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WwTP Impact Assessment

Marine WwTP Impact Assessment

P2640_R6819_Rev1 | 20 January 2026

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DOCUMENT RELEASE FORM

Jacobs

P2640_R6819_Rev1

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Rev No	Date	Reason	Author	Checker	Authoriser
Rev 0	08/01/2026	Original issue to client	DOW	YW	PAT
Rev 1	20/01/2026	Following comments from client	DOW	YW	PAT

SUMMARY

This report presents the mixing zone assessment for wastewater treatment plant (WwTP) discharges to Cork Harbour, undertaken using the calibrated and validated three-dimensional hydrodynamic and water quality model developed for the Cork Harbour Strategic Modelling Study. The assessment covers eight WwTPs (Carrigrennan, Carrigtwohill, North Cobh, Midleton, Cork Lower Harbour (CLH), Cloyne, Saleen, and Whitegate Aghada) across four time horizons (current, 2030, 2055, and 2080) for the key water quality parameters Biochemical Oxygen Demand (BOD), Dissolved Inorganic Nitrogen (DIN), and Molybdate Reactive Phosphate (MRP).

For each of the eight WwTPs, representative discharge loads (as a product of discharge flow and concentration) were determined. The discharge concentration applied is the proposed Emission Limit Value (ELV) for each WwTP and each time horizon. Current and 2030 loads are based on existing permits and measured data. From 2045, stricter European rules under the Urban Wastewater Treatment Directive recast (UWWTDr) will apply, requiring treatment plants in sensitive areas like Lough Mahon to significantly reduce nitrogen and phosphorus in their discharges. Therefore, for the 2055 and 2080 scenarios, flows were increased to reflect future conditions, and concentrations were reduced, where appropriate.

Mixing zones are the localised envelope within which the concentration of a water quality parameter is above its relevant Environmental Quality Standard (EQS) / regulatory standard for the receiving waterbody. Restrictions exist to the mixing zone of a discharge, such as the mixing zone should be restricted to the immediate vicinity of the discharge point and kept as small as practicable, and that the spatial extent of the mixing zone does not exceed 25% of the estuary width at the discharge location.

The modelling was undertaken for both Base and Notionally Clean (NC) scenarios. The Base scenario includes measured river water quality for river inputs, while the NC scenario removes upstream riverine pollution sources to isolate the impact of WwTP discharges. This approach allows the relative contribution of point source discharges and diffuse riverine inputs to be distinguished.

Under current conditions, the largest mixing zones are predicted for Carrigtwohill WwTP, with DIN mixing zones extending over 4,000m and MRP mixing zones exceeding 2,000m. These substantial mixing zones reflect the nutrient loads from the discharge combined with the shallow bathymetry and confined hydrodynamic conditions at the existing outfall location in the upper reaches of Lough Mahon, which restrict dilution and dispersion. This is consistent with the findings of the Midleton and Carrigtwohill licence review (Intertek Metoc, 2025), which identified elevated nutrient concentrations and less favourable dilution characteristics at the Carrigtwohill WwTP discharge location in Lough Mahon.

Carrigrennan WwTP, as the largest WwTP in the system, generates mixing zones that vary by parameter. For BOD, mixing zones are predicted to increase in the future, reaching 820m in summer and 1,100m in winter by 2080. For DIN, in the Base scenario, the background river concentrations cause the EQS to be exceeded in Lough Mahon, meaning definitive mixing zones from the WwTP cannot be determined. Under the NC scenario, mixing zones from Carrigrennan WwTP range from 200m to 290m under current conditions and peak at 370m (winter 2030) before reducing to 150-200m from 2055 onwards as the more stringent total nitrogen ELV under the UWWTDr takes effect. The fact that DIN mixing zones can only be determined under the Base scenario for the 2055 and 2080 summer horizons (720m and 1,010m respectively), suggests that under current river water quality conditions, background concentrations from the River Lee and other tributaries are the dominant influence on DIN levels in the receiving waters.

In contrast, Midleton WwTP is predicted to generate no mixing zone across all parameters, seasons, and horizons. This is consistent with the licence review findings that water quality impacts from Midleton WwTP are minimal. Several other smaller WwTPs, including North Cobh and Whitegate Aghada, similarly show no or minimal mixing zones due to small discharge loads relative to the assimilative capacity of their receiving waters.

CLH WwTP shows modest mixing zones owing to enhanced dispersion in the Lower Harbour. Mixing zones are predicted to increase slightly from 2055, due to increased loads as a result of population growth and the proposed transfer schemes from North Cobh and Minane Bridge WwTPs to CLH WwTP, but will remain relatively small (BOD up to 130m).

The modelling predicts substantial improvements from 2055 onwards because of proposed strategic infrastructure changes. At Carrigtwohill, the combination of outfall relocation to a more dispersive location in the main channel and the implementation of more stringent ELVs under the UWWTDr is predicted to reduce DIN mixing zones from over 4,000m to less than 100m. Similar improvements are predicted for Cloyne and Saleen WwTPs following their proposed consolidation and relocation to Whitegate Pier.

Minane Bridge WwTP is not included in the mixing zone results as it currently discharges to ground rather than directly to the marine environment. From 2055 onwards, flows from Minane Bridge are proposed for transfer to CLH WwTP, and the associated load is incorporated into the CLH modelling for the later horizons.

The results highlight the significant contribution of riverine inputs to nutrient concentrations in Cork Harbour. At several sites, the difference between Base and NC scenarios is substantial, indicating that background water quality from rivers, particularly the River Lee, contributes significantly to nutrient levels in the receiving waters.

The modelling demonstrates that the proposed strategy, including treatment upgrades, outfall relocations, and flow transfers, is compatible with achieving Water Framework Directive objectives for Cork Harbour's receiving waters.

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GLOSSARY

BOD
Biochemical Oxygen Demand

CHSMS
Cork Harbour Strategic Modelling Study

CMA
Cork Metropolitan Area

DIN
Dissolved Inorganic Nitrogen

ELV
Emission Limit Value

MRP
Molybdate Reactive Phosphate

NH4
Ammonia

SWO
Storm Water Overflow

TN
Total Nitrogen

TraC
Transitional and Coastal

TSMM
Technical Standards for Marine Modelling

UWWTD
Urban Waste Water Treatment Directive

WB
Waterbody

WwTP
Wastewater Treatment Plant

1. INTRODUCTION

1.1 Background and Purpose of Document

The Cork Metropolitan Area (CMA) is a region poised for significant growth. This anticipated growth underscores the urgent need for strategic enhancements in water supply and wastewater infrastructure to accommodate increased demands and ensure sustainable development. Uisce Éireann has highlighted the necessity for a comprehensive drainage assessment to address the challenges of rapid growth, non-compliance at wastewater treatment facilities, capacity pressures, deterioration of receiving waters, and the impacts of climate change, and new regulations. A sustainable and integrated approach to wastewater management is essential, aligning with national and international environmental directives and accommodating the evolving climate scenario, to support economic expansion, stakeholder needs, and the resilience of Ireland's wastewater infrastructure amid escalating urbanisation and service demands.

Intertek Metoc have been tasked by Uisce Éireann through Jacobs with determining the current and future assimilative capacity of the relevant freshwater (river) waterbodies and the Cork Harbour Transitional and Coastal (TraC) waterbodies to handle increased or additional discharges while meeting environmental objectives and addressing identified pressures. This includes using strategic water quality models for impact assessments across the strategy horizons (current, 2030, 2055, and 2080) without the requirement for new sampling or analysis. Intertek Metoc's role extends to reviewing statutory and policy frameworks, assessing the assimilative capacity for different timeframes, and determining effluent standards for alternative receiving waters. Additionally, Intertek Metoc identified requirements for new outfall infrastructure, considering ongoing projects, environmental constraints, and future developments. Both river and marine water quality models were used to assess Wastewater Treatment Plant (WwTP) and Storm Water Overflow (SWO) discharges' impacts. This effort aligns with Uisce Éireann’s Technical Standards for Marine Modelling (TSMM) (Uisce Éireann, 2022) and encompasses evaluating discharge options against legislative and environmental standards. It builds on previous work by Intertek Metoc for Uisce Éireann over the past two years, as part of the Cork Harbour Strategic Modelling Study (CHSMS).

This document outlines the impact assessments of WwTPs on the marine water quality, the approach of calculating the mixing zones due to set Emission Limit Values (ELVs) agreed with Uisce Éireann for WwTPs that discharge to the TraC waterbodies.

1.2 Study Approach

To determine the mixing zones for the WwTPs that discharge to Cork Harbour, the hydrodynamic and water quality model was run for various horizons and water quality parameters.

1.2.1 Model use

A three-dimensional (3D) hydrodynamic model was developed to represent the tidal waters of Cork Harbour and the adjacent coastline. It was built using the MIKE 3 FM package in accordance with Uisce Éireann’s TSMM (Uisce Éireann, 2022). The model included representation of key hydrodynamic processes: tidal forcing, wind, and density gradients (salinity and temperature).

A 3D approach was adopted to allow for stratification in the Lee Estuary and Lough Mahon, using ten vertical layers to resolve the water column and halocline. The flexible mesh ranged from around 500 m offshore to less than 25 m in key areas. Bathymetry was based on high-resolution datasets, supplemented with bespoke surveys in intertidal zones and estuarine margins. Offshore boundaries were derived from the FES Global Tide Model, while temperature and salinity inputs came from the

M5 metocean buoy. River inflows were based on the EPA HydroTool and gauge data; WwTP and trade discharges were defined using data from Uisce Éireann and relevant permits.

The model was calibrated and validated against TSMM requirements. This information is available in the calibration and validation report (Intertek, December 2023).

1.2.2 Mixing Zones

Mixing zones are the localised envelope within which the concentration of a water quality parameter is above its relevant EQS / regulatory standard for the receiving waterbody. Restrictions exist to the mixing zone of a discharge, such as mixing zone should be restricted to the immediate vicinity of the discharge point and kept as small as practicable, and that the spatial extent of the mixing zone does not exceed 25% of the estuary width at the discharge location.

1.2.3 WwTPs

Mixing zone calculations have been undertaken for nine WwTPs in the Harbour. These are Carrigrennan (Cork), CLH (Cork Lower Harbour), Carrigtwohill, Midleton, North Cobh, Whitegate, Cloyne, Saleen, and Minane Bridge WwTPs.

Marine modelling has been undertaken for the preferred option for each horizon. At the times in the strategy, flows from various WwTPs are transferred to new discharge locations or to other WwTPs. This includes North Cobh, Cloyne, Saleen, and Minane Bridge (River Valley) WwTPs.

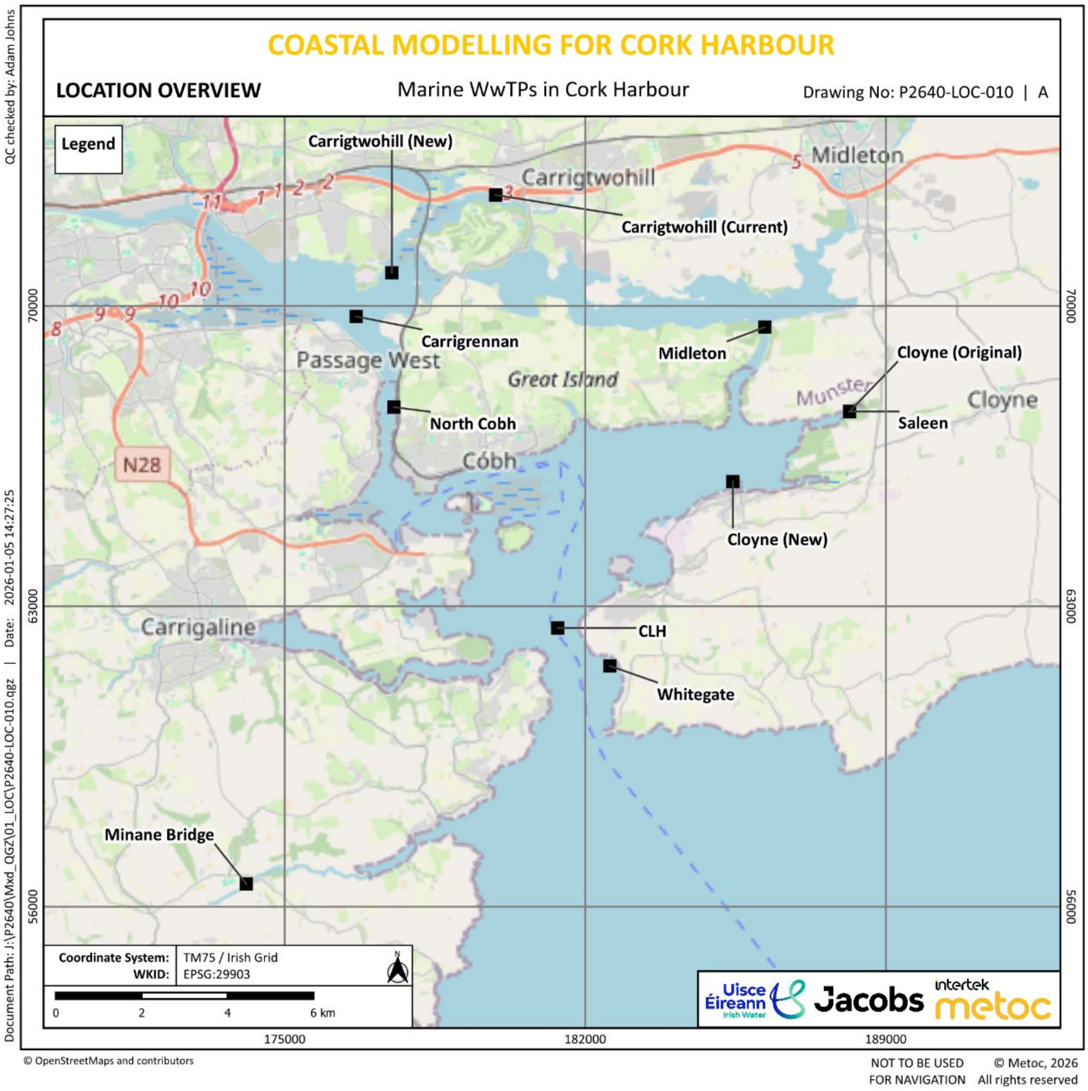
Under the Current and 2030 scenarios, Minane Bridge WwTP discharges to ground. This means that the discharge does not reach the marine environment in large quantities. Therefore, its load has been removed from the modelling under these two scenarios.

Between 2030 and 2055, the following transfer schemes will be constructed and initiated:

- The Carrigtwohill WwTP discharge location to be moved to the channel between Carrigrennan and the Martello Tower (coordinates: 179911, 72583 ING).
- Cloyne WwTP discharge location to be moved from the Saleen Estuary to an existing discharge near Whitegate Pier.
- Discharge from Saleen WwTP to be transferred to Cloyne WwTP, thus discharging near Whitegate Pier.
- Minane Bridge WwTP to be transferred to CLH WwTP.
- North Cobh WwTP to be transferred to CLH WwTP.

Figure 1-1 presents the current and future locations of these WwTPs.

Figure 1-1 Marine WwTPs in Cork Harbour



2. MODEL SCENARIOS

2.1 WwTP Inputs

The strategy horizon flows used in the model are provided in Table 2-1. Current flows are measured by the current sampled flows where available, augmented with network modelling where data is lacking. The future scenarios are an average daily flow calculated primarily based on the expected population equivalents in each of the years 2030, 2055, and 2080. These were chosen to structure short, medium, and long-term planning in a consistent way with Uisce Éireann's national planning framework. A conservative representation of infiltration was included in the calculation of the average daily flows, which is a reasonable representation of winter conditions when more water will typically be in the network systems. Therefore, the average daily flows as outlined in the WwTP general strategy are used as the winter flows. These have been scaled based on the current measured flows so that summer flows are reasonably represented.

Existing sewerage networks were utilised for each time horizon (2030, 2055, and 2080). The flows and network scenarios below are the final preferred option of the general strategy.

Table 2-1 Horizon Flows

WwTP	Summer Flow (m^3/s)				Winter Flow (m^3/s)			
	Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
Carrigrennan	1.281	1.761	2.209	2.378	1.727	2.374	2.977	3.204
Carrigtwohill	0.077	0.125	0.132	0.137	0.106	0.172	0.181	0.188
North Cobh	0.007	0.003	0.004	0.005	0.011	0.006	0.007	0.008
Midleton	0.086	0.096	0.096	0.096	0.112	0.125	0.125	0.125
CLH	0.153	0.153	0.186	0.209	0.245	0.244	0.297	0.334
Cloyne	0.007	0.010	0.012	0.014	0.007	0.010	0.012	0.014
Saleen	0.002	0.003	0.003	0.004	0.002	0.003	0.003	0.004
Minane Bridge	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002
Whitegate Aghada	0.011	0.011	0.013	0.014	0.011	0.011	0.013	0.014

Permits of ELVs are usually set for biochemical oxygen demand (BOD), total nitrogen (TN), and total phosphate (TP). These are represented in the modelling for the various horizons and scenarios. In the future, the UWWTDr will define the ELVs for given PEs. These will apply from 2045, which means that the 2055 and 2080 horizons require the UWWTDr limits. These ELVs are given in Table 2-2 for BOD, Table 2-3 for TN, and Table 2-4 for TP. There is no requirement of TP for WwTPs that discharge to the coastal waters as no phosphorus standard applies to coastal waterbodies. For those WwTPs a representative ELV of 2.5mg/l is used for TP.

WwTPs located in Lough Mahon and the upper estuaries (Carrigrennan, Carrigtwohill, North Cobh, and Midelton WwTPs) are in a nutrient sensitive waterbody. These require tertiary treatment to meet more stringent discharge standards for nitrogen and phosphorus, as specified under the UWWTDr. Specifically, they must achieve TP concentrations of 1-2mg/l and TN concentrations of 10-15mg/l (depending on plant size) or demonstrate at least 70-80% reduction in nutrient loads. Midelton and Carrigtwohill are currently under licence review (Intertek Metoc, 2025). This report seeks to build upon that study.

Table 2-2 Horizon BOD ELVs

WwTP	Current	2030	2055	2080
Carrigrennan	25	25	25	25
Carrigtwohill	25	25	25	25
North Cobh	25	25	25	25
Midleton	25	25	25	25
CLH *	245	245	245	245
Cloyne	25	25	25	25
Saleen	25	25	25	25
Minane Bridge	25	25	25	25
Whitegate Aghada	25	25	25	25

* At CLH WwTP, the discharge is shared with numerous other industrial discharges. The permit ELV for this combined discharge is set at 245mg/l for BOD. This is therefore input into the model, as opposed to the wastewater component only.

Table 2-3 Horizon TN ELVs

WwTP	Current	2030	2055	2080
Carrigrennan	25	25	8	8
Carrigtwohill	25	25	10	10
North Cobh	25	25	25	25
Midleton	15	15	10	10
CLH *	DIN 95	DIN 95	DIN 95	DIN 95
Cloyne	45	45	45	45
Saleen	30	30	30	30
Minane Bridge	15	15	15	15
Whitegate Aghada	54	54	54	54

* At CLH WwTP, the discharge is shared with numerous other industrial discharges. The permit ELV for this combined discharge is set at 95mg/l for DIN (as opposed to TN). This is therefore input into the model, as opposed to the wastewater component only.

Table 2-4 Horizon TP ELVs

WwTP	Current	2030	2055	2080
Carrigrennan	2.5	2.5	0.5	0.5
Carrigtwohill	1.0	1.0	0.7	0.7
North Cobh	2.5	2.5	2.5	2.5
Midleton	2.0	2.0	0.7	0.7
CLH	2.0	2.0	2.0	2.0
Cloyne	2.5	2.5	2.5	2.5
Saleen	2.5	2.5	2.5	2.5
Minane Bridge	2.5	2.5	2.5	2.5
Whitegate Aghada	2.5	2.5	2.5	2.5

Nutrient standards are set for dissolved inorganic nitrogen (DIN) and molybdate reactive phosphate (MRP) under the WFD, while the ELVs are set for TN and TP for WwTPs. To assess the impact of WwTP discharges on the water quality in the receiving waters, concentrations of DIN and MRP in the WwTP discharges are needed. These are calculated from the TN and TP set for each WwTP and the ratios of DIN to TN and MRP to TP. A ratio of ammonia (NH_4) to DIN is also required to separate nitrate (NO_3) and NH_4 from DIN. These come from sampled data between 2018 and 2021. These ratios are calculated from the effluent sample data between 2018 and 2021 for each WwTP and given in Table 2-5.

Table 2-5 Sampling Ratios

WwTP	DIN:TN	NH4:DIN	MRP:TP
Carrigrennan	0.80	0.83	0.61
Carrigtwohill	0.67	0.24	0.58
North Cobh	0.68*	0.58*	0.40
Midleton	0.46	0.19	0.65
CLH	0.62	0.46	0.78
Cloyne	0.88	0.86	0.60*
Saleen	0.68*	0.58*	0.60*
Minane Bridge	0.68*	0.58*	0.60*
Whitegate Aghada	0.68*	0.90	0.60*

* Average of the sampled Carrigrennan WwTP ratios

2.2 River Inputs

The Cork Harbour model requires river flow and water quality data as boundary conditions to accurately represent the freshwater inputs entering the harbour system. Rivers are significant contributors to nutrient and pollutant loads in the harbour, and their influence must be properly characterised to assess the impact of wastewater treatment plant discharges.

2.2.1 River Flows

Seasonal river flows were derived from available gauging data and Environmental Protection Agency (EPA) monitoring records. Summer and winter flow conditions were defined to capture the natural seasonal variability in freshwater inputs to Cork Harbour.

The River Lee dominates the freshwater input to the harbour, with flows of approximately 19m³/s in summer increasing to around 77m³/s in winter. The River Glashaboy, River Owenacurra, and River Owenboy also provide substantial flows, each ranging from roughly 1.2 to 1.6m³/s in summer and 4.3 to 5.6m³/s in winter. Smaller tributaries and streams, including the Carrigtwohill, Tramore, and Minane catchments, contribute more modest flows but are nonetheless important for local water quality conditions near discharge locations.

The full set of river flows and concentrations used in the model is presented in Table 2-6.

Table 2-6 River Flows and Concentrations

River	Flow **(m³/s)**	BOD **(mg/l)**	Ammonia **(mg/l)**	Nitrate **(mg/l)**	Phosphate **(mg/l)**
	Summer				
River Glashaboy	1.56	1.55	0.14	6.13	0.11
River Owenacurra	1.43	0.70	0.01	4.42	0.03
River Owenboy	1.24	1.14	0.02	4.47	0.03
River Dungourney	0.60	0.74	0.04	4.59	0.03
Minane	0.36	1.36	0.05	4.52	0.04
Donnavanig	0.07	0.00	0.00	0.00	0.00
West Ballintra	0.05	0.00	0.00	0.00	0.00
Farrannamanagh	0.16	0.74	0.04	4.59	0.03
Carrigtwohill	0.18	1.29	0.21	6.13	0.02
Tramore	0.27	1.29	0.21	6.13	0.02
River Curragheen	0.71	1.78	0.35	4.48	0.04
River Lee	19.01	1.30	0.04	2.08	0.02
Knocknamadderee	0.08	0.74	0.04	4.59	0.03
Hilltown	0.12	1.29	0.21	6.13	0.02
Bride	0.35	29.18	0.49	8.35	0.22
Ringabella	0.02	0.00	0.02	0.10	0.01
	Winter				
River Glashaboy	5.57	1.57	0.57	5.05	0.11
River Owenacurra	4.29	0.95	0.02	4.49	0.04
River Owenboy	4.86	0.89	0.06	5.37	0.04
River Dungourney	1.65	1.09	0.04	4.34	0.04
Minane	1.23	1.08	0.06	5.41	0.03
Donnavanig	0.07	0.00	0.00	0.00	0.00
West Ballintra	0.05	0.00	0.00	0.00	0.00
Farrannamanagh	0.52	1.09	0.04	4.34	0.04

River	Flow (m³/s)	BOD (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)
Carrigtwohill	0.63	1.29	0.12	5.05	0.08
Tramore	0.89	1.29	0.12	5.05	0.08
River Curragheen	2.15	1.77	0.37	4.24	0.08
River Lee	77.04	1.13	0.05	2.80	0.03
Knocknamadderee	0.26	1.09	0.04	4.34	0.04
Hilltown	0.39	1.29	0.12	5.05	0.08
Bride	2.08	8.07	0.52	5.84	0.19
Ringabella	0.05	0.00	0.02	0.10	0.01

2.2.2 Notionally Clean River Scenario

In addition to charactering rivers using measured water quality data, a "Notionally Clean" (NC) River scenario was developed. In this scenario, upstream sources of pollution from human activity, including agriculture and septic tank discharges, are removed from the river inputs. This is done by setting the concentrations of the river to 20% of the Excellent standard. Ballincollig WwTP was not scaled down as part of the River Lee being set at the notionally clean concentrations and is represented separately.

The purpose of this scenario is to isolate and demonstrate the impact of Uisce Éireann's wastewater treatment plant discharges in situations where river contributions to water quality pressures are significant. By comparing the Base and NC scenarios, the relative influence of riverine inputs versus point source discharges can be clearly distinguished. This approach is particularly valuable in Cork Harbour, where model predictions indicate that rivers are substantial contributors to nutrient concentrations in the transitional waters.

3. MODEL RESULTS

Model results are presented as water quality indicative plots, showing the mixing-zone sizes for BOD, DIN, and MRP. DIN and MRP classification threshold concentrations vary with salinity. Cork Harbour is divided into eight WFD waterbodies, and the classification threshold concentrations for DIN and MRP are determined by salinity data measured for each waterbody. Which waterbody a WwTP is in will dictate what the standard threshold concentration are. Threshold concentrations for Good status are given in Table 3-1 for each WwTP for BOD, DIN, and MRP. Water quality indicative plots for the four horizons are presented in Appendix A, for both the current and notionally clean conditions for the rivers. These plots are presented whenever a length is given for a mixing zone.

Table 3-1 Determinand Thresholds

WwTP	Summer and Winter	Summer		Winter	
	BOD: 95%ile (mg/l)	DIN: Median (mg/l)	MRP: Median (mg/l)	DIN: Median (mg/l)	MRP: Median (mg/l)
Carrigrennan	4	0.57	0.026	0.89	0.051
Carrigtwohill	4	0.57	0.046	0.89	0.051
North Cobh	4	0.29	0.026	0.89	0.028
Midleton	4	0.31	0.027	0.60	0.03
CLH	4	0.24	0.026	0.31	0.027
Cloyne	4	0.44	0.043	0.63	0.047
Saleen	4	0.44	0.026	0.63	0.027
Minane Bridge	4	0.31	0.025	0.38	0.026
Whitegate Aghada	4	0.19	0.025	0.22	0.026

This section presents the mixing zone modelling results for each WwTP discharging to Cork Harbour. Results are presented for BOD, DIN, and MRP across current conditions and future horizons (2030, 2055, and 2080). Where applicable, results are provided for both the Base scenario (which includes measured river water quality as river inputs) and the NC scenario (which removes upstream riverine pollution sources to isolate the WwTP impact).

Mixing zone lengths are expressed in metres (m). A value of 'None' indicates that no mixing zone is required to achieve compliance with environmental quality standards at the point of discharge. 'NA' indicates that the scenario is not applicable for that parameter and facility (e.g. the Base scenario has a smaller mixing zone length, and therefore the NC scenario does not need to be used). 'ND' indicates that the mixing zones covers a large area and / or interacts with other discharges.

It should be noted that several strategic infrastructure changes occur between the 2030 and 2055 horizons, including the relocation of Carrigtwohill WwTP's outfall, the transfer of flows from North Cobh, Cloyne, Saleen, and Minane Bridge WwTPs, and the implementation of more stringent ELVs under the UWWTDr for WwTPs in nutrient-sensitive areas. These changes are reflected in the mixing zone results and are discussed in the relevant sections below.

3.1 Carrigrennan WwTP

Carrigrennan is the largest WwTP serving Cork Harbour, with flows increasing substantially from 1.28m³/s (summer) and 1.73m³/s (winter) currently, to 2.34m³/s and 3.20m³/s respectively by 2080. As a WwTP located in Lough Mahon, a nutrient-sensitive waterbody, it is subject to the more stringent tertiary treatment requirements under the UWWTDr, which will apply from 2045 onwards. This is reflected in the reduced TN ELV (from 25 mg/l to 8 mg/l) and TP ELV (from 2.5 mg/l to 0.5 mg/l) for the 2055 and 2080 horizons.

For BOD, mixing zones are assessed under the Base scenario, reflecting the organic load from the discharge. In summer (Figure A-1), the mixing zone extends from 400 m currently, increasing to 580 m by 2030 and reaching 820 m for both the 2055 and 2080 horizons. Winter condition (Figure A-2) produces a larger mixing zone due to higher flows from the WwTP (which includes a conservative representation of greater infiltration), starting at 510 m currently and expanding to 730 m (2030), 1,020 m (2055), and 1,100 m (2080). The increase in mixing zone size over time corresponds to the projected growth in population equivalent and associated flows.

DIN presents a contrasting pattern where the NC scenario becomes the relevant condition for assessing the WwTP's impact, as the impact from the river loads is significant. Under NC conditions, where upstream riverine pollution sources are removed, summer mixing zones (Figure A-4) range from 200 m (current) to 240 m (2030), then decrease to 150 m for both 2055 and 2080. Winter NC mixing zones (Figure A-5) follow a similar trajectory, starting at 290 m currently, increasing to 370 m by 2030, then reducing to 200 m for both later horizons. The reduction in DIN mixing zones for the 2055 and 2080 horizons reflects the implementation of more stringent nitrogen ELVs under the UWWTDr, requiring tertiary treatment. The Base scenario includes rivers, which results in excessive mixing zones for the current and the 2030 scenario. Therefore, Base DIN mixing zones (Figure A-3) are only shown for the 2055 and 2080 horizons in summer (720 m and 1,010 m), indicating that under current river water quality conditions, the WwTP discharge is not the dominant source of nitrogen, the River Lee and other tributaries, which dominate freshwater inputs to the harbour, contribute substantially to background DIN concentrations.

For MRP, mixing zones are assessed under the Base scenario, with summer (Figure A-6) values ranging from 170 m (current) to 210 m (2030), then decreasing notably to 90 m (2055) and 110 m (2080). Winter MRP mixing zones (Figure A-7) are larger, at 290 m currently, 330 m by 2030, and reducing to 140–150 m for the later horizons. The marked reduction in MRP mixing zones from 2055 onwards directly reflects the substantially reduced TP ELV (0.5 mg/l compared to 2.5 mg/l currently), demonstrating the effectiveness of the planned tertiary treatment upgrades.

Table 3-2 Carrigrennan WwTP Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
BOD	**Summer**	400	580	820	820	NA	NA	NA	NA
	Winter	510	730	1020	1100	NA	NA	NA	NA
DIN	**Summer**	ND	ND	720	1010	200	240	150	150
	Winter	ND	ND	ND	ND	290	370	200	200
MRP	**Summer**	170	210	90	110	NA	NA	NA	NA
	Winter	290	330	140	150	NA	NA	NA	NA

3.2 Carrigtwohill WwTP

Carrigtwohill WwTP is located in the upper reaches of Lough Mahon and is therefore classified as discharging to a nutrient sensitive waterbody, requiring tertiary treatment under the UWWTDr from 2045. A key strategic change affects this WwTP: between 2030 and 2055, the discharge location will be relocated from its current position to a new outfall in the channel between Carrigrennan and the Martello Tower. This relocation to a more hydrodynamically active area with better dispersion characteristics explains the reduction in mixing zone sizes observed from the 2055 horizon onwards.

BOD mixing zones under the Base scenario illustrate this transformation clearly. Summer mixing zone (Figure A-8) sizes start at 400m currently and increase to 670m by 2030 but then drop dramatically to just 60m for both 2055 and 2080. Winter (Figure A-9) follows a similar pattern: 600 m currently, 990 m by 2030, then decreasing to 80 m for the later horizons. The substantial reduction is attributable to the improved dispersion and dilution at the new discharge location in the main channel, rather than any change in the BOD ELV (which remains at 25mg/l throughout).

DIN presents the largest mixing zones at this site under current and 2030 conditions. Under the Base scenario in summer (Figure A-10), current mixing zones extend to 3,150m, increasing to 4,010m by 2030, reflecting both the nutrient load and the relatively confined hydrodynamic conditions at the existing discharge location. Mixing zone sizes fall sharply to 60 to 70m for 2055 and 2080, owing to both the outfall relocation and the implementation of more stringent TN ELVs (reduced from 25mg/l to 10mg/l). The NC scenario provides insight into the WwTP's isolated impact: summer (Figure A-11) values of 540m (current) and 2,200m (2030) reduce to no mixing zone for 2055 and 2080. This comparison demonstrates that under current conditions, background riverine nitrogen concentrations contribute significantly to the observed mixing zone extent, but once these are removed, the WwTP's direct impact becomes the determining factor. Under the improved conditions (new location plus tertiary treatment), this impact becomes negligible.

MRP mixing zones are also extensive under current conditions but reduce substantially with the strategic changes. Under the Base scenario, summer (Figure A-13) values are 2,390m (current) and 3,114m (2030), with no mixing zone for 2055 and less than 40m for 2080. The NC scenario shows a similar pattern, with summer (Figure A-15) values of 2,160m (current) and 2,870m (2030) reducing to no mixing zone for 2055 and 2080. The reduction in TP ELV from 1.0mg/l to 0.7mg/l, combined with the outfall relocation, accounts for the elimination of MRP mixing zones in the later horizons.

Table 3-3 Carrigtwohill WwTP Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	***2030***	***2055***	***2080***	***Current***	***2030***	***2055***	***2080***
BOD	**Summer**	400	670	60	60	NA	NA	NA	NA
	Winter	600	990	80	80	NA	NA	NA	NA
DIN	**Summer**	3150	4010	60	70	540	2200	None	None
	Winter	ND	ND	ND	ND	470	1930	None	None
MRP	**Summer**	2390	3114	None	<40	2160	2870	None	None
	Winter	2600	3170	<40	<40	1890	2490	None	None

3.3 North Cobh WwTP

North Cobh WwTP is a relatively small WwTP with flows of just 0.007m³/s (summer) and 0.011m³/s (winter) currently. Importantly, this WwTP is scheduled for transfer to CLH WwTP between 2030 and 2055 as part of the Cork Harbour drainage strategy.

For BOD and MRP, no mixing zone is generated under any scenario or time horizon, reflecting the small discharge volumes relative to the receiving water's assimilative capacity. The results show "None" across all seasons and projection periods for the Base scenario.

DIN shows only marginal mixing zones. Under the Base scenario in summer (Figure A-17), a mixing zone of 70m is generated currently, with none for subsequent horizons. The NC scenario, which removes upstream riverine pollution sources, shows no mixing zone across all seasons and time horizons. This indicates that the small mixing zone observed under current Base conditions is primarily attributable to the high background water quality conditions in the receiving waters. Once the WwTP is transferred to CLH WwTP, the local discharge mixing zone is predicted to cease entirely.

Table 3-4 North Cobh WwTP Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
BOD	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA
DIN	**Summer**	70	ND	None	None	None	None	None	None
	Winter	ND	ND	ND	ND	None	None	None	None
MRP	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA

3.4 Midleton WwTP

Midleton WwTP discharges to the Owenacurra Estuary, which forms part of the Lough Mahon nutrient sensitive waterbody. The WwTP currently operates under relatively stringent nutrient ELVs (TN at 15mg/l and TP at 2.0mg/l), with further reductions planned for 2055 onwards under the UWWTDr (TN to 10mg/l and TP to 0.7mg/l). Flows are projected to remain stable at approximately 0.01m³/s (summer) and 0.13m³/s (winter) from 2030 through 2080.

Notably, the modelling predicts no mixing zone for Midleton WwTP across all parameters, seasons, and time horizons. For BOD, DIN, and MRP alike, the results indicate "None" for all Base scenario conditions across the current, 2030, 2055, and 2080 horizons in both summer and winter.

This outcome suggests that the discharge from Midleton WwTP is predicted to achieve compliance with EQS at the point of discharge, requiring no mixing zone under any of the modelled conditions. Several factors are likely to contribute to this result: the relatively modest discharge volumes, the already stringent ELVs (particularly for nitrogen at 15mg/l currently, compared to 25mg/l at many other sites), and the local hydrodynamic conditions in the Owenacurra Estuary that are predicted to provide sufficient dilution and dispersion.

Table 3-5 Midleton WwTP Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
BOD	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA
DIN	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA
MRP	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA

3.5 Minane Bridge WwTP

Minane Bridge WwTP is not included in the mixing zone results presented in this section. Under the current and 2030 scenarios, Minane Bridge WwTP discharges to ground rather than directly to the marine environment. This means that the discharge does not reach Cork Harbour in significant quantities, and therefore no marine mixing zone assessment is applicable for these horizons.

Between 2030 and 2055, it is proposed that flows from Minane Bridge WwTP will be transferred to CLH WwTP as part of the Cork Harbour drainage strategy. From 2055 onwards, the Minane Bridge catchment would therefore be served by CLH WwTP, and the load is incorporated into the CLH WwTP modelling for the 2055 and 2080 horizons. As such, no standalone mixing zone assessment is required for Minane Bridge WwTP.

3.6 CLH WwTP

CLH WwTP occupies a unique position in the Cork Harbour system. Unlike other WwTPs, the CLH discharge is shared with numerous industrial discharges, resulting in combined ELVs of 245mg/l for BOD and 95mg/l for DIN (rather than TN). The WwTP is also proposed to receive transferred flows from both North Cobh WwTP and Minane Bridge WwTP between 2030 and 2055, which would increase its flows from 0.15m^3/s (summer) currently to 0.21m^3/s by 2080.

For BOD under the Base scenario, summer (Figure A-18) mixing zones are predicted to remain relatively modest and stable at 90m for both the current period and 2030, then increase to 130m (2055) and 160m (2080). Winter (Figure A-19) values are modelled to follow a similar pattern: 130m for current and 2030, increasing to 170m (2055) and 180m (2080). Despite the higher BOD ELV (245mg/l compared to 25mg/l at other sites), the mixing zones are predicted to remain limited due to the WwTP's location in the Lower Harbour, where stronger tidal currents and greater water depths are expected to provide enhanced dispersion and dilution. The gradual predicted increase in mixing zone size from 2055 onwards reflects the additional flows anticipated to be transferred from North Cobh and Minane Bridge WwTPs.

DIN mixing zones under the Base scenario are predicted to be relatively small given the 95mg/l DIN ELV. In summer (Figure A-20), values are modelled at 20m currently, predicted to increase slightly to 30m by 2030, then reach 50m for both 2055 and 2080. Winter DIN mixing zones (Figure A-21) are predicted to be larger, at 100m for current and 2030, increasing to 140m for both later horizons. The NC scenario is not applicable for this WwTP, reflecting the fact that CLH is located in the Lower Harbour where riverine influences are less dominant than in the upper reaches of the estuary.

MRP shows minimal predicted mixing zones despite the combined industrial and municipal discharge. No mixing zone is predicted in summer under the Base scenario for any time horizon. In winter (Figure A-23), a consistent mixing zone of just 20m is predicted across all time horizons (current through 2080), reflecting the higher phosphorus loads during winter but suggesting that CLH's hydrodynamic conditions are expected to readily assimilate the discharge.

Table 3-6 CLH WwTP Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
BOD	**Summer**	90	90	130	160	NA	NA	NA	NA
	Winter	130	130	170	180	NA	NA	NA	NA
DIN	**Summer**	20	30	50	50	NA	NA	NA	NA
	Winter	100	100	140	140	NA	NA	NA	NA
MRP	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	20	20	20	20	NA	NA	NA	NA

3.7 Cloyne and Saleen WwTPs

Cloyne and Saleen WwTPs both currently discharge to the Saleen Estuary and are addressed together as a combined discharge since they both discharge at the top of the estuary and are subject to a common strategic intervention. Cloyne WwTP is the larger of the two facilities, while Saleen WwTP has flows of just 0.002m³/s. Under the Cork Harbour drainage strategy, it is proposed that flows from Saleen WwTP will be transferred to Cloyne WwTP between 2030 and 2055, with the combined discharge then relocated from the Saleen Estuary to an existing outfall near Whitegate Pier. This strategic consolidation is predicted to result in improvements in mixing zones from the 2055 horizon onwards.

As both WwTPs discharge at the top of estuary under current conditions and are proposed to share a common outfall from 2055, the modelled mixing zone is for the combined discharges. The results presented in Table 3-7 therefore apply to both WwTPs for the current and 2030 horizons, with the 2055 and 2080 values representing the combined Cloyne/Saleen discharge at the new Whitegate Pier location.

For BOD under the Base scenario, no mixing zone is predicted in summer (Figure A-24) for the current period, with a small mixing zone of 70m predicted by 2030, then none for 2055 and 2080. Winter shows no BOD mixing zone predicted across any time horizon. The predicted elimination of BOD mixing zones from 2055 reflects the improved dispersion characteristics expected at the new Whitegate Pier discharge location compared to the more confined Saleen Estuary.

DIN presents more substantial predicted mixing zone under current and near-term conditions. Under the Base scenario in summer (Figure A-25), mixing zones of 780m (current) and 920m (2030) are predicted, reducing to none for 2055 and 2080 following the outfall relocation. The NC scenario provides winter (Figure A-27) values of 420m (current) and 630m (2030), with none predicted for later horizons. The Base scenario also shows winter (Figure A-26) DIN values predicted at 230m (2055) and 260m (2080), indicating that even at the new location, some winter DIN mixing zone is predicted when background riverine concentrations are included. The comparison between Base and NC scenarios suggests that under current conditions in the Saleen Estuary, background water quality significantly influences the mixing zone extent.

MRP is predicted to generate mixing zones under both scenarios for the current and 2030 horizons. The Base scenario shows summer (Figure A-28) values of 360m for both current and 2030, predicted to reduce to none following the relocation. Winter Base (Figure A-29) values are 490m (current) and 620m (2030). The NC scenario shows reduced values, 320m (summer [Figure A-30] current) and 200 to 320m (winter [Figure A-31]), suggesting the contribution of riverine phosphorus to the observed mixing zones. The predicted elimination of MRP mixing zones from 2055 onwards reflects the improved conditions expected at the Whitegate Pier location.

Table 3-7 Cloyne and Saleen WwTPs Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
BOD	**Summer**	None	70	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA
DIN	**Summer**	780	920	None	None	NA	NA	NA	NA
	Winter	ND	ND	230	260	420	630	None	None
MRP	**Summer**	360	360	None	None	320	360	None	None
	Winter	490	620	None	None	200	320	None	None

3.8 Whitegate Aghada WwTP

Whitegate Aghada WwTP is in the Lower Harbour area, discharging to waters with relatively good hydrodynamic conditions and lower background nutrient concentrations than the upper estuary. The WwTP has modest flows (0.011m^3/s currently, predicted to increase slightly to 0.014m^3/s by 2080) and operates under ELVs of 25mg/l BOD, 54mg/l TN, and 2.5mg/l TP throughout all horizons.

For BOD, no mixing zone is predicted under any scenario or time horizon, reflecting both the small discharge volumes and the effective dispersion in the Lower Harbour waters. The model results show "None" across all seasons and projection periods.

DIN shows limited predicted mixing zones under the Base scenario only. In summer (Figure A-32), no mixing zone is predicted for current, 2030, or 2055 conditions, with a small mixing zone of less than 100m predicted by 2080 as flows increase marginally. Winter (Figure A-33) conditions show a consistent but minimal mixing zone of less than 100m predicted across all time horizons from current through 2080. The modest winter DIN mixing zones reflect the seasonal pattern of higher flows and loads during winter.

MRP is predicted to generate no mixing zone under any scenario or time horizon, with "None" recorded across all Base scenario conditions. The combination of the relatively low TP ELV (2.5mg/l), small discharge volumes, and favourable hydrodynamic conditions in the Lower Harbour suggest that phosphorus does not present a compliance concern at this location.

Overall, Whitegate Aghada WwTP is predicted to demonstrate minimal influence on the receiving water body, with only a modest DIN mixing zone under winter conditions, a pattern consistent with its location in the well flushed Lower Harbour.

Table 3-8 Whitegate Aghada WwTP Mixing Zone Lengths

Parameter	Season	Base				Notionally Clean			
		Current	*2030*	*2055*	*2080*	*Current*	*2030*	*2055*	*2080*
BOD	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA
DIN	**Summer**	None	None	None	<100	NA	NA	NA	NA
	Winter	<100	<100	<100	<100	NA	NA	NA	NA
MRP	**Summer**	None	None	None	None	NA	NA	NA	NA
	Winter	None	None	None	None	NA	NA	NA	NA

4. DISCUSSION AND CONCLUSION

This report presents the sizes of the mixing zones for the eight Wastewater Treatment Plants (WwTP) discharging directly to Cork Harbour. The assessment is based on modelling undertaken as part of the wider Cork Harbour Strategic Modelling Study. Mixing zones have been calculated for a series of planning horizons: current, 2030, 2055, and 2080, with the discharge load for each WwTP and each time horizon applied based on the expected discharge flow and the proposed ELV concentration.

4.1 Discussion

The mixing zone modelling results for the eight WwTPs discharging to Cork Harbour (excluding Minane Bridge WwTP) show distinct patterns linked to discharge characteristics, receiving water conditions, and the proposed strategic infrastructure changes.

Under current conditions, the largest mixing zones are predicted for Carrigtwohill WwTP, particularly for DIN and MRP. Summer DIN mixing zone size (in terms of maximum length) is predicted to be 4,000m approximately, with MRP values exceeding 2,000m. These substantial mixing zones are a consequence of the nutrient loads from the discharge combined with the relatively confined hydrodynamic conditions and shallow bathymetry at the existing outfall location in the upper reaches of Lough Mahon, which restrict dilution and dispersion. This is consistent with the findings of the Midleton and Carrigtwohill licence review (Intertek Metoc, 2025), which identified elevated DIN and MRP concentrations around the Carrigtwohill WwTP discharge and noted that the enclosed nature of the waterbody at this location gives rise to less favourable dilution characteristics. The comparison between Base and NC scenarios at this site is informative. While the NC scenario shows reduced mixing zones, substantial mixing zones remain even when upstream riverine pollution sources are removed. This suggests that the WwTP discharge itself is a significant contributor to local water quality pressures under current conditions, a conclusion also supported by the licence review which found that DIN and MRP concentrations remain elevated around the Carrigtwohill discharge even under notionally clean river conditions. As loading to Carrigtwohill increases in future horizons, the discharge would become an increasingly significant pressure on local water quality.

In contrast, the licence review found that water quality impacts from Midleton WwTP are minimal, with no discernible mixing zone for BOD or DIN and an indicative quality of High in the surrounding area. The current study confirms this finding, with the modelling predicting no mixing zone for Midleton WwTP across all parameters, seasons, and time horizons. This is the result of modest discharge volumes (and loads), already stringent ELVs (TN at 15mg/l currently, compared to 25mg/l at Carrigtwohill), and favourable dilution from the River Owenacurra.

Carrigrennan WwTP, as the largest WwTP in the system, shows moderate mixing zones that are predicted to increase over time for BOD in line with projected population growth and associated flows, with mixing zone size predicted to reach over 1,000m by 2080 under winter condition. However, the pattern for DIN is more complex due to the high riverine load from the River Lee. In the Base scenario, the background river concentrations cause the EQS to be exceeded in Lough Mahon, meaning definitive mixing zones from the WwTP cannot be determined. Therefore the NC scenario has been used to assess the isolated impact of the WwTP. Under the NC scenario, mixing zones from Carrigrennan WwTP range from 200m to 290m under current conditions and peak at 370m (winter 2030) before reducing to 150-200m from 2055 onwards as the more stringent total nitrogen ELV under the UWWTDr takes effect. The fact that DIN mixing zones can only be determined under the Base scenario for the 2055 and 2080 summer horizons (720m and 1,010m respectively), suggests that under current river water quality conditions, background concentrations from the River Lee and other tributaries are the dominant influence on DIN levels in the receiving waters.

The modelling predicts significant improvements at Carrigtwohill WwTP from 2055 onwards, with mixing zones predicted to reduce by an order of magnitude or more. This is attributable to two factors. First, the proposed relocation of the outfall to a more dispersive location in the main channel between Carrigrennan and the Martello Tower. Second, the implementation of more stringent ELVs under the UWWTDr requiring tertiary treatment, with TN reducing from 25mg/l to 10mg/l and TP reducing from 1.0mg/l to 0.7mg/l. The predicted reduction in DIN mixing zones from over 4,000m (2030) to 60 to 70m (2055 onwards) illustrates the combined effectiveness of these measures and represents a substantial improvement on the conditions identified in the licence review.

Several smaller WwTPs, including North Cobh and Whitegate Aghada, show minimal or no mixing zone across all parameters and horizons. These WwTPs benefit from small discharge volumes (and loads) relative to the assimilative capacity of their receiving waters.

Cloyne and Saleen WwTPs currently discharge to the Saleen Estuary, where mixing zones of several hundred metres are predicted for DIN and MRP. The proposed consolidation of these discharges and relocation to Whitegate Pier is predicted to eliminate most mixing zones from 2055 onwards, reflecting the improved dispersion characteristics at the new location.

CLH WwTP presents a unique case due to discharges from the WwTP being combined with industrial discharges in a shared outfall off Dognose Point in the Lower Harbour. Despite the larger discharge loading at this location, mixing zones are predicted to remain relatively small (maximum 130m for BOD) throughout all horizons. This is due to the enhanced dispersion and dilution provided by stronger tidal currents and greater water depths in the Lower Harbour.

The role of riverine inputs in determining mixing zone extent is evident throughout the results. At several sites, the difference between Base and NC scenarios is substantial, indicating that background water quality from rivers contributes significantly to nutrient concentrations in the receiving waters. This finding aligns with the licence review, which concluded that rivers are significant contributors to water quality impacts and that indicative quality across Cork Harbour improves significantly under notionally clean conditions compared to the Base scenario. The River Lee, with flows of approximately 19m^3/s in summer and 77m^3/s in winter, dominates freshwater inputs to the harbour and is a substantial source of background nutrient loading.

4.2 Conclusion

The mixing zone assessment for Cork Harbour WwTPs demonstrates that the proposed strategic infrastructure improvements are predicted to deliver substantial reductions in mixing zones across the system. The most significant improvements are anticipated at Carrigtwohill WwTP, where the combination of outfall relocation and tertiary treatment is predicted to reduce DIN mixing zones from over 4,000m to less than 100m. This represents a major improvement on the current conditions identified in the licence review, which found elevated nutrient concentrations and extended mixing zones around the existing Carrigtwohill discharge due to the confined nature of the receiving waters.

Under current conditions, mixing zones vary considerably across the WwTPs. Carrigtwohill shows the largest predicted mixing zones due to its location in the confined upper reaches of Lough Mahon, with shallow bathymetry and less favourable dilution characteristics. Carrigrennan, despite being the largest WwTP, shows more moderate mixing zones due to greater dispersion at its discharge location. Midleton WwTP is predicted to generate no mixing zone for any parameter, consistent with the licence review findings that water quality impacts from this WwTP are minimal. Several other smaller WwTPs, including North Cobh and Whitegate Aghada, similarly show no or minimal mixing zones.

The implementation of the UWWTDr from 2045, with more stringent nitrogen and phosphorus ELVs for WwTPs in nutrient sensitive areas, is predicted to result in reduced mixing zones at Carrigrennan and Carrigtwohill from 2055 onwards. The proposed transfer schemes for North Cobh, Cloyne, Saleen, and Minane Bridge WwTPs will consolidate discharges at locations with better assimilative capacity, further reducing localised water quality impacts.

The modelling also highlights the significant contribution of riverine inputs to nutrient concentrations in Cork Harbour, consistent with the findings of the licence review. At several sites, background water quality from rivers is predicted to be a more significant factor than WwTP discharges in determining compliance with EQS. This underscores the importance of catchment-wide approaches to water quality management alongside point source controls.

The modelling demonstrates that the proposed strategy, including treatment upgrades, outfall relocations, and flow transfers, is compatible with achieving WFD objectives for Cork Harbour's receiving waters.

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1 Intertek. (December 2023). Cork Harbour Calibration and Validation Report: Volume 1, Hydrodynamic Calibration and Validation Report. Report No. P2443_R6016_Rev2.

2 Intertek Metoc. (2025). P2443_R6056_Rev3 Midleton / Carrigtwohill Licence Review.

3 Uisce Éireann. (2022). Technical Standards for Marine Modelling.

APPENDIX A

Mixing Zone Plots

A.1 CARRIGRENNAN WWTP

A.1.1 BOD

Figure A-1 Base Summer Plots

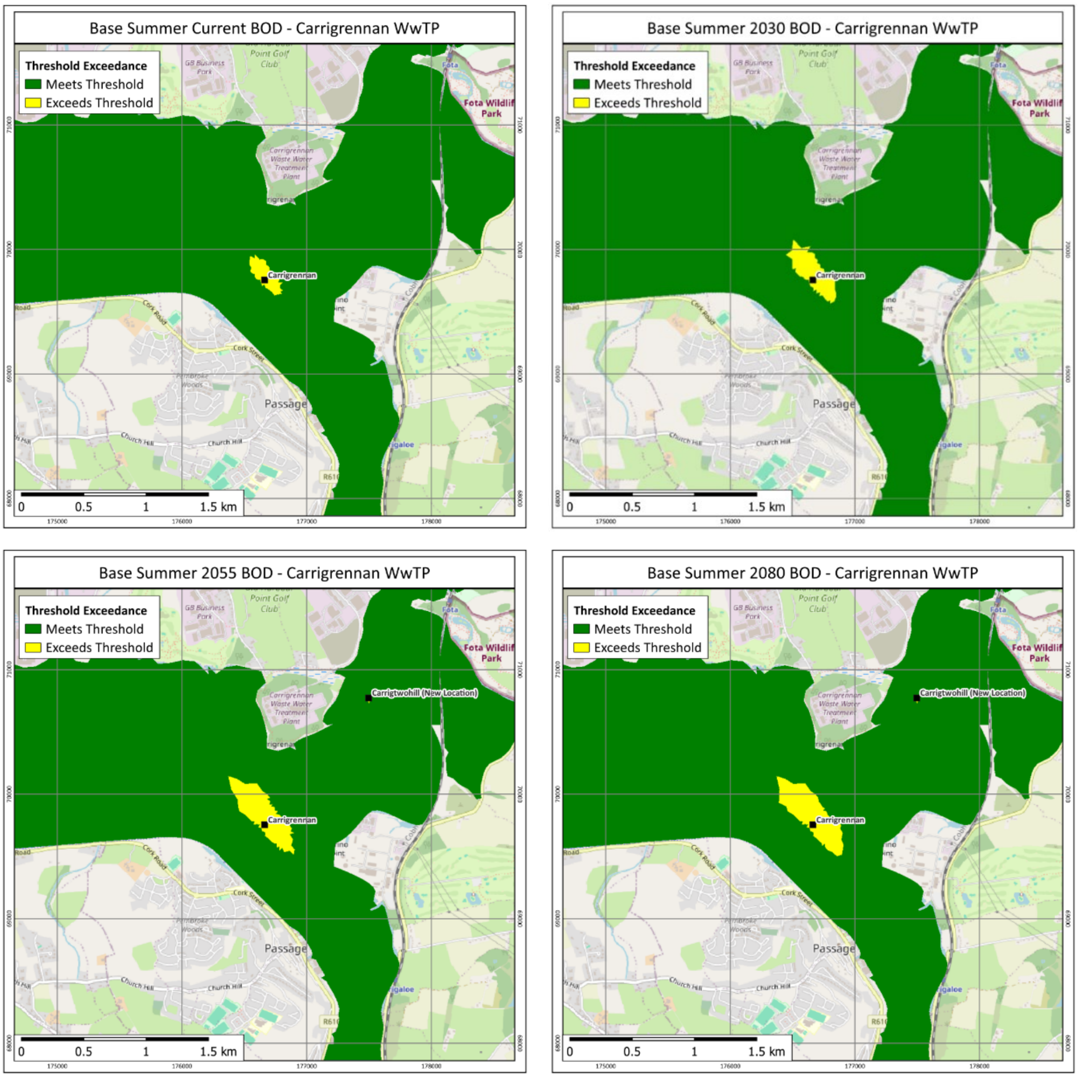
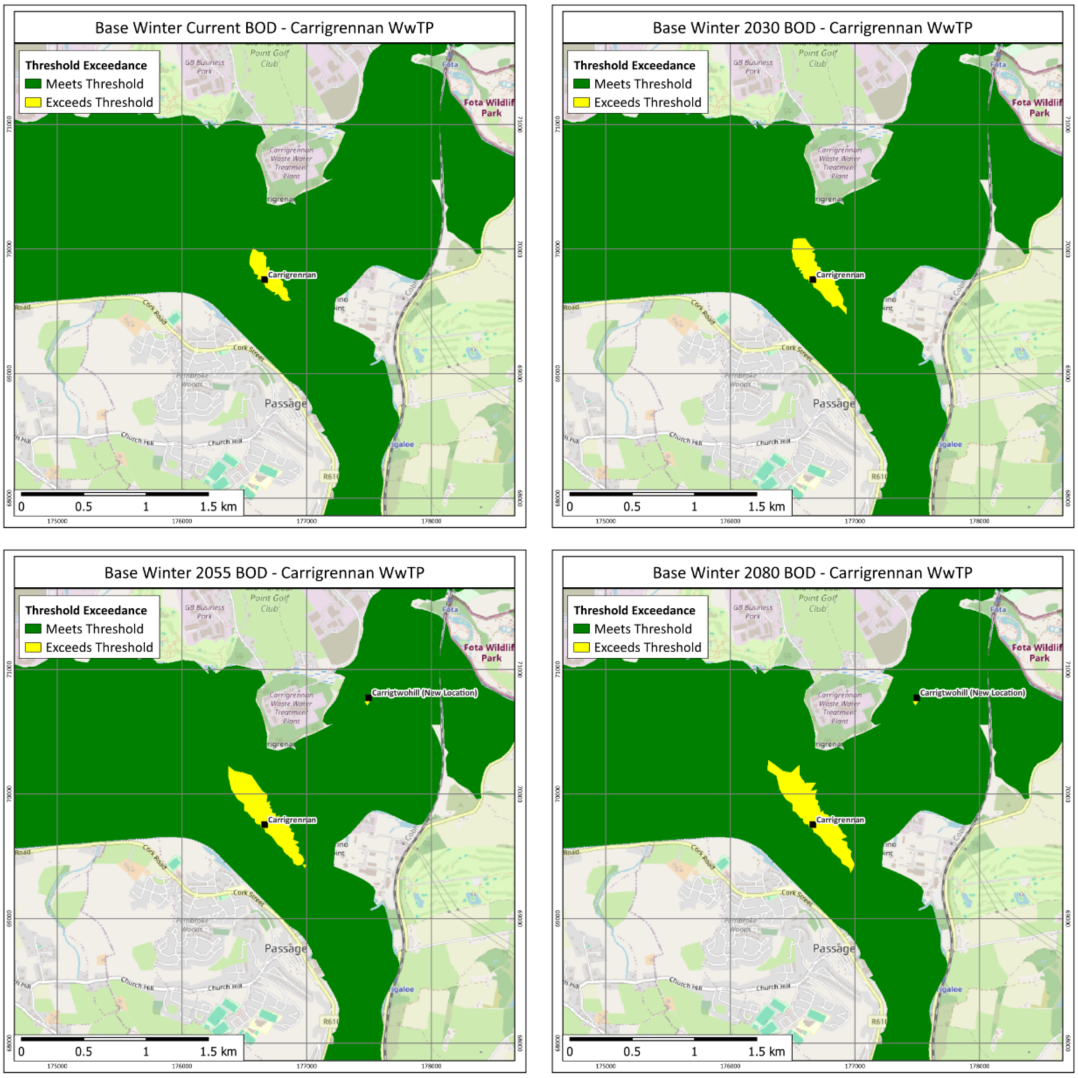


Figure A-2 Base Winter Plots



A.1.2 DIN

Figure A-3 Base Summer Plots

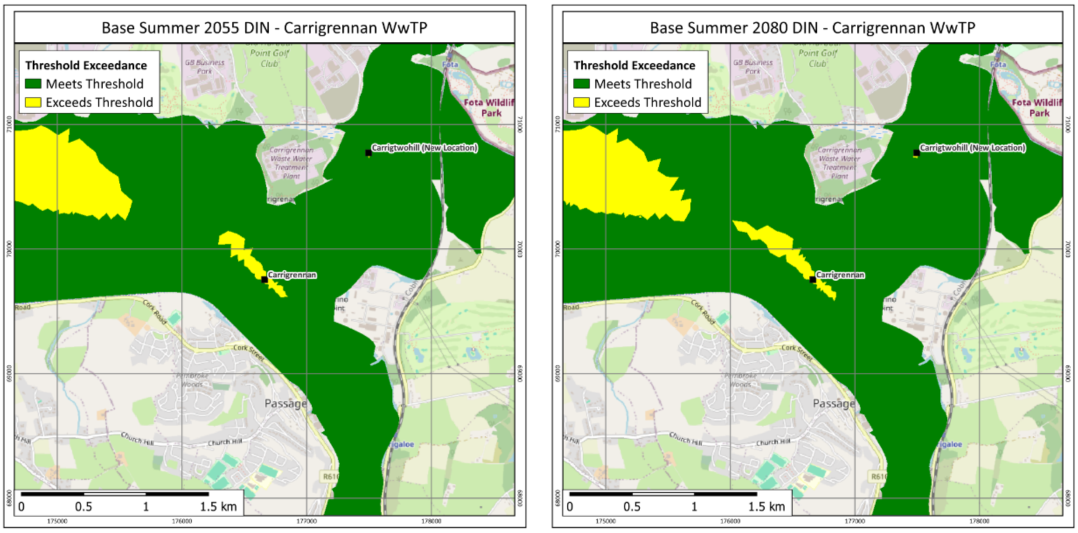


Figure A-4 Notionally Clean Summer Plots

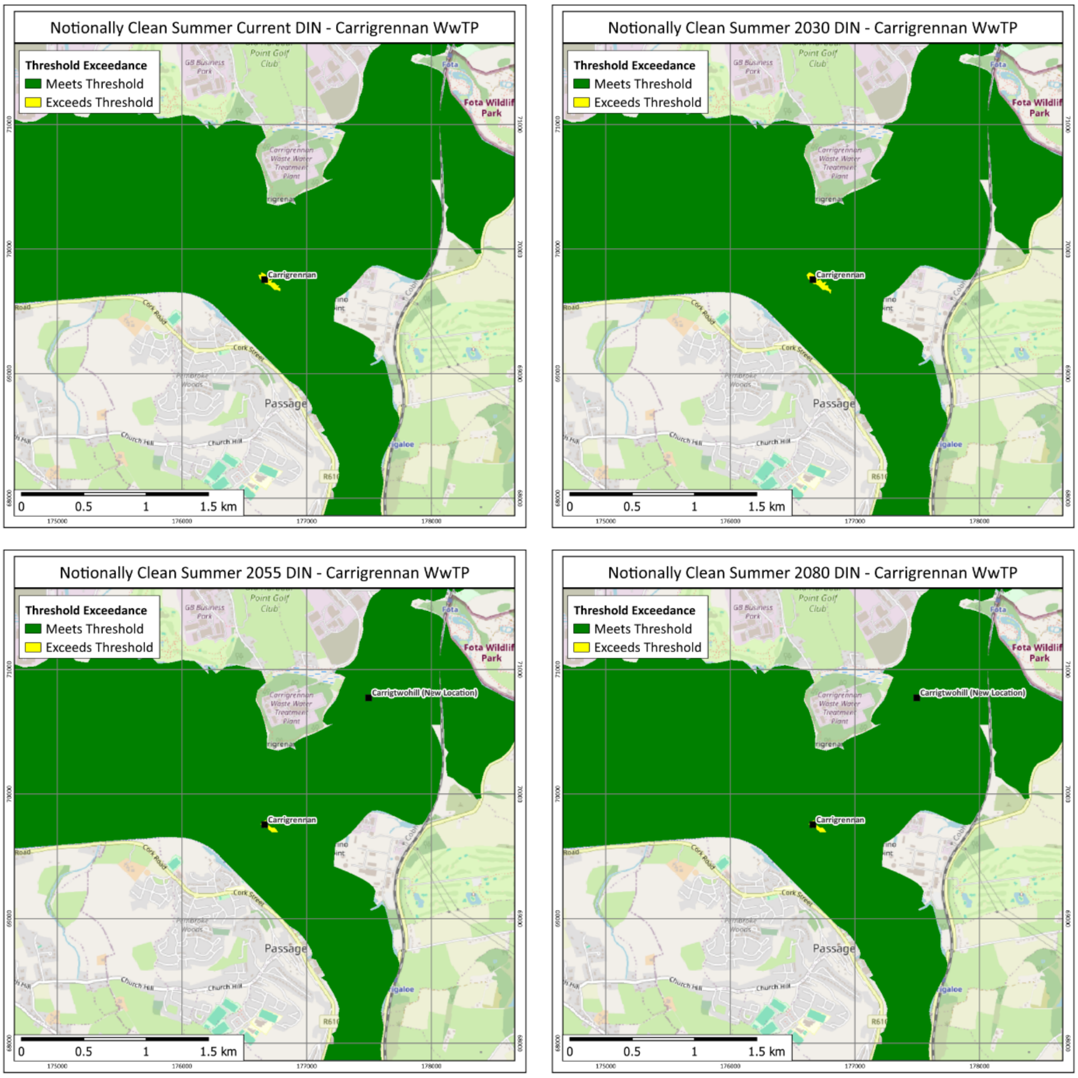
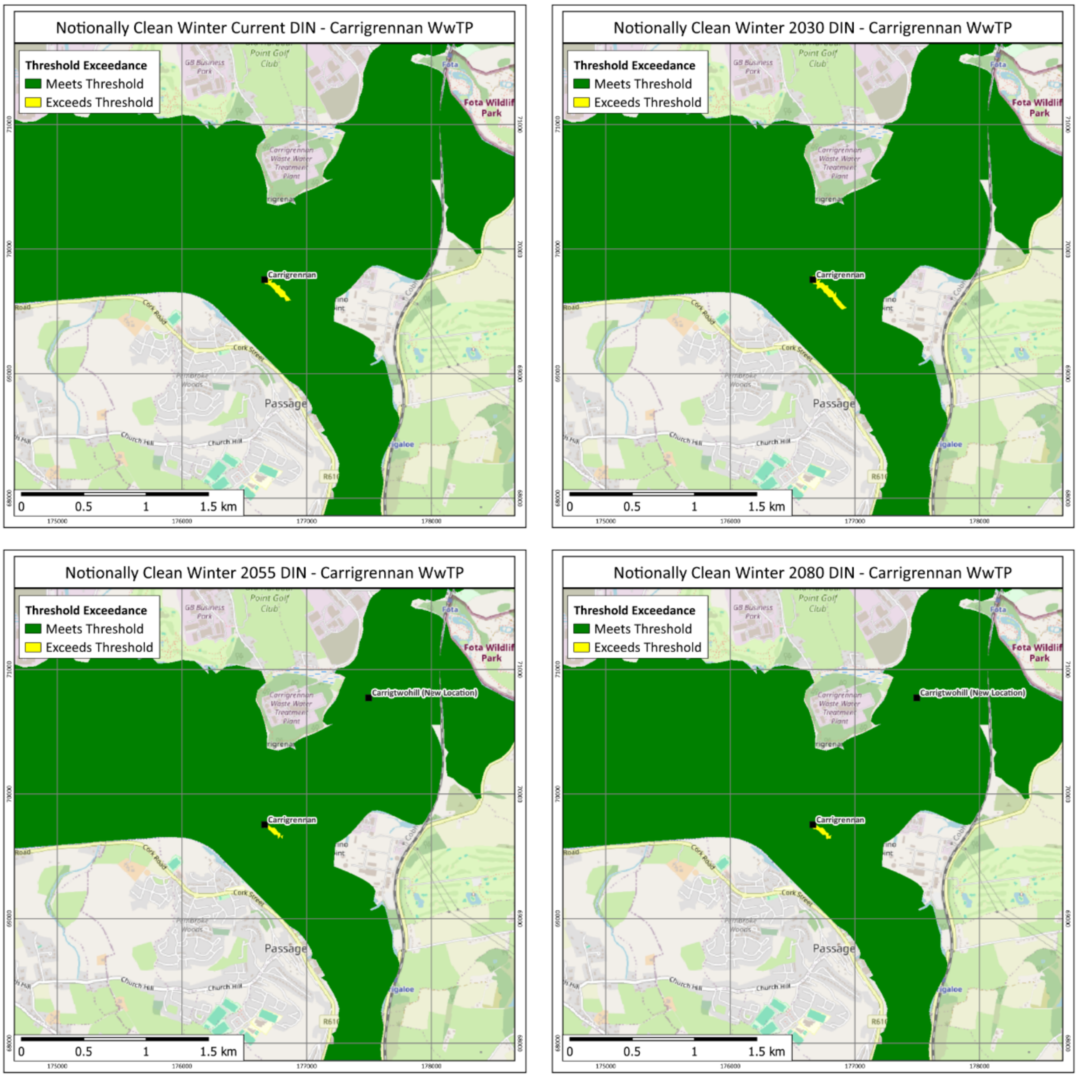


Figure A-5 Notionally Clean Winter Plots



A.1.3 MRP

Figure A-6 Base Summer Plots

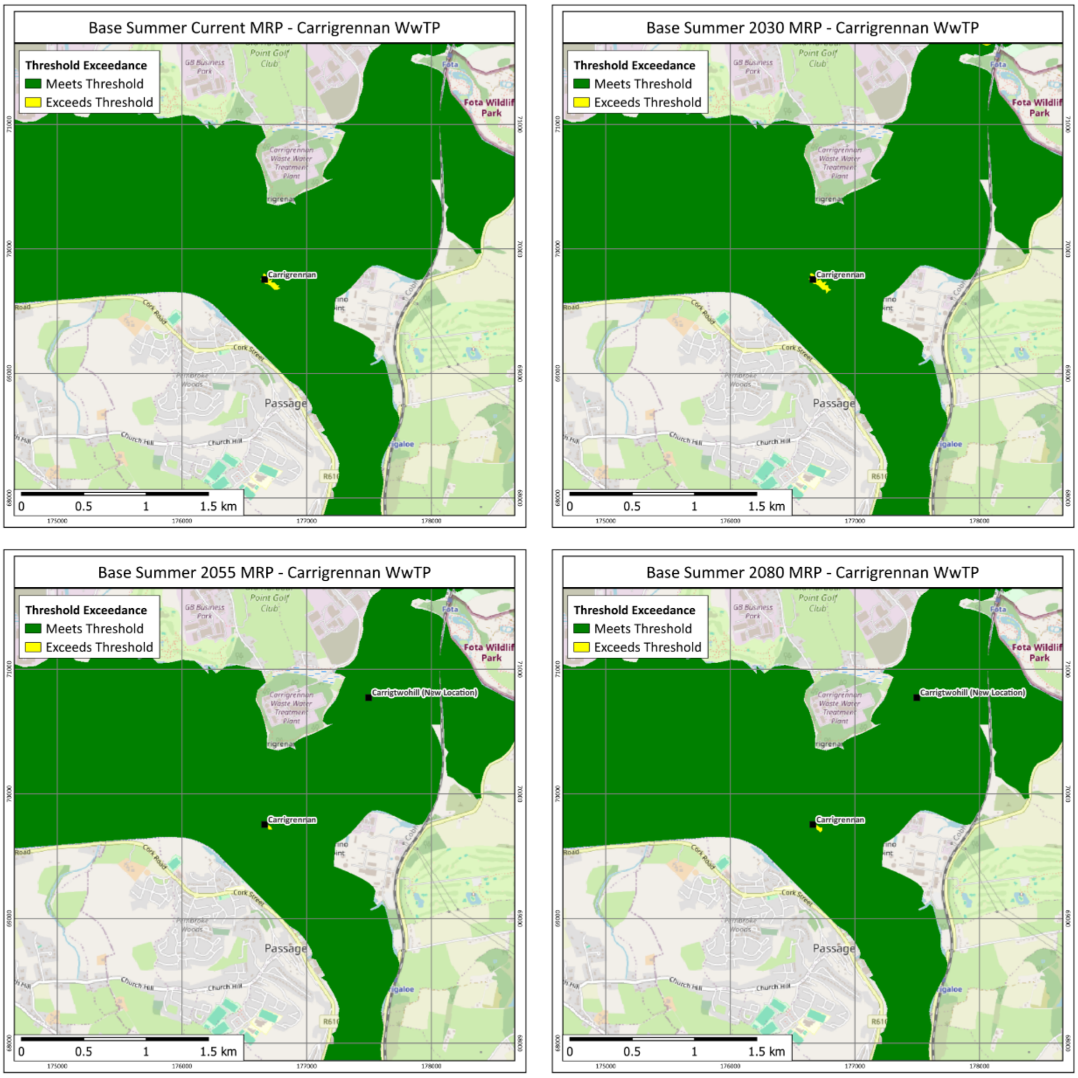
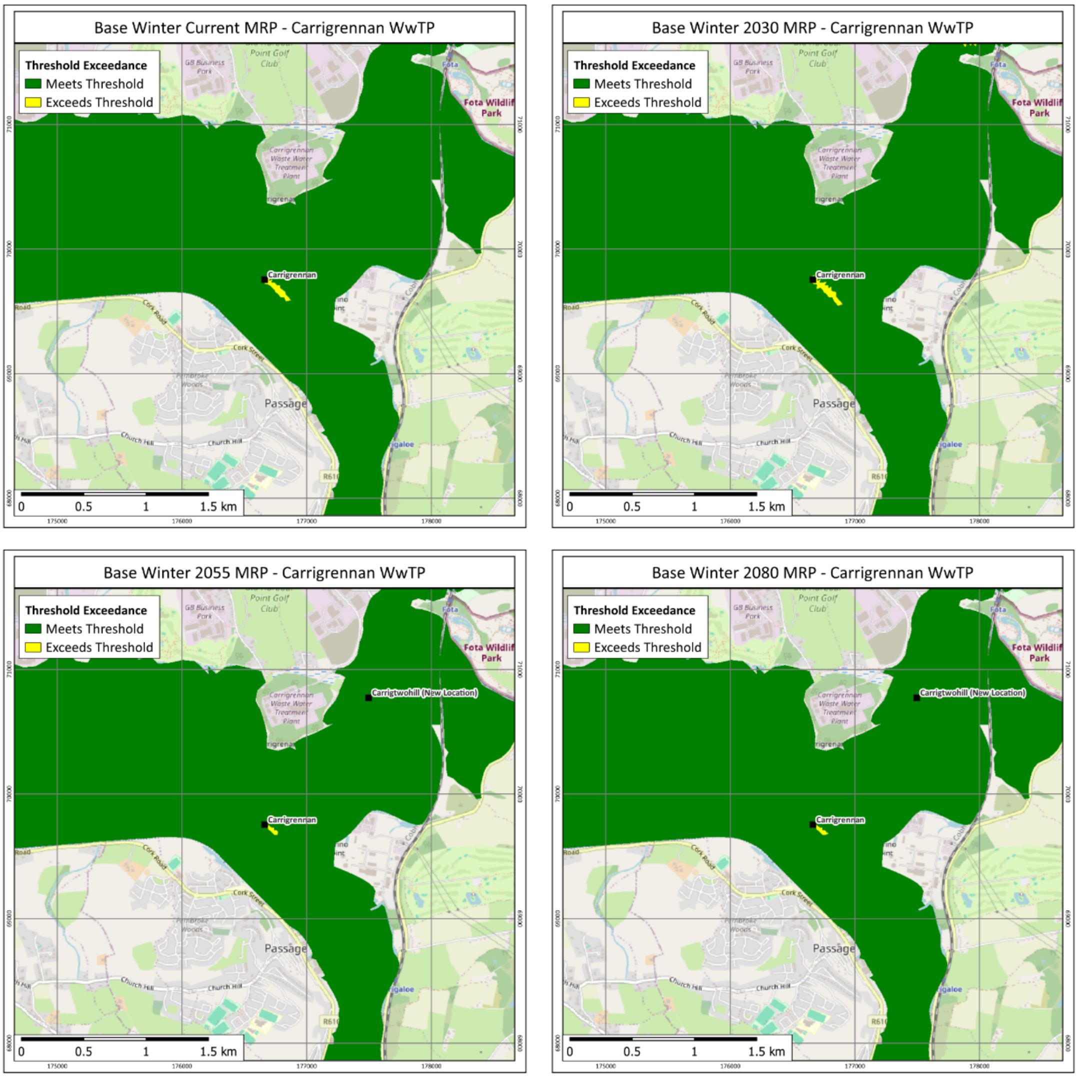


Figure A-7 Base Winter Plots



A.2 CARRIGTWOHILL WWTP

A.2.1 BOD

Figure A-8 Base Summer Plots

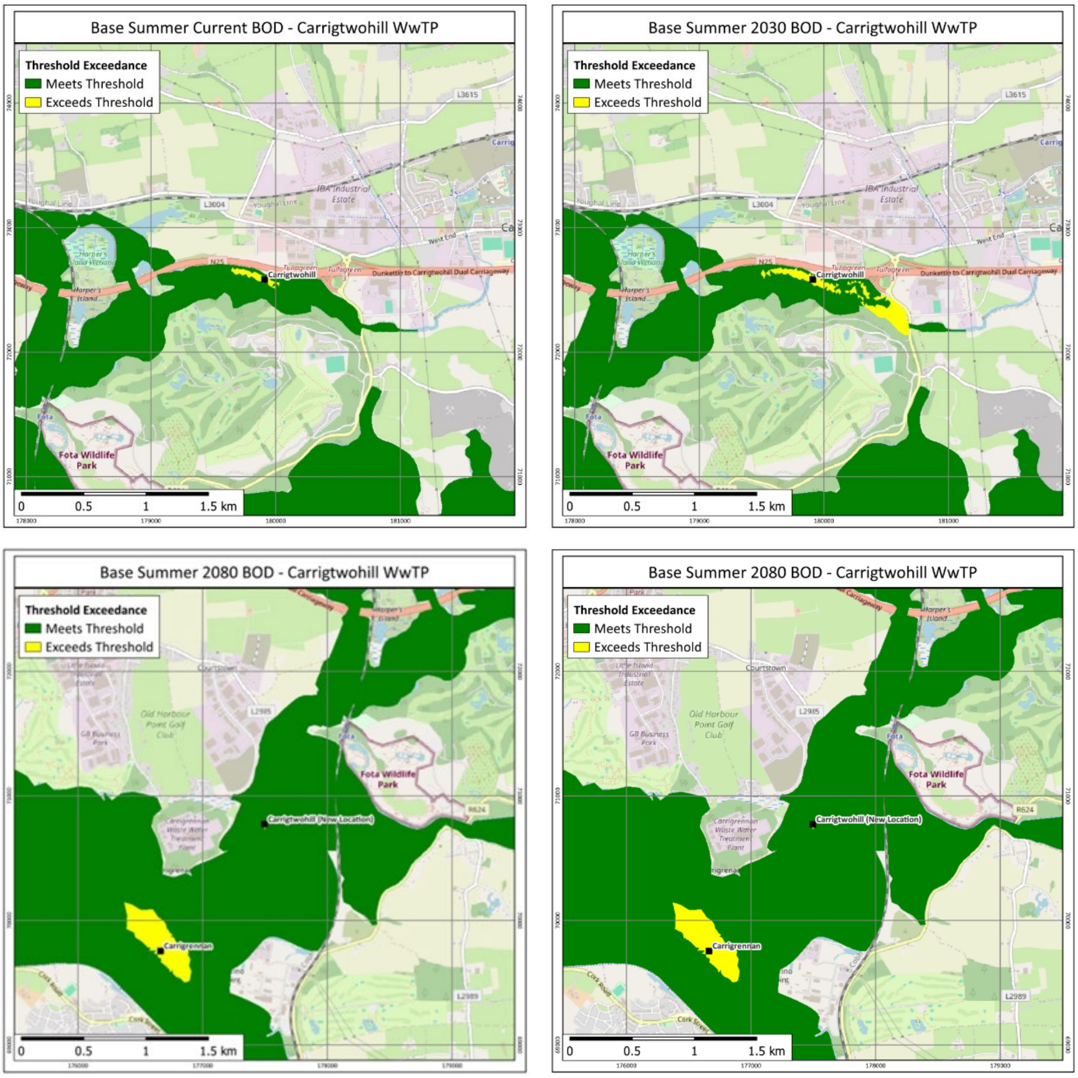
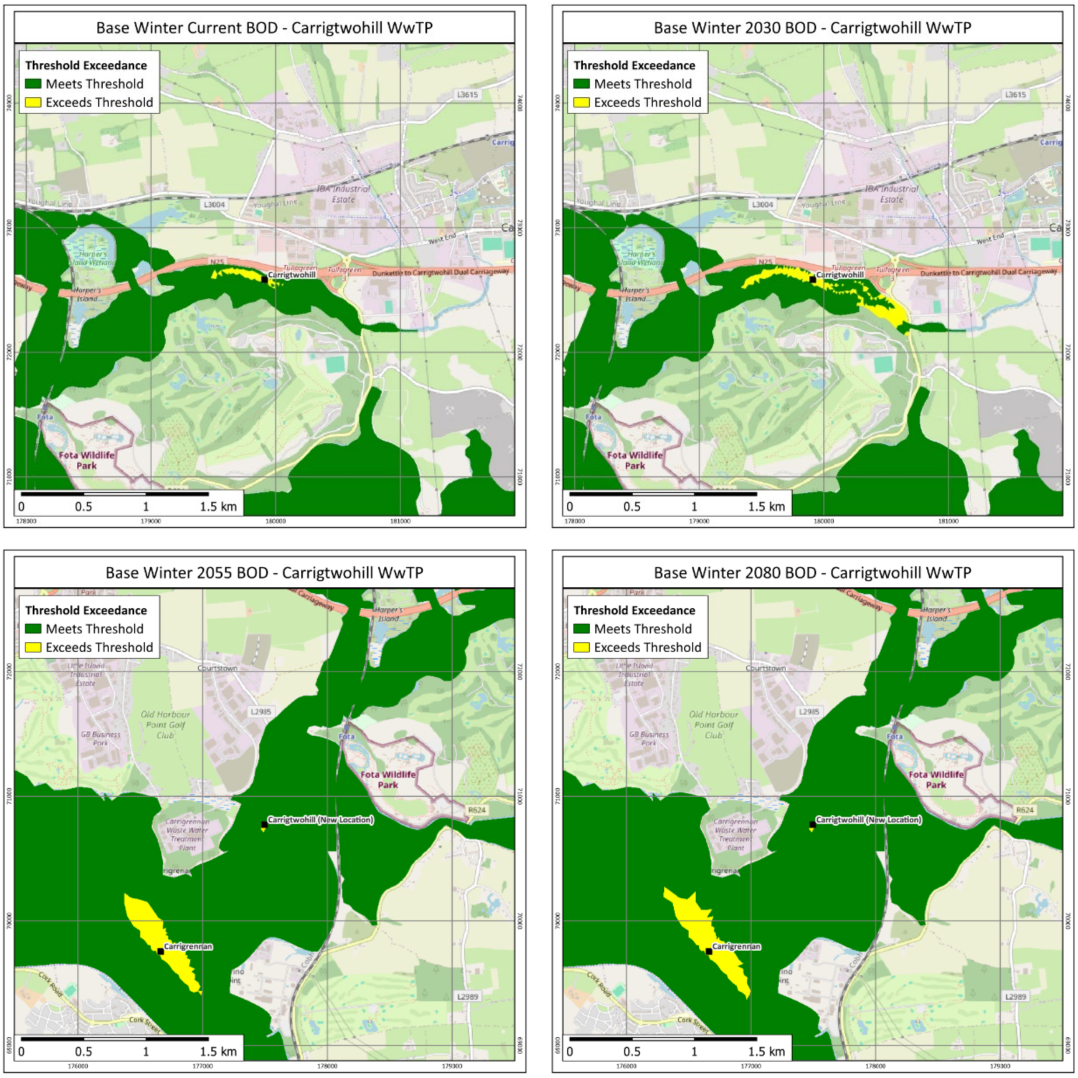


Figure A-9 Base Winter Plots



A.2.2 DIN

Figure A-10 Base Summer Plots

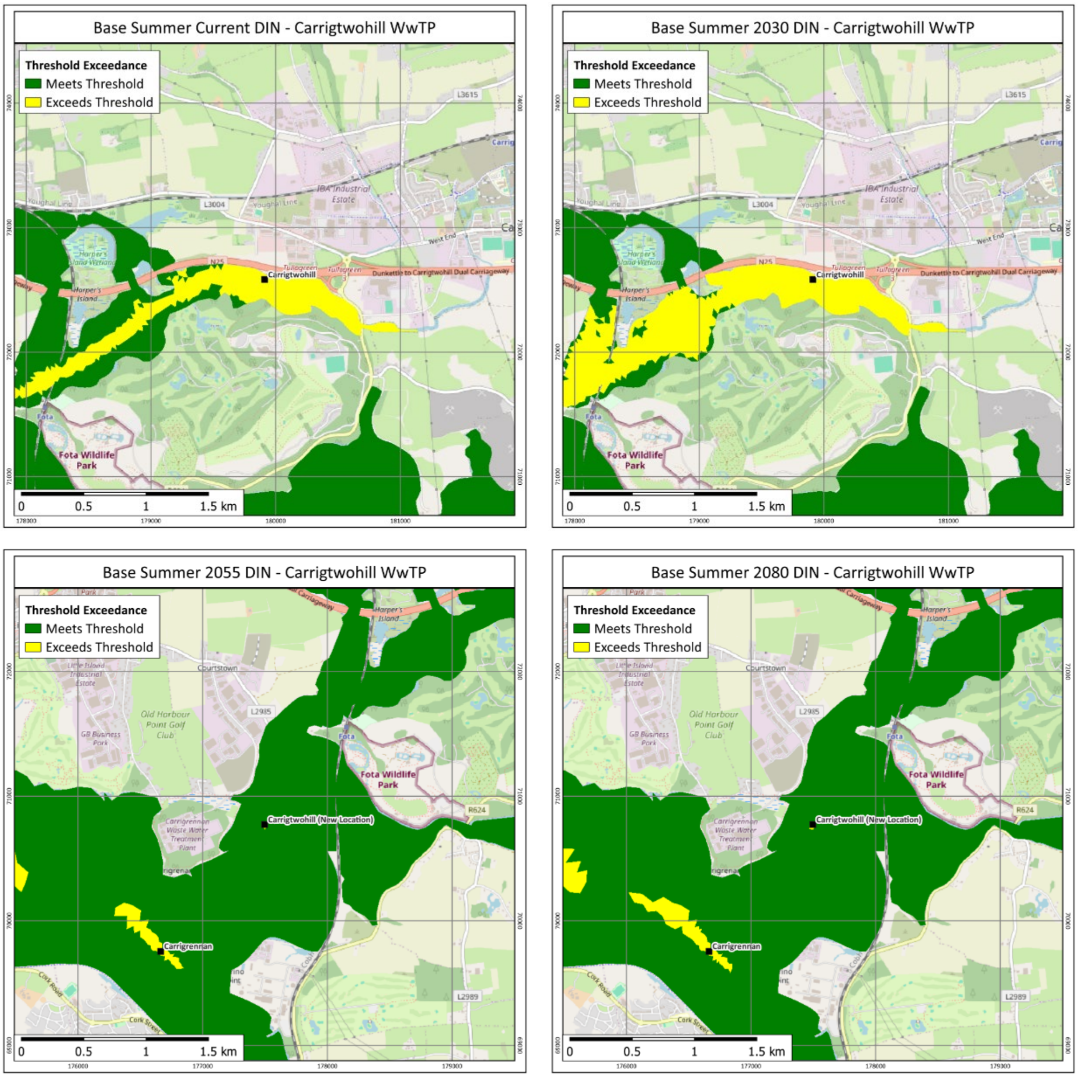


Figure A-11 Notionally Clean Summer Plots

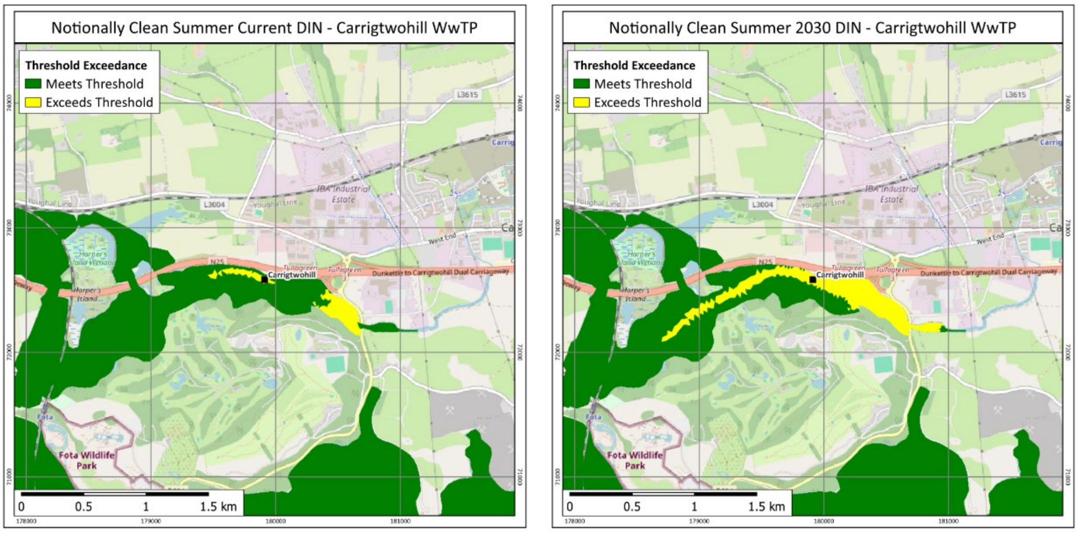
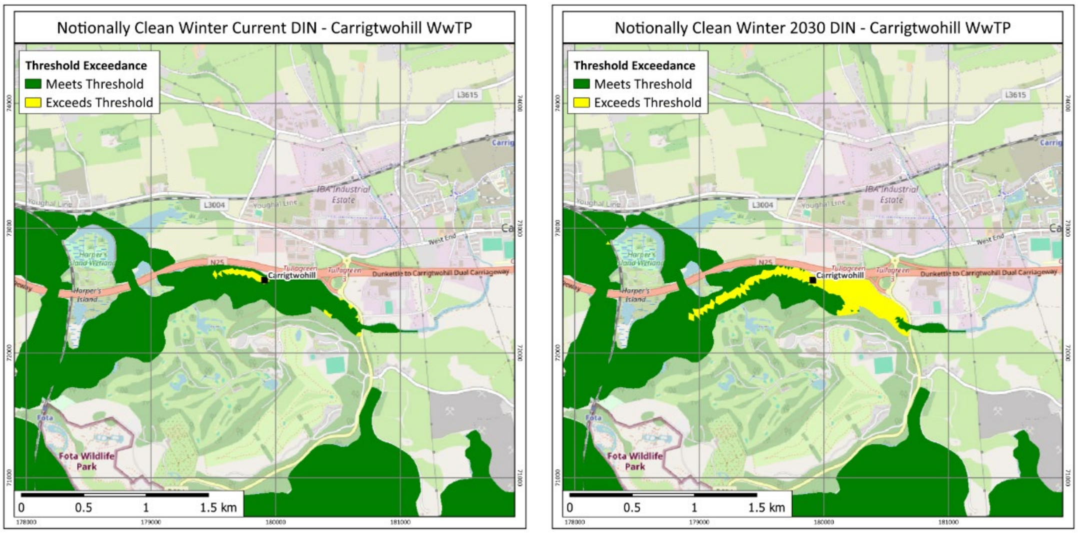


Figure A-12 Notionally Clean Winter Plots



A.2.3 MRP

Figure A-13 Base Summer Plots

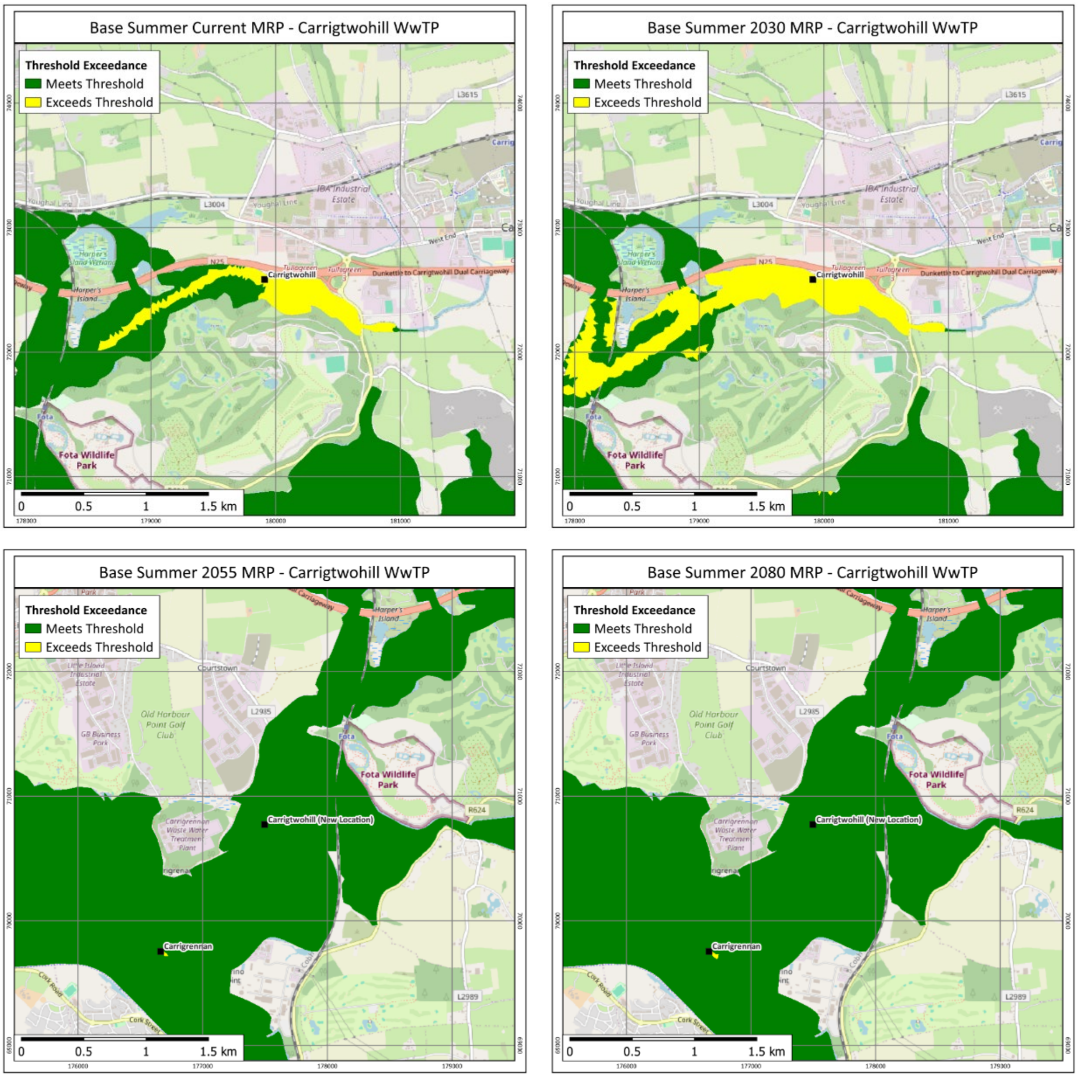


Figure A-14 Base Winter Plots

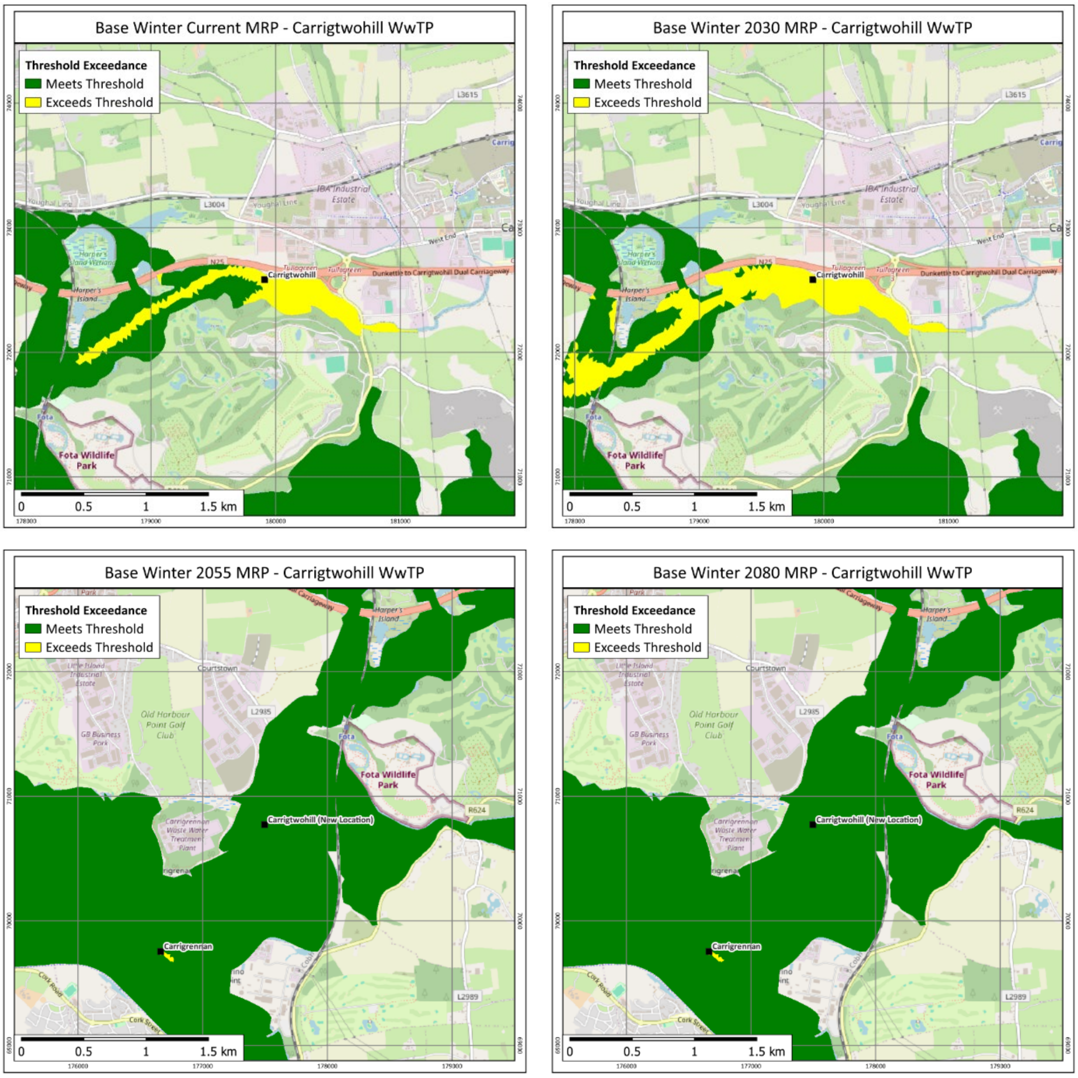


Figure A-15 Notionally Clean Summer Plots

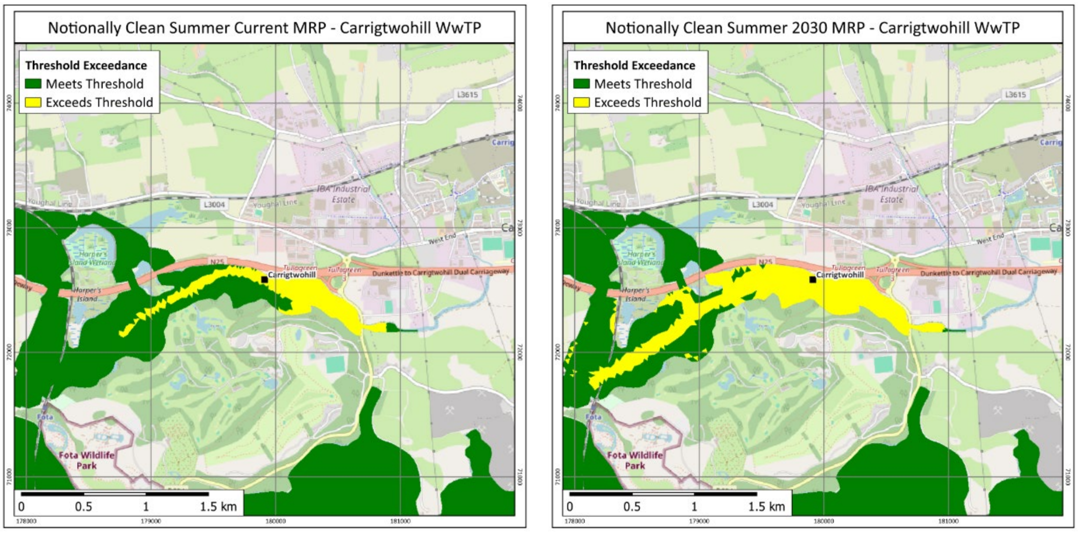
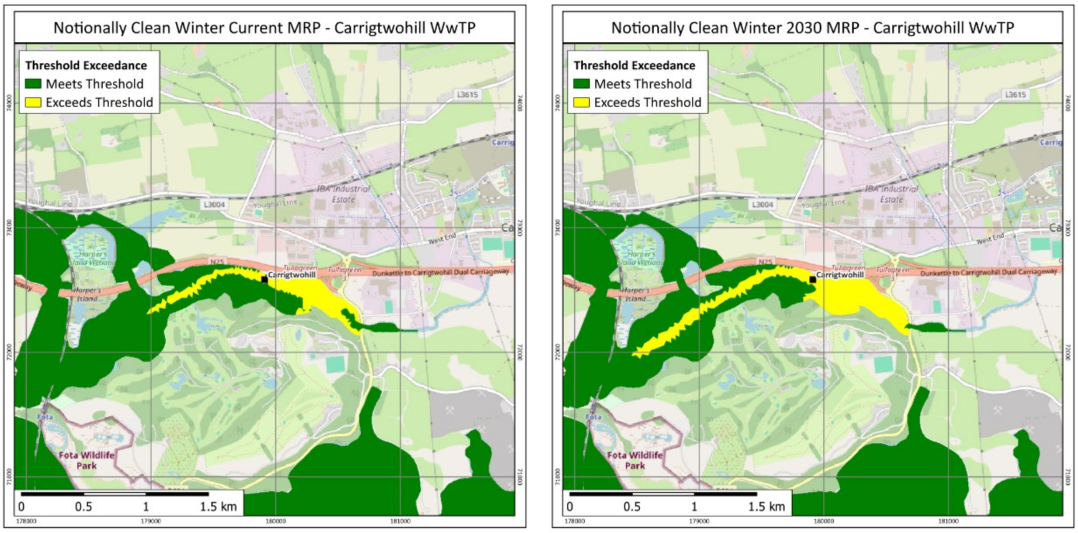


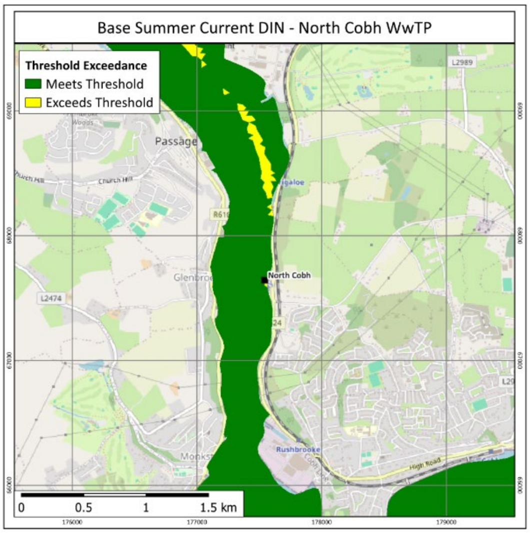
Figure A-16 Notionally Clean Winter Plots



A.3 NORTH COBH WWTP

A.3.1 DIN

Figure A-17 Base Summer Plots



A.4 CLH WWTP

A.4.1 BOD

Figure A-18 Base Summer Plots

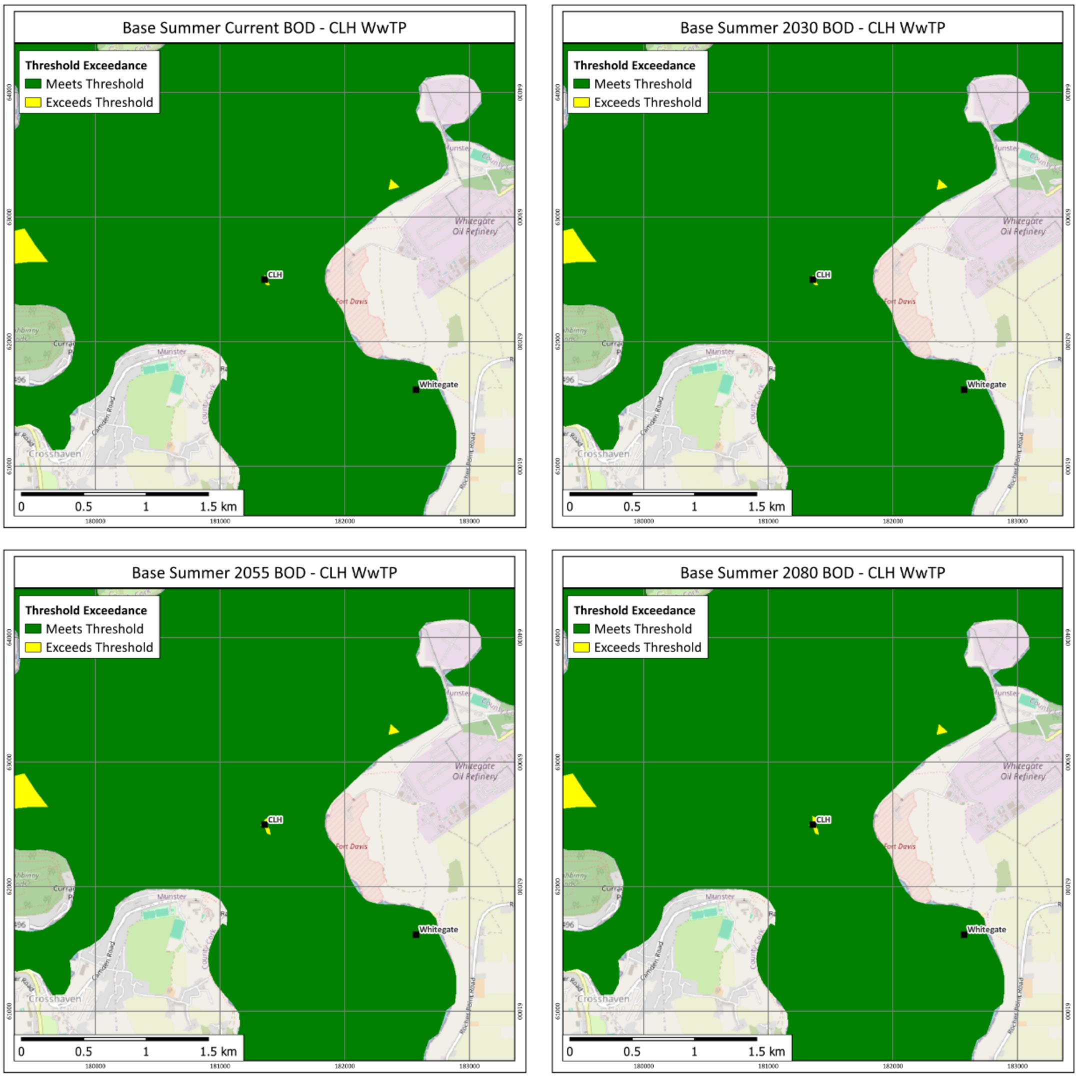
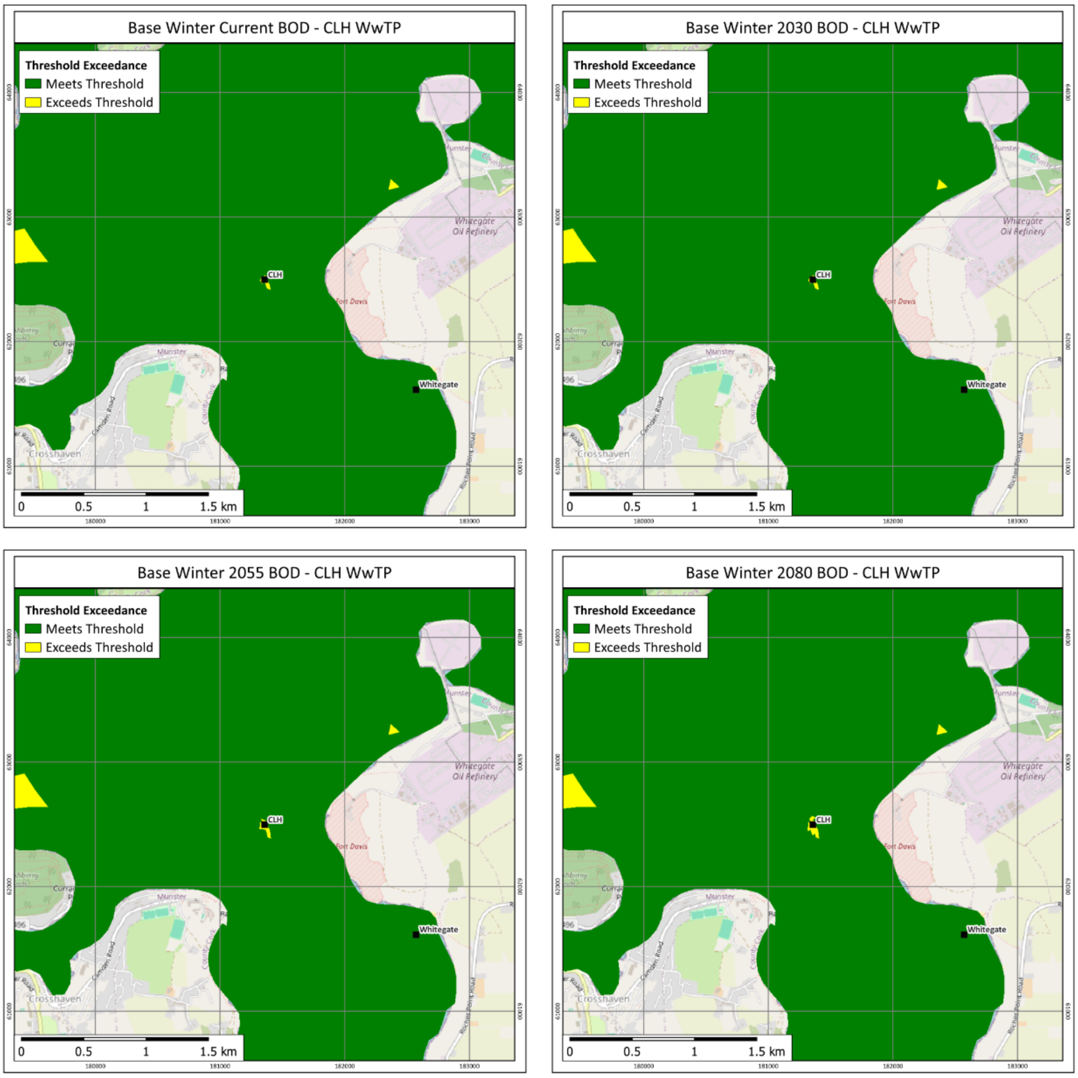


Figure A-19 Base Winter Plots



A.4.2 DIN

Figure A-20 Base Summer Plots

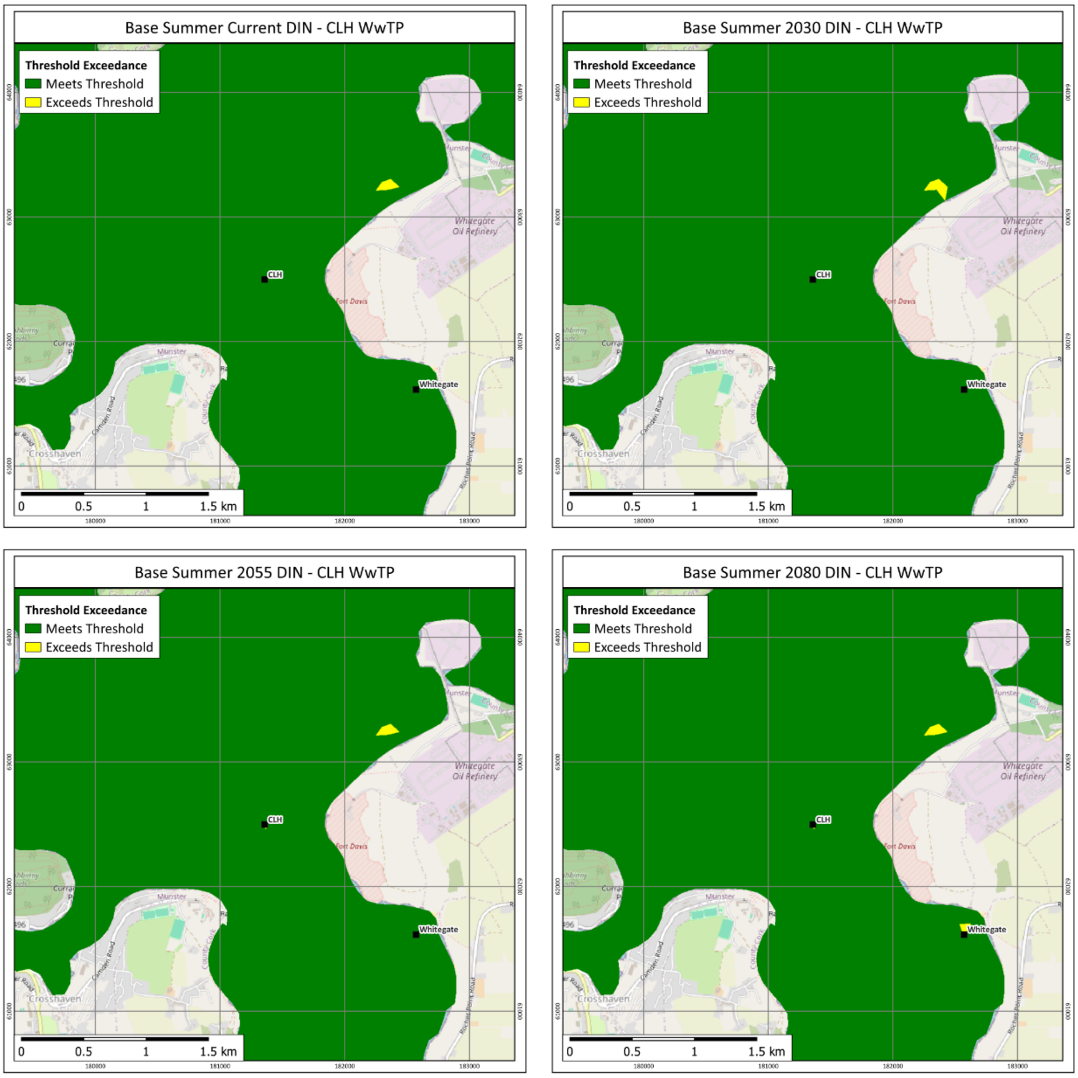
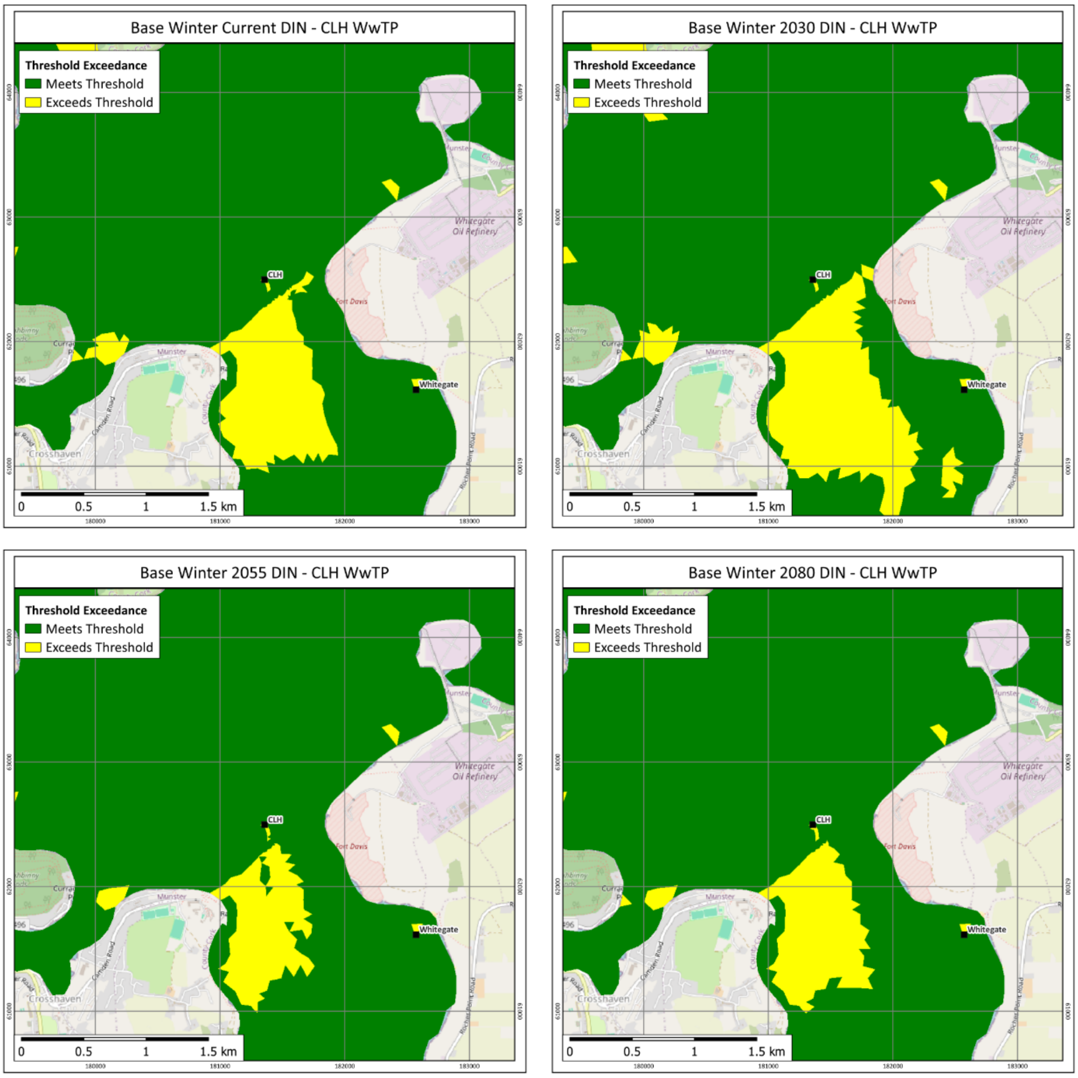
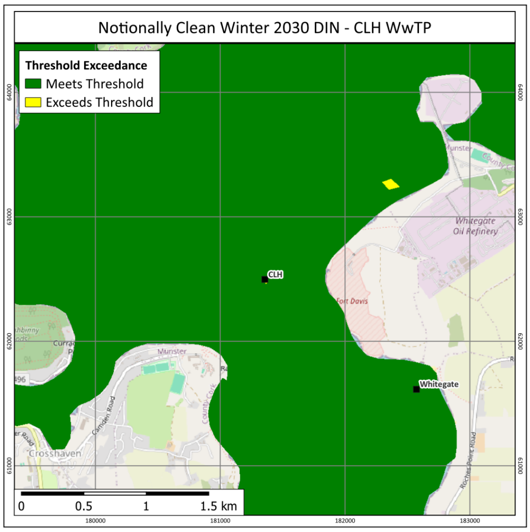


Figure A-21 Base Winter Plots



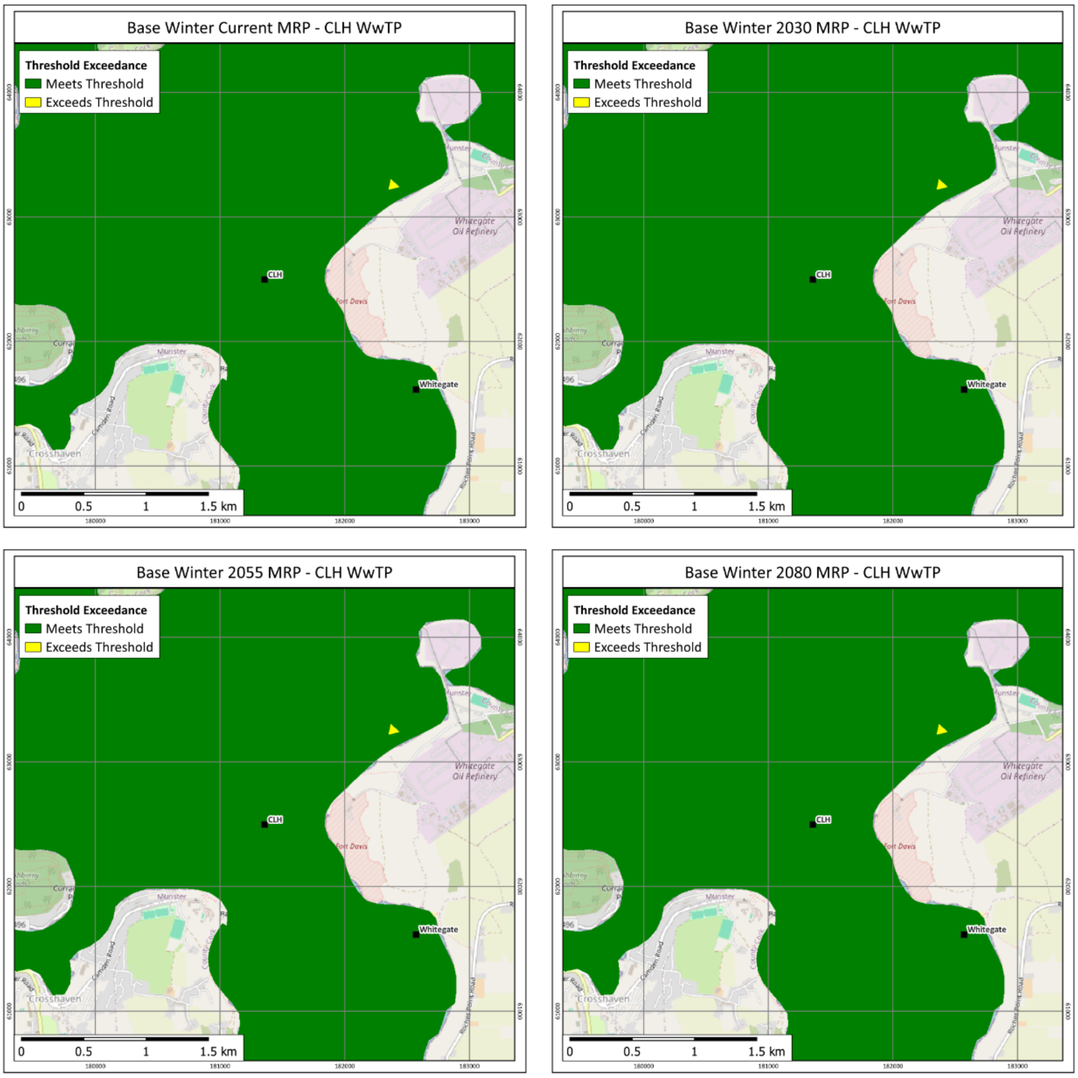
The classification concentrations for DIN are inversely calculated based on salinity. Salinity decreases further inland due to greater influence from freshwater inputs. Cork Harbour is split into eight different waterbodies, each with different levels of salinity. Since the waterbodies have different salinities, the classification concentrations are different between these waterbodies. The yellow area south of CLH has an almost straight line on its northern edge. This is due to the boundary between the waterbodies. The area south of that boundary is much more saline, which means the DIN classification concentrations are much lower. The background diffuse load from freshwater inputs to Cork Harbour is the main cause of the threshold exceedance in this waterbody. This is demonstrated in Figure A-22, which shows CLH generating a minimal mixing zone under the Notionally Clean Winter 2030 scenario (the scenario with the largest area for Base Winter DIN). On top of this background load, discharge from CLH WwTP and other WwTPs will change the shape of the mixing zone. Since the salinity is high in this area, the DIN classification concentrations are tight, so small differences in DIN concentrations will result in different shapes.

Figure A-22 Notionally Clean Winter Plots



A.4.3 MRP

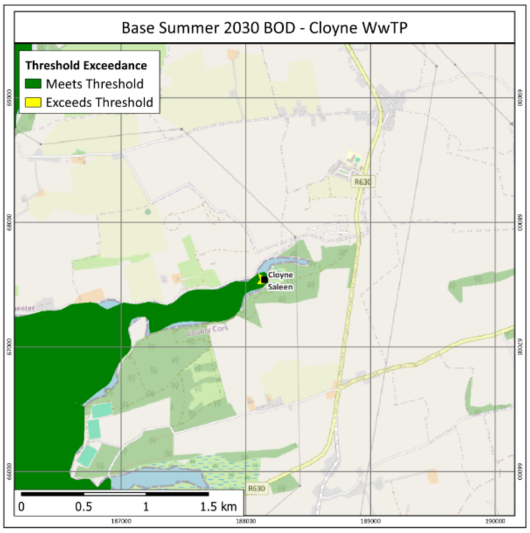
Figure A-23 Base Winter Plots



A.5 CLOYNE / SALEEN WWTPS

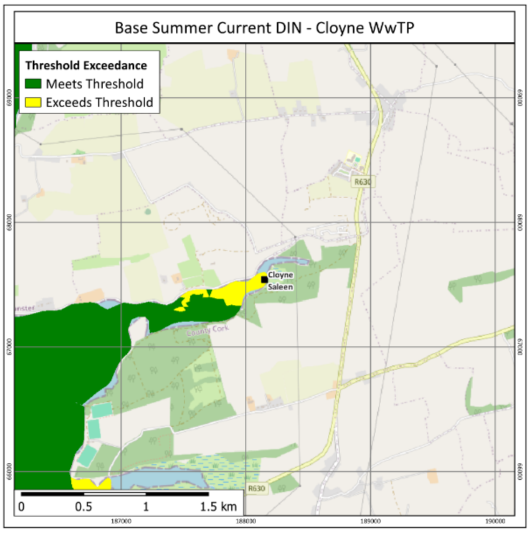
A.5.1 BOD

Figure A-24 Base Summer Plots



A.5.2 DIN

Figure A-25 Base Summer Plots



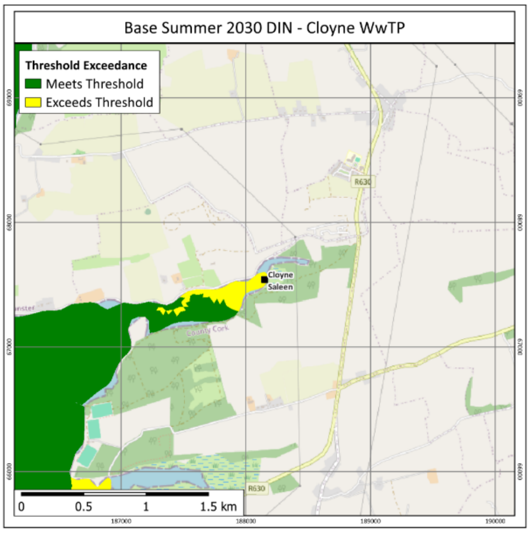
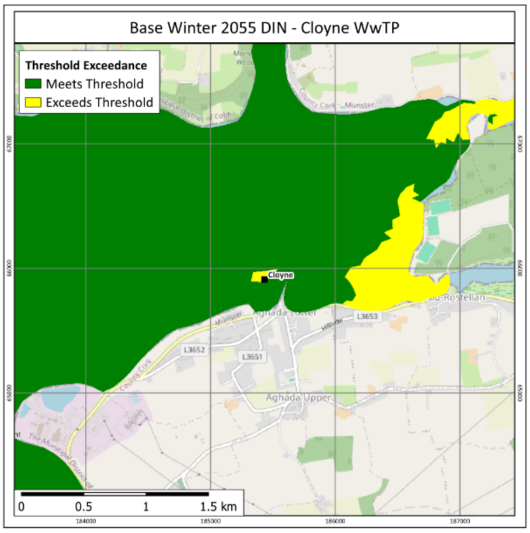


Figure A-26 Base Winter Plots



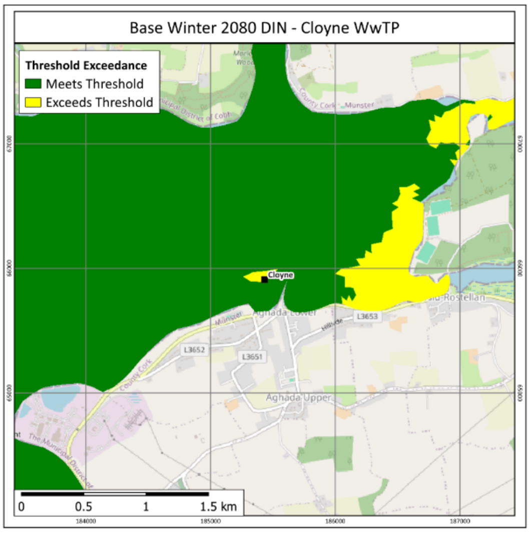
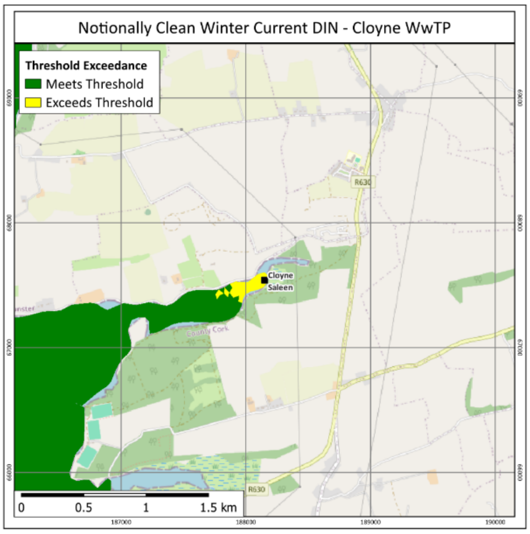
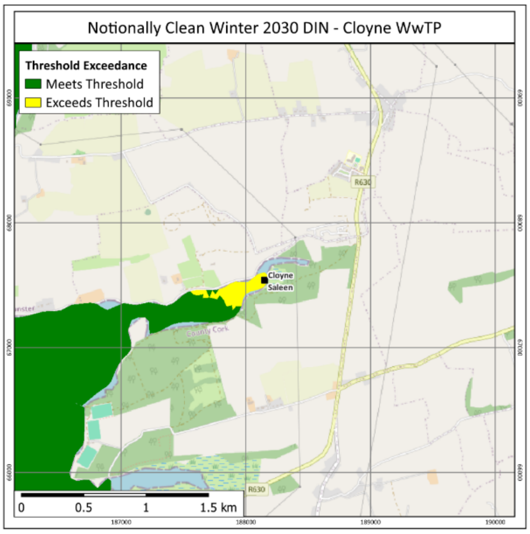


Figure A-27 Notionally Clean Winter Plots





A.5.3 MRP

Figure A-28 Base Summer Plots

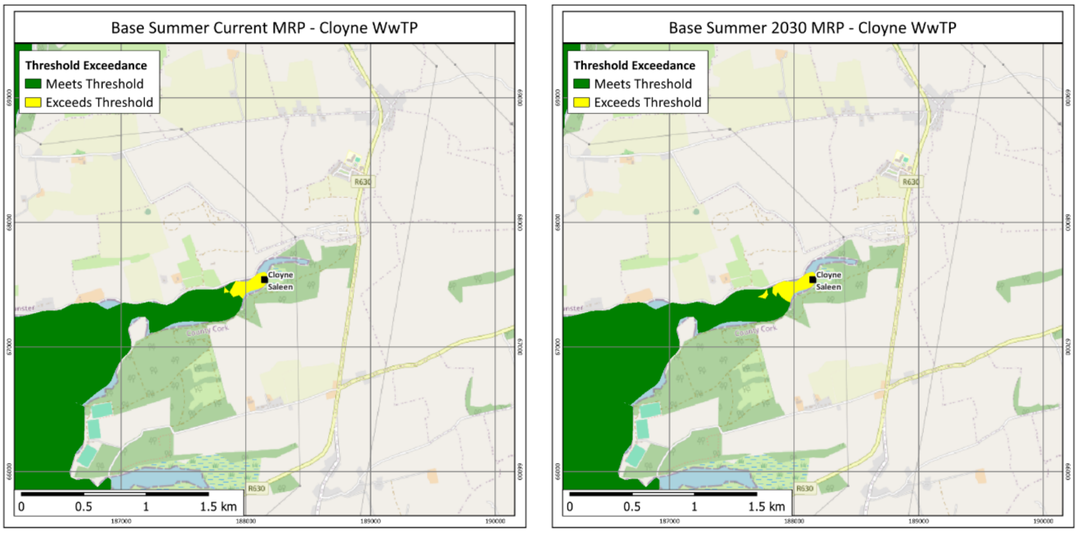


Figure A-29 Base Winter Plots

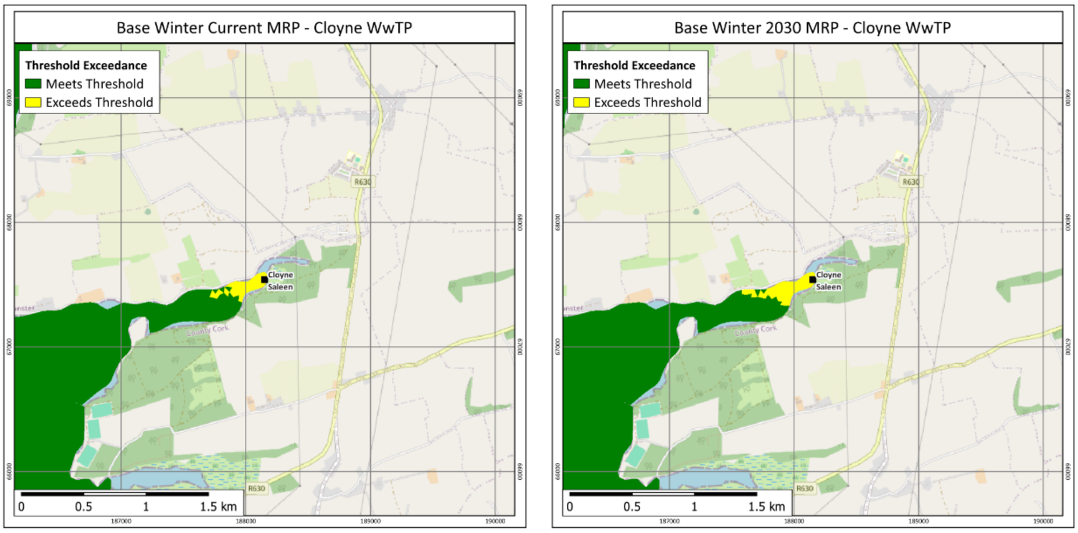


Figure A-30 Notionally Clean Summer Plots

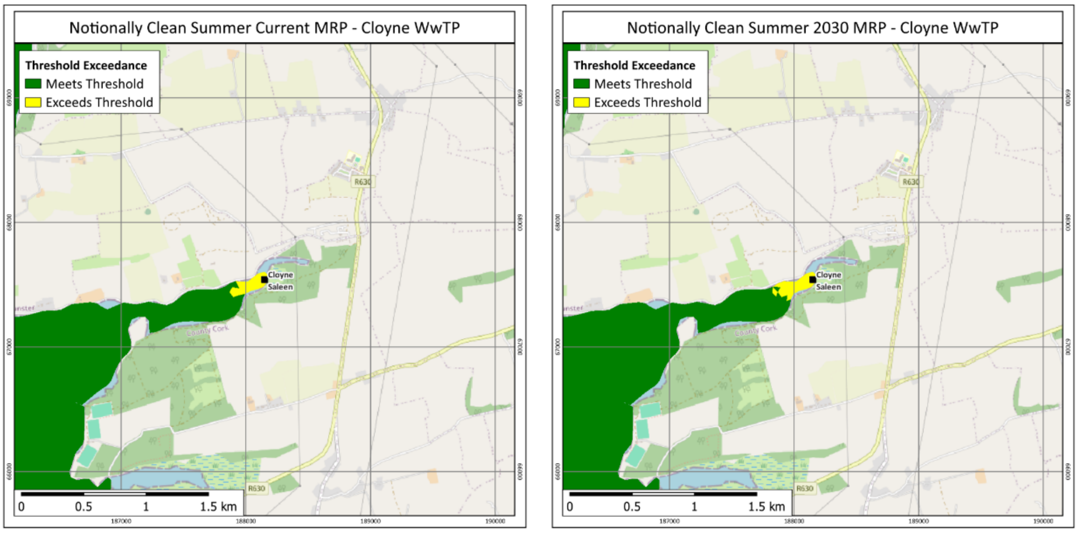
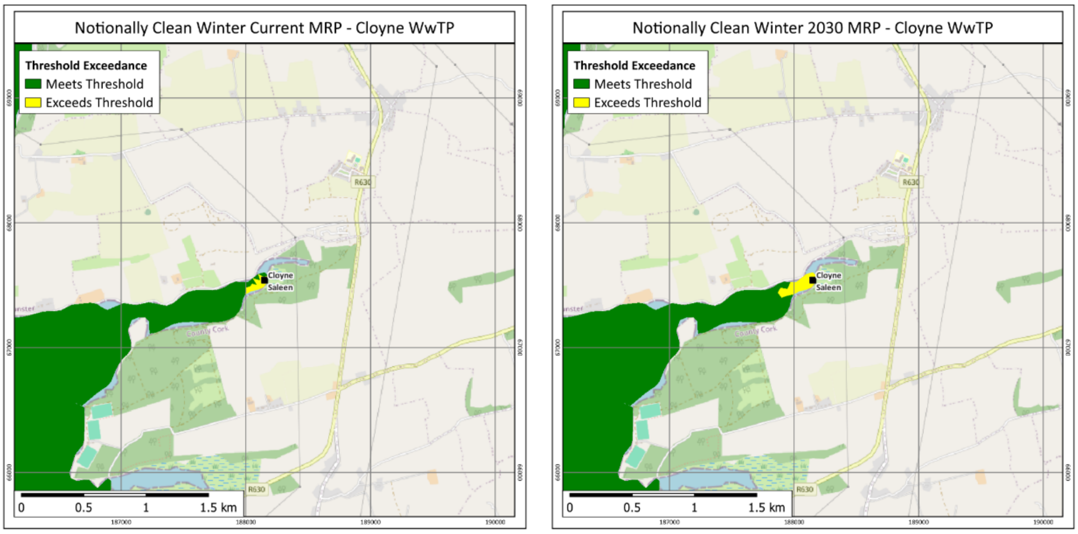


Figure A-31 Notionally Clean Winter Plots



A.6 WHITEGATE AGHADA WWTP

A.6.1 DIN

Figure A-32 Base Summer Plots

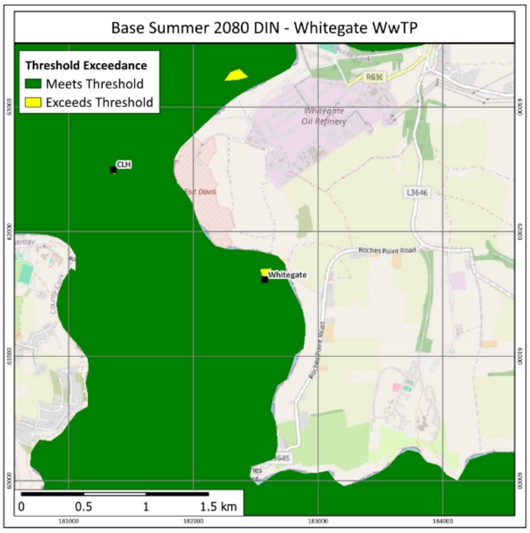
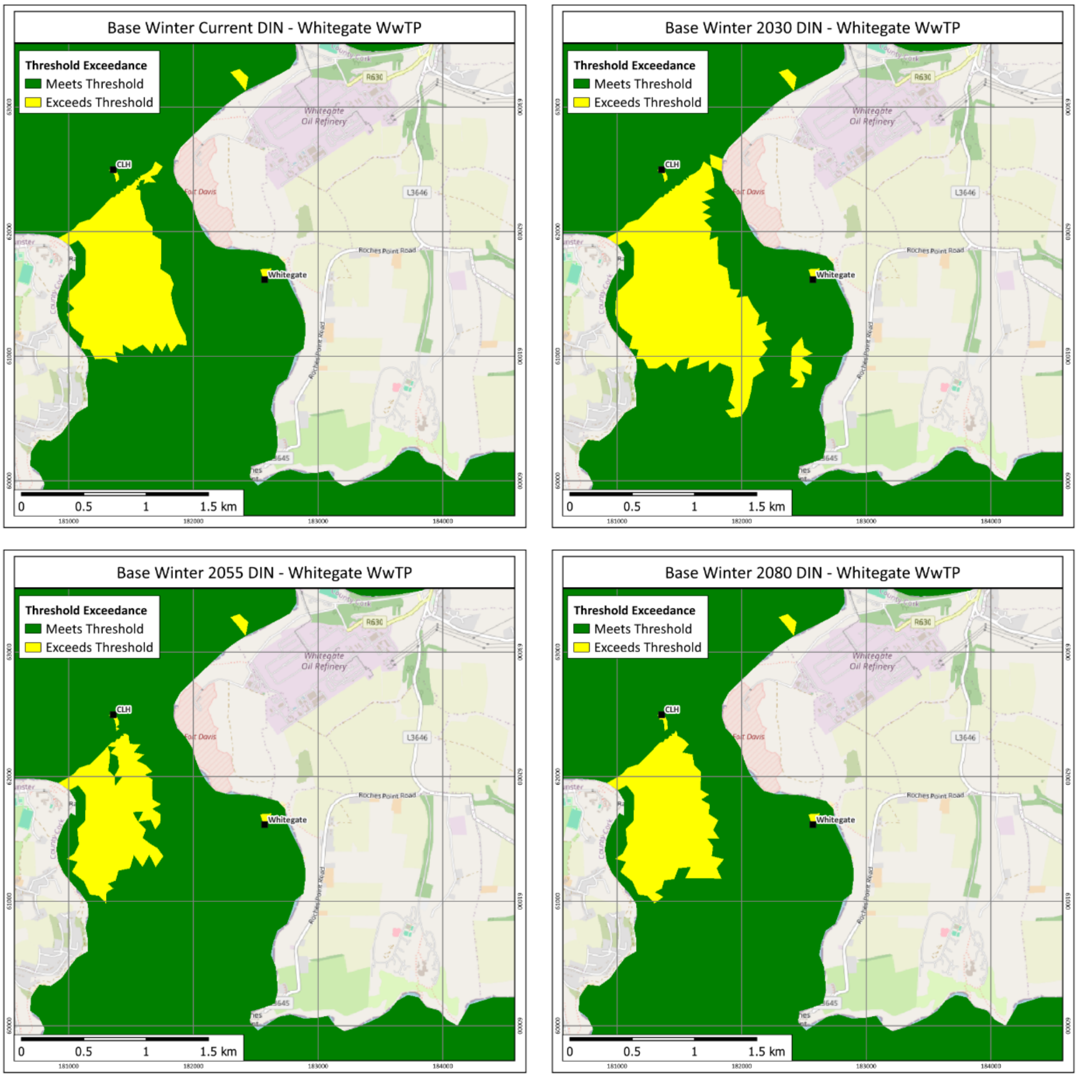


Figure A-33 Base Winter Plots



See footnote for Figure A-21 for further information about the yellow area.