the affected surface water bodies will be short-term positive impact from the operation of the proposed scheme;
- the scheme will not cause any medium or long-term deterioration in either the overall status or the status of each individual quality element of the relevant water bodies;
- the scheme will not prevent the RBMP objective of protecting/enhancing/restoring the affected water bodies to Good Status and in fact will assist in reaching this objective.

14.9 References

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