

**UISCE ÉIREANN**

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**Carlingford Lough Shellfish Water Impact  
Assessment**

**Summary Report**

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**Intertek Metoc**

Exchange House, Station Road, Liphook, Hampshire GU30 7DW, United Kingdom

## DOCUMENT RELEASE FORM

### Uisce Éireann

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Carlingford Lough Shellfish Water Impact Assessment

Summary Report

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# SUMMARY

## Introduction

Discharges from Uisce Éireann and Northern Ireland Water (NI Water) assets to inland freshwater and coastal waters are a source of bacterial load and potentially a contributing factor towards a failure to meet Water Framework Directive (WFD) requirements. The WFD target is to achieve "Good" status in all waterbodies by 2027 and there is currently no readily available method to disaggregate the sources of pollution contributing to less than "Good" status.

There is an increasing frequency of shellfish flesh quality samples from Carlingford Lough that are failing to meet Shellfish Waters Class B minimum requirements. Wastewater assets are a potential polluter that could be contributing to failure to meet water quality requirements.

SWELL (Shared Waters Enhancement and Loughs Legacy) was a €35M EU funded project, which consisted of a cross-border partnership comprising NI Water, Uisce Éireann, Loughs Agency, East Border Region and the Agri-Food and Biosciences Institute (AFBI), working collaboratively to improve water quality within the shared waters of Carlingford Lough and Lough Foyle.

For Carlingford Lough, a survey/sampling programme was undertaken, and a coastal model and a river/catchment model were built, calibrated and validated under the SWELL project. Outputs from the SWELL project were then used to assess the impact of Uisce Éireann and NI Water assets on the Carlingford Lough designated shellfish water (SFW) as part of NI Water's Integrated Environmental Modelling (IEM) Programme and as a Stage 4B Cumulative Impact Assessment under Uisce Éireann's Shellfish Assessment Programme. It was agreed that the IEM framework would address the needs for both NI Water and Uisce Éireann.

The Carlingford SFW impact assessment was carried out as a joint venture between Uisce Éireann and NI Water, initially to determine the impacts of continuous and intermittent wastewater discharges on the bacterial water quality in Carlingford Lough with respect to the regulatory framework in Northern Ireland. Intertek Metoc was commissioned to carry out the impact assessment by NI Water and as such, the initial report was prepared for NI Water and focussed primarily on NI Water requirements. Intertek was subsequently commissioned by Uisce Éireann to prepare the present report which focusses on Uisce Éireann's assessment framework / metrics.

It should be noted that Uisce Éireann refers to Storm Water Overflows (SWO) instead of combined sewer overflows (CSO), and wastewater treatment plants (WwTP) instead of wastewater treatment works (WwTW). In this report, both NI Water and Uisce Éireann terms are used depending on the ownership of the asset.

The Carlingford Lough SFW classification has varied from Class A to Class C between monitoring points since 2012. The focus of this study was to assess the impact of Uisce Éireann and NI Water assets on the SFW. Furthermore, this study also examines the impact of recent improvements at Omeath and population growth at Carlingford and Greenore on SFW quality. A pre-2024 baseline assessment was carried out with four Uisce Éireann assets (Carlingford WwTP, Greenore WwTP and two continuous discharges of untreated sewage associated with the Omeath agglomeration). NI Water assets discharging to Carlingford Lough (or its watercourses) were also included. These include 11 WwTWs and 67 intermittent discharges (wastewater pumping stations (WwPS) / CSOs). An additional post-2024 baseline assessment was also carried out in which the two untreated Omeath discharges were replaced with an ultra-violet (UV) treated discharge from the new Omeath WwTP which began operation in 2024. The post-2024 baseline scenario also accounts for increased capacity at Carlingford WwTP and Greenore WwTP and therefore represents the current operational status of Uisce Éireann assets in Carlingford Lough.

The Carlingford SFW Impact Assessment was undertaken by Intertek Metoc using STORM-OPTIMISER (S-O). S-O is a bespoke bacterial impact assessment tool which applies a 'unit impact' approach, this being the most widely adopted approach in Ireland and the UK. The 'unit impact' technique, originally developed by the Water

Research Centre in the UK and subsequently adopted in the Urban Pollution Management (UPM) manual, establishes source-to-receiver relationships under a wide range of environmental conditions supported by the simulation of a large number of model scenarios.

In addition to S-O, the SFW impact assessment used a range of modelling tool inputs developed under the SWELL project, including: Soil and Water Assessment Tool (SWAT) river models of the Newry River and its tributaries to provide pollutographs representing the diffuse runoff load; sewerage network models of the Carlingford Lough urban catchments providing 10-year spill hydrograph output in response to rainfall condition; a Delft 3D coastal hydrodynamic model; and a Delft 3D coastal water quality model. There are numerous potential sources of pollution, including wastewater assets – a total of four Uisce Éireann assets and 89 other discharges representing NI Water point source assets, rivers, streams and septic tanks were included in the assessment.

The bacterial water quality model was verified within Carlingford SFW using project-specific and historical water quality sampling data taken at a number of sampling locations. The predicted water quality results were compared to the historical water quality sampling data. To ensure the modelled results were as robust as possible, sensitivity testing was undertaken to examine the response of the predicted SFW performance by changing key parameters that are known to vary naturally (such as decay rates). This stage is used in the modelling to help understand and reduce uncertainty which might be associated with particular inputs. As the number of possible sensitivity scenarios is almost limitless, a finite set of sensitivity scenarios has been applied in this assessment which covers decay rates, WwTW / CSO and septic tank concentrations, and river loads.

Model predictions relating to the Shellfish Water Protected Area (SWPA) are summarised below:

- The majority of the SWPA meets the UPM target SFW quality standards (geomean concentration of 110 EC/100 ml and a 97<sup>th</sup> percentile concentration of 1500 EC/100 ml).
- Sensitivity tests show that predictions at most sites are sensitive to decay rate, and changes in WwTW and CSO concentrations.
- Sites AP08 and AP09 are particularly sensitive to Cranfield WwTW FE concentration. Site AP12 is particularly sensitive to the Carlingford WwTW FE concentration.
- Sites AP05 and AP06 are particularly sensitive to the concentration applied to the untreated discharges from Omeath (pre-2024).

It is noted that the majority of the SWPA is predicted to meet both the geomean and 97<sup>th</sup> percentile SFW quality standards. A small area of higher impact is located near Omeath in the pre-2024 scenario. This area is predicted to exceed the SFW Class B water quality threshold concentration in both the surface and the bottom layer. However, this area of elevated impact is not predicted in the post-2024 scenario, following the construction of a UV treated WwTP at Omeath.

The model results predict another area of elevated impact in the Newry River. However, this area is located outside the SWPA and is therefore not subject to the SFW standards. Overall, the model predictions are generally consistent with the water quality sampling data and the Shellfish Flesh Classifications.

The Baseline results quantify Uisce Éireann's current impact on the SFW. The modelling can also be used to assess future impacts based on population growth and to prioritise / target future investments.

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## GLOSSARY

### ADCP

Acoustic Doppler Current Profiler

### AFBI

Agri-Food and Biosciences Institute

### BW

Bathing Water

### CI

Confidence Interval

### CSO

Combined Sewer Overflow

### CTD

Conductivity-Temperature-Depth

### DAERA

Department of Agriculture, Environment and Rural Affairs

### DAP

Drainage Area Plan

### DO

Dissolved Oxygen

### EPA

Environmental Protection Agency

### EC

*Escherichia coli* (*E. coli*)

### EQS

Environmental Quality Standard

### EU

European Union

### FE

Final Effluent

### FFT

Flow to Full Treatment

### FWR

Foundation for Water Research

### GEBCO

General Bathymetric Chart of the Oceans

### ICM

Integrated Catchment Model

### IEM

Integrated Environmental Modelling

### LLE

Longline Environment

### MPN

Most Probable Number

### NIEA

Northern Ireland Environment Agency

### NI Water

Northern Ireland Water

### PE

Population Equivalent

### SFPA

Sea-Fisheries Protection Authority

### SFW

Shellfish Water

### SMILE

Sustainable Mariculture in Northern Irish Sea Lough Ecosystems

### SO

STORM-OPTIMISER

### SRP

Soluble Reactive Phosphorus

### SWAT

Soil and Water Assessment Tool

### SWELL

Shared Waters Enhancement and Loughs Legacy

### SWO

Surface Water Overflow

**SWPA**

Shellfish Water Protected Area

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**TP**

Total Phosphorus

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**UPM**

Urban Pollution Management

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**UV**

Ultraviolet

---

**WFD**

Water Framework Directive

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**WwPS**

Wastewater Pumping Station

---

**WwTP**

Wastewater Treatment Plant

---

**WwTW**

Wastewater Treatment Works

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**UE**

Uisce Éireann

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**UKHO**

UK Hydrographic Office

# 1. INTRODUCTION

## 1.1 Integrated Environmental Modelling

Discharges from Uisce Éireann and Northern Ireland Water (NI Water) assets to shared freshwater and coastal waters are a source of bacterial load and potential contributing factor towards a failure to meet Water Framework Directive (WFD) requirements.

The WFD target is to achieve "Good" status in all waterbodies by 2027 and there is currently no readily available method to disaggregate the sources of pollution contributing to less than "Good" status.

There is an increasing frequency of shellfish flesh quality samples from Carlingford Lough that are failing to meet Shellfish Waters Class B minimum requirements. Wastewater assets are a potential polluter that could be contributing to failure to meet water quality requirements.

The Carlingford SFW impact assessment was carried out as a joint venture between Uisce Éireann and NI Water, initially to determine the impacts of continuous and intermittent wastewater discharges on the bacterial water quality in Carlingford Lough with respect to the regulatory framework in Northern Ireland. Intertek Metoc was commissioned to carry out the impact assessment by NI Water and, as such, the initial report was prepared for NI Water and focussed primarily on NI Water requirements. Intertek was subsequently commissioned by Uisce Éireann to prepare the present report which focusses on Uisce Éireann's assessment framework / metrics.

The impact assessment for Carlingford Lough was commissioned by NI Water as part of its Integrated Environmental Modelling (IEM) Programme. However, it was agreed that the IEM modelling framework would also address the needs of a Stage 4B Cumulative Impact Assessment under Uisce Éireann's Shellfish Assessment Programme.

NI Water's IEM Programme provides an evidence-based decision-making approach to the identification of catchment pressures and environmental needs, so that improvement measures to tackle wastewater and diffuse agricultural pollution can be more sustainably and effectively targeted to meet environmental requirements at proportionate cost – a catchment scale solution to a catchment wide issue.

The IEM Programme for NI Water is based on the three pillars:

- **Protect** against flooding by managing the flow of water through a catchment from source to sea (in accordance with the aims of the European Union (EU) Floods Directive);
- **Enhance** the environment through effective wastewater management and provision of enhanced blue / green spaces to benefit local communities (to comply with environmental legislation, specifically the EU Urban Wastewater Treatment Directive and EU WFD); and
- **Grow** the economy by providing necessary capacity in drainage and wastewater management systems to facilitate new construction projects and lift developmental constraints.

The IEM Programme aims to investigate, identify and deliver sustainable asset solutions that maximise capital and operational efficiencies across the asset investment portfolio. Secondary benefits can include use of the models to inform consenting policy (in close liaison with the Northern Ireland Environment Agency (NIEA), the Department of Agriculture, Environment and Rural Affairs (DAERA) and the Environmental Protection Agency (EPA)) and other associated drivers such as scenario investigations for abstraction and the promotion and development of sustainable catchment solutions which reduce flows and energy costs.

The IEM Programme comprises the alignment and integration of core modelling work streams: river catchment models, hydrodynamic (coastal/lake) models and Drainage Area Plan (DAP) sewerage

network models. Model outputs of discharges across Ireland and Northern Ireland enable assessment of Uisce Éireann's and NI Water's impact on coastal and freshwater catchments and provide the evidence base for determination of environmental needs to meet WFD requirements.

The key modelling drivers for NI Water's IEM Programme are summarised as follows:

**Legislative Obligations** – The WFD allows for decision making at a catchment level for administering the “Polluter Pays Principle”. The IEM Programme allows for this source apportionment of pollution from wastewater, agriculture, and industry to facilitate management decisions at a wider stakeholder level.

The key objectives of the WFD are to:

- Prevent deterioration in the classification status of aquatic ecosystems, protect them and improve the ecological condition of waters.
- Aim to achieve at least good status for all waters by 2015. Where this is not possible, good status should be achieved by 2021 or 2027 (if technically feasible and not disproportionately costly).
- Promote sustainable use of water as a natural resource.
- Conserve habitats and species that depend directly on water.
- Progressively reduce or phase out releases of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment.
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants.
- Contribute to mitigating the effects of floods and droughts.

**Evidence Based Decision Making** – The IEM Programme incorporates evidence gathering to enable source apportionment and achievement of water quality targets through identification of the most appropriate and cost-effective combination of measures (wastewater/agricultural). This will facilitate value for money and sustainable delivery for those who pay for water services as is the ethos of the WFD.

**Collaboration** – The WFD fosters collaboration between all catchment stakeholders in order to sustainably manage water resources at a river basin scale. This approach can also help to advise other agencies and departments through the River Basin Management Planning process as models will be held and maintained through public sector bodies. This collaboration extends to 2D flood risk capability and proactively identifying and managing strategic growth zones through supporting forums such as Integrated Drainage Investment Plans, led by the Department for Infrastructure.

**Flexibility & Transparency** – The IEM Programme provides evidence to multiple stakeholders and aids transparency of the water order consenting process. This is with a view to moving away from unnecessarily stringent or prescriptive standards towards evidence-based decision making based on discharge impact and cost beneficial asset improvements.

**Sustainable & Proportionate** – The ultimate goal of the modelling strategy is to advise the capital works programme through a transparent and accountable decision-making process that engages multiple stakeholders. This ensures that the asset improvements delivered are proportionate to environmental needs and are undertaken in a sustainable manner. The strategy can also accommodate alternative approaches such as catchment wide permitting and offsetting through nutrient/faecal balancing.

It is the purpose of this document to set out the IEM Programme approach adopted for the Carlingford catchment, including summaries of water quality sampling campaigns, individual modelling components, model integrations, calibration and validation, model assurances and modelled baseline environmental assessments. This IEM approach, developed for and applied on behalf of NI Water,

also addresses the needs of a Stage 4B Cumulative Impact Assessment under Uisce Éireann's Shellfish Assessment Programme.

## 1.2 SWELL

SWELL (Shared Waters Enhancement and Loughs Legacy) was a €35M EU funded project, which consisted of a cross-border partnership comprising Uisce Éireann, NI Water, Loughs Agency, East Border Region and the Agri-Food and Biosciences Institute (AFBI), working collaboratively to improve water quality within the shared waters of Carlingford Lough and Lough Foyle.

The SWELL partnership utilised best practice, innovation and knowledge sharing to effectively achieve the outputs and results of the INTERREG VA Programme. Through engineering excellence, strategic catchment investigation and modelling, SWELL delivered sustainable upgrades to wastewater assets on both sides of the border in order to make a positive contribution towards achieving the Good Ecological Status under the EU WFD.

The SWELL project had three key outputs:

- Provide improved wastewater treatment for an additional 10,000 population equivalent (PE);
- Develop and deliver two sewerage network and wastewater treatment projects in Carlingford Lough and Lough Foyle, to improve water quality in shared transitional waters;
- Develop an ecosystem legacy model that can be used to drive future improvements to ecology and WFD water quality.

The project consisted of several key activities, including catchment studies, ecosystem modelling and capital upgrades (construction packages). Wastewater asset upgrades delivered improvements to wastewater assets in Ireland and Northern Ireland.

Business Cases, developed during Phase 1 of the project, identified a need for capital upgrades to be carried out at the following wastewater assets within the Carlingford Lough catchment to meet the target outputs for improved wastewater treatment. These sites, identified in advance of the modelling process, were assessed as having the greatest potential to improve water quality within the catchment. Details of the construction packages are as follows:

- Warrenpoint Wastewater Treatment Works (WwTW) – construction of new inlet works and secondary treatment to address overloading and potential loss of untreated wastewater to Carlingford Lough.
- Newpoint Wastewater Pumping Station (WwPS) – installation of a new coarse screen on the incoming sewer and new overflow fine screens to reduce the impact of storm water spilling to the adjacent Newry River.
- Omeath network improvements – upgrade in capacity of the sewer network to transfer more wastewater to a new WwTW designed by UE outside of SWELL. Note, these improvements were completed in 2024. The upgraded network includes surface water separation and redirection of storm flows.

## 1.3 Modelling Framework

The modelling framework consisted of the integration of river catchment models, coastal models and DAP models to assess Uisce Éireann's and NI Water's impact on the designated shellfish water (SFW) within Carlingford Lough. The modelling was also used to determine impacts on the designated bathing water at Cranfield. However, as this bathing water is in Northern Irish waters, only the results for the SFW assessment have been included in the present report.

The modelling will be used to inform sustainable asset planning through apportionment of bacterial and nutrient loading contributions from wastewater and agricultural sources in line with the “polluter pays principle” within the WFD.

The fundamental models (coastal, river and DAP) were developed under the SWELL project. Outputs from these models were provided for use in the Carlingford IEM study.

The IEM study followed best practice approaches and was consistent with other modelling studies undertaken by Uisce Éireann and NI Water.

A modelling framework was needed to understand and assess the environmental conditions for the Carlingford IEM. It is the purpose of the present document to set out the specific approach adopted for Carlingford, including summaries of water quality sampling campaigns, individual modelling components, model integrations, calibration and validation, model assurances and modelled Baseline environmental assessments.

## 1.4 Modelling Tools

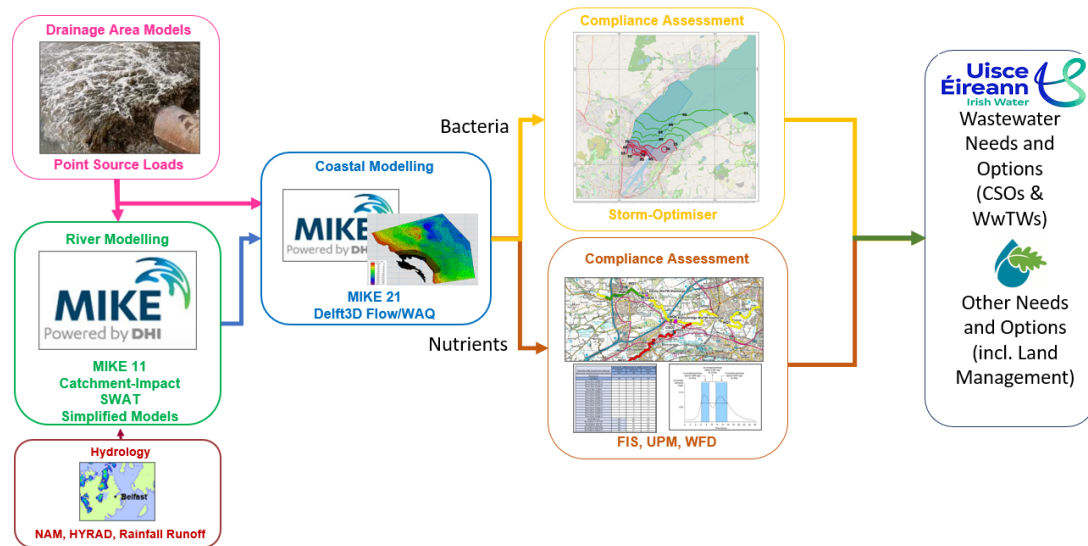
The modelling framework for the Carlingford SWELL and IEM study comprised the following modelling tools:

- InfoWorks Integrated Catchment Model (ICM) – urban drainage area modelling platform that simulates the response of the sewerage networks to rainfall by prediction of spill volume and frequency of intermittent discharges from consented overflows.
- Delft 3D Flow Model / Water Quality Model – hydrodynamic three dimensional (3D) marine modelling platform used to simulate tidal, wind and ocean currents and water quality model capable of simulating the advection and dispersion of discharged pollutants.
- SWAT (Soil and Water Assessment Tool) – river model used to simulate river flows and water quality, and to predict the environmental impact of land use, management practices and climate change.
- STORM-OPTIMISER (S-O) – Intertek Metoc-developed bacterial impact assessment tool to evaluate the impact of continuous and intermittent discharges on sensitive receivers. It allows the full assessment of bacterial impacts from multiple sources under a range of environmental conditions (e.g., tide and wind frequency conditions). It applies a ‘unit impact’ approach, originally developed by the Water Research Centre in the UK and subsequently adopted in the Urban Pollution Management (UPM) manual.

The integration of the above modelling tools was a complex operation requiring specialised expertise to effectively mimic SFW impact.

Each of the individual component models was calibrated and validated against appropriate field data prior to integration into the modelling system which is capable of optimising potential solutions to achieve the required SFW performance. Figure 1-1 details the SWELL and IEM modelling framework used for Carlingford Lough.

Figure 1-1 Modelling Framework



## 1.5 Carlingford IEM Reports

The Carlingford IEM was developed in three phases: the river models, the coastal models, and the impact assessment model. Each phase has a model build / calibration / validation report and a corresponding assurance / audit report. Table 1-1 provides a summary of these reports.

Intertek Metoc was appointed to assess water quality impacts on the Carlingford Lough designated SFW. This assessment investigated the impact of Uisce Éireann and NI Water asset operations on SFW performance using a combination of monitoring data, coastal and river numerical models, DAP models and advanced impact assessment tools.

AFBI, with Longline Environment (LLE), constructed the underpinning coastal and river models of the study area as part of SWELL. Intertek Metoc undertook an independent review of these models, and has used these models, together with outputs from DAP models of the sewerage networks, to undertake the impact assessment. RPS has undertaken an independent review of the impact assessment.

The present report includes a summary of the river and coastal models, but for full details of their development, calibration and validation the specific modelling reports listed in Table 1-1 should be consulted

Table 1-1 Carlingford Modelling Reports

Phase	Report Type	Model / Report Developer
<b>River Modelling</b>		
SWAT model application Carlingford catchment (Longline Environment, 2022)	Cal / val	Longline Environment
Carlingford SWAT Quantity Model Calibration (Intertek, 2022)	Audit	Intertek Metoc
<b>Coastal Modelling</b>		
SWELL Carlingford Hydrodynamic CalVal Report (Longline Environment, 2018)	Cal / val	Longline Environment

Phase	Report Type	Model / Report Developer
Review of the Carlingford Lough Delft3D-FLOW Model Build, Calibration and Validation (Intertek, 2024a)	Audit	Intertek Metoc
<b>Impact Assessment (NI Water IEM)</b>		
Shellfish Water and Bathing Water Bacteria Compliance Assessment (Intertek, 2024b)	Cal / val	Intertek Metoc
In progress	Audit	RPS

## 1.6 Modelling Assurance

The modelling framework approach included the commissioning of independent specialists to oversee modelling and provide assurance in relation to the developed models.

Table 1-2 sets out the assurer appointed for each of the modelling components. Individual assurance reports are available and should be read in conjunction with the individual modelling reports (for example, as listed in Table 1-1).

**Table 1-2 Carlingford Modelling Assurance**

Model	Modeller	Assurer
Drainage Area Plans – InfoWorks ICM	Atkins, RPS, AECOM	Atkins, RPS
River model – SWAT	Longline Environment	Intertek Metoc
Coastal model – Delft 3D hydrodynamic module	Longline Environment	Intertek Metoc
Impact assessment	Intertek Metoc	RPS

## 1.7 Modelling Objectives

A comprehensive assessment has been undertaken to provide an improved understanding of the impact and connectivity between Uisce Éireann and NI Water asset operations and SFW water quality. This information will allow Uisce Éireann (and NI Water) to understand the role of its assets in SFW performance in Carlingford Lough, and ultimately its role in affecting performance against statutory or policy thresholds.

Thus, the purpose of this impact assessment is:

- To better understand the impact of, and connectivity between, operation and management of Uisce Éireann and NI Water assets and SFW quality standards.
- To inform and influence Uisce Éireann and NI Water asset management and capital investment decisions through improved information and sound scientific evidence of cause and effect.
- To provide Uisce Éireann and NI Water with asset management data to better deliver effective management strategies for coastal assets, and other assets identified as having significant impact on SFW performance.

## 2. CATCHMENT DESCRIPTION

### 2.1 Geography and Land Use

Carlingford Lough is a sea lough, located between County Louth in Ireland and Counties Armagh and Down in Northern Ireland. It is approximately 15 km long and 3.7 km at its widest point. The Lough covers an area of 50 km<sup>2</sup> and has an associated drainage catchment of circa 475 km<sup>2</sup>.

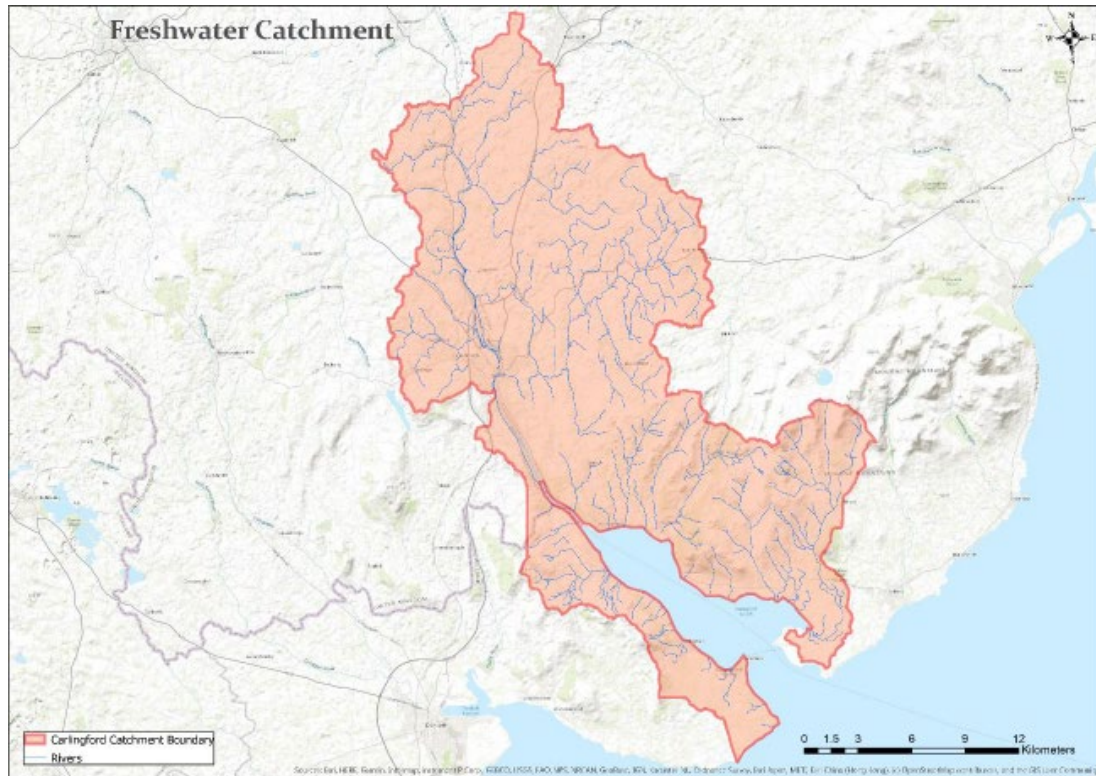
The diversity of coastal habitats and the species present in the habitats of Carlingford Lough have made it of international importance, and as such, several areas within the Lough are designated as protected sites. Carlingford Lough is also used for a variety of water sports, recreational fishing and bird / nature watching.

The southern shore of the Lough consists of extensive expanses of intertidal flats, interrupted by reefs, shingle deposits and saltmarsh. The northern shore of the Lough mainly consists of intertidal mudflats. The Lough is generally shallow, with an average water depth of approximately five metres CD. The maximum water depth is 36 m. The north-western area of the Lough has shallower depths and weaker currents compared to the outer (south-eastern) parts.

The Newry (Clanrye) River is the main freshwater input into the Lough. The river has a drainage catchment of over 300 km<sup>2</sup> and falls within the Neagh Bann River Basin District. Land in the vicinity of the Lough supports different types of forest, belts of pasture, natural grassland, moors, heath lands and agricultural areas. However, the catchment is primarily of agricultural land use with a number of small, isolated urban settlements.

The Carlingford IEM framework includes river models for the Newry River catchment and other smaller watercourses draining to Carlingford Lough as shown in Figure 2-1. The modelling work included the calibration of bacterial water quality river models. The bacteriological river models combine inputs from agriculture, septic tanks, and Uisce Éireann and NI Water assets to establish resulting bacteriological levels at the downstream limits of the models to inform subsequent marine impact models.

Figure 2-1 Carlingford Lough Catchment



## 2.2 Wastewater Sources

### 2.2.1 Uisce Éireann and NI Water Assets

The main urban areas within the Carlingford Lough catchment are located within Northern Ireland, namely Newry City which has a population of over 27,000, Warrenpoint with a population of approximately 7,000, and Rostrevor with a population of approximately 2,500. Within Ireland, the main urban centres are Carlingford with a population of circa 650 and Omeath with a population of circa 450.

There are 14 WwTWs within the Carlingford catchment (11 NI Water and three Uisce Éireann), which continuously discharge treated effluent to adjacent waterbodies. Note that Omeath Wastewater Treatment Plant (WwTP) only began operation in 2024. Prior to this discharges from Omeath were released via two Combined Sewer Overflow (CSO) associated with the Omeath agglomeration.

There are a substantial number of other intermittent discharges from storm storage tanks, CSOs and pumping station emergency overflows situated within the Carlingford catchment that discharge dilute wastewater during periods of heavy rainfall which could be impacting on water quality.

It should be noted that Uisce Éireann refers to Storm Water Overflows (SWO) instead of CSOs. However, as the original impact assessment was commissioned by NI Water, the term CSO is used to ensure consistency between the various reports.

Design and current loading data relating to the main WwTWs are provided in Table 2-1. The locations of the Uisce Éireann assets within the Carlingford Lough catchment are shown in Figure 8-1 for the pre-2024 configuration and Figure 8-2 for the post-2024 configuration. The locations of the NI Water assets within the Carlingford Lough catchment area are shown in Figure 8-4.

**Table 2-1 WwTW Discharges within the Carlingford Lough Catchment**

Treatment Works	Treatment Level	Receiving Water	Design PE	Actual PE	Notes
Annalong WwTW	Primary	Irish Sea	5,000	3,421	
Attical Tullyframe WwTW	Secondary	White Water	359	201	
Carlingford WwTP *	Secondary	Carlingford Lough	2,444		
Cranfield New WwTW	Secondary	Carlingford Lough	180	183	
Cranfield WwTW	Secondary	Carlingford Lough	1,000	4,140	
Glen Villas WwTW	Secondary	Jerretspass River	200	163	
Greenore WwTP *	Primary	Knocknagoran	112	500	
Kilkeel WwTW	Secondary	Kilkeel River	16,000	14,497	
Lurganare WwTW	Secondary	Newry River	403	407	
Mullaghglass Newry WwTW	Secondary	Bessbrook River	200	168	
Newry WwTW	Secondary	Newry Canal	115,000	58,886	
Poyntzpass WwTW	Secondary	Newry Canal	730	816	
Rathfriland Drumlough WwTW	Secondary	Clanrye River	4,000	3,977	
Warrenpoint WwTW	Secondary	Clanrye River	16,195	17,361	
Omeath WwTP *	UV	Carlingford Lough	863		Began operation in 2024

\* Uisce Éireann asset.

### 2.2.2 Septic Tanks

Septic tank flows and concentrations were calculated based on a series of predetermined sub-catchments. The discharges from each septic tank sub-basin were applied as a distributed input to the model along the reach which flows through each sub-basin. This approach was applied for both the Irish and Northern Irish septic tanks.

## 2.3 Agricultural Sources

Land use within the Carlingford catchment is predominantly rural in character. The 2012 sanitary Survey reported that agricultural land use comprised 68% of the catchment area. The latest available Farm Census Data for 2017 is presented in Figure 2-2 to Figure 2-5.

Figure 2-2 Agricultural Census Data: Poultry

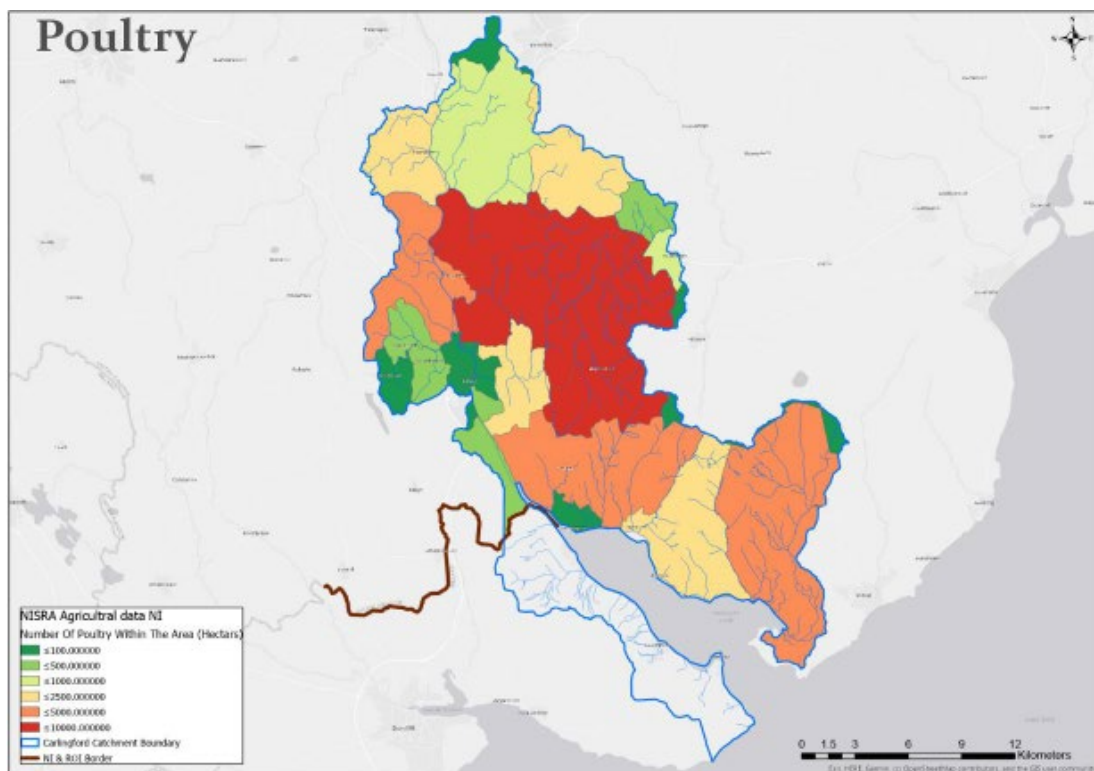


Figure 2-3 Agricultural Census Data: Pigs

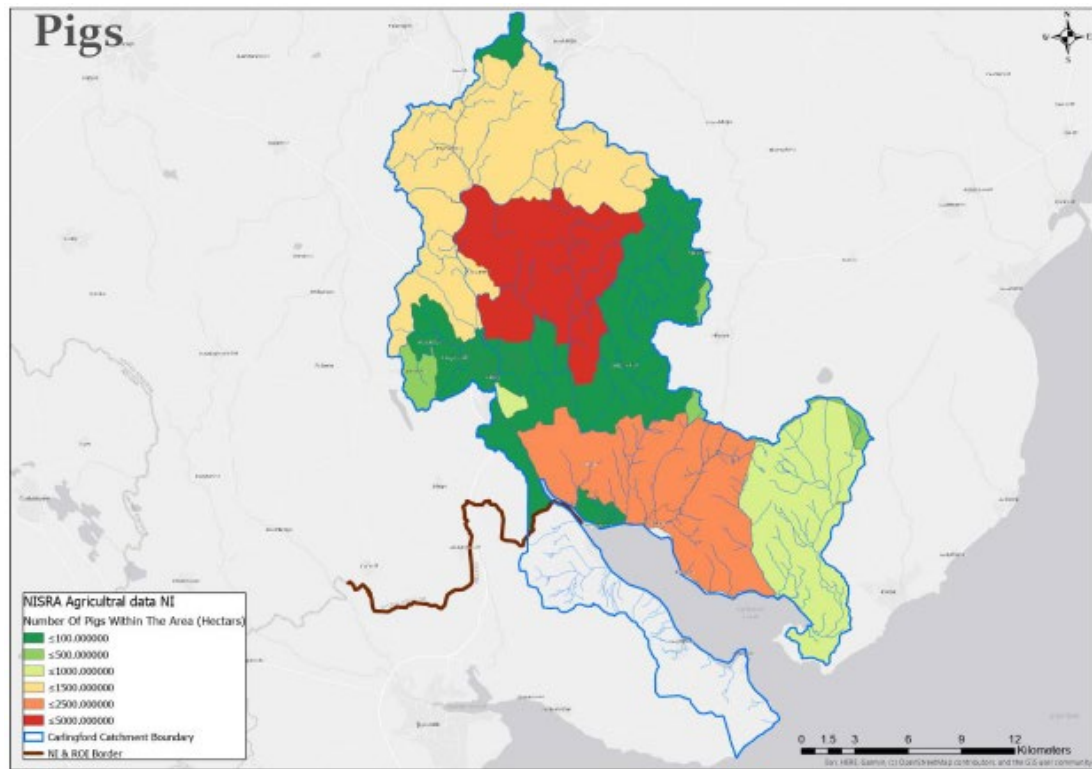


Figure 2-4 Agricultural Census Data: Cattle

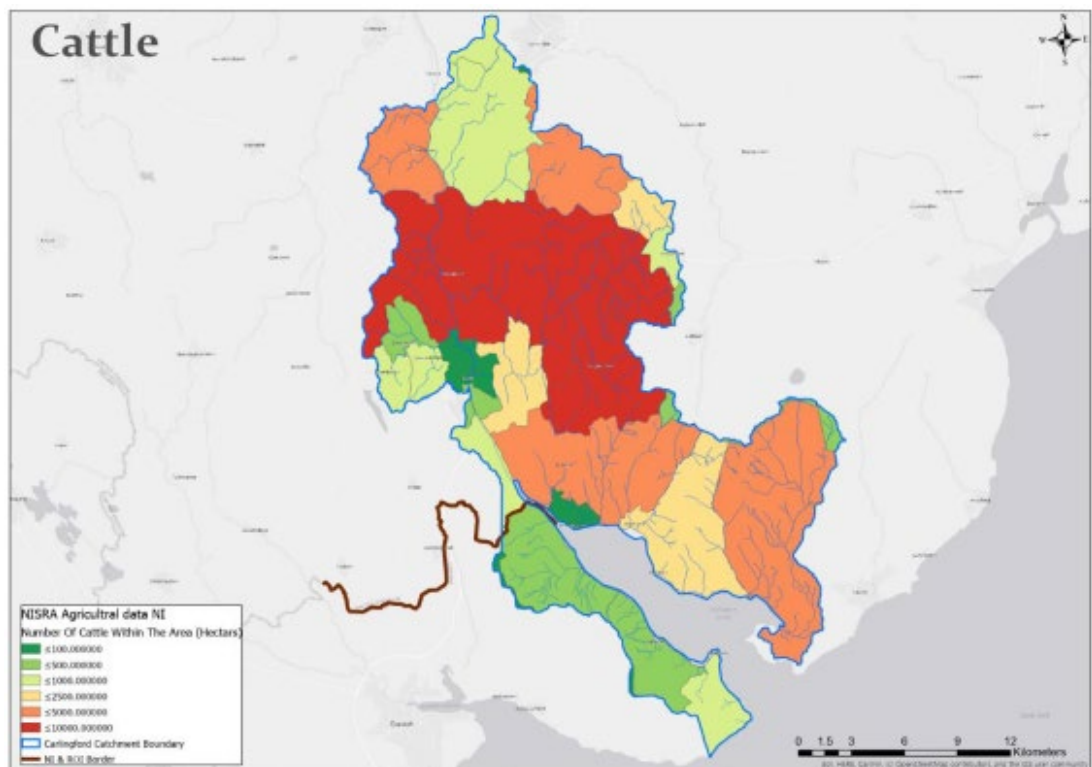
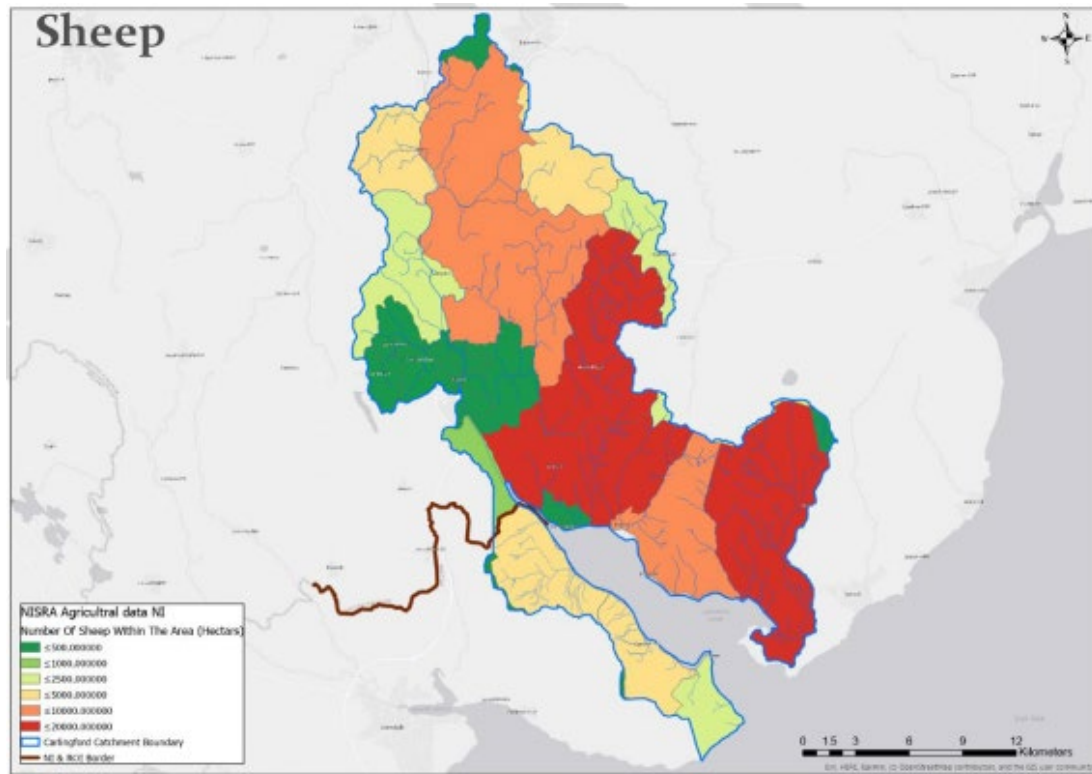


Figure 2-5 Agricultural Census Data: Sheep



## 2.4 Environmental Designations and Sensitive Areas

There are a number of EU Directives and legislation applicable to water bodies in Ireland and Northern Ireland, together with relevant environmental policies and/or guidance. While these are applicable to all member states, each member state implements its own legislation. The relevant legislation for assessing shellfish water quality is as follows:

- European Communities (Quality of Shellfish Waters) Regulations 2006 (S.I. No. 268 of 2006) (as amended) – provides Mandatory and Guide Values for a range of parameters in Schedule 2 and 4 respectively for shellfish waters;
- Regulation (EC) No 854/2004 (as amended) – lays down specific rules for the organisation of official controls on products of animal origin intended for human consumption and sets limits in Annex II for *E. coli* (EC) in live bivalve molluscs which are used by the Sea-Fisheries Protection Authority (SFPA) to classify live bivalve mollusc production and relaying areas;
- Commission Regulation (EC) No 2073/2005 (as amended) – lays down microbiological criteria in Annex I for certain micro-organisms in foodstuffs intended for human consumption, including bivalve molluscs;
- Commission Regulation (EC) No 1881/2006 (as amended), transposed into Irish law by the European Communities (Certain Contaminants in Foodstuffs) Regulations 2010 (S.I. No. 218 of 2010) – prescribes maximum concentrations in the Annex of contaminants in foodstuffs for human consumption, including bivalve molluscs.

The focus of this study is assessment of performance against the European Communities (Quality of Shellfish Waters) Regulations 2006 (S.I. No. 268 of 2006) (as amended) i.e. Shellfish Waters Directive. It should be noted that the Shellfish Water Directive (2006/113/EC) was repealed by the Water Framework Directive (2000/60/EC) on 22 December 2013. Therefore, the topic of performance against the requirements of the Shellfish Waters Directive should be subsumed within the issue of

performance of water bodies under the WFD. Nevertheless, and despite the repeal of the Shellfish Waters Directive, the Irish legislation which transposed the Shellfish Waters Regulations (S.I. No. 268) of 2006 into domestic law remains in force and the EPA considers that the standards specified in the shellfish regulations are the most appropriate for use at present.

#### 2.4.1 Carlingford Lough Shellfish Water

The designated shellfish area within the Lough covers roughly 37 km<sup>2</sup>, of which 12 km<sup>2</sup> is in Republic of Ireland water and 25 km<sup>2</sup> is in Northern Irish waters (see Figure 2-6). The licensed shellfish sites cover an area of 10.2 km<sup>2</sup>. Pacific oysters and mussels are the dominant species.

The northern shore of Carlingford Lough is licensed for mussels and oysters, whilst the southern shore is licensed for oysters, mussels and clams.

As with other water bodies, the Lough is impacted by pollution from various sources such as agricultural run-off and discharges from WWTWs. Legislation seeks to reduce the input pollution to water bodies and reduce uptake of contaminants in the shellfish flesh.

There is no mandatory value in Schedule 2 of the Shellfish Water Regulations 2006 to define shellfish water quality. However, a guide value of  $\leq 300$  faecal coliforms/100 ml shellfish flesh or intervalvular fluid is included in Schedule 4 of these Regulations. To meet the Shellfish Regulations, 75% of samples for faecal coliforms must be  $< 300$  MPN/100 ml (MPN = Most Probable Number). The SFPA does not assess shellfish quality in terms of faecal coliforms, but rather assesses on an EC/100 g shellfish flesh and intervalvular fluid basis. The SFPA takes a value of  $\leq 230$  EC MPN/100 g to be equivalent to the guide value of  $\leq 300$  faecal coliforms/100 ml (Marine Institute (2013), DOE Marine Division (2014)). The  $\leq 230$  EC MPN/100 g value corresponds to a Class A shellfish production area as classified by the SFPA. An overview of the SFPA classification approach is presented in Table 2-2.

Note there is no in-water environmental quality standard (EQS) for the determination of Designated Shellfish Water Quality. However, to assess whether agglomerations are impacting Designated Shellfish Waters, an in-water proxy EQS value is required. In the absence of a regulatory standard, Uisce Éireann is working towards UPM standards as agreed with relevant shellfish stakeholders. The standards used in this study require a geometric mean of less than 110 EC/100 ml and a 97<sup>th</sup> percentile of  $< 1500$  EC/100 ml in order to meet Class B status.

The latest SFPA shellfish production area classifications for Carlingford Lough are presented in Table 2-3.

Figure 2-6 Carlingford Lough Designated Shellfish Waters

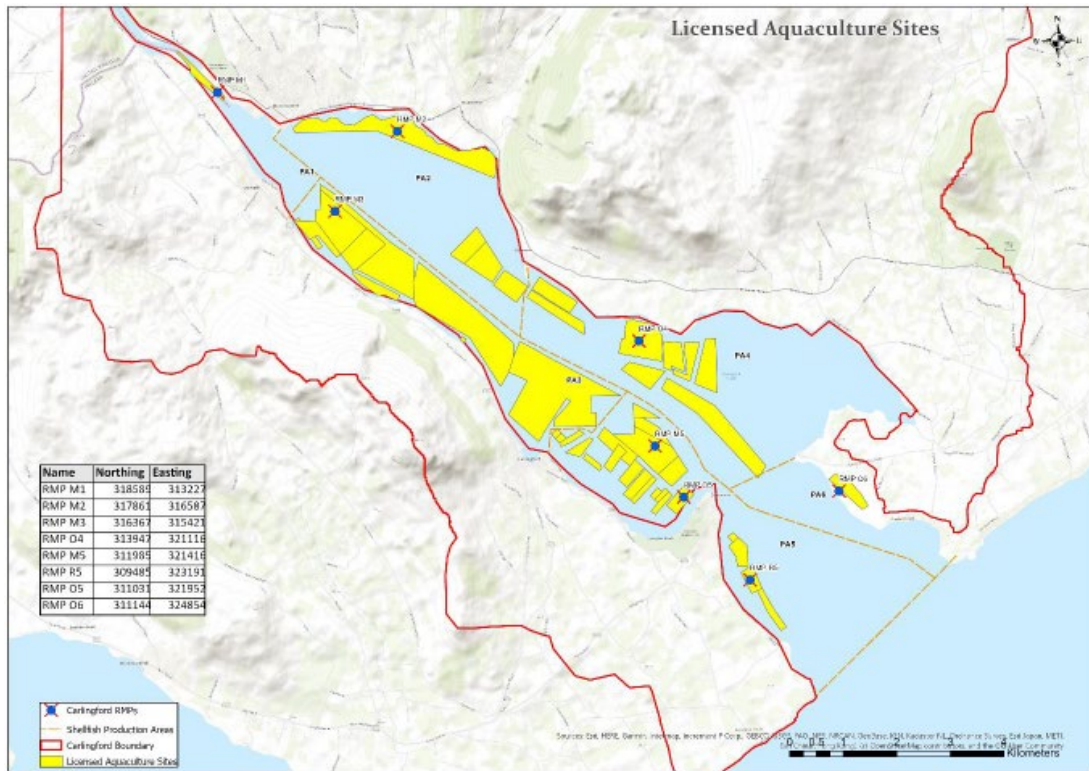


Table 2-2 Shellfish Classification and Post-harvest Treatment Required

Category	EC per 100 g Flesh and Intervalvular Liquid	Post-Harvest Treatment Required
Class A	< 230	May go directly for human consumption if end product standard met.
Class B	90% results < 4600 Remaining 10% results < 46000 100% results < 46000	Must be subject to purification or cooked by an approved method.
Class C	<46,000	Must be subject to relaying for a period of at least two months or cooked by an approved method.
Prohibited	> 46,000 EC/100 g of flesh	Harvesting not permitted.

**Table 2-3 Shellfish Classification Status (Aquafact, 2021, Food Standards Agency, 2023 & SFPA, 2023)**

Bed Name	Species	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ballyedmond	Oysters	A <sup>1</sup>	A <sup>1</sup>	A <sup>1</sup>	A <sup>1</sup>	A <sup>1</sup>	B	B	B	B	A/B <sup>2</sup>	A/B <sup>3</sup>	B
Fairgreen	Oysters	B	B	B	B	B	B	B	B	B	B	B	B
Narrow Water	Mussels	B	B	B	B/C <sup>4</sup>	B/C <sup>5</sup>	B	B	B	B	B/C <sup>6</sup>	B/C <sup>7</sup>	C
Rostrevor	Mussels	B	B	B	B	B	B	B	B	B	B	B	B
Ballagan	Oysters	A	A	A	A	A	A	A	A	A	A	A	A
Carlingford Inner M3	Mussels	B	B	B	B	B	B	B	B	B	B	B	A
Carlingford Outer M5	Mussels	A/B <sup>8</sup>	A	A	A	A	A	A/B <sup>9</sup>	A	A	A	B <sup>10</sup>	B <sup>10</sup>
Carlingford/Greenore O5	Oysters	A	A	A	A	A	A	A	A	A	A	A	B

<sup>1</sup> Provisional Classification – Classifications are described as provisional when an area is being classified for the first time or after a period in suspension. The term may also be used where an incomplete dataset of results was to hand.

<sup>2</sup> Class A from 1<sup>st</sup> August to 31<sup>st</sup> December. Class B at all other times.

<sup>3</sup> Class B from 1<sup>st</sup> May 2022 to 31<sup>st</sup> July 2022. Class A at all other times.

<sup>4</sup> Class B from 1<sup>st</sup> July 2015 to 31<sup>st</sup> October 2015. Class C at all other times.

<sup>5</sup> Class B from 1<sup>st</sup> July to 31<sup>st</sup> December 2016. Class C at all other times.

<sup>6</sup> Class B from 1<sup>st</sup> June to 31<sup>st</sup> October 2021. Class C at all other times.

<sup>7</sup> Class B from 1<sup>st</sup> June to 31<sup>st</sup> December 2022. Class C at all other times.

<sup>8</sup> Class A from 1<sup>st</sup> Feb to 30<sup>th</sup> August 2012. Class B at all other times.

<sup>9</sup> Class A from 1<sup>st</sup> Sept to 31 Dec 2018. Class B at all other times.

<sup>10</sup> Dormant fishery

## 3. EXISTING DATA REVIEW AND GAP ANALYSIS

### 3.1 Gap Analysis

A gap analysis was undertaken to identify the relevant existing data and confirm additional requirements to support the model development and impact assessments. It concluded that the following elements were required for the Carlingford Lough model development.

- Current velocity and water depths to support the coastal hydrodynamic model calibration and validation.
- River gauging for river catchment model development, calibration, and validation.
- Data for the characterisation of agreed key potential bacterial sources and quantification of connectivity in the source to receiver pathways.

### 3.2 Existing Data Sources

#### 3.2.1 Existing Models

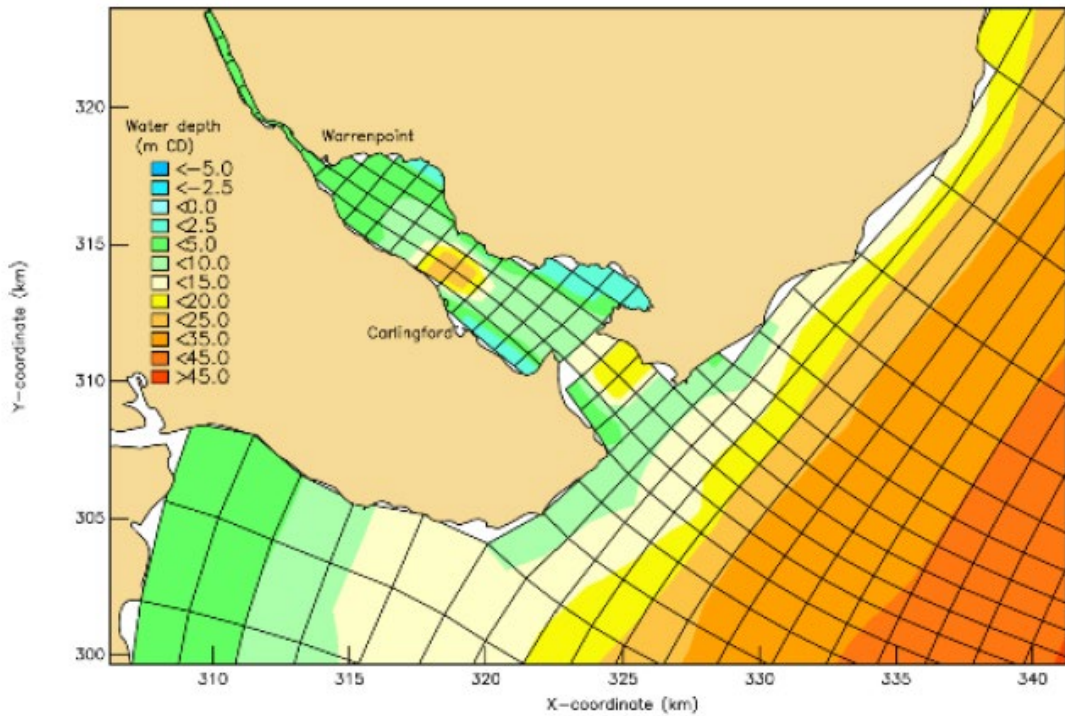
A SWAT model was built under the Sustainable Mariculture in Northern Irish Sea Lough Ecosystems (SMILE) project in 2004 to simulate nutrient inputs from agriculture and urban sources. The SWELL project updated the existing models to reflect improved modelling capability, data collection and knowledge gained during the intervening years.

A Delft 3D hydrodynamic and water quality coastal model was developed under the SMILE project in 2004. The model grid, as shown in Figure 3-1, is fairly coarse, with cell sizes within the Lough of roughly 1 km<sup>2</sup> which is too coarse to be used in the SWELL and IEM modelling studies. The SWELL project updated the existing SMILE model to reflect improved modelling capability, data collection and knowledge gained during the intervening years.

The existing model grid was therefore refined during SWELL in the following ways:

- Application of a 3D hydrodynamic model to fully resolve the hydrodynamics in the intertidal areas and river flows. Ocean boundary conditions were sourced from Delft 3D.
- Improved resolution at the key aquaculture areas.

Figure 3-1 Carlingford Lough SMILE Hydrodynamic Model



### 3.3 Historical Data

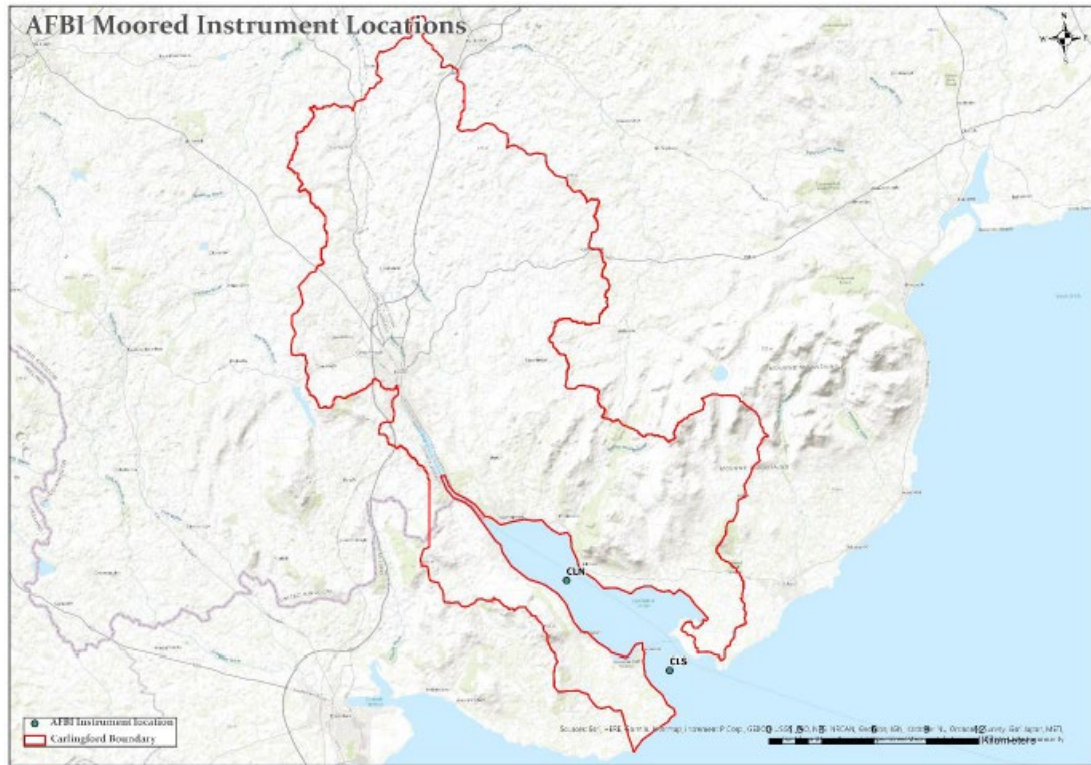
#### 3.3.1 Sampling Data

Since 2005, AFBI has maintained a regular but low intensity sampling programme in Carlingford Lough to support research objectives and NIEA / DAERA WFD monitoring. These data were utilised to contextualise the SWELL project-specific sampling and determine trends.

#### 3.3.2 Marine Instrumentation

AFBI has two instrumented moorings within Carlingford Lough (Figure 3-2), which provide measurements of conductivity, temperature, pressure, dissolved oxygen (DO), fluorescence and turbidity.

Figure 3-2 Existing AFBI Instrumented Moorings





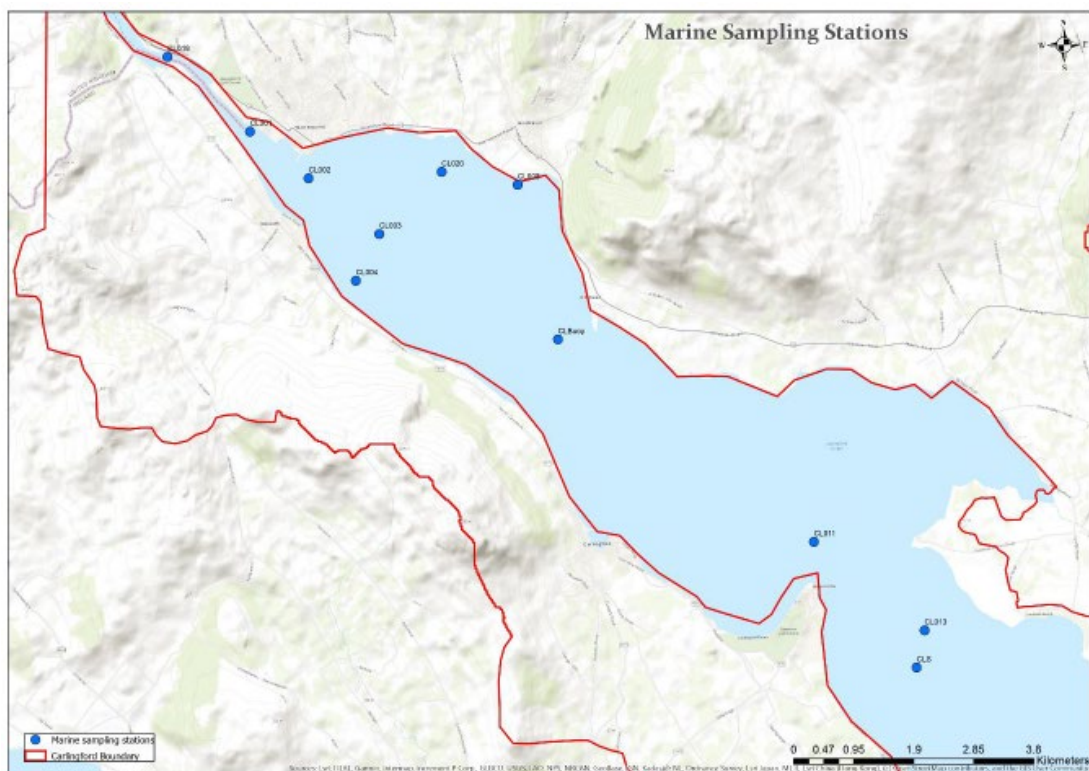
### 4.3 Marine Sampling and Instrumentation

Marine sites were sampled for physical, chemical and biological parameters every fortnight over all tidal states. In total, 11 stations were selected for marine sampling which cover the inner and outer regions of the Lough and close proximity to the mouth of the main rivers (Figure 4-2).

Nutrient and bacteria samples were taken at the surface and at one metre above the seabed. A water column CTD profiler was used when each sample was taken, to record a detailed depth profile of conductivity, temperature, depth, turbidity and fluorescence.

In addition to the existing instrumented moorings in the Lough (CLS and CLN on Figure 4-3), one additional buoy was deployed to provide better spatial coverage (CLNW on Figure 4-3). The sensors on the buoy monitored temperature, conductivity, DO, salinity, depth, chlorophyll and turbidity.

Figure 4-2 Marine Sampling Stations





## 5. RAINFALL AND DAP MODEL INPUTS

### 5.1 Rainfall

To support the modelling framework all developed models for an IEM catchment must be simulated using consistent rainfall; this supports the calibration and validation against historical data and IEM data / sampling campaigns. Consistent rainfall needs to be applied across the catchment, so that rainfall triggered overflows and peak flow events will be correctly phased. The time-step of the rainfall needs to be sufficient to drive the models applied in a particular catchment or for the modelling approach concerned (nutrient or bacterial).

The accepted approach by regulators in the UK for WFD, SFW and Bathing Water (BW) assessments is to assess over a long duration, typically at least ten years, in order to capture the natural inter-annual variability in rainfall.

Rainfall is the key driver for both the river catchment models and the sewer DAP models, as peak loadings of nutrients and bacteria will be produced during wet weather conditions which tend to dominate SFW performance.

### 5.2 Drainage Area Plans

DAP models are managed through the SWELL project and used technical specifications and processes which align to best practice and are agreed with the environmental regulator. The DAP models provided hydrograph outputs at key model stages for intermittent discharges (WwPSs and CSOs) within the Carlingford IEM catchment for selected rainfall datasets. Post-processing by IEM modelling teams applies bacterial pollutant loads to these flows for input to the impact assessment.

## 6. RIVER MODELS

### 6.1 Model Build

A SWAT model was built by LLE under the SWELL programme, to represent the hydrology and water quality of the Newry River and its tributaries. The model also covers a number of smaller rivers and streams which drain directly to Carlingford Lough. The sub-basins covered by the SWAT model are shown in Figure 6-1.

The models created a time series of the load (pollutographs) from each point source (Uisce Éireann and NI Water assets, and septic tanks) and the diffuse run-off. These pollutographs were used in the assessment to define the load entering Carlingford Lough via the rivers.

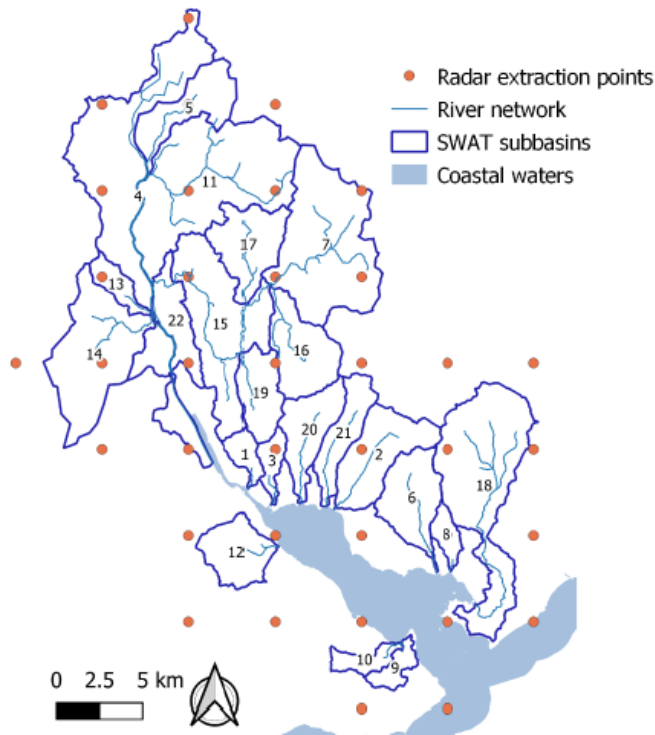
Continuous rainfall data were taken from the NIMROD dataset. Rainfall time series were extracted from the NIMROD radar data grid based on a 5 km grid (Figure 6-2) and an hourly time step. The data were then combined into one representative rainfall time series for each sub-basin using a spatially weighted average.

Additional details of the river model set up and build can be found in the detailed river modelling report (Longline Environment, 2022).

**Figure 6-1 Catchment Delineation of the Carlingford Watershed**



Figure 6-2 Rainfall Data Points



## 6.2 Model Calibration – Water Quantity

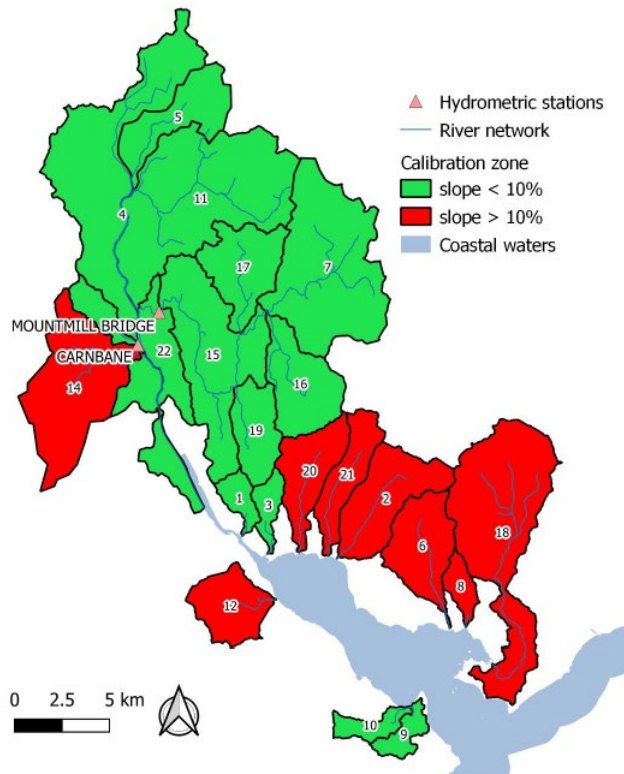
The hydrology (water quantity) was calibrated and validated at two sites – Mountmill Bridge and Carnbane (Figure 6-3). Hourly flows were available at the two calibration sites between 01/01/2009 and 31/12/2018. The data were split into calibration (01/10/2015 – 31/12/2018) and validation (01/01/2009 – 30/09/2015) periods.

For the Carlingford SWAT model, a regionalisation approach was used as it was not possible to define a single set of model parameters that provided satisfactory results at the two hydrometric stations. This was due to the slope – the Carnbane sub-basin represents steeper conditions than Mountmill Bridge. This difference was extrapolated to the entire Carlingford watershed, resulting in two “calibration zones” based on the average slope of each sub-basin (Figure 6-3).

Additional details of the river model quantity calibration can be found in the detailed river modelling report (Longline Environment, 2022).

Overall, the quantity model was considered acceptable for use in further modelling applications, including calibrating the water quality aspect.

Figure 6-3 Calibration Zones and Hydrometric Stations Used for Calibration



### 6.3 Model Calibration – Water Quality

The water quality of the Carlingford SWAT model was calibrated and validated at the sites in Figure 6-4. The Uisce Éireann and NI Water assets in Figure 6-5 were discharged into the model as part of the calibration.

A summary of the EC and nutrient concentration sampling data used to calibrate the quality model is given in Table 6-1.

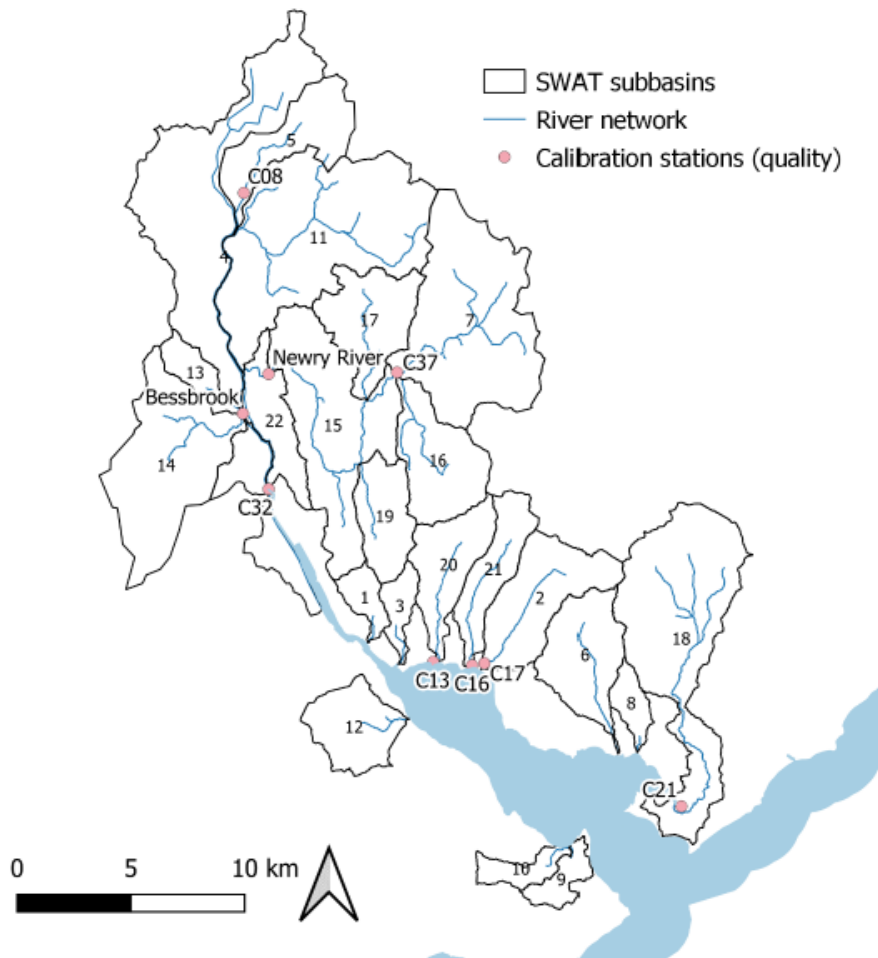
The calibration aimed to reproduce bacteria and nutrient concentrations during dry and wet weather conditions. However, as the majority of pollutant load occurs during high intensity (wet weather) events, priority was given to reproducing the concentrations during peak flows.

Overall, the SWAT water quality calibration shows:

- Good fit with the sampling data for EC concentrations during peak flows.
- Good fit with the sampling data for all nutrients, with the exception of nitrites, during peak flows. Nitrite concentrations are generally underestimated.
- Overestimation of EC, ammonia ( $\text{NH}_4$ ), nitrate ( $\text{NO}_2$ ), Soluble Reactive Phosphorus (SRP) and Total Phosphorus (TP) during low flows in the smallest rivers. This is likely due to the proportion of continuous urban discharges increasing in comparison to the river water during dry weather periods.

Additional details of the river model quality calibration can be found in the detailed river modelling report (Longline Environment, 2022).

Figure 6-4 Water Quality Calibration Sites



**Figure 6-5 Assets Discharging into SWAT Model**



**Table 6-1 Data Used for Water Quality Calibration and Validation**

Date	Stations	Name	Sampling	Cal/Val
28/01/2021	Newry River, Bessbrook	E1	Rainfall event	Calibration
10/03/2021	Newry River, Bessbrook	E2	Rainfall event	Calibration
03/05/2021	Newry River, Bessbrook	E3	Rainfall event	Calibration
27/09/2021	Newry River, Bessbrook	E4	Rainfall event	Validation
2017 - 2021	C08, C13, C17, C37		Routine sampling	Calibration
2017 - 2021	C16, C21, C32		Routine sampling	Validation

## 6.4 River Model Build Conclusion

The calibrated model produced representative bacterial (EC) and nitrate concentrations when compared to the available sampling data, in particular during peak flows. Seasonal variations were also well reproduced. The model performance is reasonable for the other parameters, with the model generally able to reproduce ranges of observed concentrations during peak flows, despite the performance being variable between stations and events.

Overall, the model is considered to produce comparable bacterial and nutrient concentrations throughout the calibration period and is therefore suitable to undertake the 10-year simulations for input to the SFW assessment tool.

## 6.5 River Model Audit

Under the SWELL project, LLE was commissioned to develop the river models, and Intertek Metoc was commissioned to review and audit the river models.

Following completion of the SWAT model, Intertek Metoc produced a report on the model build, calibration, and validation (Intertek, 2022). Intertek Metoc’s review has been based on the report provided, and ongoing discussions with LLE during the model development.

The audit objectives for the water quality calibration report for Carlingford were:

- To assess whether the models have been adequately built and verified and confirm that the software packages used are for the intended purpose.
- To assess the validity and appropriateness of input data used in the modelling study.
- To assess whether the model has been used in an appropriate manner, given the limitations and the study objectives.

Table 6-2 details the Intertek Metoc audit areas and summary comments from the audit.

**Table 6-2 River Model Audit Summary**

Model Aspect	Intertek Metoc Audit Summary
Modelling Software	Overall, use of SWAT is considered suitable for the Carlingford catchment river model.
Model Domain	Although the catchment areas of each river were not audited for hydrological connectivity, their extent looks reasonable and appears to include the major tributaries flowing into each river.
Model Construction	Overall, Intertek Metoc considers the model has been suitably parametrised with regards to the construction and inputs for the purposes of this assessment.
Bacterial Sources: Wastewater Sources	Although Intertek Metoc has not reviewed each input into the SWAT model, it is understood that all key assets/point sources have been included in the non-tidal catchments draining into Carlingford Lough.
Bacterial Sources: Agricultural Sources	The data used to define diffuse loadings into each river catchment have been based on a well-established technique and as such, this approach is considered appropriate for the purposes of this assessment.
<b>Model Performance</b>	
Input Data	The application of gauged rainfall data improved the model performance but introduced additional complications for the DAP modelling which applied radar rainfall. As the SWAT model is part of a larger programme of work it is required that the radar rainfall is applied, despite the lower performance it introduces. This limitation of the model input data is accepted, but the implications need to be recognised and understood by future users/applications.
Model Calibration: Quantity	Noting the limitation caused by the rainfall, the quantity model is acceptable for use in further modelling applications, including providing bacterial pollutographs for input to the impact assessment.

Model Aspect	Intertek Metoc Audit Summary
Model Calibration: Quality	Noting the limitations caused by the rainfall and input data (e.g. livestock and fertiliser inputs), the quality model is acceptable for use in modelling the 10-year bacteria loads entering Carlingford Lough for input to the impact assessment. Care should be taken if using the quality model in other types of assessments including WFD assessments due to the overestimation of concentrations during low flow periods.
Conclusion	Although improvements to the model could be made using rain gauge data instead of rain radar, Intertek Metoc felt that the model performs to an acceptable level for the purposes of this water quality study. Furthermore, the uncertainty in river loads will be tested during the impact assessment phase to understand the sensitivity of the model to these loads.

## 7. HYDRODYNAMIC AND DISPERSION COASTAL MODEL

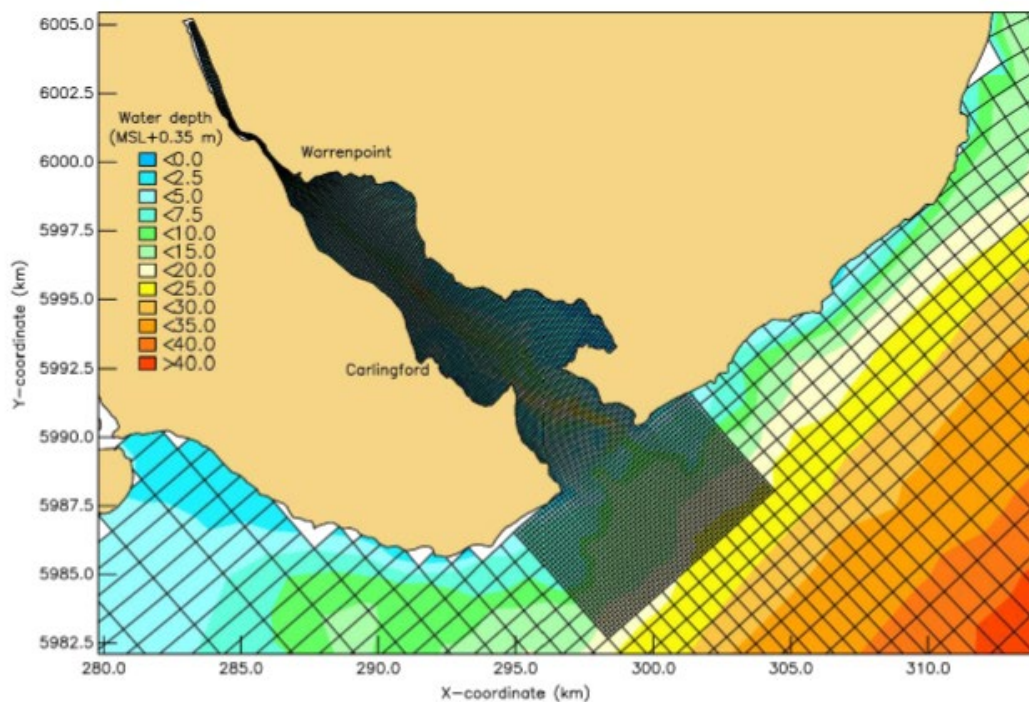
### 7.1 Model Build

A Delft 3D model was built by LLE under the SWELL project, with the aim of representing the response of the coastal environment to atmospheric, tidal, mesoscale circulation and catchment inputs.

The modelling built on the work undertaken during the SMILE project (see Section 3) and updated the model based on the latest computational capabilities with recalibration using more recent data.

The model mesh and domain is shown in Figure 7-1. Additional details on the Carlingford hydrodynamic model build can be found in the detailed coastal modelling report (Longline Environment, 2021).

**Figure 7-1 Carlingford Lough Coastal Model Mesh (Longline Environment, 2021)**



### 7.2 Hydrodynamic Model Calibration and Validation

The Carlingford Lough hydrodynamic model was calibrated against tidal conditions represented by recorded current speed and direction, and water level data from a variety of sources. Data collected from an acoustic doppler current profiler (ADCP) deployed through the SWELL project (September 2018), two long-term tide gauges (2018, and January – February 2019), and historical pressure sensor (2012) and ADCP (2015) data were used.

Calibration of the hydrodynamic model was achieved by fitting the model outputs to the observed data by altering appropriate model parameters. Model sensitivity was also tested for key parameters such as eddy viscosity and bed roughness.

The level of model calibration achieved correlates to the goodness of fit achieved between observed and modelled data. This can vary with location depending on local conditions and how well these are

represented in the model and is also dependent on the quality of the field data which is a function of instrument type, accuracy, resolution, deployment location and environmental conditions.

The guidance from the Foundation for Water Research (FWR) document 'A Framework for Marine and Estuarine Model Specification in the UK' (FWR, 1993) has been used to quantify the performance of the Carlingford hydrodynamic model. This guidance is consistent with the latest version of Uisce Éireann's Technical Standard for Marine Modelling (Irish Water, 2022) which also adopts the FWR targets for calibration and validation performance. Both visual and statistical assessments of the correlation between observed and modelled data were completed. Statistical comparison enabled the calculation of the percentage of time for which the modelled data correlate with the observed data within the tolerances defined in the FWR guidance document.

Additional details on the Carlingford hydrodynamic model calibration and validation can be found in the detailed coastal modelling report (Longline Environment, 2021).

### 7.3 Conclusions and Recommendations

LLE has developed, calibrated, and validated the Carlingford hydrodynamic model using various available datasets including ADCP survey data collected in 2018 as part of the SWELL project and historical tide gauge data.

The model underwent calibration and validation using measured water levels, current speed and current direction data from a number of ADCPs and tide gauges. The results of this calibration and validation exercise found generally acceptable correlation between the measured and modelled data over both spring and neap tides.

A thorough sensitivity analysis was completed to achieve this level of correlation. A number of model parameters were tested including bed roughness, eddy viscosity and offshore boundary conditions.

The effectiveness of the hydrodynamic model coupled with the Delft transport model in replicating the dispersion of dissolved pollutants in the Carlingford Lough area was reviewed by comparing modelled salinity and temperature against two long term (2018 – 2019) instruments inside the Lough. The model was able to well replicate the seasonal temperature cycle, albeit with some underestimation in the winter months. The model broadly replicated the seasonal salinity cycle, although it does tend to overpredict measured salinities, which may be due to it not fully capturing the impact of high freshwater river flows.

The model performed acceptably well in terms of hydrodynamics and dispersion, such that it was deemed fit for the purpose of modelling the dispersion of dissolved pollutants around Carlingford Lough.

### 7.4 Hydrodynamic and Dispersion Model Audit Summary

LLE was commissioned to undertake the Carlingford Lough hydrodynamic model build, calibration and validation as part of the SWELL project. Intertek Metoc was commissioned to review and audit this, on behalf of the SWELL partners.

Following completion of the hydrodynamic model development, LLE produced a report (Longline, 2018) on the model build, calibration, and validation. Intertek Metoc's review (Intertek, 2024a) has been based on the report provided, and ongoing discussions with LLE during the model development.

Intertek Metoc has checked that the model itself runs, but Intertek Metoc has not undertaken a detailed assessment of the model itself (i.e., review of the model configuration files themselves), as it is assumed all information provided in the report and discussions is correct.

The objectives of the audit of the Carlingford Lough hydrodynamic model build, calibration and validation report were:

- To assess whether the hydrodynamic model has been adequately built and verified and confirm that the software package used is suitable for the intended purpose.
- To assess the validity and appropriateness of the input data used in the modelling study.
- To assess whether the model can be applied in an appropriate manner, given its limitations and the study objectives.

Table 7-1 details a summary of Intertek Metoc’s audit of the Carlingford Lough coastal model.

Overall, the model performance was considered suitable for use in the bacterial impact assessments. Specifically, it provides a suitable basis for undertaking bacterial impact (production) runs within Delft3D for subsequent use in the impact assessment.

**Table 7-1 Coastal Model Audit Summary**

Model Aspect	Intertek Metoc Audit Summary
Modelling Software	Delft3D is considered appropriate for the task in hand.
Model Domain	The model domain of the base Irish Sea model extends from Garron Point in the north to Portoriel in the south with a nested Carlingford Lough higher resolution grid. Although the model would have benefited from being extended up to the tidal limit of the River Newry, the extent of the domain is considered appropriate for the objective of the current study.
Model Construction: Bathymetry	Reputable sources have been used to represent the bathymetry in the model, including sources such as the UK Hydrographic Office (UKHO) and the General Bathymetric Chart of the Oceans (GEBCO), as well as some site-specific surveys.
Model Construction: Offshore Boundaries	The Riemann invariants from the Marine Institute NEA_ROMS model have been used for subtidal water levels, while tidal water levels were obtained from the FES2014b tidal constituent atlas. This approach for defining the model boundaries is considered acceptable.
Model Construction: Freshwater Inputs	Freshwater inputs have been derived from the SWAT model developed by LLE. This model has been audited separately and is considered appropriate for the purposes of this study.
Model Construction: Other Model Set-Up Parameters	The other model parameters, e.g. the horizontal eddy viscosity, bottom roughness formulation and value and time step are considered appropriate for the purposes of this study.
<b>Model Calibration and Validation</b>	
Water Level Data	There is generally a good coverage of water level data (tide gauges and ADCPs) within Carlingford Lough. The records are sufficiently long for model calibration.
Current Velocity Data	There is generally a good coverage of current velocity data (ADCPs) within Carlingford Lough. The records are sufficiently long for model calibration.
Temperature and Salinity Data	Within Carlingford Lough, data from two CTDs are available, one within the central portion of the Lough and another towards the mouth. The spread of data is considered acceptable.
Model Performance: Hydrodynamics	The model performance against water levels and current velocities is generally good with the model replicating levels and velocities within acceptable bounds.

Model Aspect	Intertek Metoc Audit Summary
Model Performance: Dispersion	Although the model is unable to reproduce the salinity depressions observed in the data, the model generally replicates the observed salinity data at both sites.

## 8. SHELLFISH WATER IMPACT ASSESSMENT

### 8.1 Overview of Assessment Approach

The SFW impact assessment was undertaken by Intertek Metoc and used a range of modelling tools, namely:

- SWAT river models of the Newry River, its tributaries and other nearby watercourses to provide pollutographs representing the diffuse runoff load, Uisce Éireann and NI Water assets and septic tanks that drain to these river catchments.
- Sewerage network models of the Annalong, Cranfield, Kilkeel, Newry and Warrenpoint urban catchments, providing 10-year spill hydrograph output in response to rainfall condition.
- A Delft 3D coastal hydrodynamic model to simulate advection and dispersion by tidal and wind-driven currents.
- A Delft 3D coastal water quality model to simulate the advection, dispersion and decay of microbial pollutants based on a unit discharge approach.
- An impact assessment model (S-O) to combine and process outputs from the sewerage network, river, and coastal water quality models in order to generate predictions of impact that are comparable to the SFW standards, and source apportionment to identify the discharges responsible for these impacts.

### 8.2 Potential Sources

#### 8.2.1 Uisce Éireann Assets

Four Uisce Éireann assets were included in the pre-2024 assessment – Carlingford WwTP, Greenore WwTP and two untreated continuous discharges associated with the Omeath agglomeration. The locations of these assets are shown in Figure 8-1. It is important to note that in the pre-2024 assessment, discharges from Carlingford and Greenore WwTPs have not been separated into storm and Final Effluent (FE) components. This follows the simplified method of modelling WwTPs that was adopted in the original SWELL assessment (see Section 8.4.3 for more detail).

From 2024 onwards, the two untreated discharges associated with the Omeath agglomeration were replaced with a new ultra-violet (UV) treated WwTP, known as Omeath WwTP. Furthermore, discharges from Carlingford and Greenore WwTPs are separated into storm and FE components, to provide a more accurate representation of these discharges. In the post-2024 scenario, the storm component for Carlingford WwTP is moved to its correct discharge location which is different from the discharge location for the FE component of Carlingford WwTP. The locations of the assets used in the post-2024 scenario are shown in Figure 8-2.

The discharge locations used to represent assets in the coastal water quality model are shown in Figure 8-3.

#### 8.2.2 Northern Ireland Water Assets

There is a total of 89 NI Water point source assets (11 WwTWs, 67 CSOs / WwPS and 11 septic tanks) included in the assessment. The locations of these assets are shown in Figure 8-4, with the discharge locations used to represent these assets in the coastal water quality model shown in Figure 8-3. The NI Water assets discharge either direct to the coastal environment or to river catchments that subsequently drain to the coastal environment.

Figure 8-1 Carlingford Lough Uisce Éireann Asset Locations (Pre-2024)

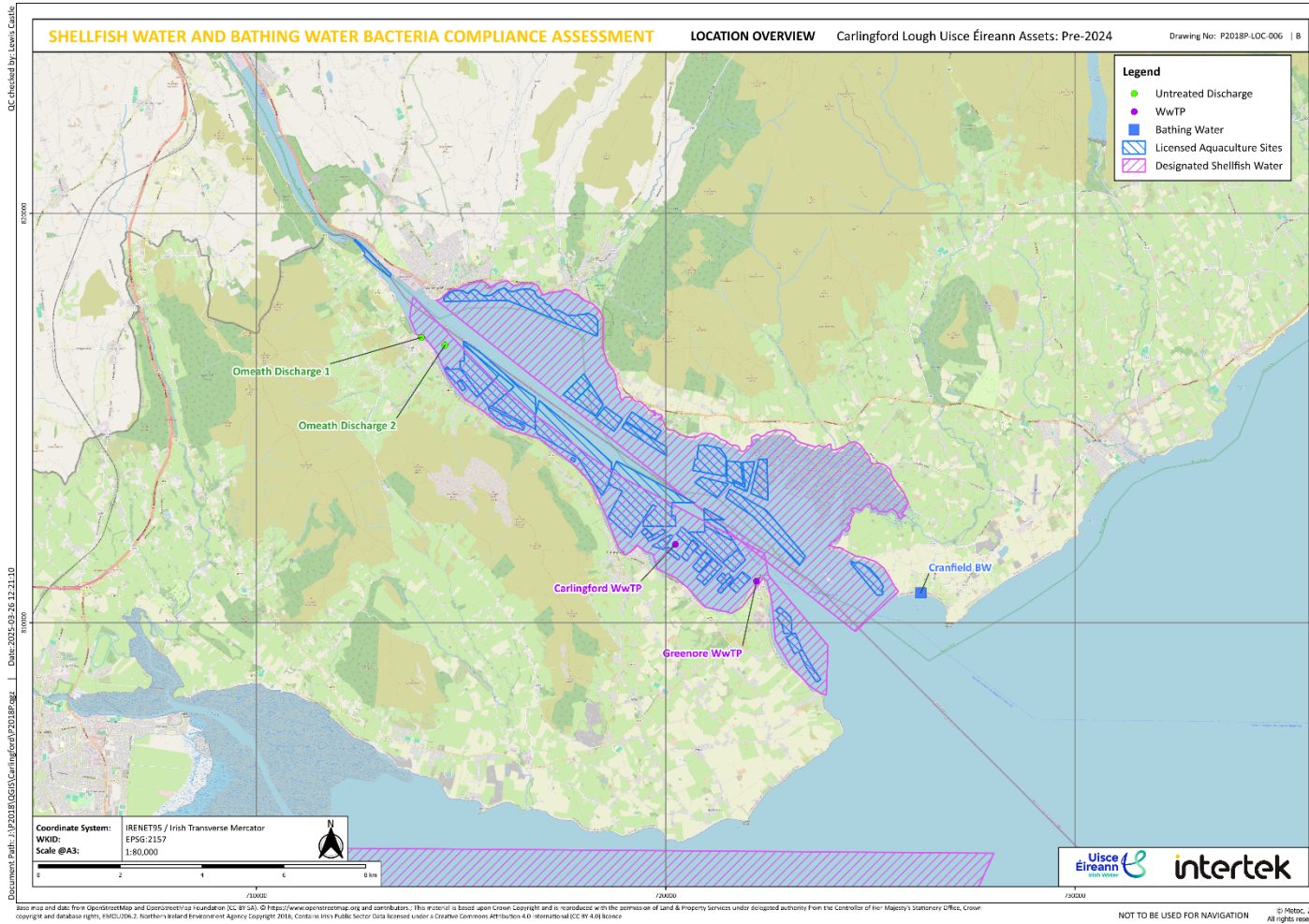


Figure 8-2 Carlingford Lough Uisce Éireann Asset Locations (Post-2024)

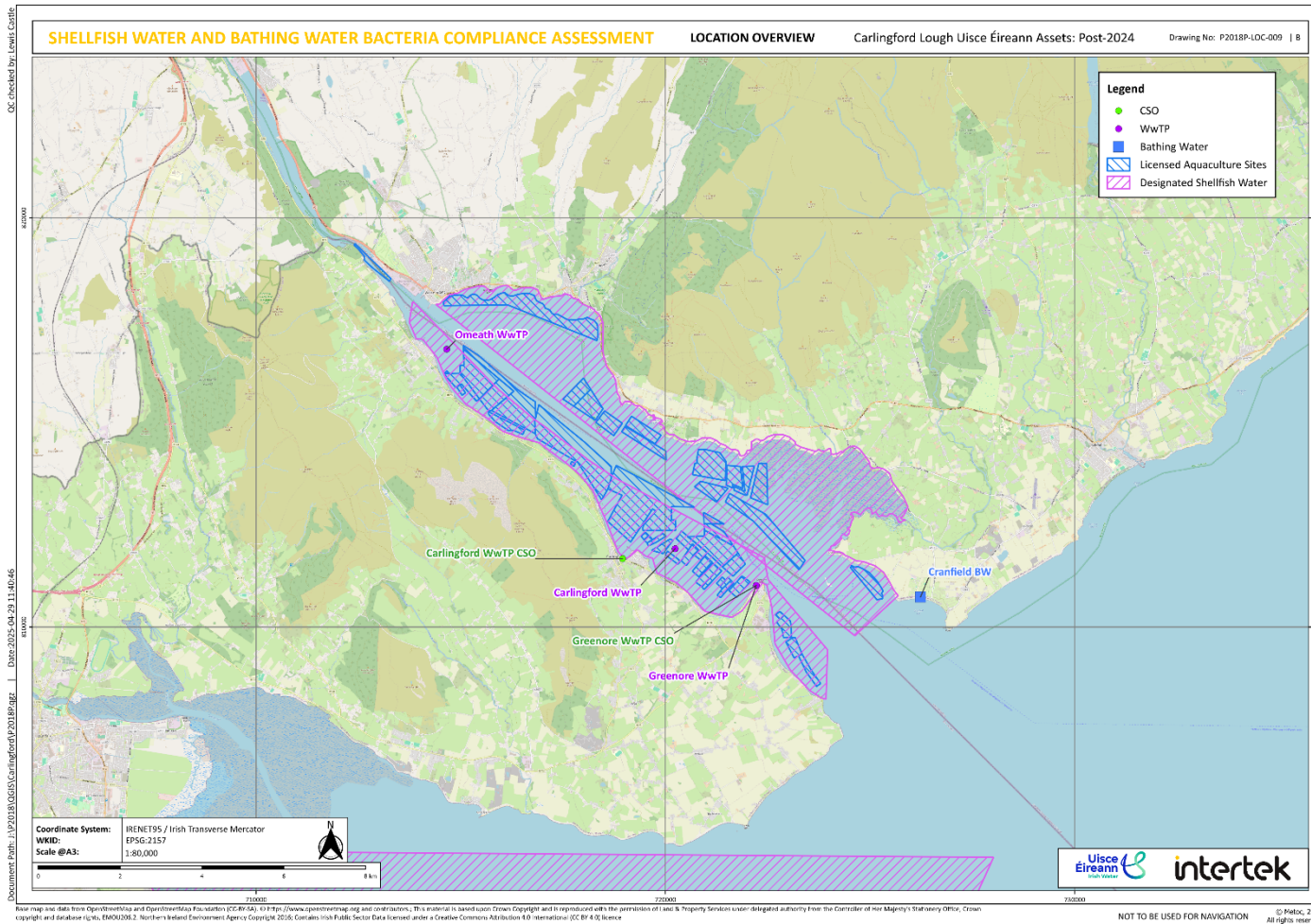


Figure 8-3 Carlingford Lough Model Discharge Locations

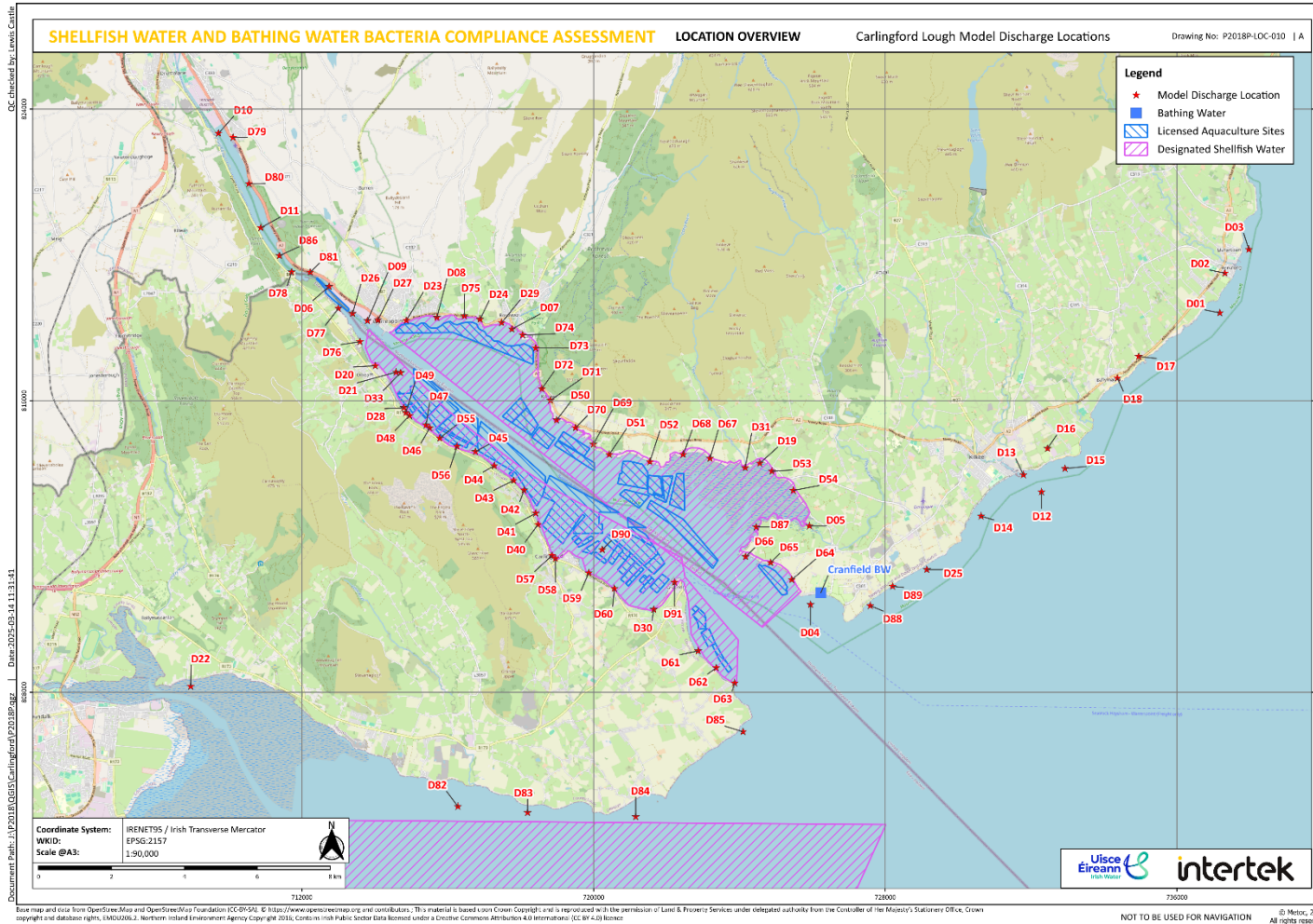
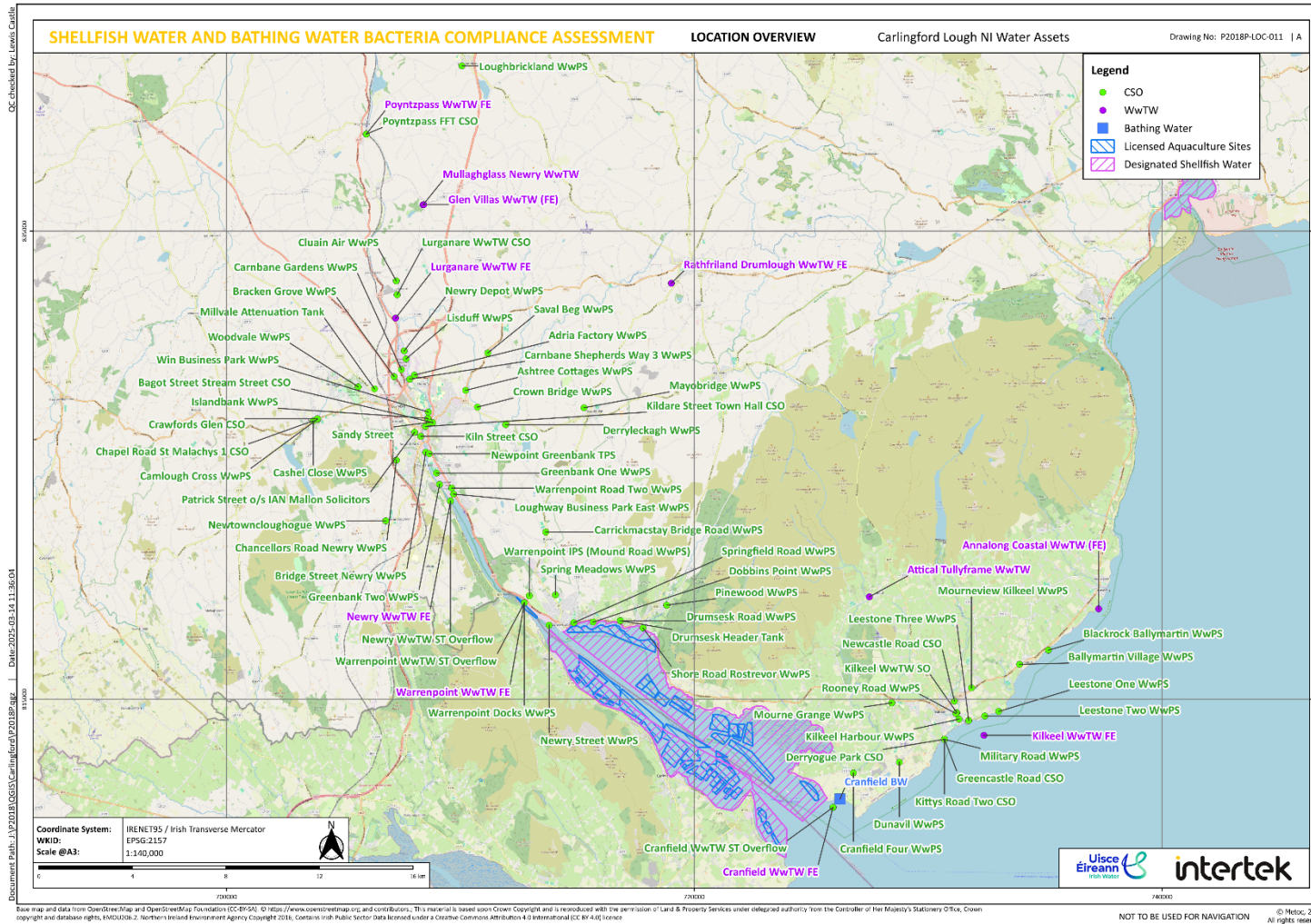


Figure 8-4 Carlingford Lough NI Water Asset Locations



### 8.2.3 Rivers and Streams

Bacteria loads have been obtained from the SWAT river model for the Newry River, its tributaries and a number of smaller rivers and streams which drain directly to the Lough. This allowed the following sources in each sub-basin to be modelled:

- Uisce Éireann and NI Water point source discharges (WwTWs, CSOs and WwPSs), all of which were modelled individually.
- Private septic tanks, which were modelled as groupings on a sub-catchment basis.
- Diffuse loads to represent run-off from agricultural land.

These loads were provided in the form of pollutographs (time series of bacterial flux) which were used to define the load entering Carlingford Lough via the rivers.

Watercourses draining into the Carlingford Lough catchment that were not modelled within SWAT were included in the model using a scaled approach. Time-varying bacterial concentrations for these watercourses were scaled from select donor rivers as a function of their respective catchment sizes.

### 8.2.4 Septic Tanks

Two types of septic tanks have been included in the assessment. The two types were both modelled in SWAT by discharging into the relevant sub-basin; however, they were modelled separately so that their impacts could be distinguished:

- NI Water / Uisce Éireann owned septic tanks that are likely to discharge into a watercourse;
- 22 private septic tanks.

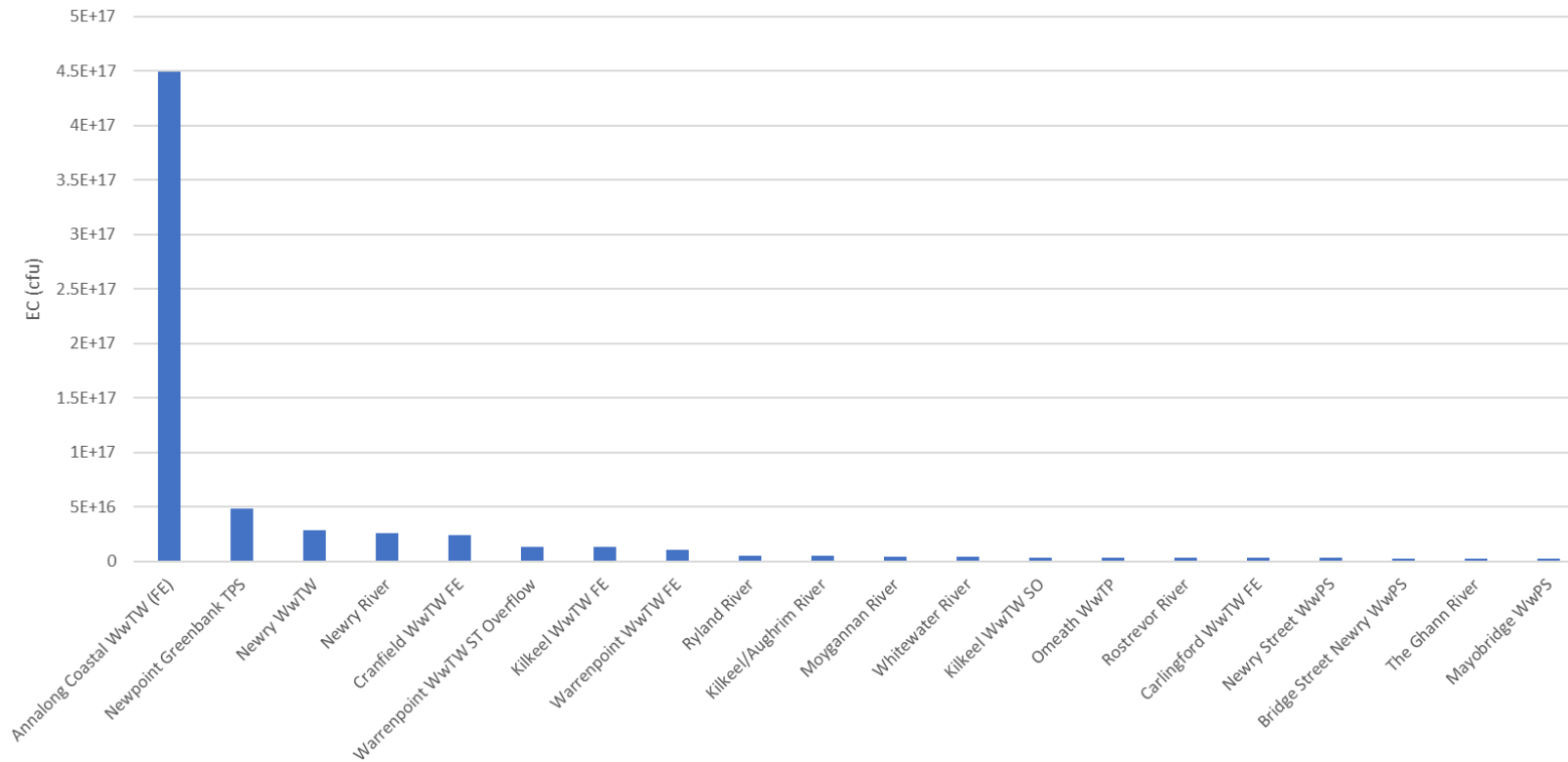
## 8.3 Input Load Analysis

Analysis of the EC input loads for the post-2024 model scenario was undertaken by Intertek Metoc. The total load from each input source has been defined by multiplying the flow with the bacterial concentration for each timestep, then summing all timesteps. The input load analysis has been carried out using ten years of timeseries data. The analysis has been based on ten full years of simulated discharges.

The input load analysis shows which sources have the largest predicted discharge loads. However, it does not necessarily predict the sources that will have the biggest impact on water quality in the SFW as the individual impact of each source is determined by multiple factors, including distance from the SFW, discharge load, and spill patterns (e.g. frequent small spills, or large but infrequent spills).

Figure 8-5 presents the bacterial loads of the top 20 ranked sources for EC as modelled in the post-2024 baseline scenario.

Figure 8-5 Post-2024 Input Load Analysis of Sources (top 20) – EC



## 8.4 Assessment Methodology

The impact assessment integrates environmental conditions with sewer network model hydrographs, river model outputs and coastal water quality modelling outputs to predict the bacteriological impacts throughout Carlingford Lough and the surrounding coastal waters. These impacts can be compared to the relevant water quality standards for SFWs.

The impact assessment modelled the impact of all potential sources at the Carlingford Lough SFW. Verification of the modelled outputs has been undertaken by comparing the model predictions against historical water quality sampling data.

### 8.4.1 Wind Conditions

Wind data are an important component of the impact assessment approach because the frequency, direction and speed of different winds can affect pollutant transport and thus impacts.

The impact assessment has been run under seven wind scenarios. Representative wind conditions were determined using long term data (2009 – 2018) from the Met Office station at Killowen (54.067°N, 6.183°W), which is located in the Carlingford Lough area.

Table 8-1 gives a summary of the wind conditions used in the assessment. The wind frequencies given in the table have been used to weight the impact of individual wind conditions in the impact assessment.

**Table 8-1 Wind Conditions Applied in the S-O Assessment**

Wind Condition	Wind Direction (°N)	Wind Speed (m/s)	Frequency (%)
Wind 1 (No Wind)	n/a	0.0	4.53
Wind 2	60	3.2	2.70
Wind 3	120	4.3	27.96
Wind 4	180	4.5	7.75
Wind 5	240	6.6	8.79
Wind 6	300	5.7	38.36
Wind 7	0	3.4	9.91

### 8.4.2 Decay Rates

Bacterial mortality is primarily affected by sunlight (ultraviolet (UV) radiation) and therefore varies significantly both spatially and temporally, depending on the time of day/year, cloud cover, water turbidity and other factors.

The bacterial decay rate in a long-term impact assessment can be represented by the  $T_{90}$  value, which is the time required for 90% of the bacterial population to die. It is the most commonly used parameter for describing bacterial mortality.

For the impact assessment, a  $T_{90}$ -value for EC of 20 hours was used for the summer, and a  $T_{90}$  value of 40 hours was used for the winter season to reflect the generally lower levels of sunlight in winter.

Using these values in the calibration exercise gave model predictions that are in good agreement with the water quality sample data taken at the SFW.

### 8.4.3 STORM-OPTIMISER

S-O is a bespoke bacterial impact assessment model. S-O applies a 'unit impact' approach, this being the most widely adopted approach in the UK and Ireland. A 'unit impact' technique, originally developed by the Water Research Centre in the UK and subsequently adopted in the UPM manual, establishes source-to-receiver relationships under a wide range of environmental conditions supported by the simulation of a large number of model scenarios. The specific use of S-O, as a unit impact approach, is accepted by NIEA, the UK Environment Agency, Natural Resources Wales and the Scottish Environment Protection Agency and allows for long period time series data (typically up to ten years) to be modelled under a large number of environmental (wind and tide) conditions. Output is then verified against statistical distributions of bacteria concentrations from SFW monitoring samples and the verified model applied to generate the percentile values that can be compared directly to SFW standards and classifications.

A short summary of key stages in the set-up, verification and application of S-O is provided below.

#### 8.4.3.1 Verification (Pre-2024)

The impact assessment has been verified at Carlingford SFW using the historical water quality sampling data taken at sampling locations shown in Figure 8-6. The predicted water quality results are compared directly to the historical water quality sampling data.

For the SFW, the impact assessment was verified against bacterial water quality samples collected specifically as part of the SWELL project at 12 locations across Carlingford Lough. These data were collected between April 2019 and February 2020. Samples were collected at both the surface and bottom layers. This is considered to be a good dataset in terms of spatial coverage. However, the sample numbers are somewhat limited, with roughly 15-17 samples per site. Sampling data are particularly limited at sampling location CLVL (assessment point AP13), which is the location furthest upstream in the Newry River channel. At this location only six samples were collected from the surface layer and five samples from the bottom layer. For verification purposes, a log-normal distribution was fitted to each dataset, and the geomean and 97<sup>th</sup> percentile EC concentration was calculated from this in order to evaluate against the SFW standards for Class B waters (geomean of less than 110 EC/100 ml and 97<sup>th</sup> percentile of less than 1500 EC/100 ml). During model verification, the measured geomean and 97<sup>th</sup> percentile EC concentrations were compared against equivalent data predicted by the impact assessment model.

The SWELL sampling data were collected prior to the construction of Omeath WwTP, which did not begin operation until 2024. Hence, the model was validated against a pre-2024 formulation of UE assets. In particular, this includes two untreated discharges within the Omeath agglomeration, which were in operation prior to the construction of Omeath WwTP.

The verification process during the impact assessment involved adjusting parameters, within reasonable ranges, which are known to vary naturally. A key verification parameter is  $T_{90}$  – the time taken for 90% of the bacteria population to decay.  $T_{90}$  is primarily driven by the amount of UV light that can penetrate the water – more light, e.g. on a sunny day, or in clearer water, results in a shorter  $T_{90}$  as bacteria decay quicker. Less light (e.g. cloudy conditions, during the night, or in deeper or more turbid water), results in a longer  $T_{90}$  as bacteria persist.

Other tests were undertaken during the verification process, in order to test the sensitivity of the model to inputs that are known to vary or are uncertain. These tests included: varying the concentrations applied to treated effluent and untreated intermittent discharges; varying river loads; and varying septic tank loads.

The concentration of Cranfield WwTW FE was found to be a key verification parameter. This asset was found to play a crucial role in model verification at the three SFW locations in the south of the Lough (AP08, AP09, and AP12). Cranfield WwTW FE is screened only. However, applying the default value

for crude sewage of  $2 \times 10^7$  EC/100 ml led to a significant overprediction of impacts at the three locations mentioned above. There is anecdotal evidence to suggest significant infiltration in the Cranfield catchment. The concentration of Cranfield WwTW FE is therefore likely to be lower than this default value. A concentration of  $1 \times 10^6$  EC/100 ml was determined to provide the best model fit. These values were ultimately used in the baseline model. Sensitivity tests showing the impact of using default values for Cranfield WwTW FE are shown in Section 8.5.1.3.

Furthermore, the concentrations of the two UE untreated discharges associated with Omeath agglomeration were also found to be key verification parameters. These assets play a crucial role in model verification at nearby assessment locations including AP05 and AP06 (which are closest to these discharges). Default concentrations provided by UE were originally applied to these assets in the pre-2024 baseline scenario (Scenario 1a). The default conservative concentrations provided for these assets were  $1 \times 10^7$  EC/100 ml for flows less than 8.8 l/s and  $5 \times 10^6$  EC/100 ml for flows above 8.8 l/s. These assets were assumed to discharge crude sewage at flows less than 8.8 l/s. Flows above 8.8 l/s were assumed to be heavily diluted by rainwater and were therefore given a lower concentration.

Applying these default values led to a significant overprediction in the geomean concentration at a number of locations including AP05 and AP06. No effluent sampling was undertaken to accurately determine the EC concentration from the two discharges associated with the Omeath agglomeration. However, comparisons against the sampling data suggest that the discharge concentration is likely to be significantly lower than the originally applied default values – potentially due to infiltration to the system which is a known phenomenon at other similar assets. A concentration of  $1 \times 10^6$  EC/100 ml applied across all flow rates was determined to provide the best model fit. This value was ultimately used in an alternative baseline model (known as Scenario 1b). Key differences between Scenario 1a and Scenario 1b are provided in Table 8-2.

#### 8.4.3.2 Post-2024 Scenario

Following model verification, a post-2024 baseline scenario (Scenario 2) was run. This represents the current operational status of UE assets in Carlingford Lough, with Omeath WwTP replacing the two untreated discharges associated with the Omeath agglomeration. Furthermore, the operational capacity of Carlingford and Greenore WwTPs are increased to represent increased population growth in these areas. Key differences between Scenario 1a/1b and Scenario 2 are provided in Table 8-2.

It is important to note that in the post-2024 scenario, discharges from Carlingford and Greenore WwTPs are split into separate storm and FE components, with different concentrations applied to each component (see Table 8-2). This is a more accurate method of modelling these assets, compared to the method used in the original SWELL project (subsequently adopted in Scenarios 1a and 1b), which applied a single concentration to both the storm and FE components. The storm component for Carlingford WwTP has been moved to its correct discharge location (D58) which is different to the FE discharge location (D90). However, although these changes are applied to the post-2024 scenario, they do not reflect an operational change in these assets after this time period, and instead solely reflect an improvement in modelling methodology. It is also important to note that in the post-2024 scenario, flows for Omeath WwTP above 8.8 l/s have been assigned a concentration of  $5 \times 10^6$  EC/100 ml. In order to achieve calibration in the pre-2024 scenario, the concentration for the two untreated discharges associated with the Omeath agglomeration were lowered to  $1 \times 10^6$  EC/100 ml across all flow rates. Applying a concentration of  $5 \times 10^6$  EC/100 ml to flows from Omeath WwTP above 8.8 l/s in the post-2024 scenario is therefore potentially conservative.

#### 8.4.3.3 Summary of Pre-2024 and Post-2024 Baseline Scenarios

The Baseline Assessment has therefore included three different scenarios:

- Scenario 1a – Pre-2024 with conservative concentrations for Omeath untreated discharges.
- Scenario 1b – Pre-2024 with ‘best-fit’ concentrations for Omeath untreated discharges.

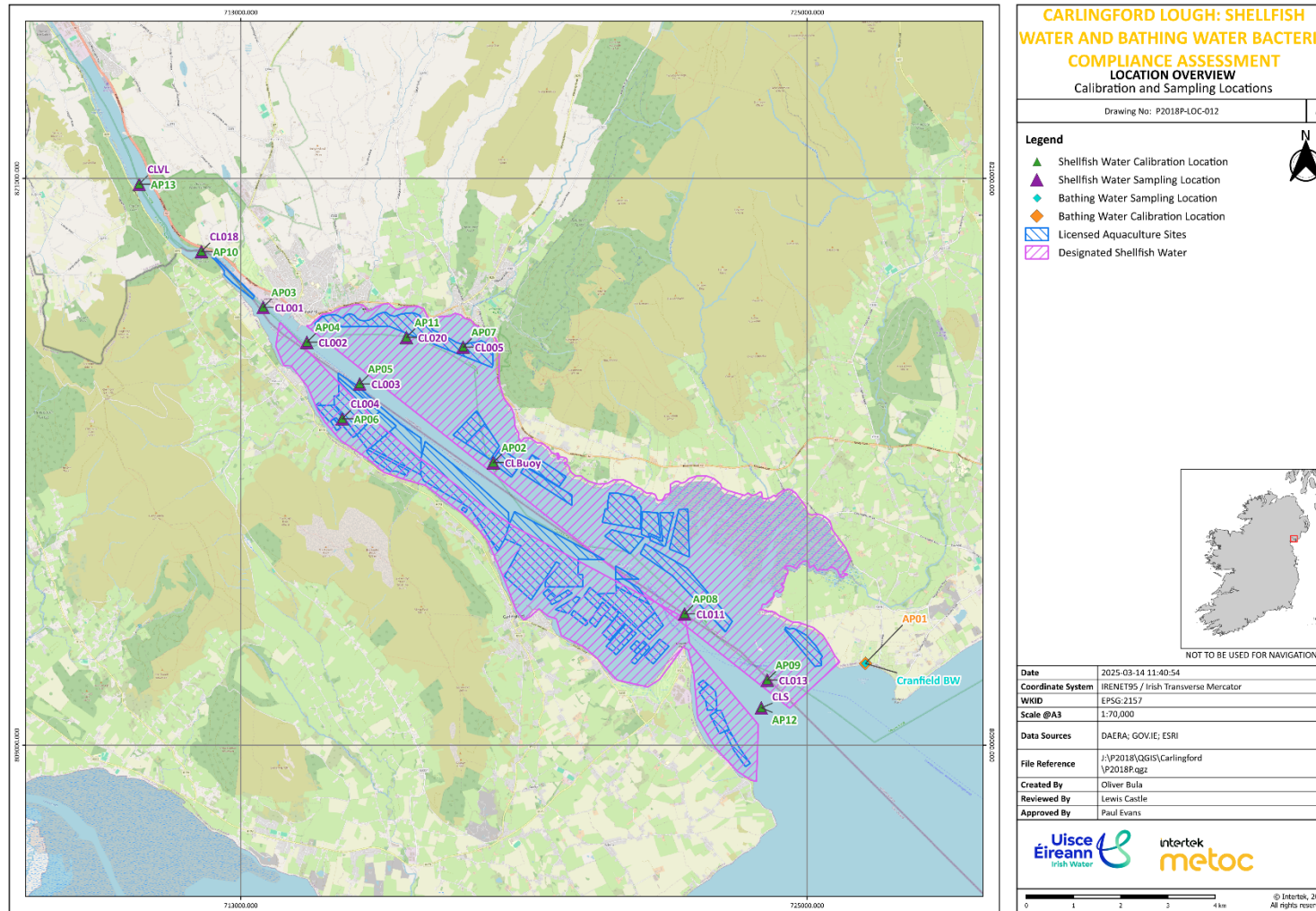
- Scenario 2 – Post 2024 with Omeath untreated discharges replaced with UV treated discharge at Omeath WwTP, increased capacity at Carlingford WwTP and Greenore WwTP, separated storm and FE components for Carlingford and Greenore WwTPs and storm component for Carlingford WwTP moved to D58.

A summary of the key inputs for these three scenarios is provided in Table 8-2.

**Table 8-2 Summary of Pre-2024 and Post-2024 Baseline Scenarios**

Period	Name	Greenore WwTP		Carlingford WwTP		Discharges associated with Omeath Agglomeration		Omeath WwTP	
		Flow (l/s)	Concentration (EC/100 ml)	Flow (l/s)	Concentration (EC/100 ml)	Flow (l/s)	Concentration (EC/100 ml)	Flow (l/s)	Concentration (EC/100 ml)
Pre - 2024	Scenario 1a	Avg. Flow = 0.379 FFT = 1.137	1 x 10 <sup>6</sup>	Avg. Flow = 7.9 FFT = 23.7	1 x 10 <sup>5</sup>	As provided in Hydrograph	1 x 10 <sup>7</sup> if flow < 8.8 l/s 5 x 10 <sup>6</sup> if flow > 8.8 l/s Note: when flow > 8.8 l/s all flow has concentration of 5 x 10 <sup>6</sup>	NA	NA
	Scenario 1b	Avg. Flow = 0.379 FFT = 1.137	1 x 10 <sup>6</sup>	Avg. Flow = 7.9 FFT = 23.7	1 x 10 <sup>5</sup>	As provided in Hydrograph	1 x 10 <sup>6</sup>	NA	NA
Post - 2024	Scenario 2	Avg. Flow = 0.52 FFT = 1.55 Formula A = 3.1	Continuous = 1 x 10 <sup>6</sup> Intermittent = 5 x 10 <sup>6</sup>	Avg. Flow = 9.79 FFT = 20.58 Formula A = 28.32	Continuous = 1 x 10 <sup>5</sup> Intermittent = 5 x 10 <sup>6</sup> Note: Intermittent discharge moved to D58	NA	NA	As provided in Hydrograph (Sum of two discharges in Omeath Agglomeration)	1 x 10 <sup>4</sup> if flow < 8.8 l/s 5 x 10 <sup>6</sup> if flow > 8.8 l/s Note: if flow > 8.8 l/s only flow above threshold has concentration of 5 x 10 <sup>6</sup>

Figure 8-6 Bacterial Water Quality Sampling Locations



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#### 8.4.3.4 Sensitivity Testing

To ensure the model predictions were as robust as possible, sensitivity testing was undertaken to examine the response of the predicted SFW performance by changing key parameters that are known to vary naturally (such as decay rates). This stage can help remove some uncertainty which might be associated with particular inputs.

As the number of possible sensitivity scenario permutations is almost limitless, a finite set of sensitivity scenarios has been applied in this assessment. These scenarios are outlined in Table 8-3. The results for the sensitivity runs are presented in Section 8.5.1.3.

Note, the results of the sensitivity run are presented for the post-2024 baseline scenario (Scenario 2).

**Table 8-3 Summary of Sensitivity Analyses**

Input / Parameter	Value Applied in Model Runs
Decay Rates (T <sub>90</sub> )	SFW Low: 10 hrs for EC in summer, 20 hrs for EC in winter SFW High: 40 hrs for EC in summer, 80 hrs for EC in winter
WwTW FE Concentrations	Low: 10 times lower than baseline values High: 10 times higher than baseline values
CSO Concentrations	Low: 10 times lower than baseline values High: 10 times higher than baseline values
Septic Tank Concentrations	Low: 10 times lower than baseline values High: 10 times higher than baseline values
River loads	Low: 10 times lower than baseline values High: 10 times higher than baseline values

As discussed in Section 8.4.3.1, the Baseline model run used a lower value for Cranfield WwTW FE than the initial default value. An additional sensitivity test is presented to show the impact of using the default value for crude untreated sewage at Cranfield WwTW.

**Table 8-4 Summary of Specific Sensitivity Analyses**

Input / Parameter	Value Applied in Model Runs
Cranfield WwTW FE Concentration	Using default value for Crude Sewage of 2x10 <sup>7</sup> EC/100 ml. This is 20 times higher than the concentration used in the baseline run.

## 8.5 Baseline and Needs Assessments

Three Baseline model scenarios were run – two for the pre-2024 situation (Scenario 1a for conservative discharge concentrations and Scenario 1b for best fit concentrations), and one post-2024 scenario (Scenario 2). The pre-2024 Baseline scenarios were by necessity used for model verification, since all measured comparison data predate the improvements to Omeath WwTP in 2024. The post-2024 Baseline scenario effectively also acts as a Needs assessment, establishing the scale of any interventions that may be required to improve water quality to meet the SFW standards, and the key sources to target to achieve these improvements.

## 8.5.1 SFW Assessment Results

### 8.5.1.1 Percentile Concentration

In addition to the 12 verification sites, model predictions were extracted at an additional 505 locations for the SFW assessment, to give a total of 517 locations through the Lough. This provided sufficient spatial coverage to enable contour plots of predicted concentrations to be produced.

The comparison of the modelled and measured geomean, 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup> and 97<sup>th</sup> percentile concentrations for each of the sampling (verification) sites in the SFW assessment are provided in Table 8-5 to Table 8-10 for the surface and bottom layers of all three modelled baseline scenarios: Scenario 1a (Table 8-5 and Table 8-6), Scenario 1b (Table 8-7 and Table 8-8) and Scenario 2 (Table 8-9 and Table 8-10). See Table 8-2 for an overview of the key differences between each modelled scenario.

The geomean and 97<sup>th</sup> percentile concentrations for the surface and bottom layers are plotted for each modelled scenario in Figure 8-7 to Figure 8-10. These are the key percentiles for SFW performance in Ireland.

Table 8-5 to Table 8-10 and Figure 8-7 to Figure 8-10 also show the 95% confidence interval (CI) on the percentile concentrations derived from the sample data. These limits are calculated using a methodology for determining confidence limits from small datasets using a log-normal distribution described in Chakraborti & Li (2007).

The verification results show that Scenario 1a overpredicts the geomean EC concentrations, particularly at AP05 and AP06, although it should be noted that the concentrations are all relatively low. At AP05, the predicted geomean concentration is 44 EC/100 ml in the surface layer for Scenario 1a compared to 6 EC/100 ml in the sampling data. At AP06, the predicted geomean concentration is 201 EC/100 ml in the surface layer for Scenario 1a compared to 12 EC/100 ml in the sampling data.

The verification results show that the predicted geomean EC concentrations in Scenario 1b generally agree well with the measured data at the majority of locations in the surface and bottom layers. Predicted geomean concentrations fall within the 95% CI of the measured data at all assessment points and visual observation shows a generally good fit at most of these sites. This suggests that the EC concentrations associated with the two untreated discharges in the Omeath agglomeration are likely to be significantly lower than the original default conservative values applied in Scenario 1a.

The verification results show that the predicted 97<sup>th</sup> percentile EC concentrations in Scenario 1b also agree well with the measured data at the majority of locations in the surface and bottom layers. Predicted 97<sup>th</sup> percentile EC concentrations fall within the 95% CI of the measured data at most assessment points. The predicted concentration at AP08 is slightly outside the 95% CI in both the surface and bottom layer, and the prediction at AP09 is also slightly outside the 95% CI, but only in the bottom layer. Visual comparison shows a generally good fit at most sites, although predicted concentrations are overestimated at AP06 in the bottom layer and underestimated at AP13 in the surface layer.

AP13 is the only location where the measured data (surface layer only) show a geomean concentration in excess of the target 110 EC/100 ml Class B threshold and a 97<sup>th</sup> percentile concentration in excess of the 1500 EC/100 ml target (surface layer only). Despite the model predictions falling well within the 95% CI at AP13, this location shows a significant underprediction at the geomean concentration at both the surface and bottom layer and a significant underprediction at the 97<sup>th</sup> percentile concentration in the surface layer. With regard to this result, the following points are noted:

- This assessment point (AP13) only has six measured samples at the surface and five samples at the bottom. This limited sampling data set contributes to the large uncertainty in the sampled geomean concentration values, as indicated by the large error bars.

- AP13 is located within a fairly narrow part of the Newry River channel at a site that experiences significant tidal variation (e.g. change in water depth and channel width from high to lower water). This means that model predictions here may in part reflect the accuracy of the model in representing these localised conditions, but they will not necessarily translate to poor model performance across the wider lough (as evidenced by the good verification elsewhere).
- Sensitivity testing has shown that it is not possible to improve the verification at AP13 without having a negative impact on the verification at other nearby locations (e.g. AP10).
- AP13 is upstream of any SWPA or designated shellfish harvesting area. It is therefore considered a less important model location than the verification sites within the sensitive waters.

Both the measured data and the model predictions indicate that the SWPA easily meets the target SFW standard of a geomean concentration of 110 EC/100 ml and a concentration of 1500 EC/100 ml at the 97<sup>th</sup> percentile, at all locations excluding AP13. At AP13, the sampled geomean concentration is 220 EC/100 ml and the sampled 97<sup>th</sup> percentile is 5,659 EC/100 ml for the surface layer, both of which exceed the relevant targets. However, as noted previously, this is based on a limited number of samples (six samples), and this location is outside the SWPA. The sampled geomean and 97<sup>th</sup> percentile concentrations for the bottom layer at AP13 both meet the targets (93 EC/100 ml and 669 EC/100 ml respectively).

Figure 8-11 to Figure 8-14 present contour plots of predicted impact in Carlingford Lough for the pre-2024 scenario (Scenario 1b) for the 110 and 1500 EC/100 ml thresholds, surface and bottom layer respectively. Figure 8-15 to Figure 8-18 present contour plots of predicted impact in Carlingford Lough for the post-2024 scenario (Scenario 2) for the 110 and 1500 EC/100 ml thresholds, surface and bottom layer respectively. These plots have been produced by contouring model predictions for over five hundred individual assessment points throughout Carlingford Lough. These plots show the percentage of time that predicted concentrations are less than the 110 EC/100 ml and 1500 EC/100 ml SFW thresholds. To meet the SFW water quality standard for Class B, geomean concentrations should be less than 110 EC/100 ml, and concentrations should be less than 1500 EC/100 ml for at least 97% of the time. The plots are therefore colour-coded – areas in green indicate that the standards are met, and areas shown in red indicate that predicted concentrations exceed the standards.

It is noted that the majority of the SWPA is predicted to meet both the geomean and 97<sup>th</sup> percentile SFW thresholds. A small area of higher impact is located near Omeath in the pre-2024 Scenario (Figure 8-11 to Figure 8-14). This area is predicted to exceed the SFW Class B concentration threshold in both the surface and the bottom layer and at both thresholds. However, this area of elevated impact is not present in the post-2024 Scenario (Figure 8-15 to Figure 8-18), following the construction of a UV treated WwTP at Omeath.

The model predictions also show another area of elevated impact in the Newry River. However, this area is located outside the SWPA and is therefore not 'non-compliant' since SFW quality standards do not apply here.

There are also a number of other small areas of elevated impact that are predicted to exceed the 97<sup>th</sup> percentile threshold. These areas do not exceed the geomean threshold, suggesting that the exceedance is driven by an intermittent discharge (which tend to impact higher percentiles, whilst continuous discharges tend to drive performance at lower percentiles).

The model results are generally consistent with the water quality sampling data and the SFPA Shellfish Flesh Classifications, which are predominantly Class A and B. The vast majority of Carlingford Lough is predicted to meet the SFW standard >95% of the time.

**Table 8-5 SFW Assessment – Pre-2024 Baseline Results (Scenario 1a): Surface**

Sample Site / Assessment Point	Geomean Concentration (EC/100 ml)			50th percentile Concentration (EC/100 ml)			75th percentile Concentration (EC/100 ml)			90th percentile Concentration (EC/100 ml)			97th percentile Concentration (EC/100 ml)		
	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction
CLBuoy / AP02	3	1 – 6	4	3	1 – 6	4	8	3 – 20	10	20	7 – 65	23	53	14 – 227	37
CL001 / AP03	46	19 – 111	68	46	20 – 108	63	141	56 – 369	106	383	124 – 1,266	228	1,027	255 – 4,570	618
CL002 / AP04	21	7 – 60	51	21	7 – 58	49	80	26 – 257	87	268	68 – 1,149	209	891	163 – 5,473	551
CL003 / AP05	6	2 – 20	44	6	2 – 20	43	28	8 – 108	73	113	24 – 593	181	444	64 – 3,506	456
CL004 / AP06	12	4 – 40	201	12	4 – 39	203	55	16 – 202	356	212	46 – 1,065	590	803	122 – 6,017	1,001
CL005 / AP07	1	0 – 4	7	1	0 – 4	7	6	2 – 22	17	23	5 – 112	41	85	13 – 610	131
CL011 / AP08	1	1 – 3	2	1	1 – 3	2	4	2 – 10	3	10	4 – 30	4	25	7 – 98	8
CL013 / AP09	1	0 – 2	1	1	0 – 2	1	2	1 – 5	2	5	2 – 16	3	13	3 – 51	4
CL018 / AP10	50	23 – 109	67	50	24 – 106	61	130	57 – 306	109	306	112 – 888	283	714	207 – 2,698	801
CL020 / AP11	2	1 – 6	6	2	1 – 6	6	8	2 – 32	14	33	7 – 180	38	134	19 – 1,099	123
CLS / AP12	1	0 – 2	2	1	0 – 2	1	2	1 – 6	2	6	2 – 21	4	16	4 – 76	6
CLVL / AP13	220	31 – 1,594	99	220	36 – 1,346	84	704	96 – 5,835	190	2,010	170 – 29,756	539	5,659	259 – 172,380	1,651

**Table 8-6 SFW Assessment – Pre-2024 Baseline Results (Scenario 1a): Bottom**

Sample Site / Assessment Point	Geomean Concentration: (EC/100 ml)			50th percentile Concentration: (EC/100 ml)			75th percentile Concentration: (EC/100 ml)			90th percentile Concentration: (EC/100 ml)			97th percentile Concentration: (EC/100 ml)		
	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction
CLBuoy / AP02	3	1 – 7	4	3	1 – 7	3	8	3 – 21	9	22	7 – 71	17	55	14 – 245	31
CL001 / AP03	14	5 – 38	54	14	6 – 37	51	48	17 – 140	84	140	40 – 532	164	404	85 – 2,148	452
CL002 / AP04	4	1 – 12	34	4	1 – 12	34	15	5 – 54	56	54	12 – 259	88	188	31 – 1,322	180
CL003 / AP05	3	1 – 8	13	3	1 – 7	14	10	3 – 30	27	30	8 – 123	46	92	18 – 539	67
CL004 / AP06	11	5 – 24	117	11	5 – 24	115	29	12 – 72	213	72	25 – 219	347	174	47 – 699	676
CL005 / AP07	3	1 – 7	7	3	1 – 7	7	9	3 – 28	18	28	8 – 108	37	82	17 – 447	114
CL011 / AP08	2	1 – 3	2	2	1 – 3	2	4	2 – 10	3	10	4 – 27	4	22	6 – 81	8
CL013 / AP09	1	0 – 2	2	1	0 – 2	1	3	1 – 6	2	6	2 – 18	3	14	4 – 56	4
CL018 / AP10	24	8 – 68	61	24	8 – 66	56	82	27 – 264	98	253	64 – 1,084	239	768	141 – 4,731	657
CL020 / AP11	2	1 – 6	6	2	1 – 6	6	8	2 – 28	16	28	6 – 142	35	102	16 – 768	105
CLS / AP12	1	0 – 2	2	1	0 – 2	1	2	1 – 6	2	6	2 – 24	4	17	3 – 100	6
CLVL / AP13	93	22 - 399	55	93	25 - 342	52	189	45 – 872	91	357	59 – 2,547	257	669	70 – 8,182	683

**Table 8-7 SFW Assessment – Pre-2024 Baseline Results (Scenario 1b): Surface**

Sample Site / Assessment Point	Geomean Concentration (EC/100 ml)			50th percentile Concentration (EC/100 ml)			75th percentile Concentration (EC/100 ml)			90th percentile Concentration (EC/100 ml)			97th percentile Concentration (EC/100 ml)		
	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction
CLBuoy / AP02	3	1 – 6	2	3	1 – 6	1	8	3 – 20	2	20	7 – 65	6	53	14 – 227	18
CL001 / AP03	46	19 – 111	41	46	20 – 108	36	141	56 – 369	72	383	124 – 1,266	202	1,027	255 – 4,570	601
CL002 / AP04	21	7 – 60	24	21	7 – 58	22	80	26 – 257	46	268	68 – 1,149	113	891	163 – 5,473	341
CL003 / AP05	6	2 – 20	13	6	2 – 20	12	28	8 – 108	28	113	24 – 593	62	444	64 – 3,506	179
CL004 / AP06	12	4 – 40	35	12	4 – 39	31	55	16 – 202	62	212	46 – 1,065	149	803	122 – 6,017	570
CL005 / AP07	1	0 – 4	3	1	0 – 4	2	6	2 – 22	8	23	5 – 112	36	85	13 – 610	126
CL011 / AP08	1	1 – 3	1	1	1 – 3	1	4	2 – 10	2	10	4 – 30	3	25	7 – 98	4
CL013 / AP09	1	0 – 2	1	1	0 – 2	1	2	1 – 5	2	5	2 – 16	2	13	3 – 51	3
CL018 / AP10	50	23 – 109	51	50	24 – 106	43	130	57 – 306	97	306	112 – 888	269	714	207 – 2,698	792
CL020 / AP11	2	1 – 6	3	2	1 – 6	2	8	2 – 32	7	33	7 – 180	33	134	19 – 1,099	118
CLS / AP12	1	0 – 2	1	1	0 – 2	1	2	1 – 6	2	6	2 – 21	2	16	4 – 76	4
CLVL / AP13	220	31 – 1,594	95	220	36 – 1,346	81	704	96 – 5,835	186	2,010	170 – 29,756	535	5,659	259 – 172,380	1648

**Table 8-8 SFW Assessment – Pre-2024 Baseline Results (Scenario 1b): Bottom**

Sample Site / Assessment Point	Geomean Concentration: (EC/100 ml)			50th percentile Concentration: (EC/100 ml)			75th percentile Concentration: (EC/100 ml)			90th percentile Concentration: (EC/100 ml)			97th percentile Concentration: (EC/100 ml)		
	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction
CLBuoy / AP02	3	1 – 7	2	3	1 – 7	1	8	3 – 21	2	22	7 – 71	5	55	14 – 245	16
CL001 / AP03	14	5 – 38	27	14	6 – 37	24	48	17 – 140	53	140	40 – 532	137	404	85 – 2,148	433
CL002 / AP04	4	1 – 12	10	4	1 – 12	9	15	5 – 54	20	54	12 – 259	47	188	31 – 1,322	147
CL003 / AP05	3	1 – 8	3	3	1 – 7	2	10	3 – 30	6	30	8 – 123	12	92	18 – 539	32
CL004 / AP06	11	5 – 24	21	11	5 – 24	19	29	12 – 72	40	72	25 – 219	107	174	47 – 699	472
CL005 / AP07	3	1 – 7	3	3	1 – 7	2	9	3 – 28	7	28	8 – 108	30	82	17 – 447	109
CL011 / AP08	2	1 – 3	1	2	1 – 3	1	4	2 – 10	2	10	4 – 27	3	22	6 – 81	4
CL013 / AP09	1	0 – 2	1	1	0 – 2	1	3	1 – 6	2	6	2 – 18	3	14	4 – 56	3
CL018 / AP10	24	8 – 68	43	24	8 – 66	36	82	27 – 264	82	253	64 – 1,084	222	768	141 – 4,731	644
CL020 / AP11	2	1 – 6	3	2	1 – 6	2	8	2 – 28	6	28	6 – 142	28	102	16 – 768	99
CLS / AP12	1	0 – 2	1	1	0 – 2	1	2	1 – 6	2	6	2 – 24	2	17	3 – 100	4
CLVL / AP13	93	22 – 399	46	93	25 – 342	40	189	45 – 872	82	357	59 – 2,547	247	669	70 – 8,182	673

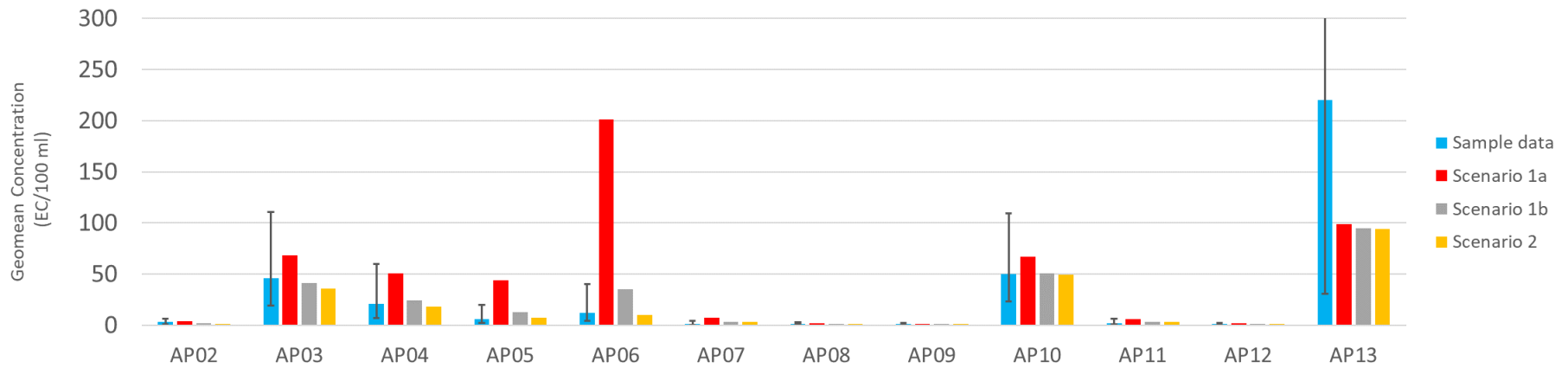
**Table 8-9 SFW Assessment – Post-2024 Baseline Results (Scenario 2): Surface**

Sample Site / Assessment Point	Geomean Concentration (EC/100 ml)			50th percentile Concentration (EC/100 ml)			75th percentile Concentration (EC/100 ml)			90th percentile Concentration (EC/100 ml)			97th percentile Concentration (EC/100 ml)		
	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction
CLBuoy / AP02	3	1 – 6	1	3	1 – 6	1	8	3 – 20	1	20	7 – 65	4	53	14 – 227	17
CL001 / AP03	46	19 – 111	36	46	20 – 108	33	141	56 – 369	71	383	124 – 1,266	201	1,027	255 – 4,570	601
CL002 / AP04	21	7 – 60	18	21	7 – 58	17	80	26 – 257	41	268	68 – 1,149	110	891	163 – 5,473	341
CL003 / AP05	6	2 – 20	7	6	2 – 20	8	28	8 – 108	21	113	24 – 593	52	444	64 – 3,506	179
CL004 / AP06	12	4 – 40	10	12	4 – 39	7	55	16 – 202	29	212	46 – 1,065	129	803	122 – 6,017	565
CL005 / AP07	1	0 – 4	3	1	0 – 4	1	6	2 – 22	7	23	5 – 112	35	85	13 – 610	126
CL011 / AP08	1	1 – 3	1	1	1 – 3	1	4	2 – 10	2	10	4 – 30	3	25	7 – 98	4
CL013 / AP09	1	0 – 2	1	1	0 – 2	1	2	1 – 5	2	5	2 – 16	2	13	3 – 51	3
CL018 / AP10	50	23 – 109	49	50	24 – 106	42	130	57 – 306	96	306	112 – 888	269	714	207 – 2,698	792
CL020 / AP11	2	1 – 6	3	2	1 – 6	1	8	2 – 32	6	33	7 – 180	33	134	19 – 1,099	118
CLS / AP12	1	0 – 2	1	1	0 – 2	1	2	1 – 6	2	6	2 – 21	3	16	4 – 76	4
CLVL / AP13	220	31 – 1,594	94	220	36 – 1,346	80	704	96 – 5,835	186	2,010	170 – 29,756	535	5,659	259 – 172,380	1648

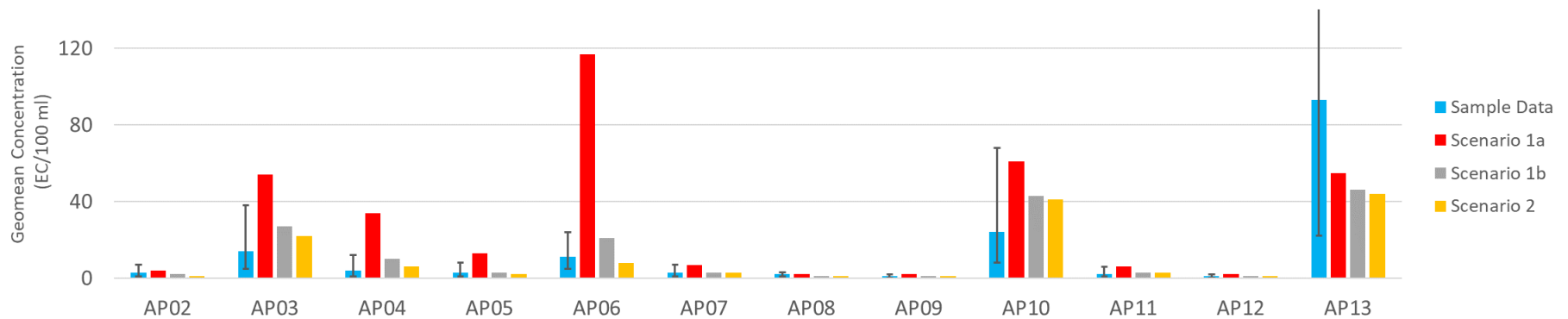
**Table 8-10 SFW Assessment – Post-2024 Baseline Results (Scenario 2): Bottom**

Sample Site / Assessment Point	Geomean Concentration: (EC/100 ml)			50th percentile Concentration: (EC/100 ml)			75th percentile Concentration: (EC/100 ml)			90th percentile Concentration: (EC/100 ml)			97th percentile Concentration: (EC/100 ml)		
	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction	Sample Data	95% CI	Model Prediction
CLBuoy / AP02	3	1 – 7	1	3	1 – 7	1	8	3 – 21	1	22	7 – 71	4	55	14 – 245	16
CL001 / AP03	14	5 – 38	22	14	6 – 37	22	48	17 – 140	52	140	40 – 532	136	404	85 – 2,148	433
CL002 / AP04	4	1 – 12	6	4	1 – 12	6	15	5 – 54	16	54	12 – 259	45	188	31 – 1,322	147
CL003 / AP05	3	1 – 8	2	3	1 – 7	1	10	3 – 30	3	30	8 – 123	10	92	18 – 539	31
CL004 / AP06	11	5 – 24	8	11	5 – 24	6	29	12 – 72	21	72	25 – 219	95	174	47 – 699	463
CL005 / AP07	3	1 – 7	3	3	1 – 7	1	9	3 – 28	6	28	8 – 108	30	82	17 – 447	109
CL011 / AP08	2	1 – 3	1	2	1 – 3	1	4	2 – 10	2	10	4 – 27	3	22	6 – 81	4
CL013 / AP09	1	0 – 2	1	1	0 – 2	1	3	1 – 6	2	6	2 – 18	3	14	4 – 56	3
CL018 / AP10	24	8 – 68	41	24	8 – 66	34	82	27 – 264	81	253	64 – 1,084	221	768	141 – 4,731	644
CL020 / AP11	2	1 – 6	3	2	1 – 6	1	8	2 – 28	5	28	6 – 142	28	102	16 – 768	99
CLS / AP12	1	0 – 2	1	1	0 – 2	1	2	1 – 6	2	6	2 – 24	3	17	3 – 100	4
CLVL / AP13	93	22 – 399	44	93	25 – 342	39	189	45 – 872	81	357	59 – 2,547	247	669	70 – 8,182	673

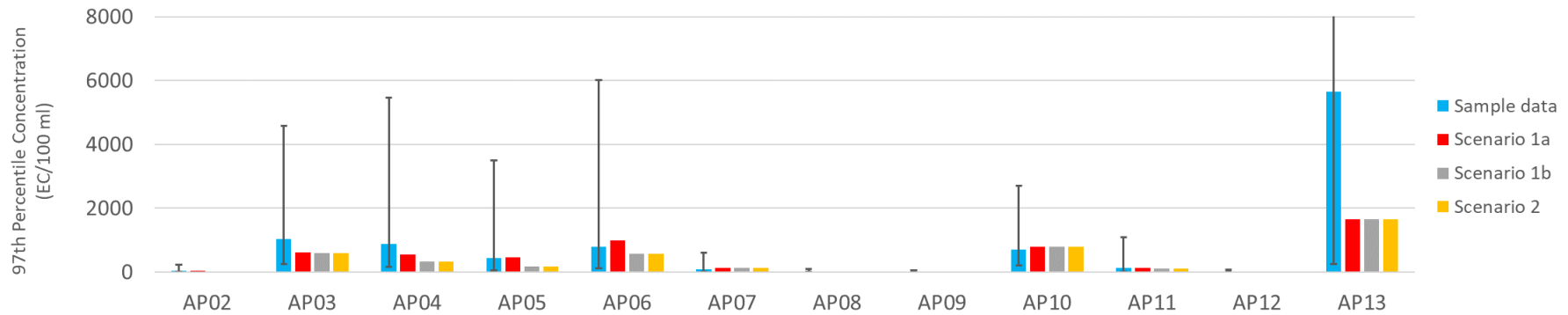
**Figure 8-7 SFW Assessment – Geomean Concentration: Sampled Data and Baseline Results: Surface**



**Figure 8-8 SFW Assessment – Geomean Concentration: Sampled Data and Baseline Results: Bottom**



**Figure 8-9 SFW Assessment – 97<sup>th</sup> Percentile Concentration: Sampled Data and Baseline Results: Surface**



**Figure 8-10 SFW Assessment – 97<sup>th</sup> Percentile Concentration: Sampled Data and Baseline Results: Bottom**

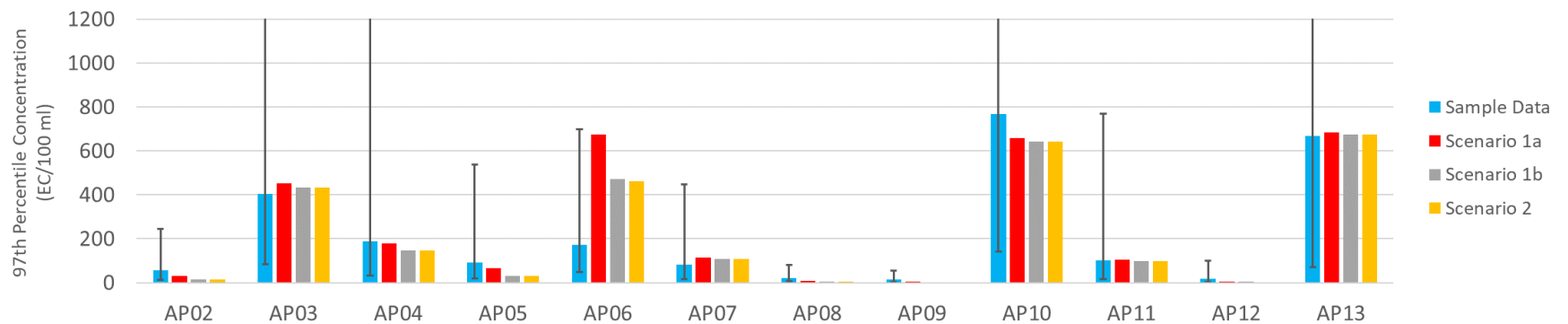
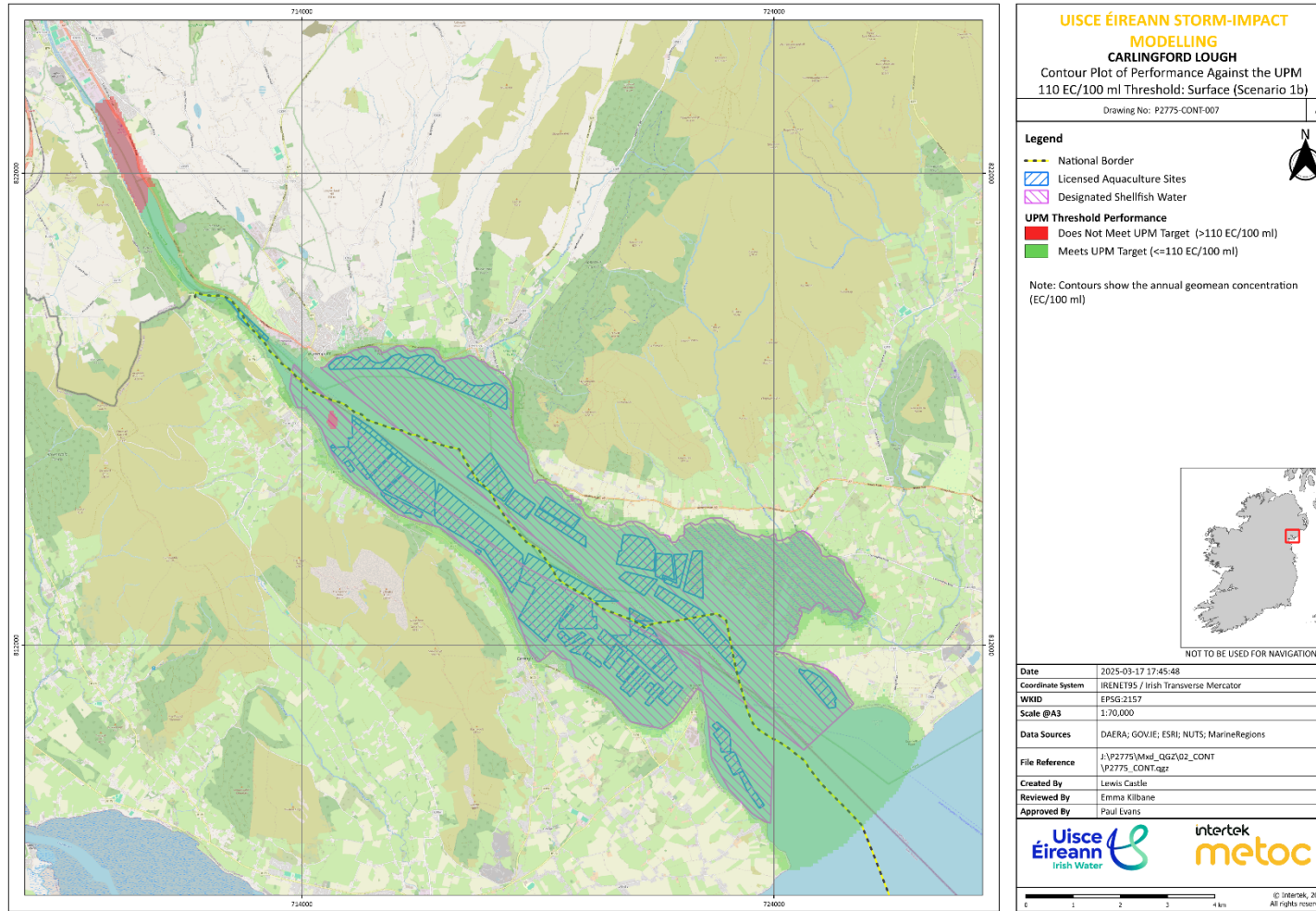
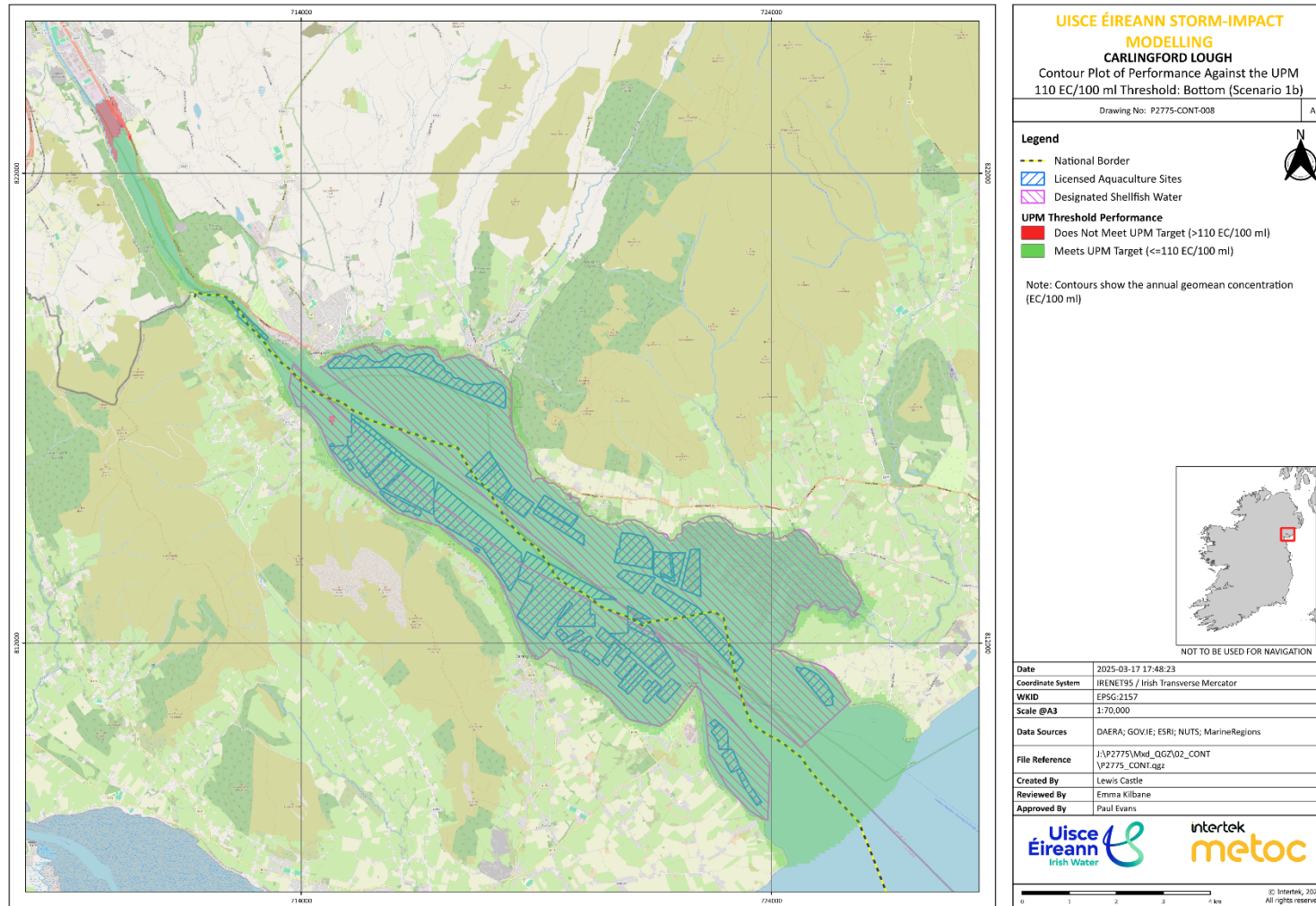


Figure 8-11 Contour Plot of Performance Against the 110 EC/100 ml SFW Threshold for the Pre-2024 Baseline Scenario (Scenario 1b): Surface



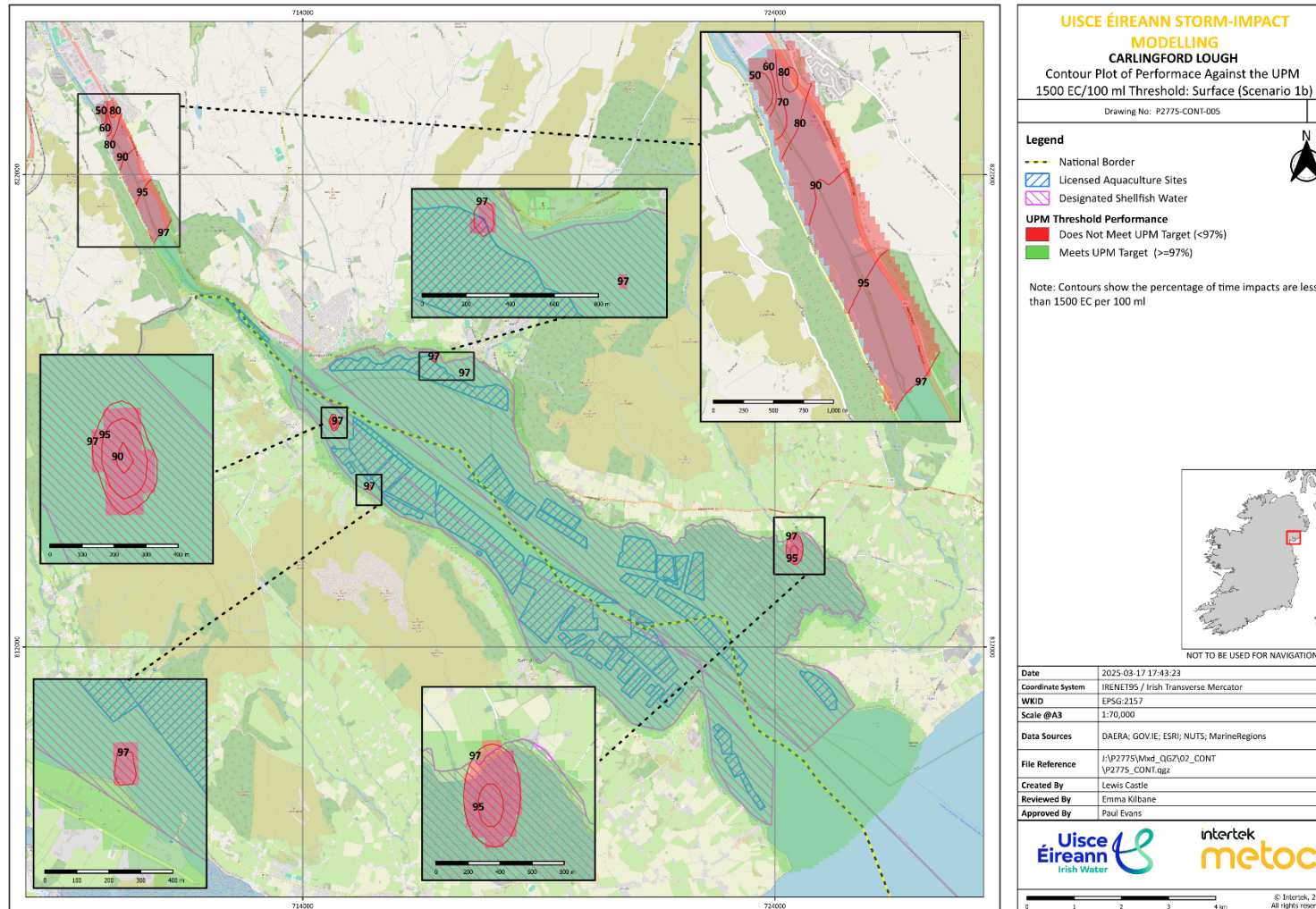
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Figure 8-12 Contour Plot of Performance Against the 110 EC/100 ml SFW Threshold for the Pre-2024 Baseline Scenario (Scenario 1b): Bottom



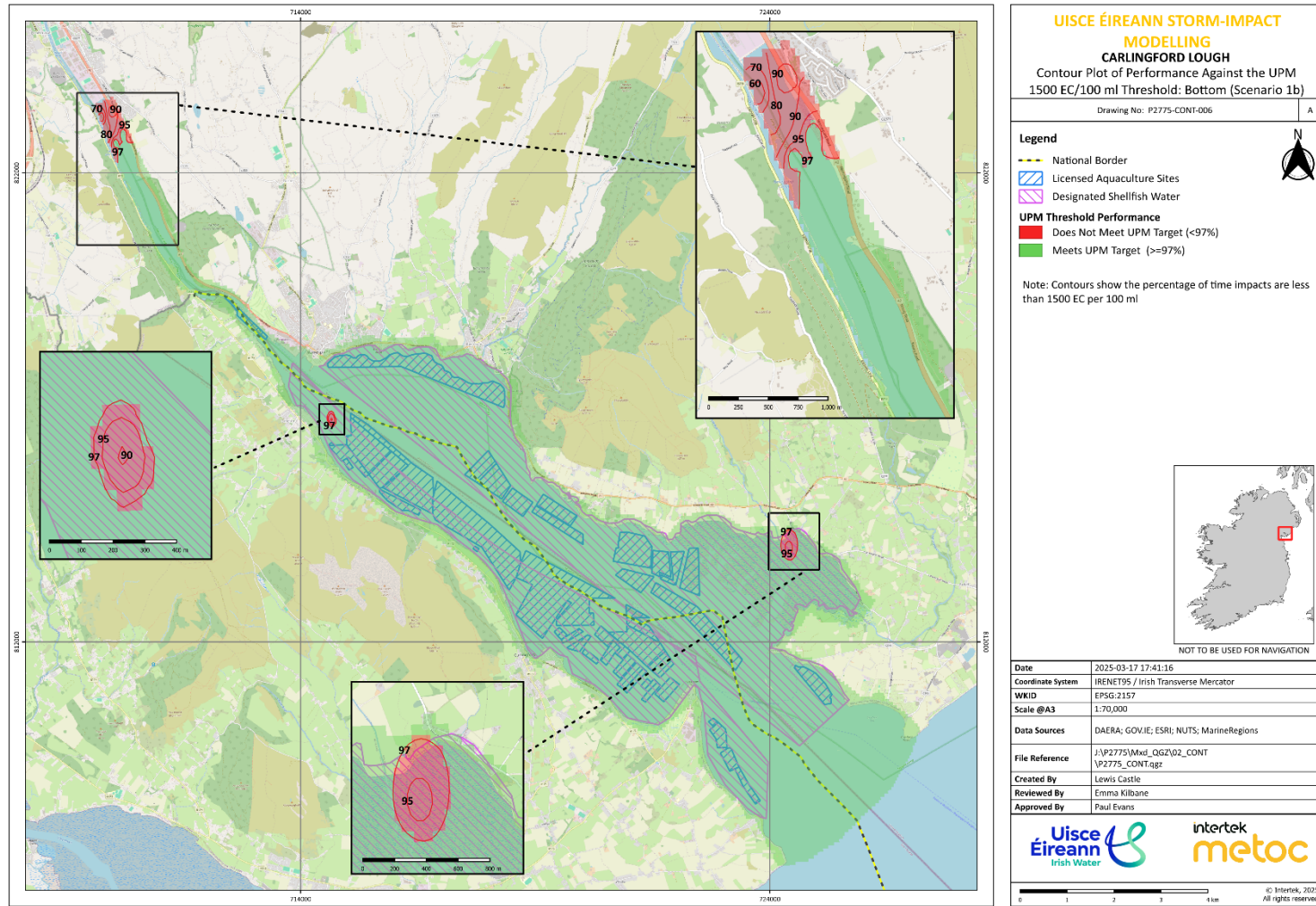
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Figure 8-13 Contour Plot of Performance Against the 1500 EC/100 ml SFW Threshold for the Pre-2024 Baseline Scenario (Scenario 1b): Surface



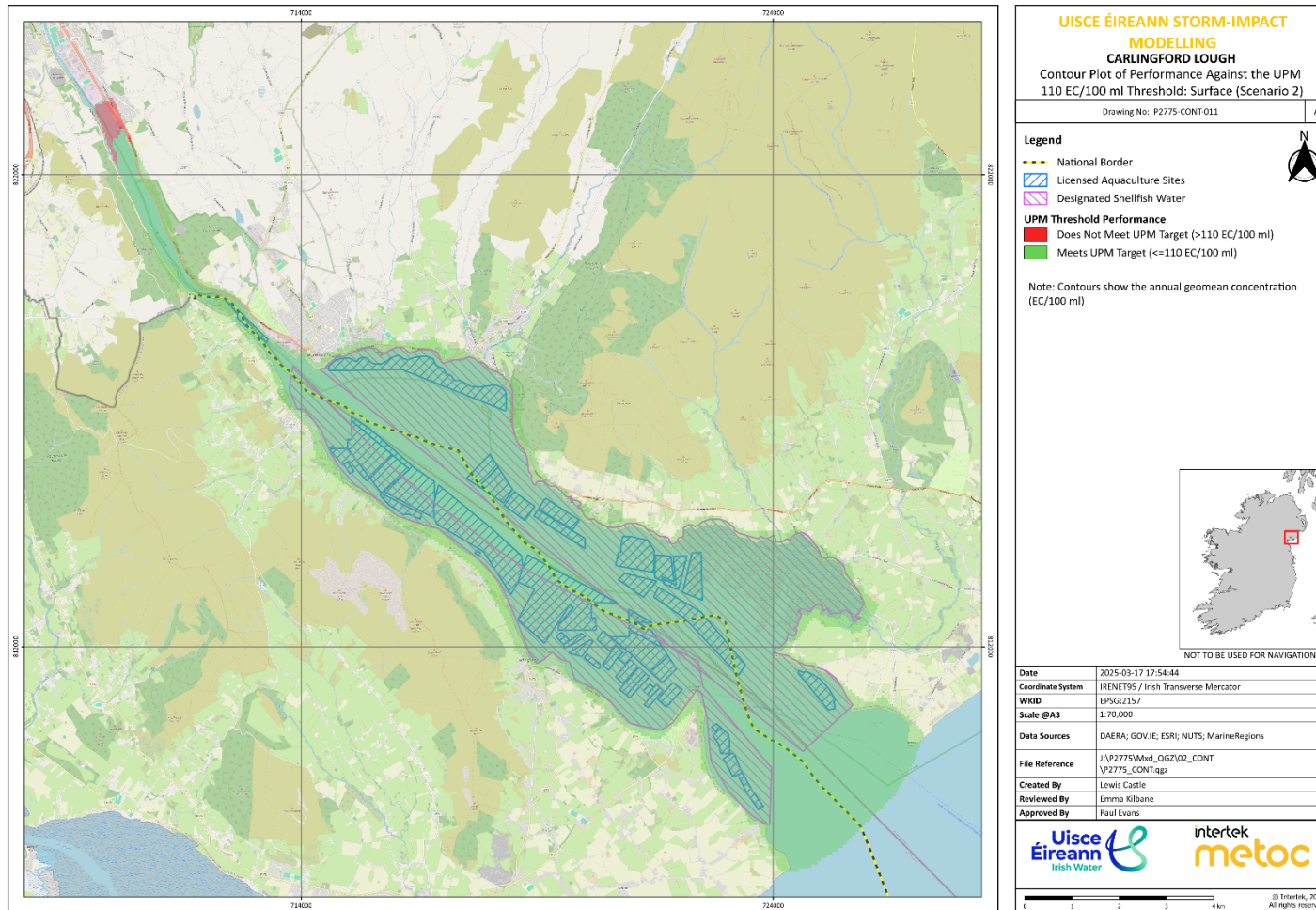
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Figure 8-14 Contour Plot of Performance Against the 1500 EC/100 ml SFW Threshold for the Pre-2024 Baseline Scenario (Scenario 1b): Bottom



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Figure 8-15 Contour Plot of Performance Against the 110 EC/100 ml SFW Threshold for the Post-2024 Baseline Scenario (Scenario 2): Surface

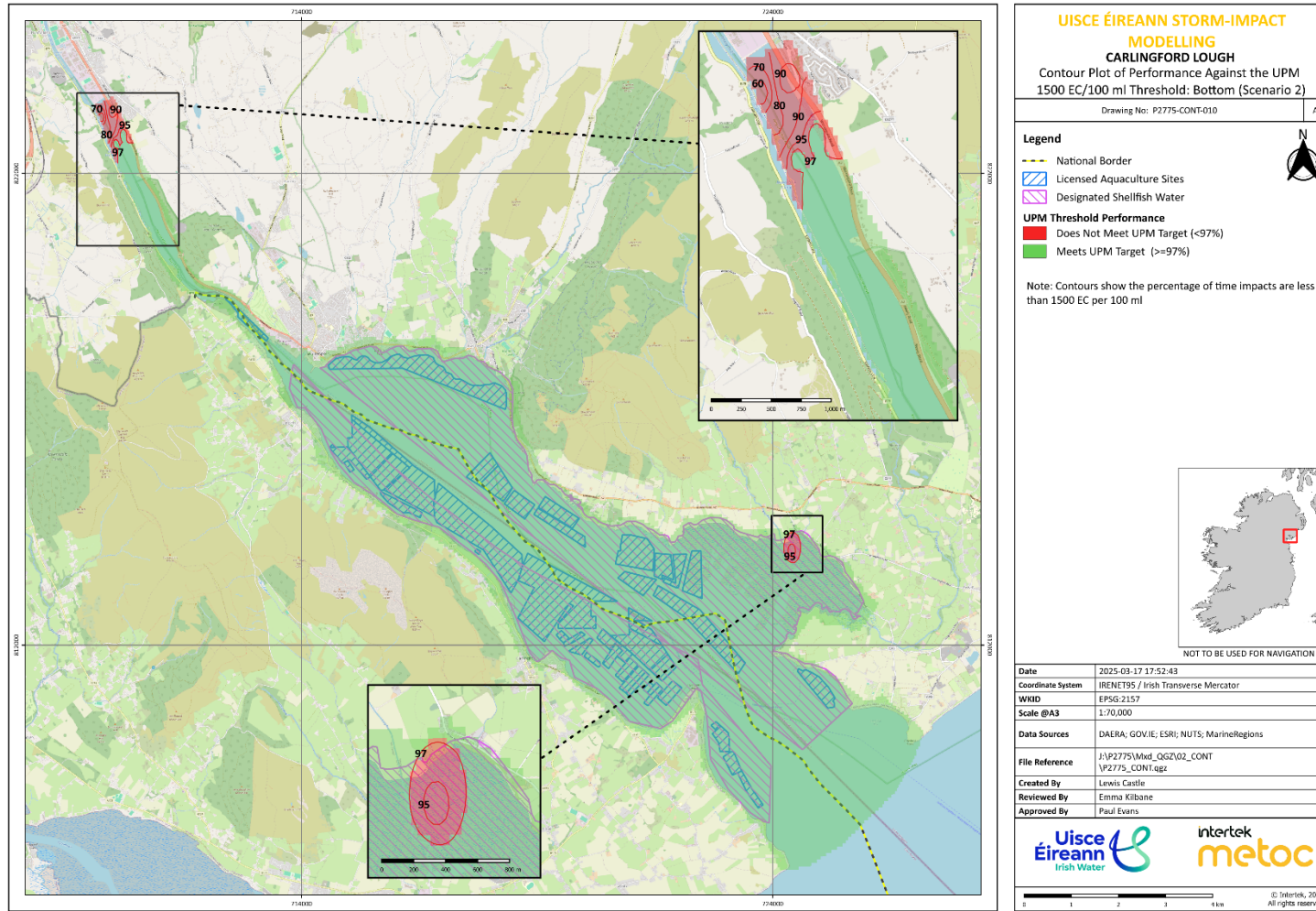


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Figure 8-18 Contour Plot of Performance Against the 1500 EC/100 ml SFW Threshold for the Post-2024 Baseline Scenario (Scenario 2): Bottom



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### 8.5.1.2 Source Apportionment

The impact assessment approach allows assessment of the relative contribution of individual sources to SFW impacts at each individual assessment point. The source apportionment of impacts at the geomean and 97<sup>th</sup> percentile EC concentration has been calculated for the post-2024 Baseline Scenario (Scenario 2) for the seven sampling (model verification) locations in Irish waters and the four SFWA flesh sampling locations. Note that locations AP08, AP09 and AP72 never exceed either the 110 EC/100 ml or the 1500 EC/100 ml thresholds at any point during the model simulation. Hence, no source apportionment could be derived for these locations.

In total, 154 sources were included in the assessment (some of these modelled sources representing more than one discharge, in the case of septic tanks). Maps of the pie charts are shown graphically in Figure 8-19 to Figure 8-22 for the surface and bottom layers at the geomean and 97<sup>th</sup> percentile concentrations. These plots highlight contributors with >2% predicted impact at each assessment point, with the 'All Other' category representing the total contribution from the remaining sources. These lower-ranked sources are relatively unimportant in terms of bacterial impact in the SWPA and would realistically not be considered were improvements to SFW quality required.

It should be noted that all sample data/model verification locations are predicted to be compliant with geomean and 97<sup>th</sup> percentile SFW standard in the baseline model. In addition, most locations have relatively low predicted concentrations which should be taken into account when considering the significance of the source apportionment. A discharge that has a high percentage contribution to a low impact may in fact not be that important in terms of overall water quality. As such, the source apportionment analysis must be considered in the overall context of water quality performance. A large contribution from a particular source does not necessarily indicate that any improvement at that source is required.

Details of the total impacts and source apportionment results are available at all 517 assessment locations if required.

Figure 8-19 Baseline Assessment Source Apportionment: Surface, Geomean

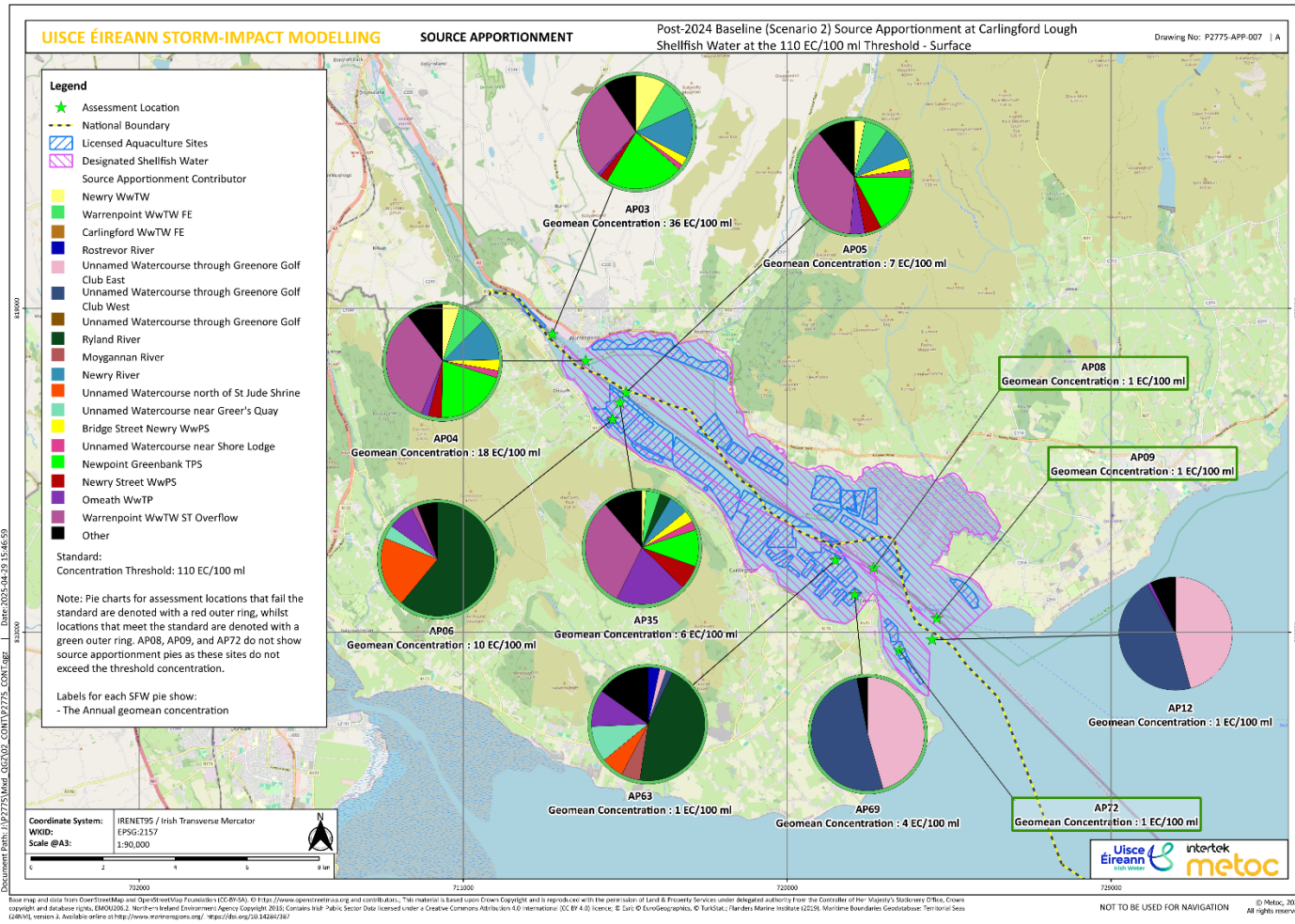


Figure 8-20 Baseline Assessment Source Apportionment: Bottom, Geomean

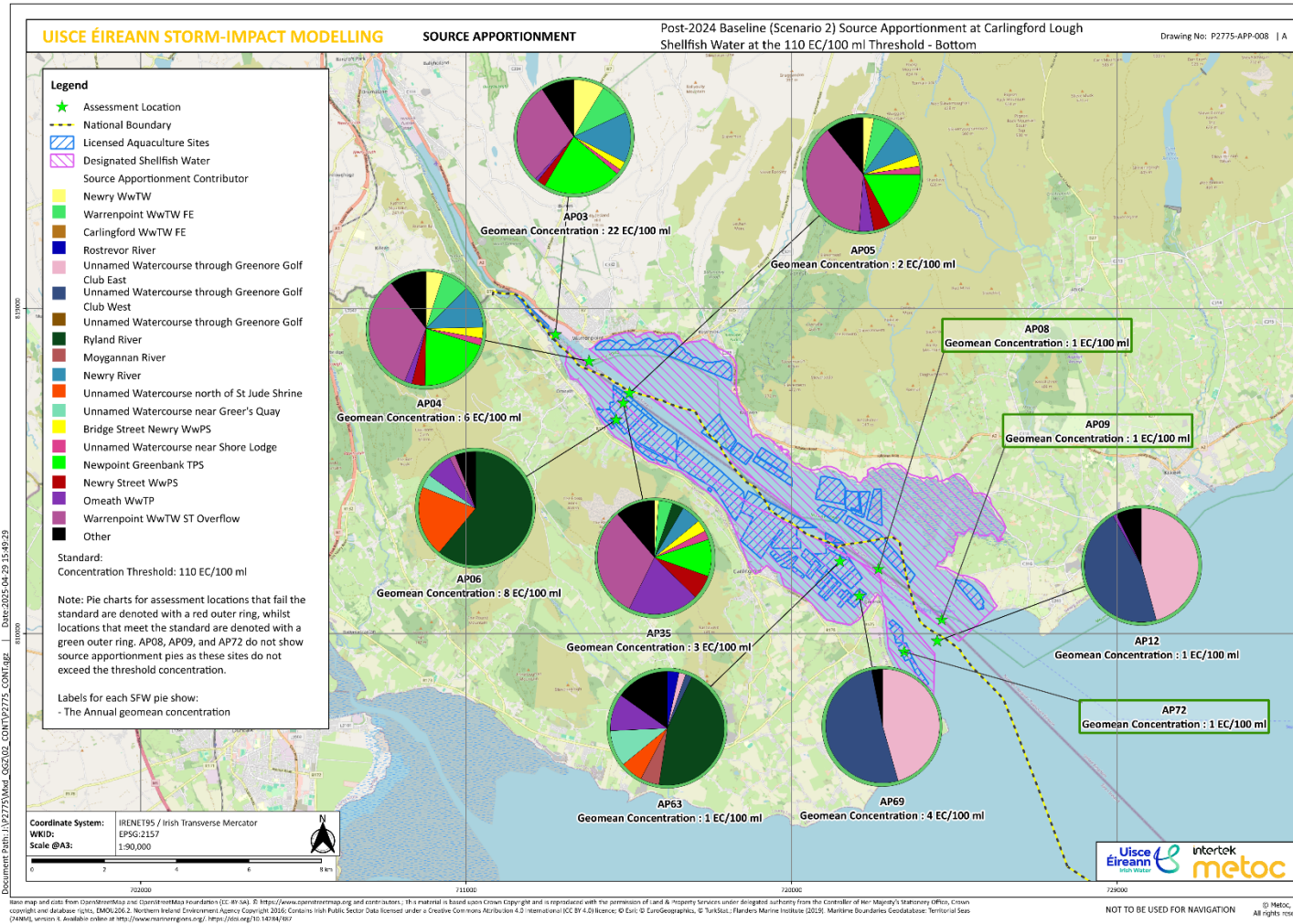


Figure 8-21 Baseline Assessment Source Apportionment: Surface, 97<sup>th</sup> Percentile

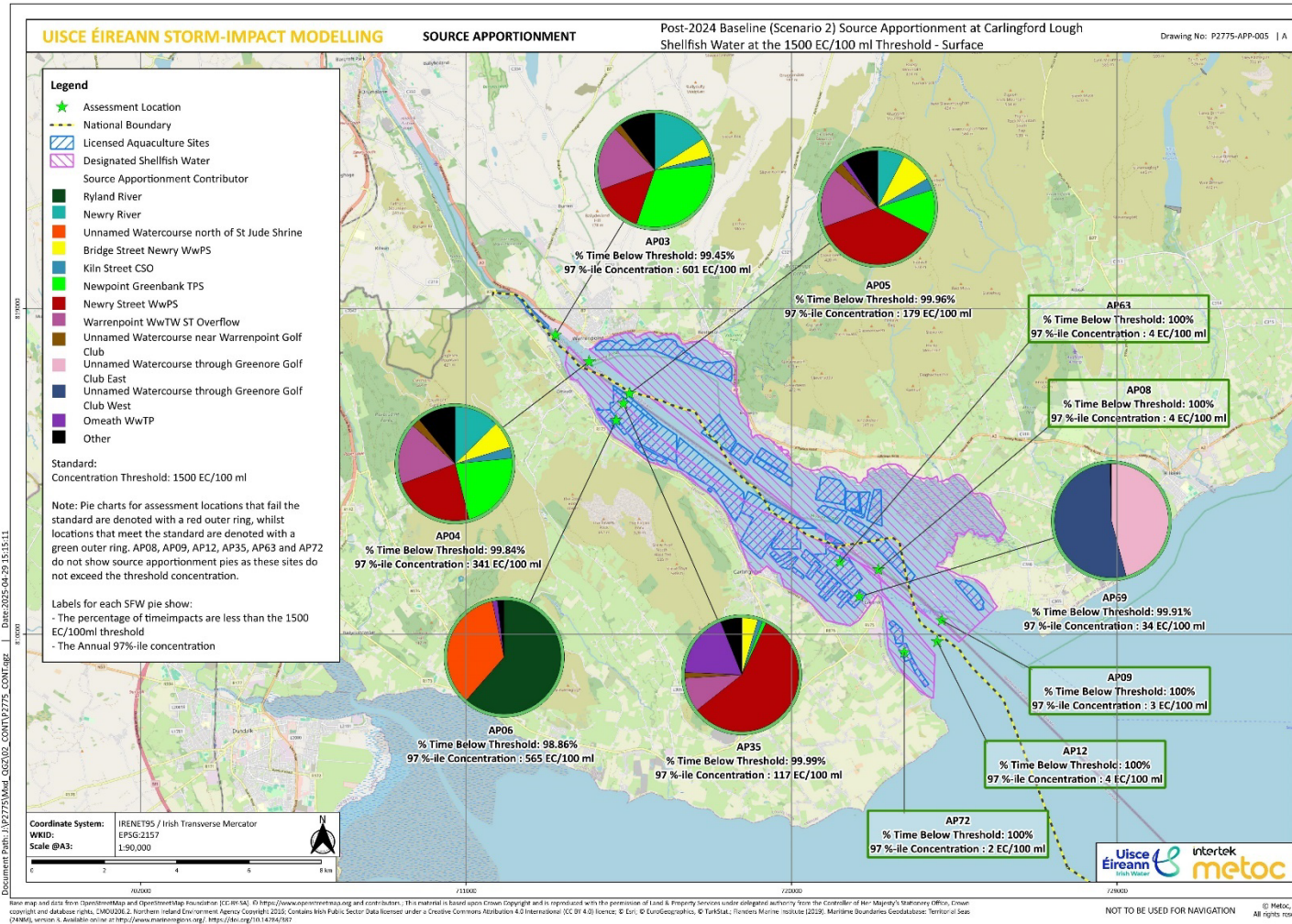
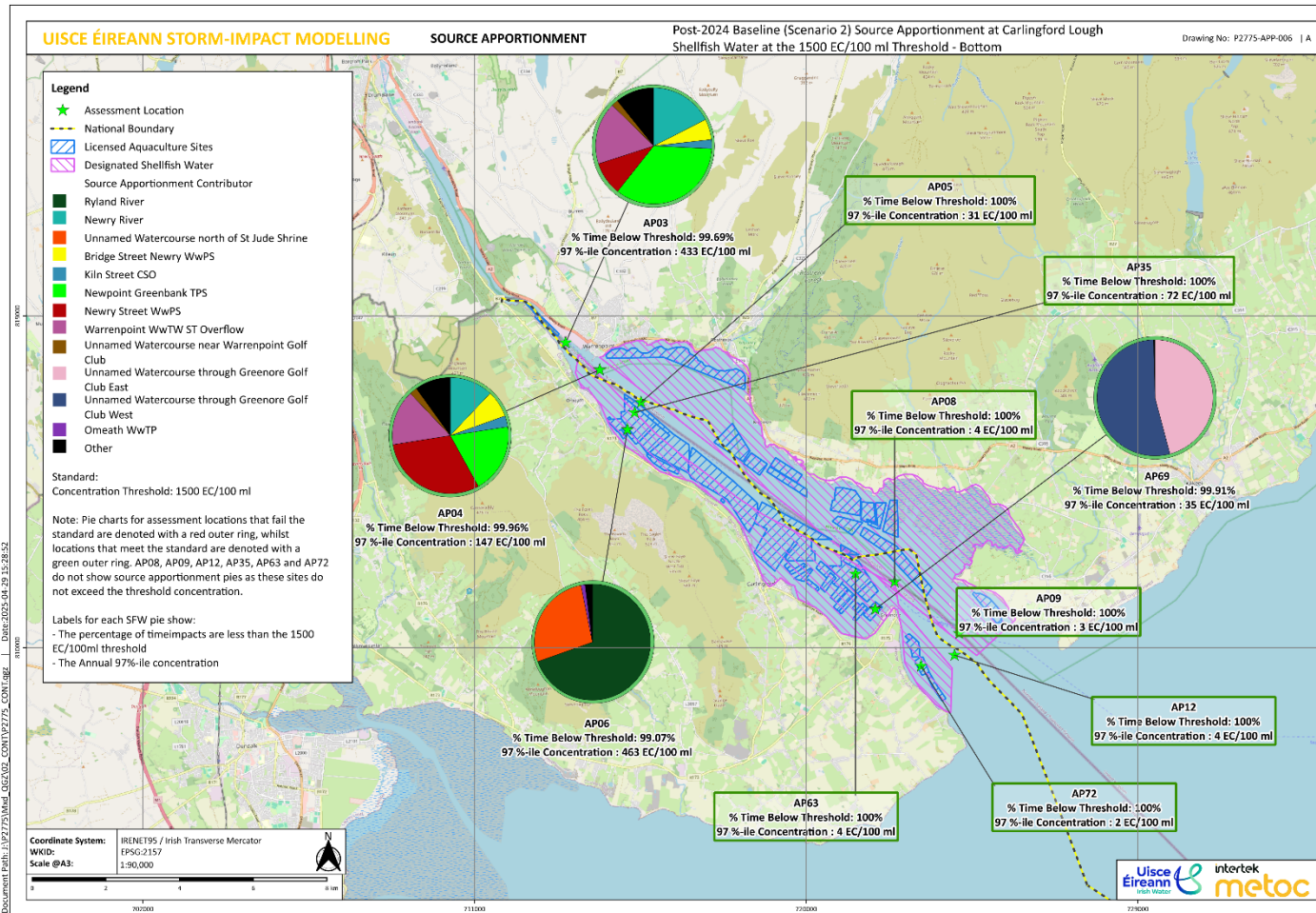


Figure 8-22 Baseline Assessment Source Apportionment: Bottom, 97<sup>th</sup> Percentile



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### 8.5.1.3 Sensitivity Testing

A number of sensitivity tests were undertaken in the impact assessment to assess the sensitivity of predicted impacts to different input parameters. Table 8-11 to Table 8-14 and Figure 8-23 to Figure 8-26 show the predicted geomean and 97<sup>th</sup> percentile EC concentrations in the surface and bottom layers for the sensitivity tests compared to the post-2024 baseline scenario (Scenario 2) at the 12 model verification locations. The suite of sensitivity tests undertaken is described in Section 8.4.3.4.

#### **Decay Rates**

The sensitivity tests show that most of the verification sites are sensitive to T<sub>90</sub> decay rates. The baseline T<sub>90</sub> values for EC were 20 hours for summer and 40 hours for winter. In the results tables, the lower T<sub>90</sub> corresponds to a faster rate of decay, with T<sub>90</sub> values of 10 hours for summer and 20 hours for winter. The higher T<sub>90</sub> corresponds to a slower decay rate, with T<sub>90</sub> values of 40 hours for summer and 80 hours for winter.

#### **Asset Loads (WwTWs and CSOs)**

The WwTW and CSO loads were increased and decreased by a factor of 10. The sensitivity tests show that most sites are sensitive to the input load from WwTWs and CSOs. AP03, AP04, AP10 and AP13 are shown to be particularly sensitive to WwTW concentrations at the geomean concentration and to CSO concentrations at the 97<sup>th</sup> percentile concentration.

#### **Septic Tank Loads**

The septic tank loads were increased and decreased by a factor of 10. There was no significant impact on the predicted geomean or 97<sup>th</sup> percentile concentrations at any site due to changes in septic tank loads.

#### **Rivers**

The river loads were increased and decreased by a factor of 10. Changes to river loads have little impact at the geomean threshold but most sites (excluding AP08, AP09 and AP12) are sensitive to river loads at the 97<sup>th</sup> percentile concentration.

#### **Additional Sensitivity Tests**

In addition to the general sensitivity tests, sensitivity testing was carried out specifically on Cranfield WwTW FE. The results of these tests show that AP08 and AP09 are particularly sensitive to the concentration of Cranfield WwTW FE. Using default values for Cranfield WwTW FE, which are 20 times higher than the values used in the baseline model, caused the predicted geomean concentration at AP09 to increase from 1 EC/100 ml to 14 EC/100 ml in the surface layer and from 1 EC/100 ml to 19 EC/100 ml in the bottom layer. The 97<sup>th</sup> percentile concentration at AP09 increased from 3 EC/100 ml to 49 EC/100 ml in the surface layer and from 3 EC/100 ml to 58 EC/100 ml in the bottom layer.

**Table 8-11 Sensitivity Scenarios: Predicted Geomean Concentrations (EC/100 ml) at the Model Verification Locations: Surface**

	AP02	AP03	AP04	AP05	AP06	AP07	AP08	AP09	AP10	AP11	AP12	AP13
<b>Post-2024 Baseline (Scenario 2)</b>	1	36	18	7	10	3	1	1	49	3	1	94
<b>High T90</b>	3	88	49	21	24	7	3	3	117	8	3	215
<b>Low T90</b>	1	14	6	3	5	2	1	1	18	2	1	34
<b>WwTW x10</b>	4	244	119	39	29	5	8	9	318	6	8	598
<b>WwTW /10</b>	1	9	5	3	8	3	1	1	13	3	1	26
<b>CSO x10</b>	2	68	33	13	13	6	2	1	93	6	2	182
<b>CSO /10</b>	1	28	14	6	10	2	1	1	38	3	1	72
<b>Rivers x10</b>	2	52	26	12	28	7	2	2	71	6	2	140
<b>Rivers /10</b>	1	34	16	6	6	2	1	1	45	2	1	86
<b>Septic Tanks x10</b>	2	40	20	8	28	4	1	1	56	5	2	114
<b>Septic Tanks /10</b>	1	36	18	7	7	3	1	1	48	3	1	92
<b>Default Value for Cranfield WwTW FE</b>	2	36	18	8	10	3	10	14	49	3	6	94

**Table 8-12 Sensitivity Scenarios: Predicted Geomean Concentrations (EC/100 ml) at the Model Verification Locations: Bottom**

	AP02	AP03	AP04	AP05	AP06	AP07	AP08	AP09	AP10	AP11	AP12	AP13
<b>Post-2024 Baseline (Scenario 2)</b>	1	22	6	2	8	3	1	1	41	3	1	44
<b>High T90</b>	3	58	19	5	18	7	3	3	99	7	3	116
<b>Low T90</b>	1	8	3	1	4	2	1	1	16	2	1	15
<b>WwTW x10</b>	4	149	38	7	19	5	8	11	268	6	8	284
<b>WwTW /10</b>	1	6	3	2	6	3	1	1	10	3	1	12
<b>CSO x10</b>	2	41	12	3	10	5	2	2	78	5	1	89
<b>CSO /10</b>	1	17	5	2	7	2	1	1	31	2	1	34
<b>Rivers x10</b>	2	32	10	4	21	6	2	2	59	6	2	65
<b>Rivers /10</b>	1	20	6	2	5	2	1	1	38	2	1	41
<b>Septic Tanks x10</b>	2	24	7	2	19	4	1	1	46	5	2	51
<b>Septic Tanks /10</b>	1	22	6	2	6	3	1	1	40	3	1	44
<b>Default Value for Cranfield WwTW FE</b>	2	22	7	2	8	3	11	19	41	3	6	44

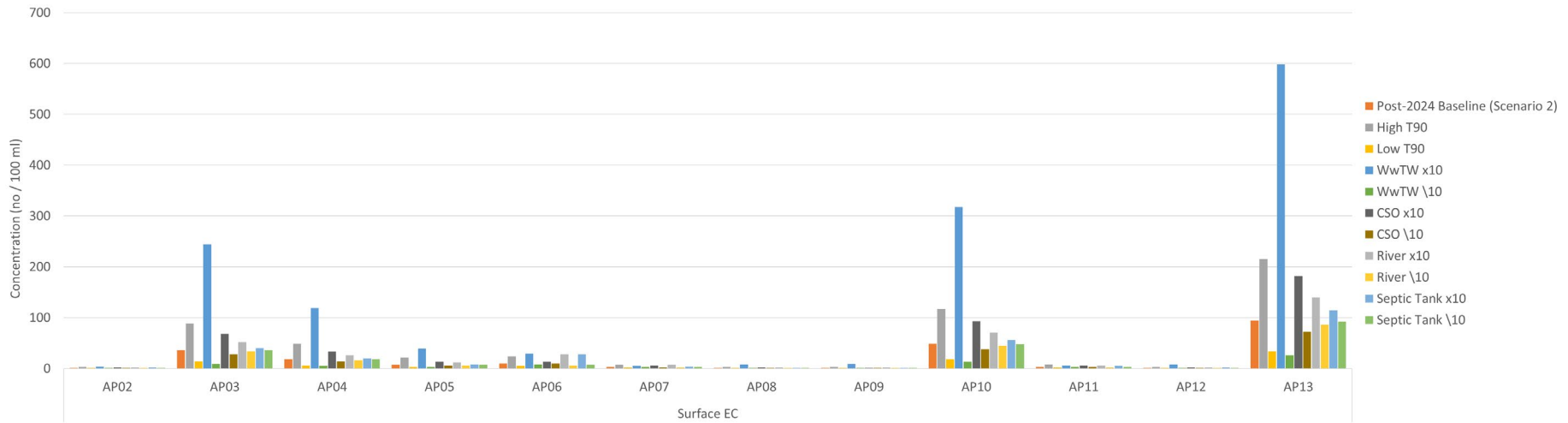
**Table 8-13 Sensitivity Scenarios: Predicted 97<sup>th</sup> Percentile Concentrations (EC/100 ml) at the Model Verification Locations: Surface**

	AP02	AP03	AP04	AP05	AP06	AP07	AP08	AP09	AP10	AP11	AP12	AP13
<b>Post-2024 Baseline (Scenario 2)</b>	17	601	341	179	565	126	4	3	792	118	4	1,648
<b>High T90</b>	53	1,148	713	401	727	241	11	8	1,583	226	11	2,974
<b>Low T90</b>	4	293	147	72	415	52	1	1	339	52	1	748
<b>WwTW x10</b>	35	1,158	729	455	895	134	30	26	1,510	129	27	3,151
<b>WwTW /10</b>	16	554	308	154	540	125	2	1	734	117	2	1,543
<b>CSO x10</b>	55	4,624	2,555	1,276	697	451	7	5	5,852	281	6	11,969
<b>CSO /10</b>	13	207	124	71	558	96	3	3	301	104	4	640
<b>Rivers x10</b>	111	1,541	869	450	5,273	948	14	9	2,332	1,031	18	5,128
<b>Rivers /10</b>	7	510	289	153	106	46	3	3	643	30	3	1,300
<b>Septic Tanks x10</b>	18	612	347	183	629	128	4	3	810	122	5	1,689
<b>Septic Tanks /10</b>	17	600	341	179	559	126	4	3	790	118	4	1,644
<b>Default Value for Cranfield WwTW FE</b>	18	602	342	180	565	126	58	49	792	118	27	1,648

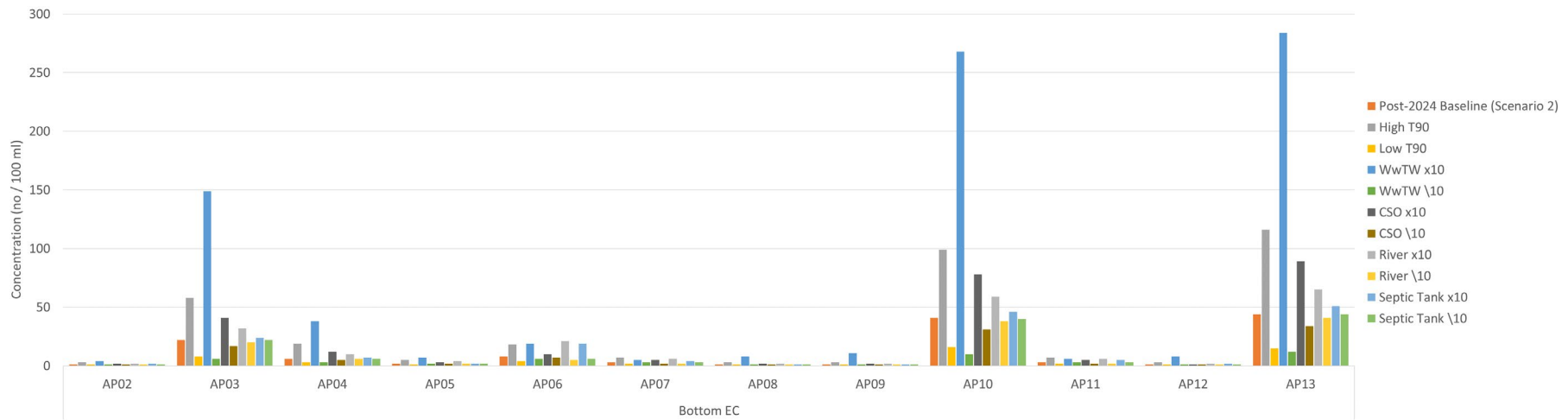
**Table 8-14 Sensitivity Scenarios: Predicted 97<sup>th</sup> Percentile Concentrations (EC/100 ml) at the Model Verification Locations: Bottom**

	AP02	AP03	AP04	AP05	AP06	AP07	AP08	AP09	AP10	AP11	AP12	AP13
<b>Post-2024 Baseline (Scenario 2)</b>	16	433	147	31	463	109	4	3	644	99	4	673
<b>High T90</b>	49	868	337	87	602	214	11	8	1,300	198	11	1,406
<b>Low T90</b>	4	197	54	9	334	43	1	1	283	41	1	274
<b>WwTW x10</b>	30	950	444	106	651	118	31	30	1,284	111	27	1,176
<b>WwTW /10</b>	14	393	126	25	448	108	2	1	594	98	2	629
<b>CSO x10</b>	48	3,257	1,026	172	554	406	7	5	4,805	255	6	5,136
<b>CSO /10</b>	12	157	62	17	457	80	3	3	242	86	4	236
<b>Rivers x10</b>	105	1,097	373	104	4,370	794	14	8	1,824	844	17	1,872
<b>Rivers /10</b>	6	366	123	23	79	42	3	3	530	27	3	558
<b>Septic Tanks x10</b>	16	443	150	31	529	111	4	3	658	103	5	685
<b>Septic Tanks /10</b>	16	432	146	31	456	109	4	3	643	99	4	672
<b>Default Value for Cranfield WwTW FE</b>	17	433	147	31	463	109	58	58	645	99	26	673

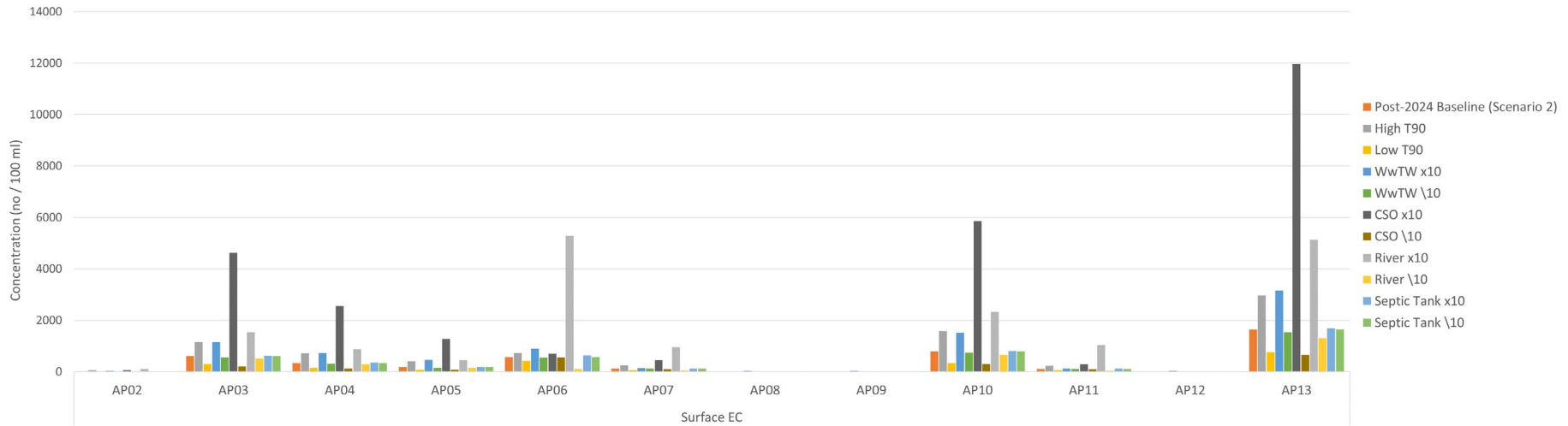
**Figure 8-23 General Sensitivity Tests: Predicted Geomean EC Concentrations at the Model Verification Locations: Surface**



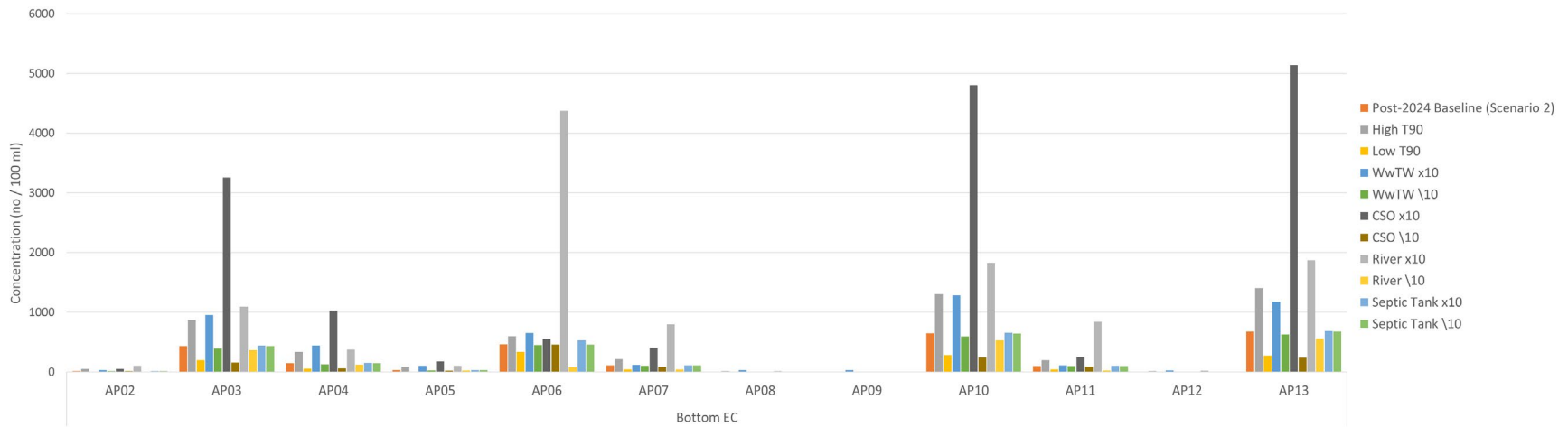
**Figure 8-24 General Sensitivity Tests: Predicted Geomean EC Concentrations at the Model Verification Locations: Bottom**



**Figure 8-25 General Sensitivity Tests: Predicted 97<sup>th</sup> Percentile EC Concentrations at the Model Verification Locations: Surface**



**Figure 8-26 General Sensitivity Tests: Predicted 97<sup>th</sup> Percentile EC Concentrations at the Model Verification Locations: Bottom**



## 8.6 Discussion and Conclusion

This assessment has investigated the impacts of Uisce Éireann and NI Water assets, and other bacterial discharges, on the water quality at Carlingford Lough SFW. The investigation included:

- Analysis of historical data.
- Predictive assessments using a combination of coastal, riverine and sewerage network modelling tools.
- A unit-impact based assessment process using Intertek Metoc's S-O assessment tool, an established approach that has been used for the majority of detailed water quality assessments for SFWs (and BWs) in the UK and for some in Ireland.

Contributions from each source to the impact at the receiving waters have been determined, and the most significant contributors identified.

Predicted outputs from the impact assessment have been verified against historical water quality data at Carlingford Lough SFW using appropriate model parameters, followed by sensitivity testing to determine the significance of these various parameters.

### 8.6.1 Baseline / Needs

Results from the Baseline Assessment predict that the majority of the SWPA meets the SFW quality standard. A small area of higher impact is located near Omeath in the pre-2024 Scenario. This area is predicted to exceed the SFW Class B water quality threshold concentration in both the surface and the bottom layer. However, this area of elevated impact is not present in the post-2024 Scenario following the construction of a UV treated WwTP at Omeath.

The model results predict another area of elevated impact in the Newry River. However, this area is located outside the SWPA and is therefore not subject to the SFW thresholds. Overall, the model predictions are generally consistent with the water quality sampling data and the DAERA Shellfish Flesh Classifications.

It should be noted that the majority of the SWPA is predicted to be compliant with the SFW standards (geomean and 97<sup>th</sup> percentile). In addition, the majority of Carlingford Lough (outside the SWPA) also lies below the SFW threshold concentrations.

### 8.6.2 Sensitivity Testing

The sensitivity of the modelled SFW performance to inputs that are uncertain or known to vary naturally was tested by changing the key model parameters and assessing the influence on the results. Sensitivity testing was carried out against the post-2024 baseline scenario (Scenario 2).

- At both the geomean and 97<sup>th</sup> percentile EC concentrations, the model performance is sensitive to decay rates, WwTW FE concentrations and CSO concentrations.
- The model performance was not sensitive to septic tank loads at either the geomean or 97<sup>th</sup> percentile EC concentration.
- The model performance at the 97<sup>th</sup> percentile EC concentration was sensitive to changes in river loads; however, little change was seen at the geomean concentration.
- During verification, the SFW sites in the south of the lough (AP08 and AP09) were also found to be sensitive to the concentration used for Cranfield WwTW FE. The concentration of this asset was reduced compared to the standard default value in order to achieve good model verification. There is anecdotal evidence to suggest high infiltration into this sewerage catchment which provides further justification for lowering the concentration of this asset.

### 8.6.3 Conclusions

This assessment has investigated the impacts of Uisce Éireann and NI Water assets, and other bacterial sources, on the water quality in Carlingford Lough SWPA.

Contributions from each source to the impact across the SWPA have been determined in the assessment, and the most important contributors have been identified.

The sampling data and model predictions in Carlingford Lough SWPA are in generally good agreement with flesh sampling. Both the water quality sampling and model predictions generally indicate that Class B or higher performance dominates across the lough.

Overall, the pre-2024 Baseline provides an acceptable fit with the sampled SFW data. As such, the model is considered fit for use in Options testing.

## 8.7 Carlingford Lough Shellfish Water Impact Assessment Audit Summary

NI Water appointed Intertek Metoc in combination with RPS to assess water quality impacts on the Carlingford Lough designated SFW.

This assessment investigated the impact of Uisce Éireann and NI Water asset operations on SFW performance using a combination of monitoring data, coastal and river numerical models, sewerage network models, and advanced impact assessment tools.

LLE constructed the underpinning coastal and river models of the study area under the SWELL project. Intertek Metoc undertook an independent review of these models, and used the outputs from these models, together with outputs from DAP models of the sewerage networks, to undertake the impact assessment. RPS undertook an independent review of the impact assessment report issued to NI Water.

### 8.7.1 Audit Objectives

The objectives of the audit of the Carlingford Lough Baseline SFW impact assessment modelling were:

- To assess the validity and appropriateness of input data used.
- To assess whether the impact assessment model has been adequately verified.
- To assess whether the models have been used in an appropriate manner, given their limitations and the study objectives.

### 8.7.2 Audit Summary

The initial comments from RPS's audit in March 2024 stated that they were happy with the suitability and performance of the impact assessment model and did not raise any points of concern. The formal audit report has not yet been produced, but it is not anticipated that any changes to the impact assessment report will be required.

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