Greater Dublin Drainage Project Addendum

Environmental Impact Assessment Report Addendum:
Volume 3A Part B of 6

Appendix A8.1 - Responses to Marine Water Quality Questions at the 2019 Oral Hearing

Uisce Éireann

October 2023

An Bord Pleanála Oral Hearing

Irish Water

Greater Dublin Drainage

Response to Inspector's Questions

Marine Water Quality – Alan Berry

Water Quality Standards

Inspector's Query:

1 It would be useful for discussions next week to have a document which set out various terminology and standards for water quality in particular. Possibility of confusion between 'high', and 'excellent' standards and it would be helpful to put the project in context with what it proposes to achieve.

Response:

2 The response below has been extracted from the text of Chapter 8 Marine Water Quality in Volume 3 Part A of the EIAR, specifically Section 8.1.2 Water Framework Directive and Section 8.1.6 Bathing Waters Directive.

3 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive (WFD)) commits member states to preventing deterioration and achieving at least "Good" status in all of their rivers, lakes, transitional, coastal and groundwaters by the year 2015.

4 The European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2015 (S.I. No. 386 of 2015) came into effect in 2015 and apply to all surface waters and give effect to the measures needed to achieve the environmental objectives established for surface waterbodies by the Water Framework Directive. The water quality standards proposed for the general physico-chemical conditions supporting the biological elements in transitional and coastal waters are listed in Table 8.1 of the EIAR.

Table 8.1: Environmental Quality Objectives from Environmental Objectives (Surface Waters) (Amendment) Regulations 2015 (S.I. No. 386 of 2015)

Parameter	Transitional	Coastal
Biochemical Oxygen Demand (BOD) (mg/l O_2)	n/a	Good status ≤ 4.0 (95th percentile)
Dissolved Inorganic Nitrogen (DIN) (mg/l N)		
0 psu[1]	Good status ≤ 2.60	Good status ≤ 2.60
34.5 psu	Good status ≤ 0.25	Good status ≤ 0.25
34.5 psu	High status ≤ 0.17	High status ≤ 0.17
Molybdate Reactive Phosphorus (MRP) (mg/l P)		n/a
0–17 psu	≤ 0.06	
35 psu	≤ 0.04	
psu: The practical salinity unit defines salinity in terms of a conductivity ratio of a sample to that of a solution of 32.4336g of Potassium Chloride (KCl) at 15ºC in 1kg of solution. A sample of seawater at 15°C with a conductivity equal to this KCl solution has a salinity of exactly 35 psu.		

5 Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality came into force on 24 March 2006 and repealed the 1976 Quality of Bathing Waters Directive with effect from 31 December 2014.

6 The Bathing Water Quality Regulations 2008 (S.I. No. 79 of 2008), as amended, transposed the Bathing Water Directive into Irish Law on 24 March 2008. It established a new classification system for bathing water quality based on four classifications: 'Poor', 'Sufficient', 'Good' and 'Excellent'. The classification criteria are detailed in Table 8.2 of the EIAR.

Table 8.2: Bathing Water Quality Regulations 2008 (S.I. No. 79 of 2008)

Parameter	Excellent	Good	Sufficient
Escherichia coliform (colony forming units (cfu)/100ml)	250[1]	500[1]	500[2]
Intestinal enterococci (cfu/100ml)	100[1]	200[1]	185[2]
1 By 95% or more samples 2 By 90% or more samples 'Poor' quality values are any values worse than the 'Sufficient' quality value.			

Diffuser Modelling

Inspector's Query:

7 Could Mr. Berry please address if he thinks there is significance of modelling for single port.

Response:

8 MarCon were commissioned by Jacobs in 2013 to undertake a mathematical modelling study of the coastal waters of north County Dublin to examine the relative merits of two marine outfall locations with respect to the mixing capacity of the receiving water body, pursuant to the Proposed Project.

9 The modelling study was undertaken to determine the dilution and dispersion characteristics from two outfall locations, in order to progress detailed modelling work. This preliminary modelling study was based on the information available in 2013.

10 The CORMIX model used for this study was intended as a first-order, screening/design model. It does not carry out detailed hydrodynamic calculations using the exact geometry of the discharge location, nor does it explicitly handle dynamic ambient currents (i.e., tides). It uses a simplified representation of the physical conditions at the discharge location to approximate the fundamental behaviour of the plume.

11 As detailed designs have not been undertaken for the diffuser at this planning stage of the GDD project, it was not possible to provide accurate diffuser configuration specifics to the CORMIX model.

12 Therefore, the modelling study considered the multiport diffuser as a virtual, single port of similar discharge characteristics in order to ascertain dilution characteristics in the receiving waters at distance from the outfall and hence the mixing extents. The virtual single port represented a 'worst-case scenario', as initial dilution for the multiport will be greater than that for the virtual, single port.

13 The modelling study was used to determine the relative merits between two locations off the coast of north County Dublin for a proposed new treated effluent outfall. The metrics used to determine the relative merit of each outfall location were the initial mixing lengths and dilution characteristics.

14 A full water quality dispersion modelling study was subsequently undertaken in the next phase of the Proposed Project to quantify the magnitude of impacts on the various sensitive receptors for a range of determinands of concern, as part of the GDD EIAR.

15 In summary, there is no significance in only modelling a single port diffuser as the purpose of the near-field modelling study was to assess the relative merits (not the magnitude of impacts) of two marine outfall locations with respect to the mixing capacity of the receiving water body.

Model Calibration Accuracy

Inspector's Query:

16 Could Mr. Berry address the issue of errors in modelling and what is meant by 'excellent' and 'good.'

Response:

Model Calibration Standards

17 The response below has been extracted from the text of Chapter 8 Marine Water Quality in Volume 3 Part A of the EIAR, specifically Section 8.2.3 Hydrodynamic Calibration.

18 The appropriateness of Model predictions to field data can be assessed in two ways:

- Visual comparison of the model output against observed data: the shape, trend, range and limits of model output and observed data; and
- Statistical comparison of the difference between observation and the model in order to determine the frequency with which the model fits observation within defined limits.

19 In practise, both methods should be used, as no single method provides a full assessment of model performance. In the case of the present calibration; current magnitudes and water levels were assessed both visually and statistically, while current directions were assessed only visually. This is because they are derived from vector quantities (making useful statistical analysis difficult) and because the visual assessment is very clear.

20 In the absence of a widely adopted industry standard for a definition on calibration requirements, the numerical model was considered against a set of performance metrics, defined in a Guidance Note developed by ABPmer[1], based on a variety of statistical measures.

21 It is important to note that statistical measures comprise only a part of the 'fit-for-purpose' assessment of model performance, with further discussion required to provide a more detailed understanding of the suitability of the model. In addition to the performance metrics, experience has shown that visual checks are an important part of the model calibration and validation process. Visual checks can identify patterns between the measured and modelled time-series that may not be as obvious from the performance metrics.

22 Under certain conditions, models can meet statistical calibration standards but appear to perform poorly in a visual comparison. Conversely, seemingly accurate models judged visually can fall outside of statistical standards.

23 The performance metrics in the ABPmer Guidance Note are presented below and provide a comparative measure for both temporal and peak features of the calibration data, thus providing an initial fit-for-purpose assessment of the numerical model, which is further substantiated by visual checks. Results are presented as a range of magnitude difference, percentage difference and root mean square (RMS) values.

24 The following performance metrics are offered by ABPmer:

- Water levels: mean level differences should be within ±0.2m while the percentage differences should be within 15% of spring tidal ranges and 20% of neap tidal ranges. Water level phasing at high and low water should be within ±20 minutes, while RMS scores should be less than 0.2

[1] *Numerical Model Calibration and Validation Guidance. ABP Marine Environmental Research Ltd. File Note R/1400/112.*

- Flows: modelled speeds should be within ±0.2 m/s or ±10 -20% of equivalent peak observed speeds, while model directions should be within ±20o of observed directions, and phasing within ±20 minutes. RMS scores should be less than 0.2, while scatter index scores should be less than 0.5.

25 In addition to the statistical analysis of the numerical model as described above, a further assessment of the model performance throughout the calibration period has been carried out. For this assessment, a further set of tolerances has been applied to the results from the hydrodynamic model and an analysis of the frequency (throughout calibration period) that the tolerances are met has been undertaken.

26 The tolerances applied to this stage of the calibration are taken from the Foundation for Water Research (FWR) guidelines[2] for coastal models and are described as follows:

- Water levels: an absolute tolerance of ±0.1m or a relative tolerance of ±10% of the measured spring tidal range

- Current speed: an absolute tolerance of ±0.1m/s or a relative tolerance of ±10% of the peak measured current speed

- Current direction: an absolute tolerance of ±30o

- Phasing: an absolute tolerance of ±15 minutes.

27 In an attempt to further describe the relative levels of calibration between sites, a qualitative scale of fit has been applied, based on the FWR guidelines and described as follows:

'Excellent Fit'	-	Calibration tolerances are achieved >90% of the time
'Very Good Fit'	-	Calibration tolerances are achieved >80% of the time
'Good Fit'	-	Calibration tolerances are achieved >70% of the time
'Reasonable Fit'	-	Calibration tolerances are achieved >60% of the time
'Poor Fit'	-	Calibration tolerances are achieved <60% of the time

28 In addition to allowing comparison of the relative level of calibration between sites to be made, this qualitative scale also assists in making a comparison between the visual 'fit' of the data (as provided, for example, by a time-series plot of modelled versus measured data) and the statistical assessment of model performance.

29 The above qualitative scale of fit defines the terms "Excellent" and "Good" as requested by the Inspector.

Issues of errors in model.

30 The response below has been extracted from the text of Chapter 8 Marine Water Quality in Volume 3 Part A of the EIAR, specifically Section 8.2.3 Hydrodynamic Calibration.

31 The model was calibrated for a 30-day period from the 18th July 2012 to the 17th August 2012, a period which included representative neap and spring tides.

32 Modelled tidal levels were compared against measured data at both the Skerries and Howth tide gauge locations in order to provide a quantitative assessment of inaccuracies in tidal characterisation.

[2] *A Framework for Marine and Estuarine Model Specification in the UK. Foundation for Water Research, March 1993.*

33 Modelled current speeds and directions were compared against measured data at the ADCP locations A, B and C in order to provide a quantitative assessment of inaccuracies in tidal characterisation.

34 In order to quantify model calibration, a series of quantitative statistics have been calculated to compare water levels, current speeds and directions. The statistical assessment includes the derivation of the metrics listed above. The results are presented in Table 8.4 and Table 8.5 of the EIAR with PASS and FAIL of the above metrics highlighted where applicable.

Location	Water Level Bias (m)	Water Level Bias (% measured spring range)	Water Level RMS
Skerries	0.11	3.2	0.19
Howth	0.02	0.67	0.15
* Positive values denote model is over-predicting; negative values denote under-prediction			

Table 8.4: Calibration of Modelled Current Speeds Against Tide Gauge Data

Location	Flow Speed Bias (m/s)	Flow Speed Bias (% Max Speed)	Flow Speed RMS	Scatter Index
ADCP A	-0.05	-4.71	0.13	0.36
ADCP B	0.04	5.19	0.10	0.28
ADCP C	0.02	1.86	0.11	0.25

Table 8.5: Calibration of Modelled Current Speeds Against Acoustic Doppler Current Profilers Data

35 The results of an assessment of the proportion of calibration period where modelling tolerances are met is presented in Table 8.6 of the EIAR. The results include all locations at which instruments were deployed in order that a comparison of the model performance across the domain can be made.

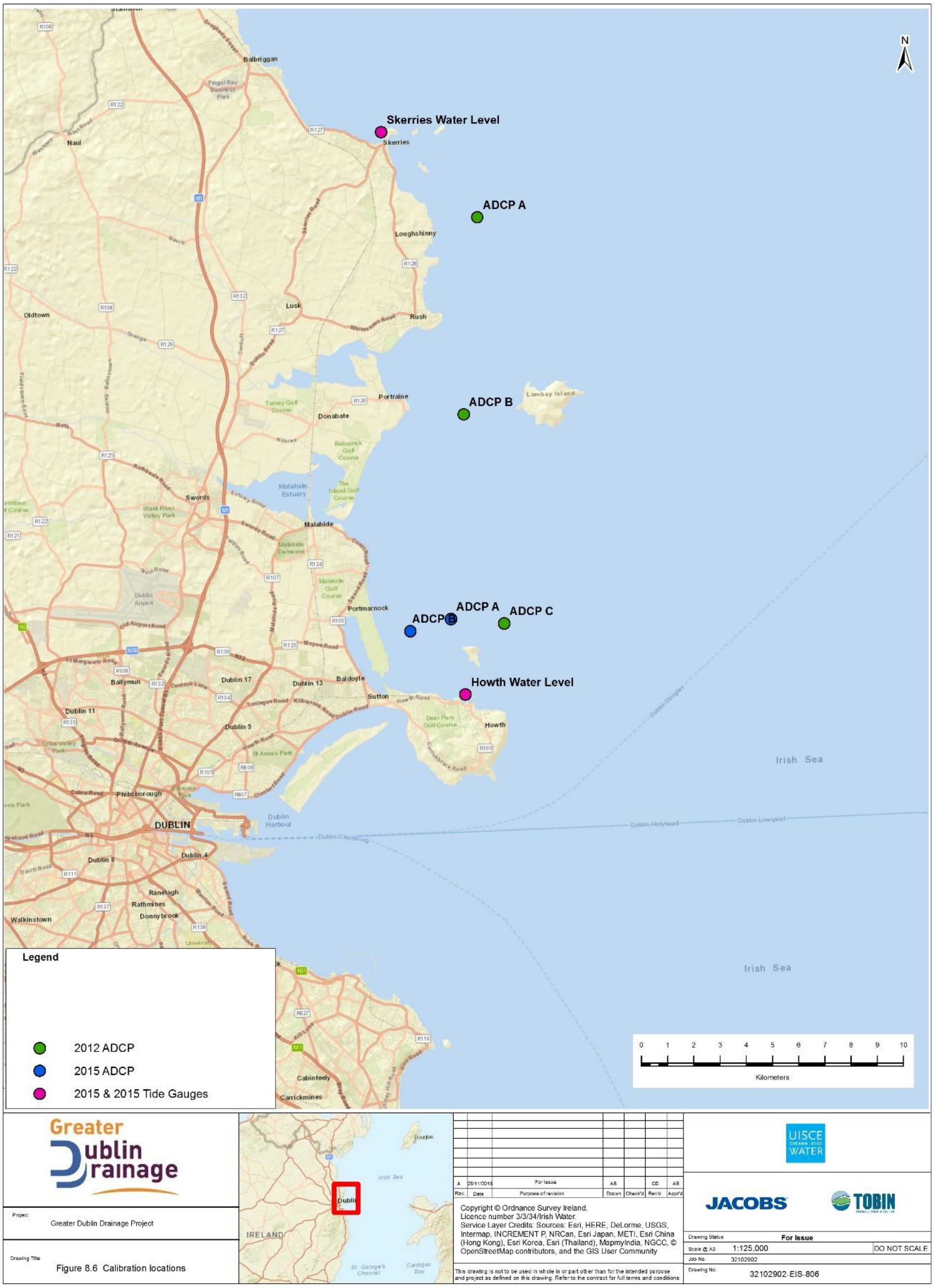
Location	% of Time Tolerances Are Met (%)		Qualitative Description
	Water Level	Current Speed	
Water Levels			
Skerries	92		Excellent
Howth	96		Excellent
Currents			
ADCP A		63	Reasonable
ADCP B		63	Reasonable
ADCP C		75	Good

Table 8.6: Qualitative Summary of Hydrodynamic Model Fit Against Calibration Data.

36 In general, the comparison of the modelled and measured datasets, both statistically and visually, demonstrates a robust calibration agreement. Overall, Table 8.6 shows that the model is providing an 'excellent' representation of water levels and, generally, between a 'good' and 'reasonable representation of current speeds and directions at the ADCP locations.

37 It is noted that the calibration of the model was 'good' at ADCP C location (the location of the proposed GDD marine outfall).

38 The summary of results presented above show that the numerical model has been successfully calibrated and validated against field measurements, to provide a sufficiently accurate representation of the hydrodynamics within the study region.



EIAR Figure 8.6: Calibration locations

An Bord Pleanála Oral Hearing

Irish Water

Greater Dublin Drainage

General Response to Water Quality Model

Marine Water Quality – Alan Berry

1. Addressing issues of the water quality modelling as being 'only' a desk study I would like to make reference to two of MarCon's contextually significant previous water quality and shellfish assessment projects.

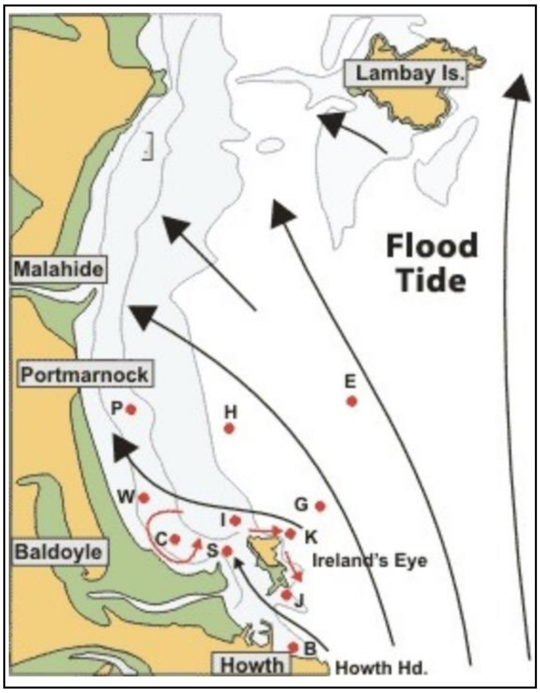
2. From 2005 to 2015 MarCon were engaged by the United Kingdom Environment Agency to develop and maintain a suite of water quality models for the Environment Agency for the purposes of meeting their obligations under the Habitats and Bathing Waters Directives. Our models were used by the Environment Agency to independently assess all applications for Waste Water and IPPC discharge licences in Morecambe Bay (significant commercial shellfisheries), Ribble Estuary (significant bathing waters including Blackpool and St. Annes beaches), Mersey Estuary, Severn Estuary and the Bristol Channel.

3. In addition, from 2007 to 2009, MarCon were commissioned by Bord Iascaigh Mhara to develop water quality and shellfish management models of mussel and oyster production areas in selected regions around the Irish coast. This modelling was published by the United Nations Food and Agriculture Organisation (UNFAO) as a case study highlighting best practice in shellfishery management practices.

Specific response to Cllr Healy and others on water quality model

4. Returning to the present Proposed Project, with respect to the circulation patterns around Ireland's Eye as predicted by the model. Shown in the following figures is the model's representation of the flood and ebb tides compared directly with the maps from Howth Yacht Club. This material has previously been presented in the Response to An Bord Pleanala of Jan 2019.

5. The results from the calibrated and validated hydrodynamic computer model shows a high level of agreement with the maps produced by Howth Yacht Club. The computer model is a dynamic model, calculating changes in water surface level, tidal currents, water quality concentrations on a second by second basis as the dynamics of the system change. Although the maps from Howth Yacht Club indicate effluent will be washed ashore to Portmarnock and Baldoyle on flooding tides, the maps do not account for the dispersion or dilution of effluent, nor the ever changing direction and the strength of the tidal currents over the course of a tidal cycle.



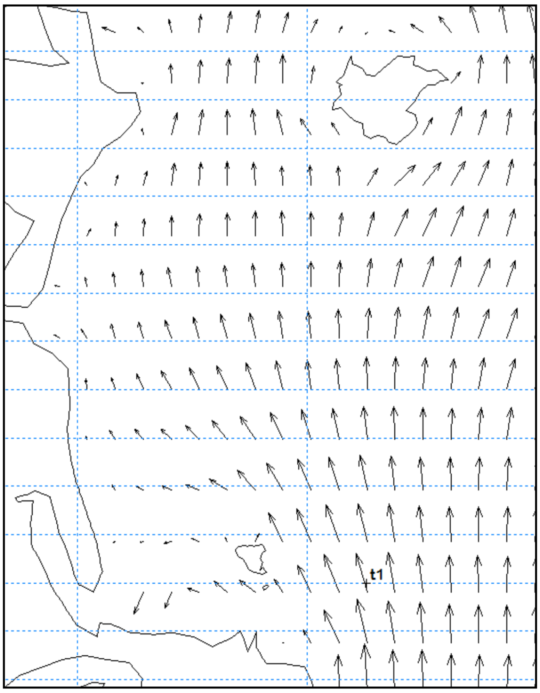


Fig 1(a): Howth Yacht Club: Flood Tide **Fig 1(b): GDD model: Flood Tide**

6. Comparing Fig 1(a) with Fig 1(b) (from the Response to An Bord Pleanala of Jan 2019) for flood tide circulation patterns between Howth and Lambay Island it can be seen that; (i) both maps show the flooding tide to the north and east of Ireland's Eye stronger than the flooding tide between Ireland's Eye and the Baldoyle Estuary as well as showing the same direction for the tidal currents; (ii) to the north of Ireland's Eye both maps show the flooding tide on a northwesterly heading with a notable westerly component towards Portmarnock; (iii) both maps show the flooding tide diverging to the east and west around Lambay Island;

7. Comparing Fig 2(a) with Fig 2(b) for ebb tide circulation patterns between Howth and Lambay Island it can be seen that; (i) both maps show the ebbing tide between Ireland's Eye and Lambay Island on a south-southeasterly heading, with the 'offshore' ebbing tide to the east of Lambay Island on a southerly heading; (ii) both maps show the nearshore ebbing tide on a south-southeasterly heading meeting then turning due east off Baldoyle Estuary.

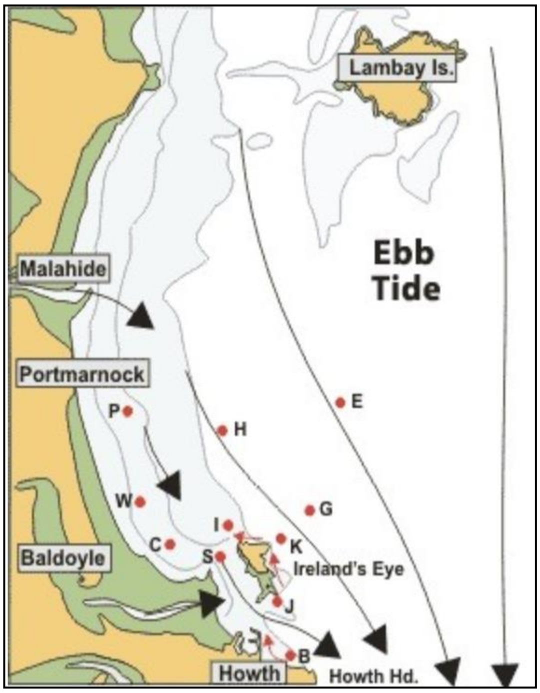


Fig 2(a): Howth Yacht Club: Ebb Tide

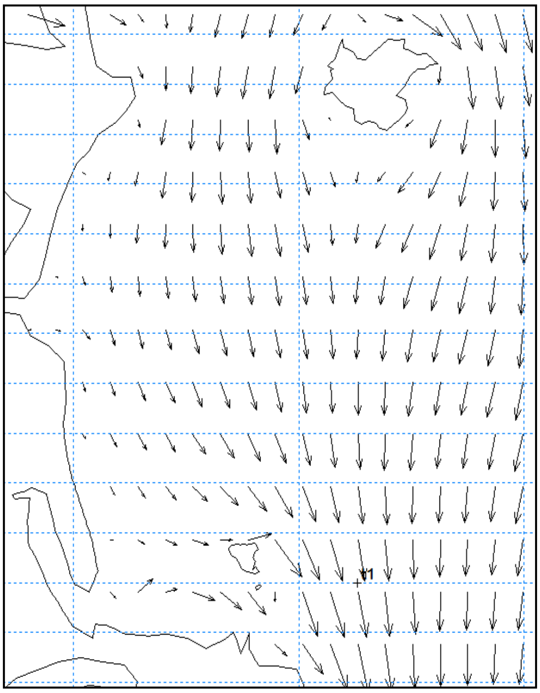


Fig 2(b): GDD model: Ebb Tide

8. At higher resolution, comparing Fig 3(a) with Fig 3(b) (from the Response to An Bord Pleanala of Jan 2019) for flood tide circulation patterns around Ireland's Eye it can be seen that; (i) both maps show the flooding tide between Ireland's Eye and Howth on a northwesterly heading, with a much weaker tidal current immediately to the east of Howth Harbour; (ii) both maps show the magnitude of the flooding current to the east and west of Ireland's Eye to be almost equal; (iii) both maps show an anti-clockwise re-circulation / gyre structure to the west of Ireland's Eye and to the north of Baldoyle Estuary; (iv) both maps show an anti-clockwise re-circulation / gyre structure immediately north of Ireland's Eye at a much lesser magnitude than that of the predominant northwesterly flooding tide.

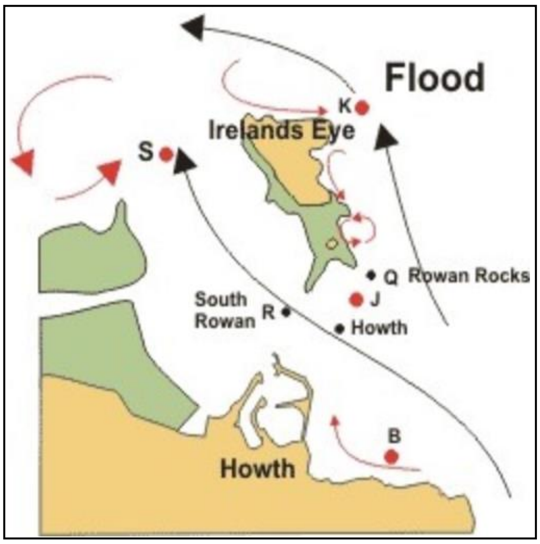


Fig 3(a): Howth Yacht Club: Flood Tide

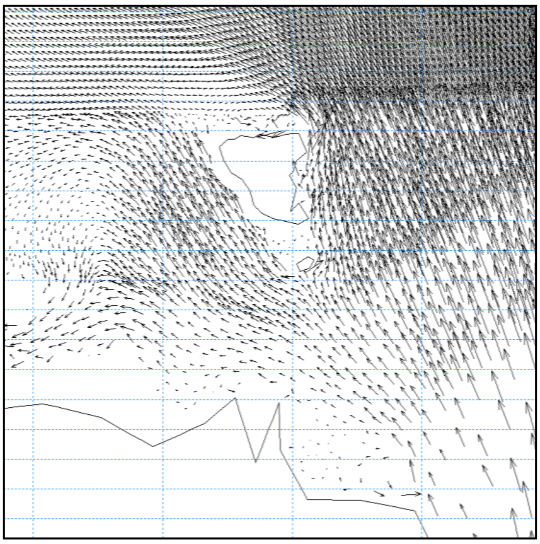
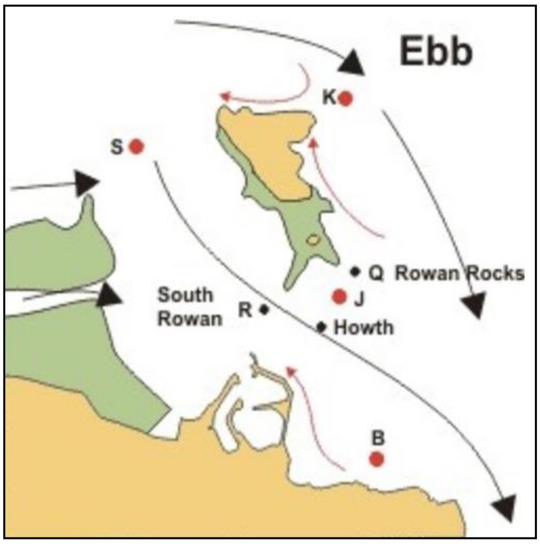


Fig 3(b): GDD model: Flood Tide

9. Comparing Fig 4(a) with Fig 4(b) for ebb tide circulation patterns around Ireland's Eye it can be seen that; (i) both maps show the ebbing tide between Ireland's Eye and Howth on a southeasterly heading, with a counter current immediately to the east of Howth Harbour heading in a northerly direction; (ii) both maps show the magnitude of the ebbing current to the north, east and west of Ireland's Eye to be almost equal; (iii) both maps show a weak counter current immediately to the east of Ireland's Eye; (iv) both maps show a weak clockwise re-circulation / gyre structure immediately north of Ireland's Eye.



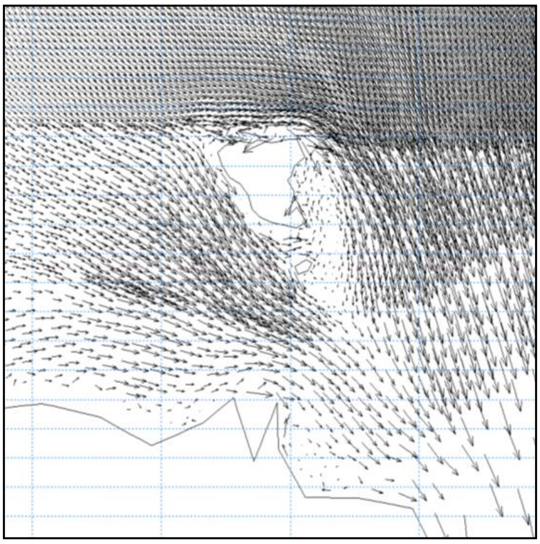


Fig 4(a): Howth Yacht Club: Ebb Tide **Fig 4(b): GDD model: Ebb Tide**

10. Moving on to the accuracy of the model in representing observed dispersion patterns in the region around Ireland's Eye; the solute transport (advection) model was calibrated against 2015 dye release surveys from locations around the area of interest, with 4 releases taking place on a spring tide and again on a neap (20th April 2015 and 9th June 2015 respectively. I submit a number of diagrams as presented in Appendix 8.1 of the EIAR.

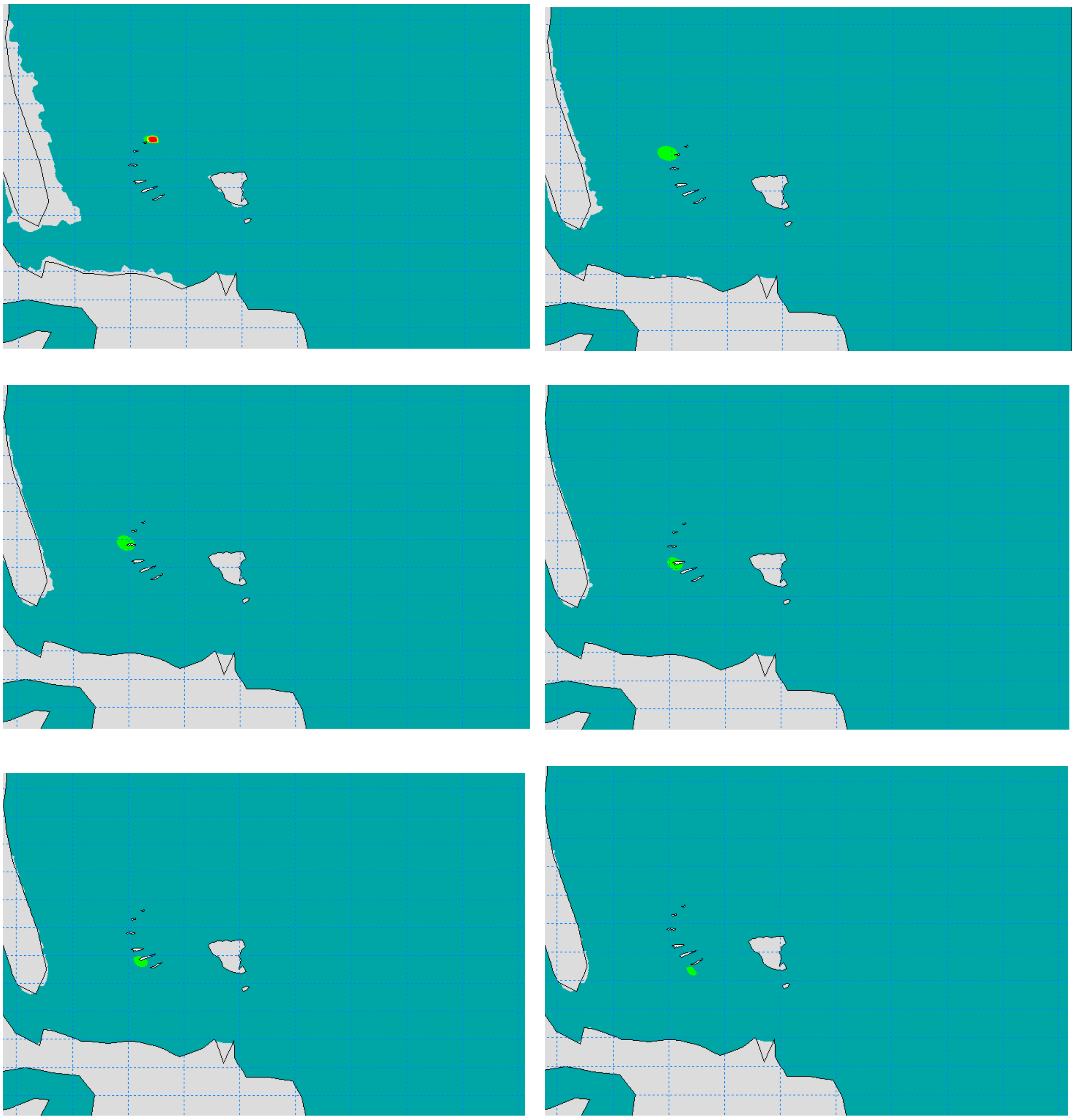


Figure A1.15 – Dye Release, Spring 1

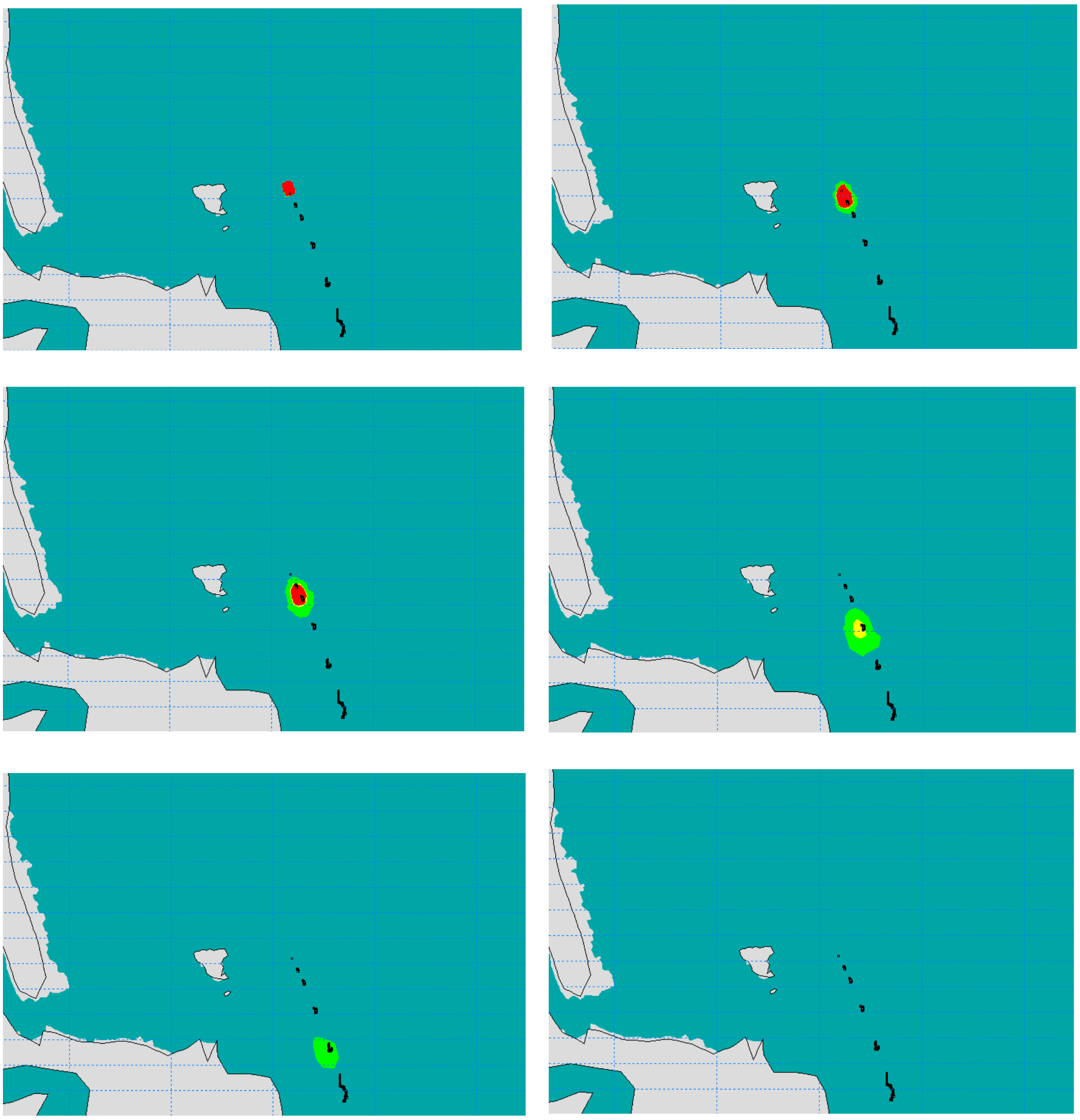
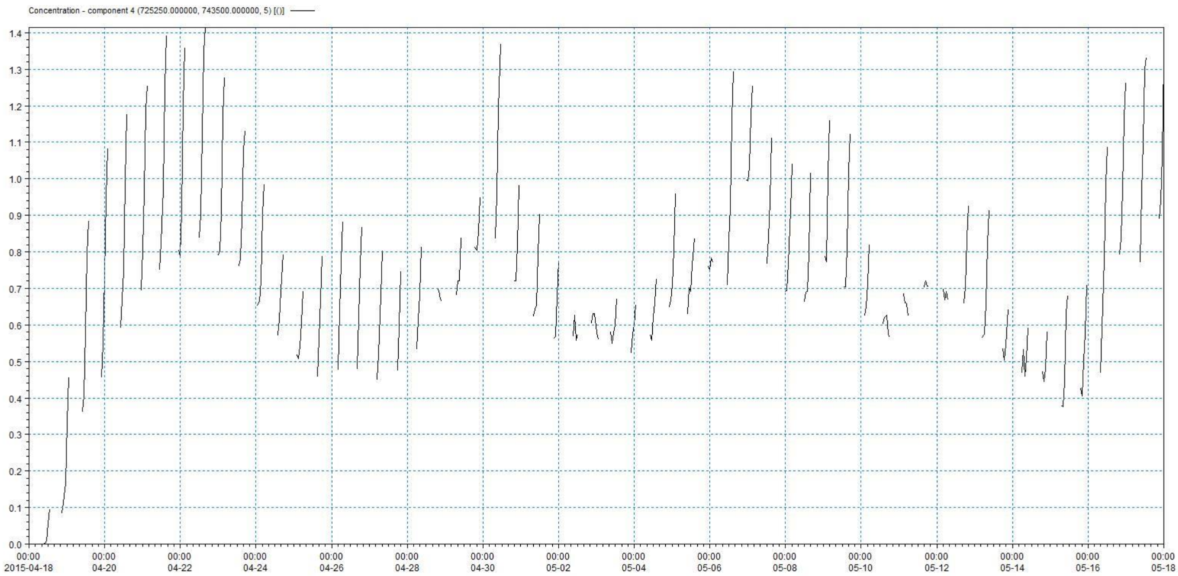


Figure A1.16 – Dye Release, Spring 2

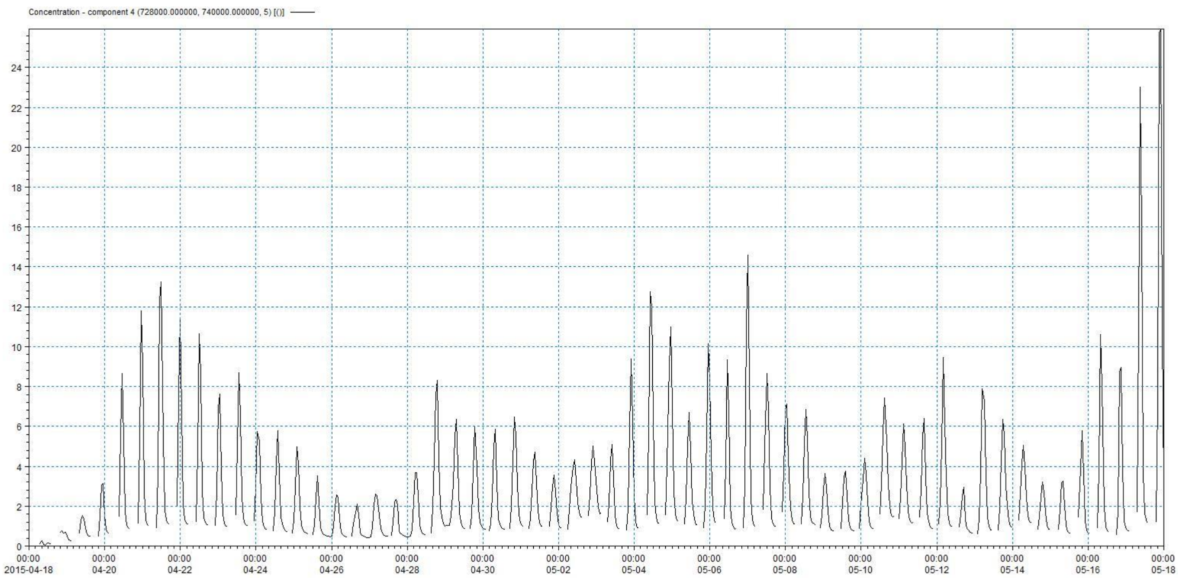
Figure A1.21 – Dye Release, Neap 3

11. These diagrams show that the model is capable of representing dispersion plumes in the area of interest around Ireland's Eye, both to the west and east of the island. The information published in the EIAR and Appendices shows that the model accurately represented the advection and dispersion of solute plumes throughout the area of interest.

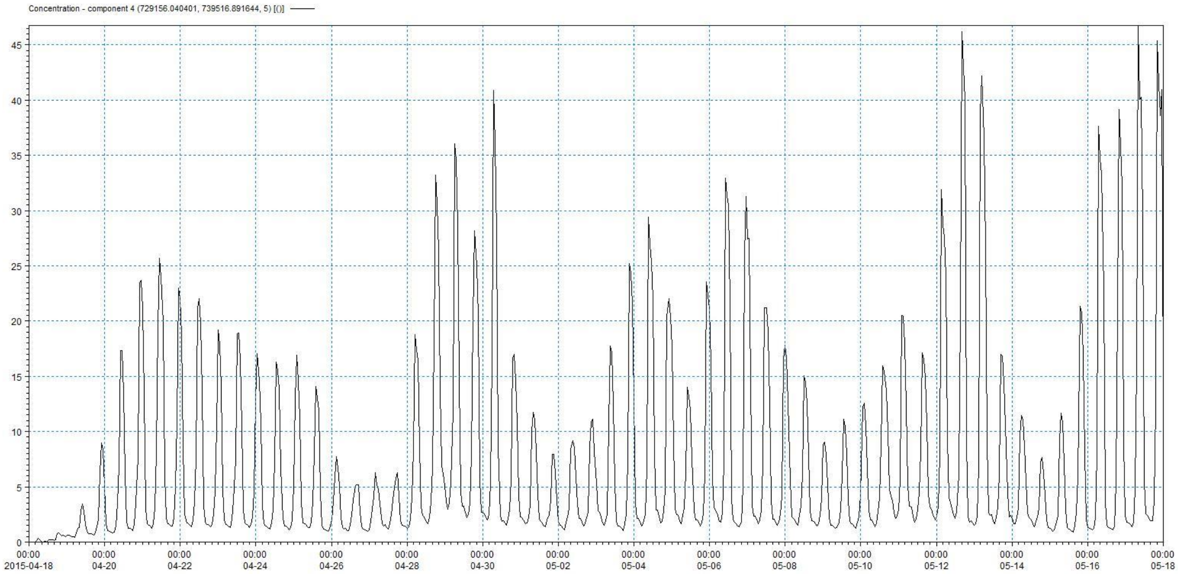
12. Specifically responding to Cllr Healy request that modelling results have been inadequately presented, I submit the following assessment at Velvet Strand, Claremont, Balscadden Beach and Irelands Eye (closest location to outfall) for the proposed discharge subject to UV treatment.



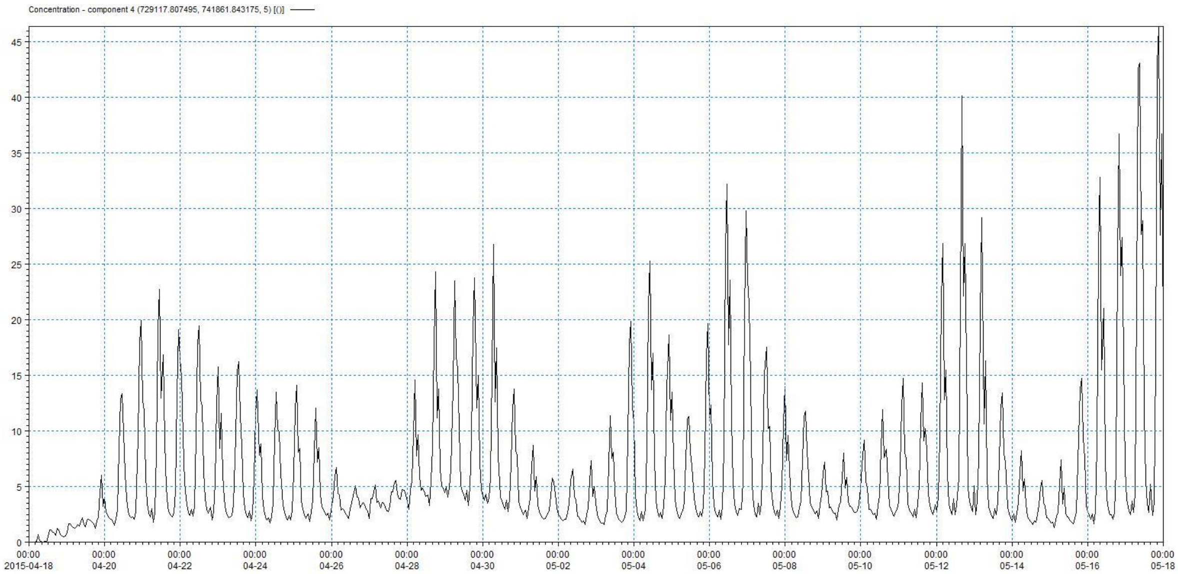
Velvet Strand



Claremont



Balscadden



Irelands Eye

13. With respect Inspector, all the information pertaining to the water quality modelling simulations, the accuracy of model predictions, the process to arrive at the most environmentally advantageous location for the proposed project's outfall, have been presented in the Proposed Project's ASA reports, the EIAR and associated Appendices which have been subject to various rounds of public consultation. The original assertion in the EIAR remain valid; the model as developed, calibrated and applied, represents the best available representation of the circulation patterns throughout the area of interest.

14. The modelling results presented in the EIAR have shown that the location for the Proposed project outfall will not impinge on the Excellent bathing waters status at any of the designated beaches. Out of an abundance of caution, the inclusion of UV treatment on the effluent will ensure the outfall will not impact the Class A designated shellfish waters.