Figure 33: Velocity vector and current speeds at high tide

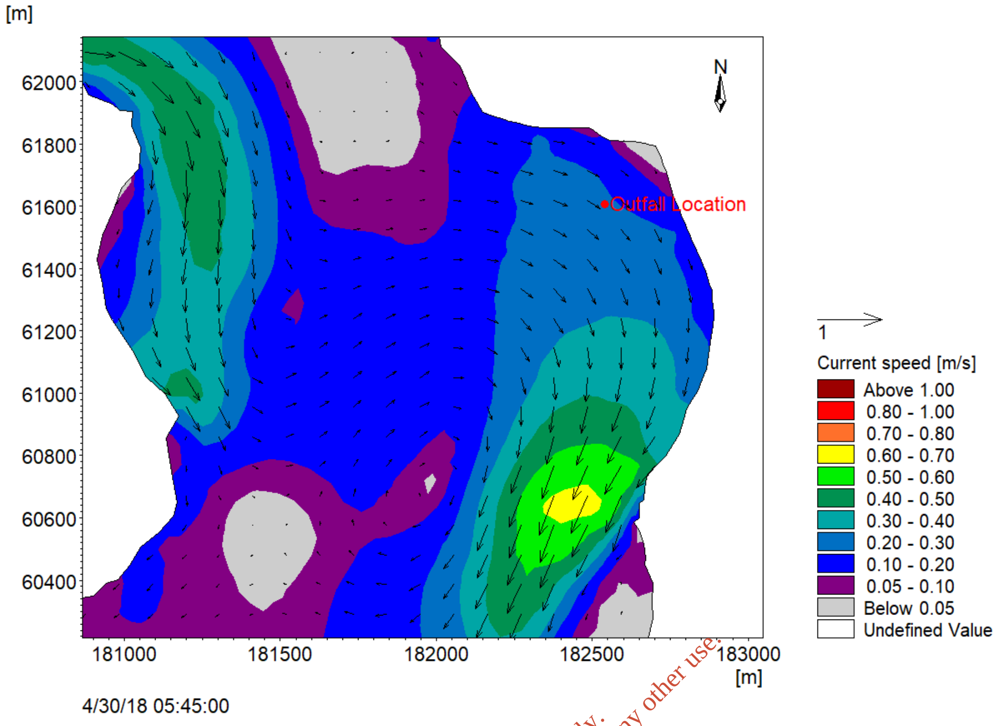
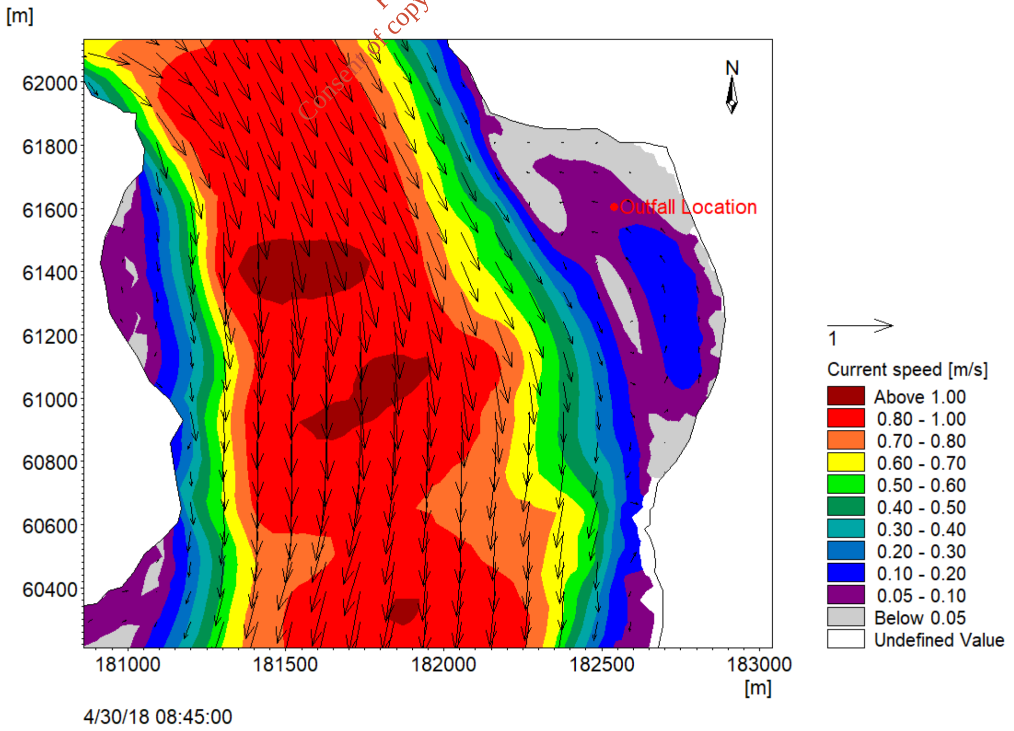


Figure 34 presents current speeds and velocities at mid ebb tide. As with flood tide conditions, a secondary circulation is leading to very different hydrodynamic conditions in Whitebay and in the main channel.

Figure 34: Velocity vector and current speeds at mid-ebb tide



5.5.2 Neap tide

Figure 35 presents the current speed and velocity vector plot for the moment in time from our neap tide validation in which the modelled data and recorded data diverge on the flood tide as described in Section 5.4.2 and presented in Figure 28.

It can be seen from the plot that the low simulated current speed at the monitoring point is due to the development of a secondary circulation in the northern section of Whitebay. As noted previously, a strong localised and temporal current at the surface was observed to occur at this location on the ebb tide. It is not possible for a depth integrated model to simulate such a phenomenon.

Figure 35: Velocity vector and current speeds – flood tide for neap conditions

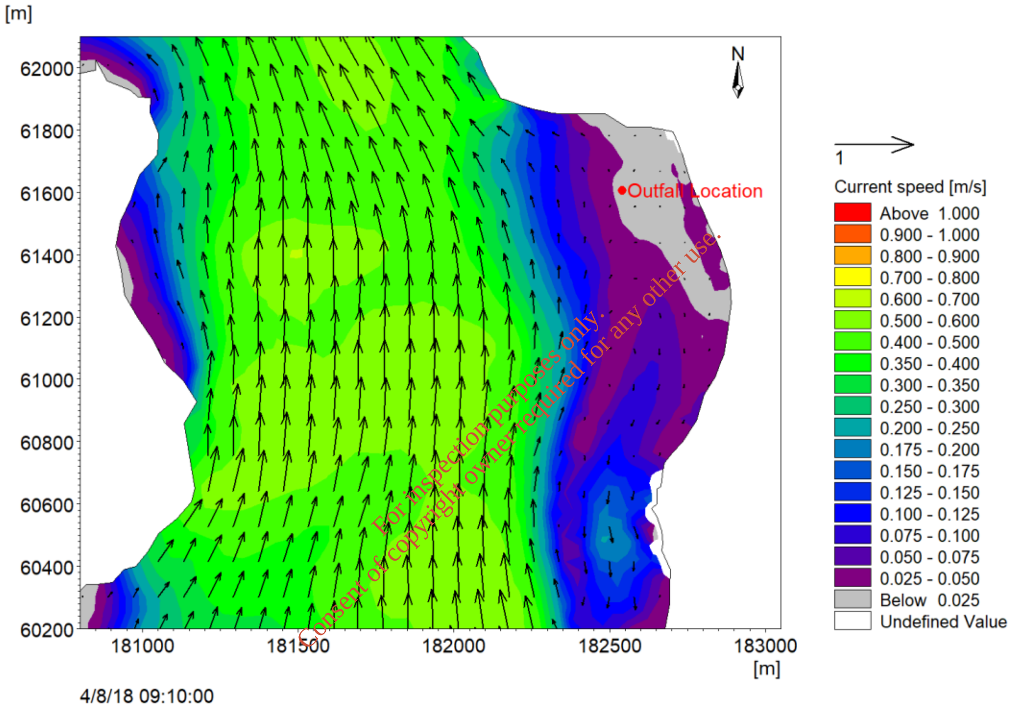
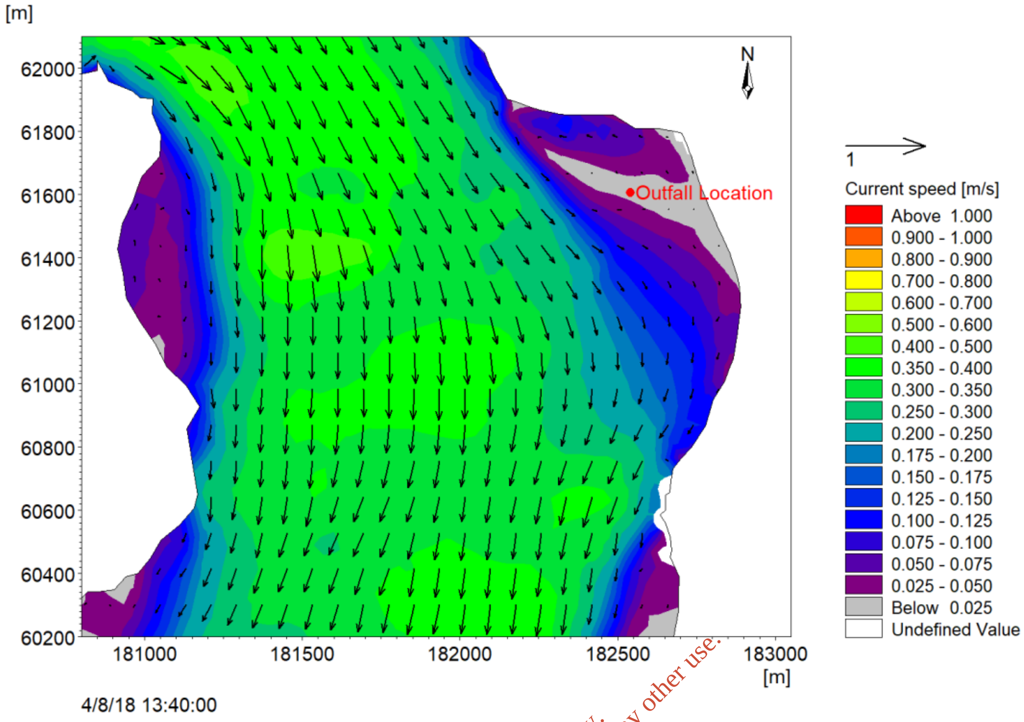


Figure 36 presents the current speed and velocity vector plots for the point on the ebb tide in which our modelled data and recorded data diverge as described in Section 5.4.2 and presented in Figure 28. As with the flood tide conditions presented in the previous section, a secondary circulation has formed in the area to the North of Whitebay and is leading to a drop in current speed at the location of interest.

Figure 36: Velocity vector and current speeds – ebb neap tide



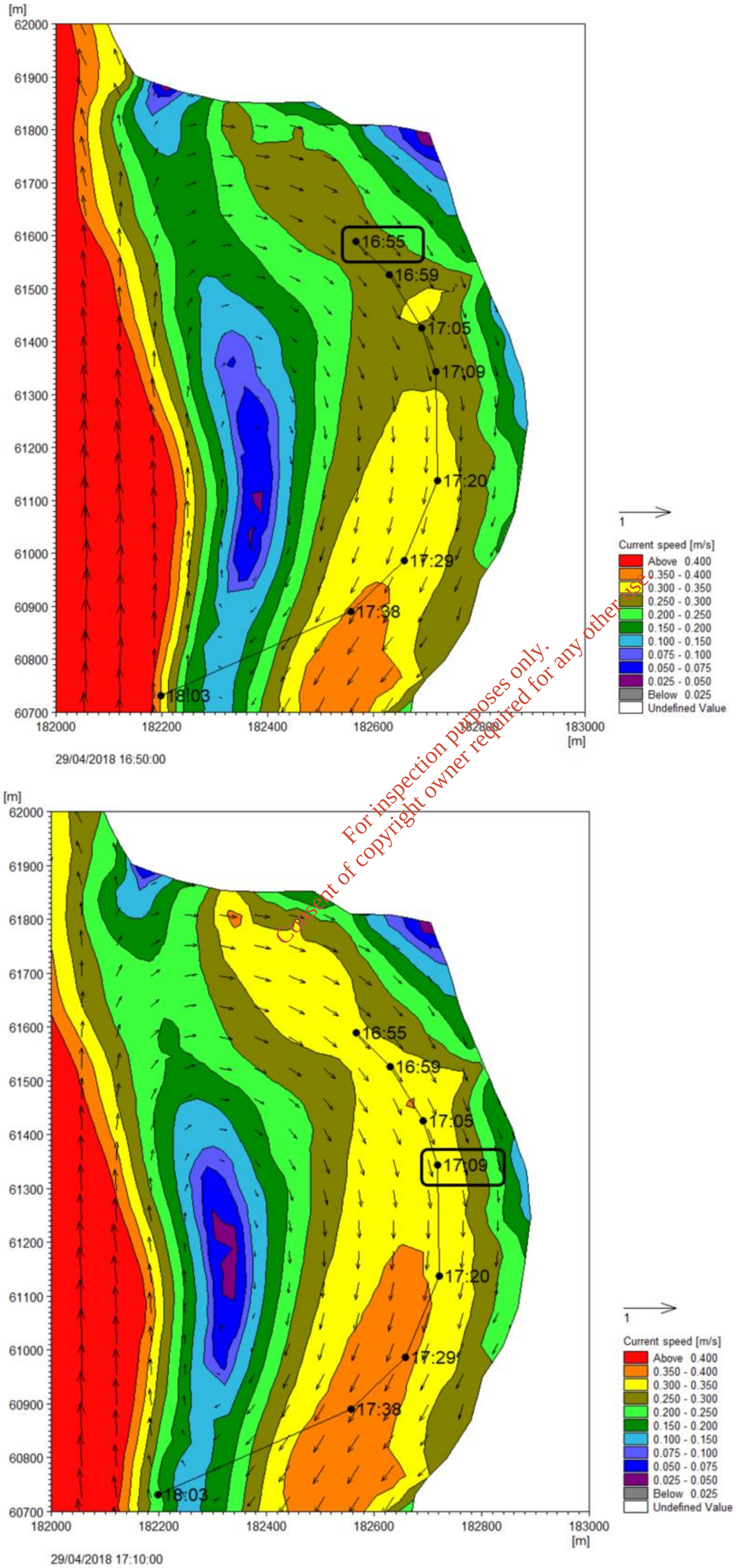
5.6 Drogue Data – Current Direction Validation

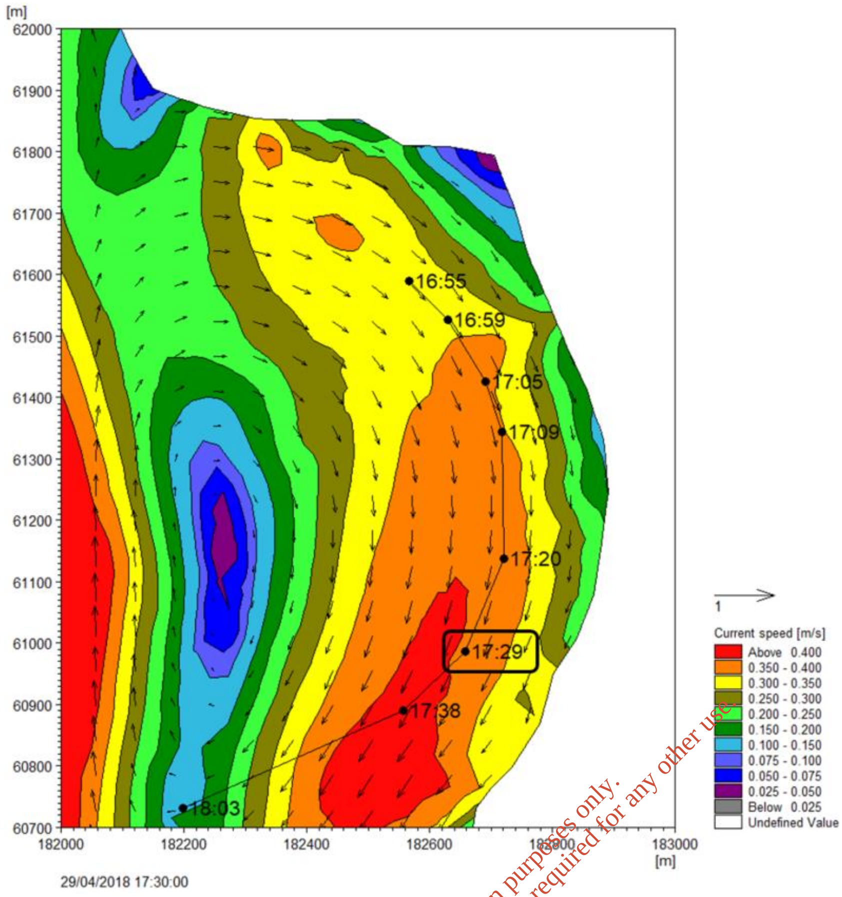
Drogue data was collected for a spring and neap tidal cycle as part of the marine survey and has been used to provide further validation of the modelled current direction.

As the area of interest is within the estuary and bounded by the geometry of the harbour (i.e. it is not in the open sea which would be very sensitive to wind and wave action) the drogue track data is deemed to be representative of the surface currents. It needs to be considered however that as the model simulates depth averaged currents and not the surface currents, comparing the model with the drogue data is not a direct like for like comparison.

Figure 37 presents the current speed and velocity vector plots for four stages of the ebb tide. The time and position of the drogue track throughout the duration of the ebb tide is superimposed in black. The drogue time/location highlighted in black corresponds to the same time at which the velocity vectors are taken from. It is evident from the plots that the modelled current direction is well matched to the directional track of the drogue throughout the ebb tide.

Figure 37: Spring ebb tide drogue validation




[m]
62000
61900
61800
61700
61600
61500
61400
61300
61200
61100
61000
60900
60800
60700
182000
182200
182400
182600
182800
183000
[m]
16:55
16:59
17:05
17:09
17:20
17:29
17:38
18:03
1
Current speed [m/s]
Above 0.400
0.350 - 0.400
0.300 - 0.350
0.250 - 0.300
0.200 - 0.250
0.150 - 0.200
0.100 - 0.150
0.075 - 0.100
0.050 - 0.075
0.025 - 0.050
Below 0.025
Undefined Value
29/04/2018 17:30:00

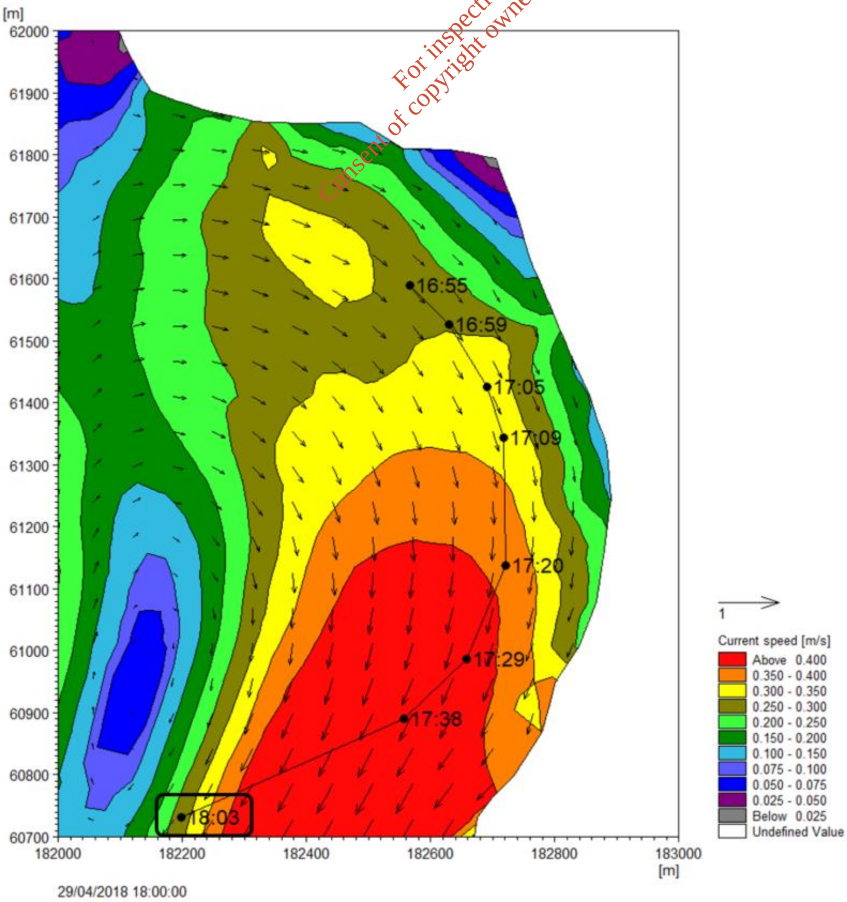
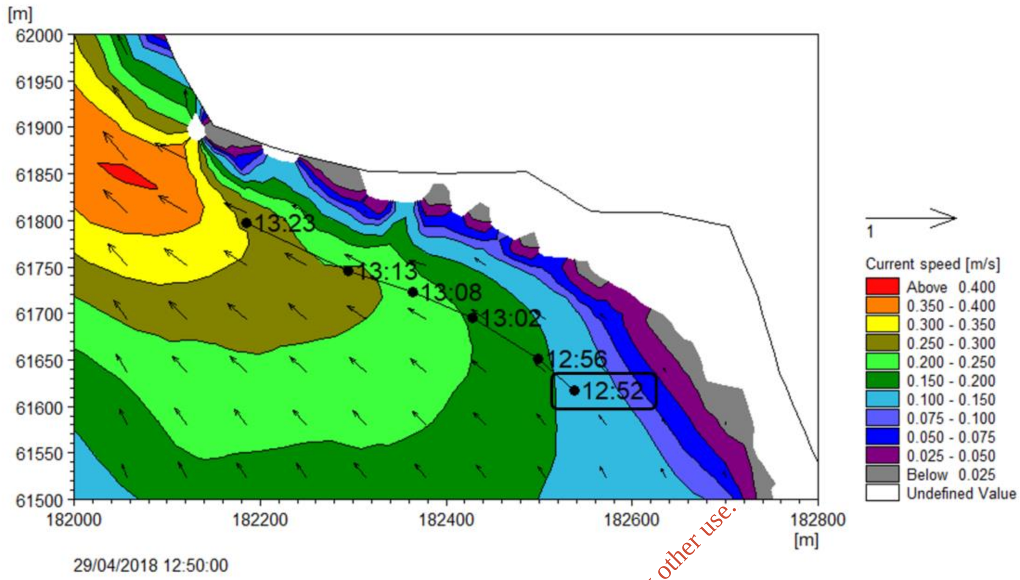
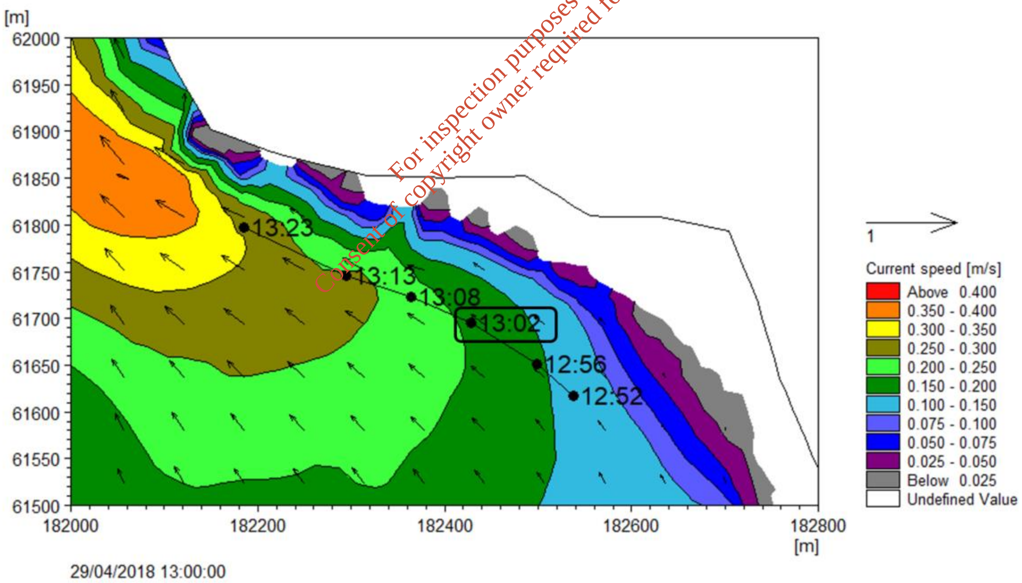
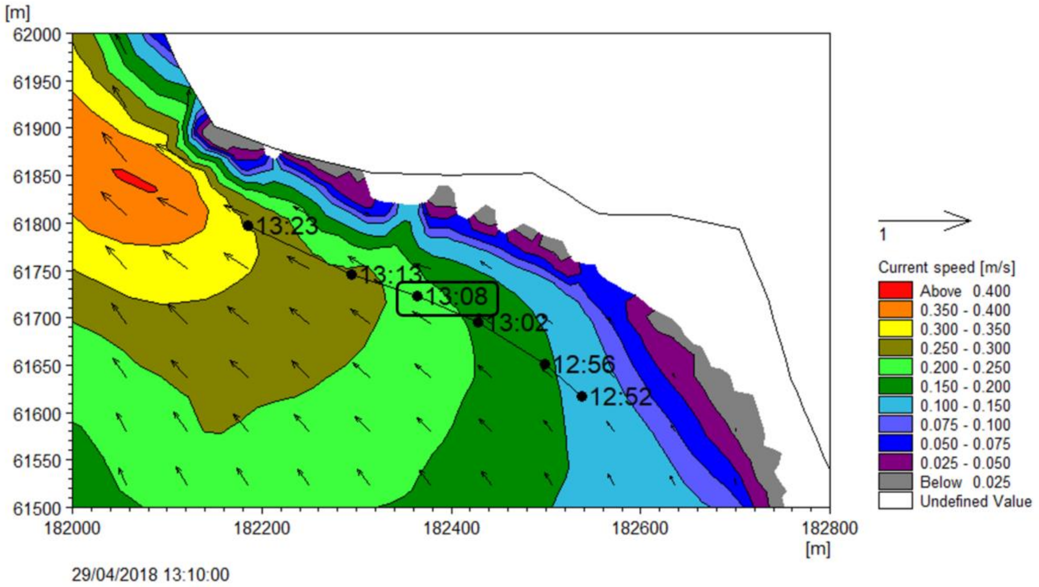

[m]
62000
61900
61800
61700
61600
61500
61400
61300
61200
61100
61000
60900
60800
60700
182000
182200
182400
182600
182800
183000
[m]
16:55
16:59
17:05
17:09
17:20
17:29
17:38
18:03
1
Current speed [m/s]
Above 0.400
0.350 - 0.400
0.300 - 0.350
0.250 - 0.300
0.200 - 0.250
0.150 - 0.200
0.100 - 0.150
0.075 - 0.100
0.050 - 0.075
0.025 - 0.050
Below 0.025
Undefined Value
29/04/2018 18:00:00

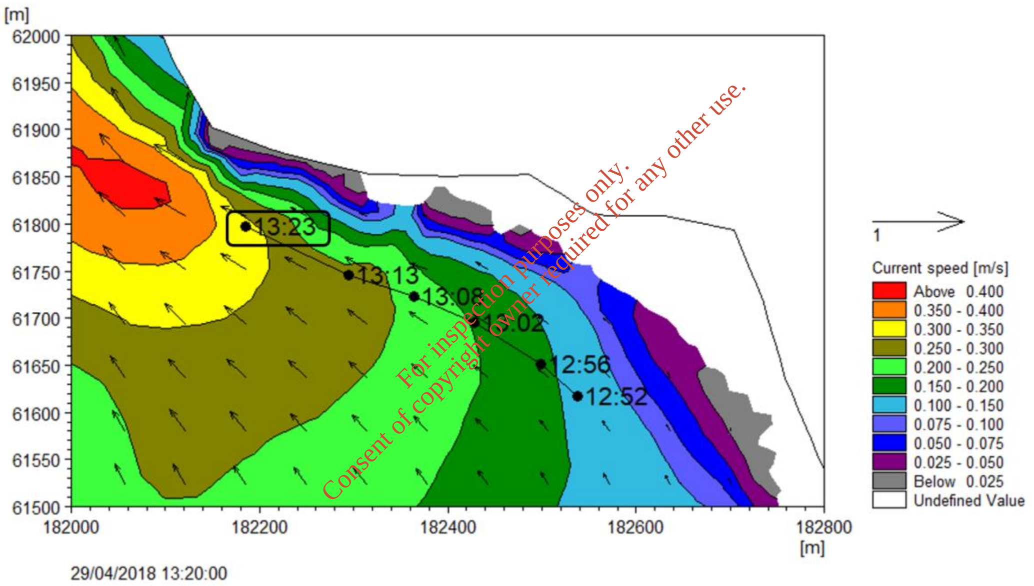
Figure 38 presents the current speed and velocity vector drogue validation for the flood tide. It is evident from the plots that the modelled current direction is well validated by the directional track of the drogue data.

Figure 38: Spring flood tide drogue validation









5.7 Additional Water Level Validation

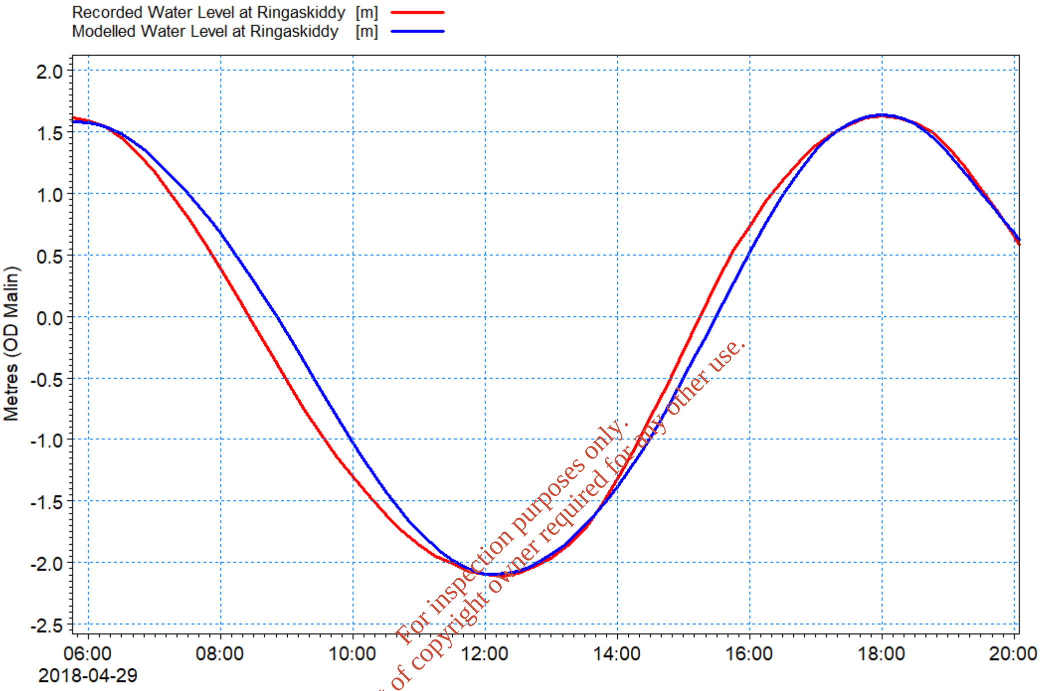
5.7.1 Spring tide water level

Further validation of the model was undertaken for water levels recorded at the Ringaskiddy and Tivoli gauges in Cork Harbour which are located some distance from the primary area of interest in Whitebay. As outlined in Section 4, due to the need to find a compromise between mesh resolution and the computational time of the model, the cell sizes of the mesh in areas located away from the key area of interest in Whitebay are coarser than the cell sizes used in Whitebay. While this ensures high precision in the model for the main area of interest, the model is less accurate in other further away areas such as in the vicinity of Ringaskiddy and Tivoli. This needs to be considered when assessing the validation for both of these locations.

The spring tide water level validation at Ringaskiddy is presented in Figure 39 for the same time period as the outfall location recorded data.

It can be seen from the figure that the modelled water level is well matched to the recorded maximum and minimum water levels at both high and low tides respectively. The model is also well mated to the time at which high and low water occurs. During the ebb tide the model overestimates water levels while on the flood tide the reverse occurs and the model slightly underestimates levels.

Figure 39: Ringaskiddy Water Level Validation – visual analysis



The statistical analysis for the spring tide water level calibration at Ringaskiddy is presented in Table 21.

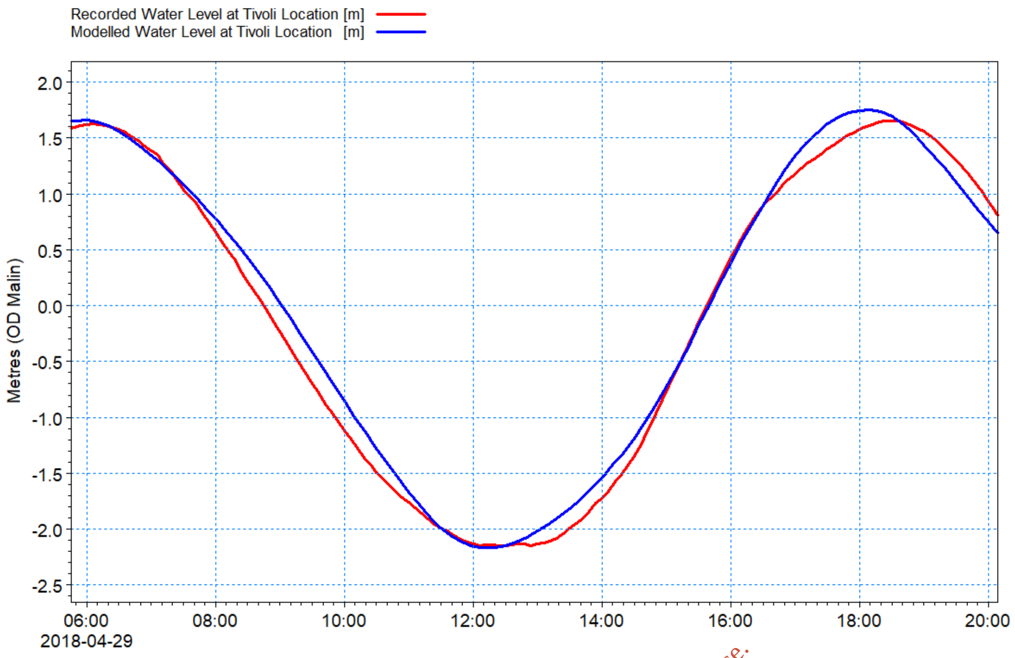
The absolute levels at high water (29/04/2018 18:15) and low water (29/04/2018 12:15) are within the ±0.1m tolerances specified in the IW guidelines. However, over the full spring tidal cycle, the model is within the absolute tolerances only 54% of the time. The RSME value of the observed and modelled water level throughout the spring tidal cycle is 0.1826m, which exceeds the tolerance specified in the guidelines. This statistical analysis indicates a moderate model validation against the recorded water levels which is in keeping with the results presented in the visual analysis in Figure 39.

Table 21: Statistical performance results for Spring Tide water level calibration at Ringaskiddy

Time	Recorded Water Level (mOD)	Modelled Water Level (mOD)	Absolute difference between modelled and recorded (m)
29/04/2018 07:45	0.60	0.84	0.24
29/04/2018 08:15	0.16	0.48	0.32
29/04/2018 08:45	-0.30	0.08	0.37
29/04/2018 09:15	-0.75	-0.36	0.39
29/04/2018 09:45	-1.13	-0.81	0.32
29/04/2018 10:15	-1.47	-1.23	0.24
29/04/2018 10:45	-1.75	-1.59	0.15
29/04/2018 11:15	-1.95	-1.88	0.07
29/04/2018 11:45	-2.07	-2.05	0.02
29/04/2018 12:15	-2.11	-2.09	0.01
29/04/2018 12:45	-2.03	-2.02	0.02
29/04/2018 13:15	-1.86	-1.83	0.03
29/04/2018 13:45	-1.55	-1.55	0.00
29/04/2018 14:15	-1.08	-1.19	0.11
29/04/2018 14:45	-0.56	-0.75	0.20
29/04/2018 15:15	0.00	-0.25	0.25
29/04/2018 15:45	0.53	0.27	0.26
29/04/2018 16:15	0.94	0.76	0.17
29/04/2018 16:45	1.26	1.18	0.08
29/04/2018 17:15	1.48	1.47	0.01
29/04/2018 17:45	1.61	1.62	0.01
29/04/2018 18:15	1.62	1.62	0.00
29/04/2018 18:45	1.50	1.46	0.04
29/04/2018 19:15	1.22	1.17	0.05
29/04/2018 19:45	0.85	0.84	0.01
29/04/2018 20:15	0.43	0.50	0.07

The water level validation at Tivoli is presented in Figure 40. It can be seen from the figure that the model is well matched to the recorded data as regards both the timing and the maximum and minimum water levels at high and low tide respectively. As with the validation at Ringaskiddy, the model overestimates waters levels on the ebb tide. It also overestimates water levels for the first circa two hours of the flood tide but is then well matched to it for the remainder of the flood tide.

Figure 40: Tivoli Water Level Validation – visual analysis



The statistical analysis for the spring tide water level validation at Tivoli is presented in Table 22.

The absolute levels at low water (29/04/2018 12:15) are within the ±0.1m tolerances specified in the IW guidelines, while absolute tolerances at high water (29/04/2018 18:15) are slightly exceeded. Over the full spring tidal cycle, the model is within the absolute tolerances 39% of the time. The RSME value of the observed and modelled water level throughout the spring tidal cycle is 0.1572m, which exceeds the tolerance specified in the guidelines.

Table 22: Statistical performance results for Spring Tide water level validation at Tivoli

Time	Recorded Water Level (mOD)	Modelled Water Level (mOD)	Absolute difference between modelled and recorded (m)
29/04/2018 07:45	0.87	0.94	0.07
29/04/2018 08:15	0.44	0.61	0.17
29/04/2018 08:45	0.00	0.23	0.23
29/04/2018 09:15	-0.47	-0.19	0.28
29/04/2018 09:45	-0.92	-0.63	0.28
29/04/2018 10:15	-1.32	-1.07	0.25
29/04/2018 10:45	-1.63	-1.47	0.15
29/04/2018 11:15	-1.88	-1.84	0.04
29/04/2018 11:45	-2.08	-2.09	0.01
29/04/2018 12:15	-2.14	-2.17	0.03
29/04/2018 12:45	-2.13	-2.09	0.04
29/04/2018 13:15	-2.10	-1.93	0.17
29/04/2018 13:45	-1.88	-1.69	0.19
29/04/2018 14:15	-1.54	-1.37	0.17

Time	Recorded Water Level (mOD)	Modelled Water Level (mOD)	Absolute difference between modelled and recorded (m)
29/04/2018 14:45	-1.08	-0.97	0.11
29/04/2018 15:15	-0.47	-0.46	0.00
29/04/2018 15:45	0.14	0.11	0.03
29/04/2018 16:15	0.69	0.65	0.04
29/04/2018 16:45	1.04	1.13	0.09
29/04/2018 17:15	1.29	1.50	0.20
29/04/2018 17:45	1.50	1.71	0.20
29/04/2018 18:15	1.63	1.74	0.11
29/04/2018 18:45	1.62	1.59	0.04
29/04/2018 19:15	1.45	1.28	0.17
29/04/2018 19:45	1.14	0.92	0.21
29/04/2018 20:15	0.71	0.58	0.13

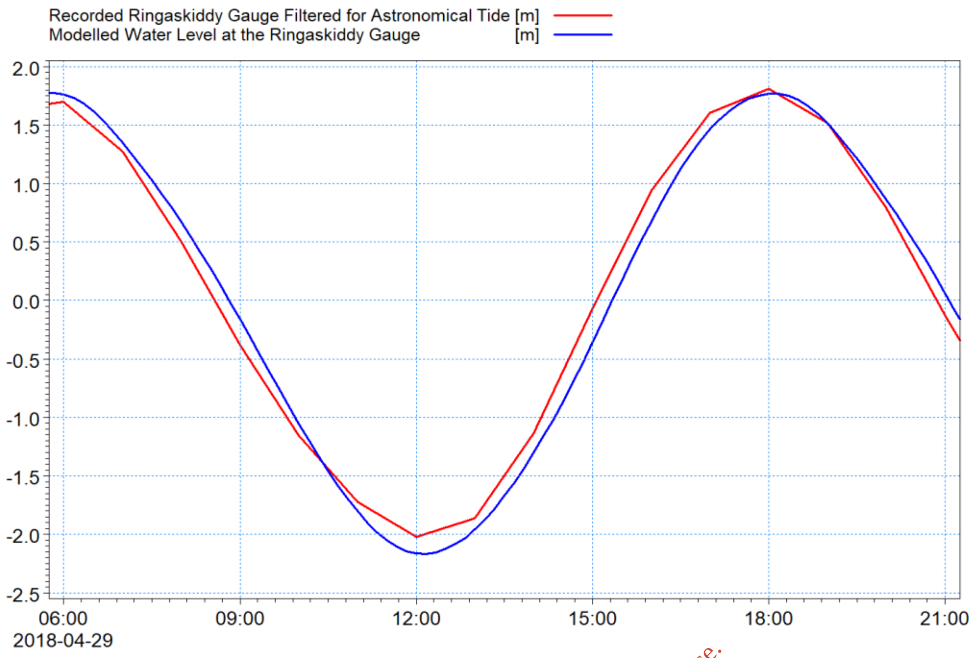
5.7.2 Astronomical tide validation

The model was also validated for astronomical tidal data using the following approach:

- Data from the Ringaskiddy gauge was filtered using data analysis techniques to produce an astronomical-only tidal signal for a 1-month period;
- Separately, an astronomical tidal signal for the open boundary condition was produced using the MIKE21 Tide Prediction of Heights tool for the same period;
- The model was run with the astronomical tidal boundary and compared against the derived astronomical tidal data from the gauge.

Figure 41 presents the astronomical spring tide validation for the same period as that presented in Section 5.3.

Figure 41: Astronomical spring tide water level validation



It can be seen from the figure that the match between the modelled astronomical water level and the derived astronomical water level is moderate: both tidal signals are in phase but there are differences in the water levels of circa 20-30mm through the tidal cycle. The model correctly predicts high tide water level and slightly underestimates the minimum water level during at low tide.

5.8 Discussion

The hydrodynamic model has been calibrated and validated against recorded data at the key site of interest in Whitebay. The model is well matched against recorded water level and current direction for both Spring and Neap tides. The model is also well matched against recorded Spring tide current speeds.

The neap tide current speed calibration is well matched for certain stages of the tide. The model however shows a divergence from the recorded data at two different points in time due to the formation of an eddy in the northern area of Whitebay. Strong localised currents were observed to occur on the surface at the site of interest which cannot be simulated with a depth integrated hydrodynamic model and this accounts for the divergence between the modelled and recorded data.

Further water level validation of the model was undertaken with data from the Ringaskiddy and Tivoli gauges. Given that these points are located away from the key area of interest in Whitebay they are resolved with a lower grid mesh resolution in the model and hence the modelled hydrodynamics in these areas is not as detailed as in Whitebay. Setting up the model in this way ensures a balance is achieved between its run time and its accuracy in the key areas. Given that Ringaskiddy and Tivoli are both located outside the tidal excursion of Whitebay, the ability of the model to accurately assess the impact of discharges from the proposed outfall is not in any way compromised.

The results of the water level validation demonstrate that the modelled water levels at these gauges is well matched against the recorded maximum and minimum water levels at high and low water. The modelled tide is also in phase with the recorded data. There are however differences in water level on both the ebb and flood tides caused by the localised grid resolution. Given that Ringaskiddy and Tivoli are outside the key area of interest, these differences are not deemed to have any significant impact on the ability of the model to assess the impact of discharge from the proposed outfall in Whitebay.

The accuracy of the model in simulating the hydrodynamics of the harbour have therefore been demonstrated and it can be concluded that the model is suitable for use in assessing the impact of the discharges from the proposed WwTP for Whitegate/Aghada.

6 Water Quality Modelling

6.1 Overview

This chapter describes the development and running of the Water Quality Ecolab model which is coupled to the hydrodynamic model described in the previous chapter. The results of the baseline and proposed scenario model runs are also presented in this chapter.

6.2 Dispersion Coefficient

The dispersion coefficient parameter is a key parameter of the WQ model and needs to be specified as part of the model build. It can be calibrated using salinity data or a dye study. However, neither salinity nor dye study data was collected as part of the marine survey. It was concluded that the salinity range at the outfall location would be insufficient to allow an accurate dispersion coefficient calibration to be made. A dye study was not undertaken as it was deemed by Arup that a dye study at the site would have offered not have provided a sufficiently accurate dataset with which to calibrate the model. The specification of the dispersion coefficient in the model is instead based on best practice within the industry and our extensive experience in developing coastal dispersion models. A sensitivity analysis has also been undertaken to assess if the findings of the model change when the dispersion coefficient is varied.

The Scaled Eddy Viscosity (SEV) formulation has been used to define the dispersion coefficient in the WQ model. This formulation allows for the dispersion coefficient to vary in time and space and also accounts for the varying cell size of the computational mesh. It is the most accurate specification of the dispersion coefficient within the MIKE system.

The SEV requires a scaling factor to be defined which amplifies or dampens the dispersion process. Different scaling constants have been tested against the recorded drogue data tracks to assess the variation in WQ concentrations resulting from changes to the scaling factor using the following methodology:

- An instantaneous release of a conservative pollutant was simulated by the model. The time and location of the release corresponds directly to the time and location of the drogue release;
- The track of the conservative pollutant's plume has been determined by extracting the maximum concentrations from the model run over the period for which the drogue was deployed;
- By plotting the maximum concentrations against the recorded drogue track they can be compared with each other.

The results are presented in Figure 42 to Figure 45. Four separate cases are presented: one flood and one ebb tide simulation for both Spring and Neap tide conditions. The recorded drogue track is presented with the black points and lines in each of the figures.

The numbers correspond to the time at which the location of the drogue was recorded by the surveyor. The format of the time stamp is hour-minute-second. The colour palette for the conservative pollutant has not been included in the figures as the actual modelled concentrations are somewhat arbitrary given that the purpose of the exercise is to present the track of the plume.

It can be seen that in each of the cases the track of the modelled plume is very similar to the recorded drogue track. The only noticeable difference is towards the end of the Spring tide ebb release where the drogue track and modelled track diverge slightly. It is also evident from the plots that the model is not sensitive to changes in the specification of the scaling factor of the SEV as the plume is very similar for each of the four values assessed. We have therefore used a scaling factor of 1.0 in the model for the baseline model simulations.[5]

[5] As it is a scaling factor, the number is dimensionless.

Figure 42: Neap tide conditions – ebb tide release

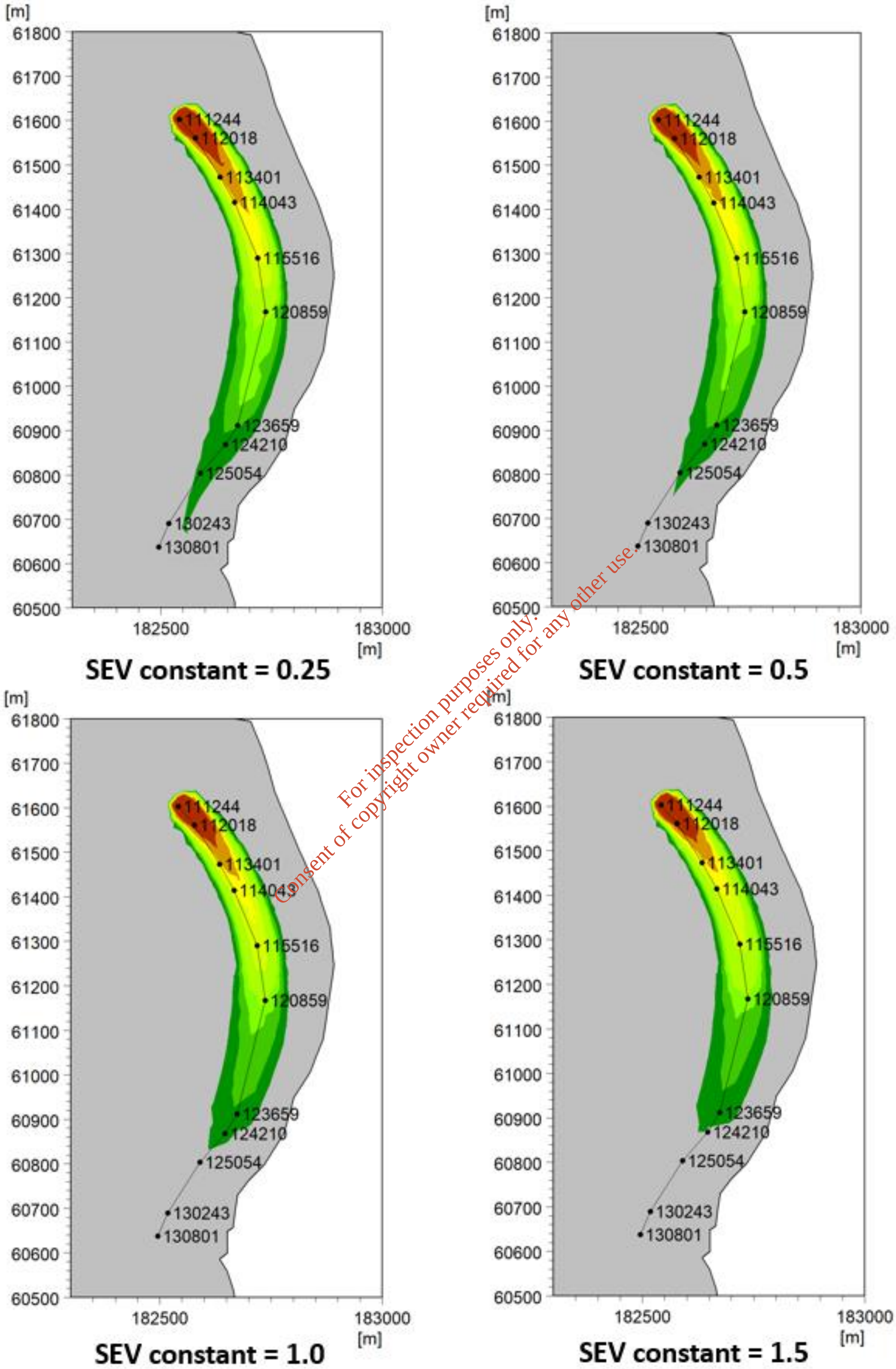


Figure 43: Neap tide conditions – flood tide release

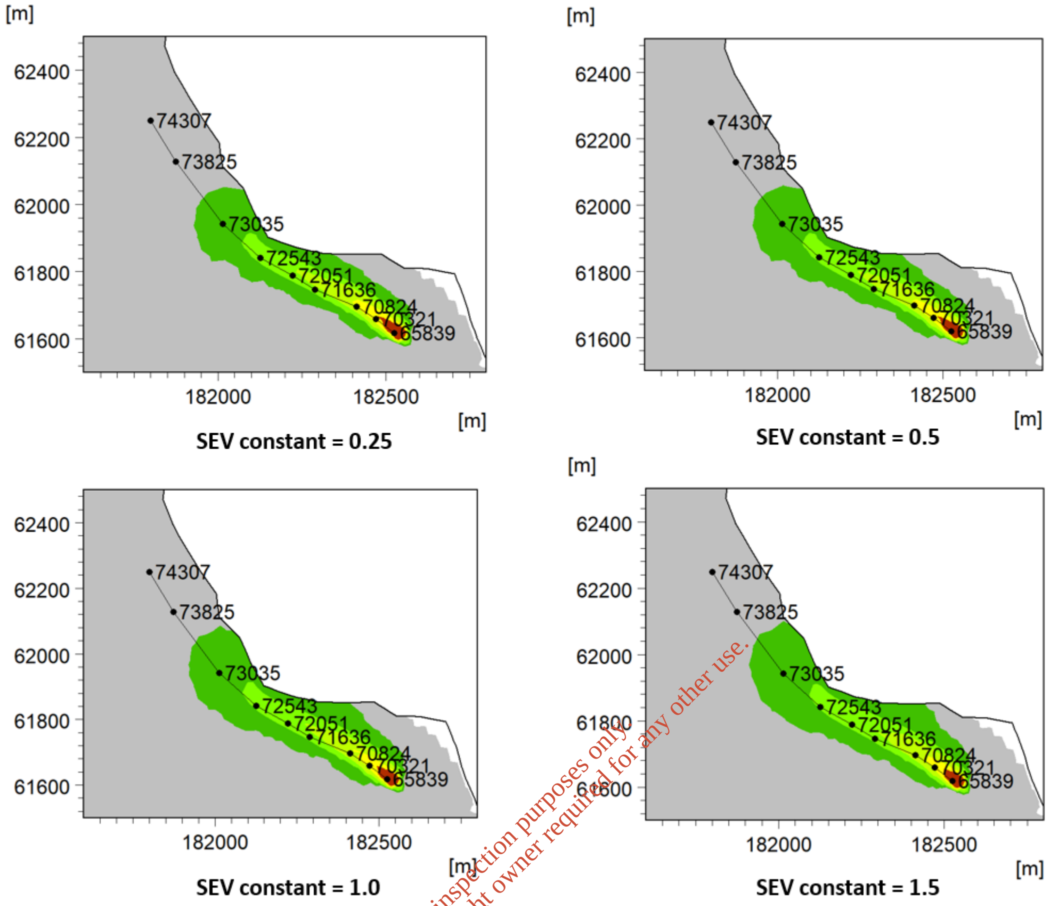


Figure 44: Spring tide conditions – ebb tide release

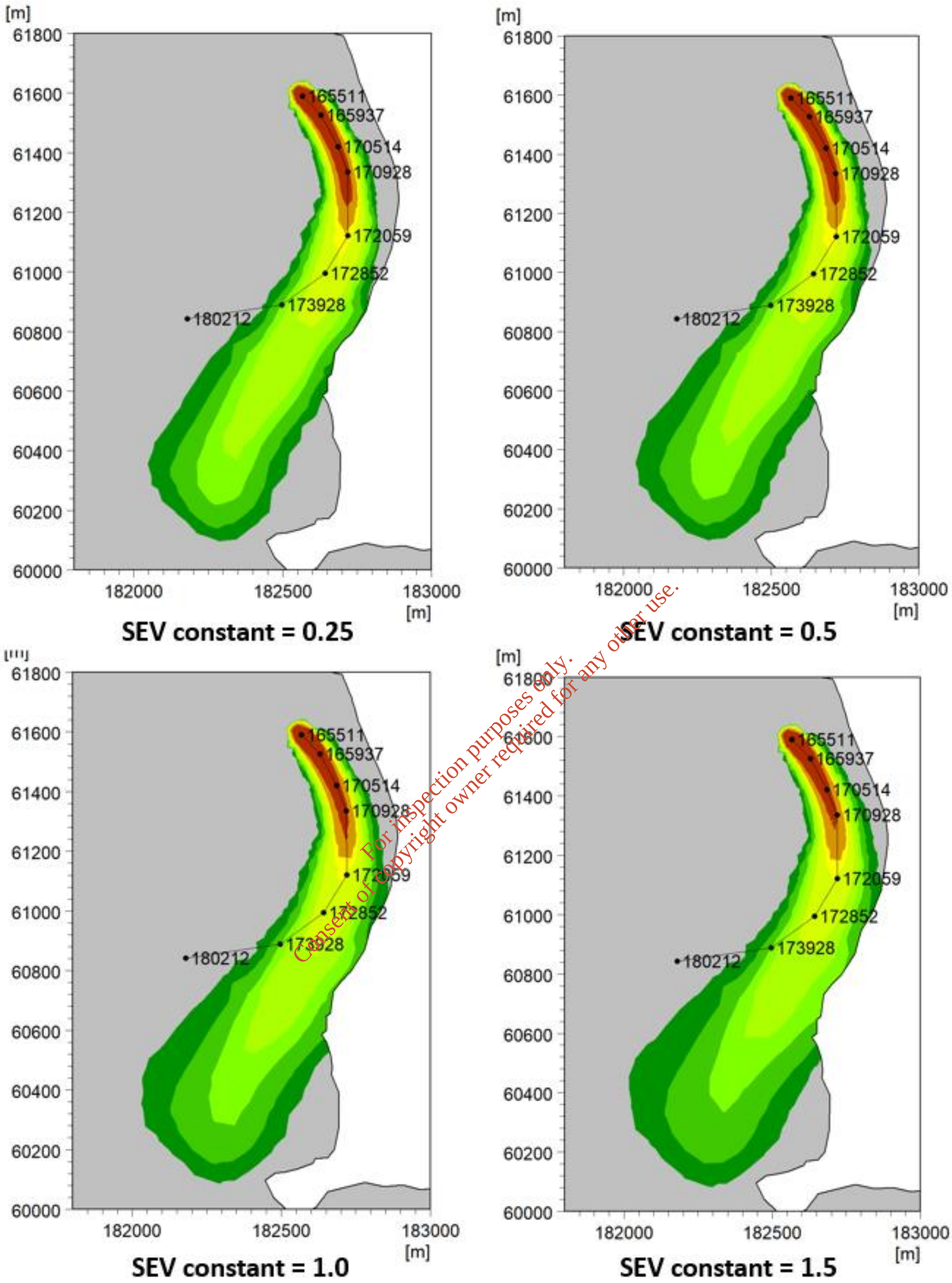
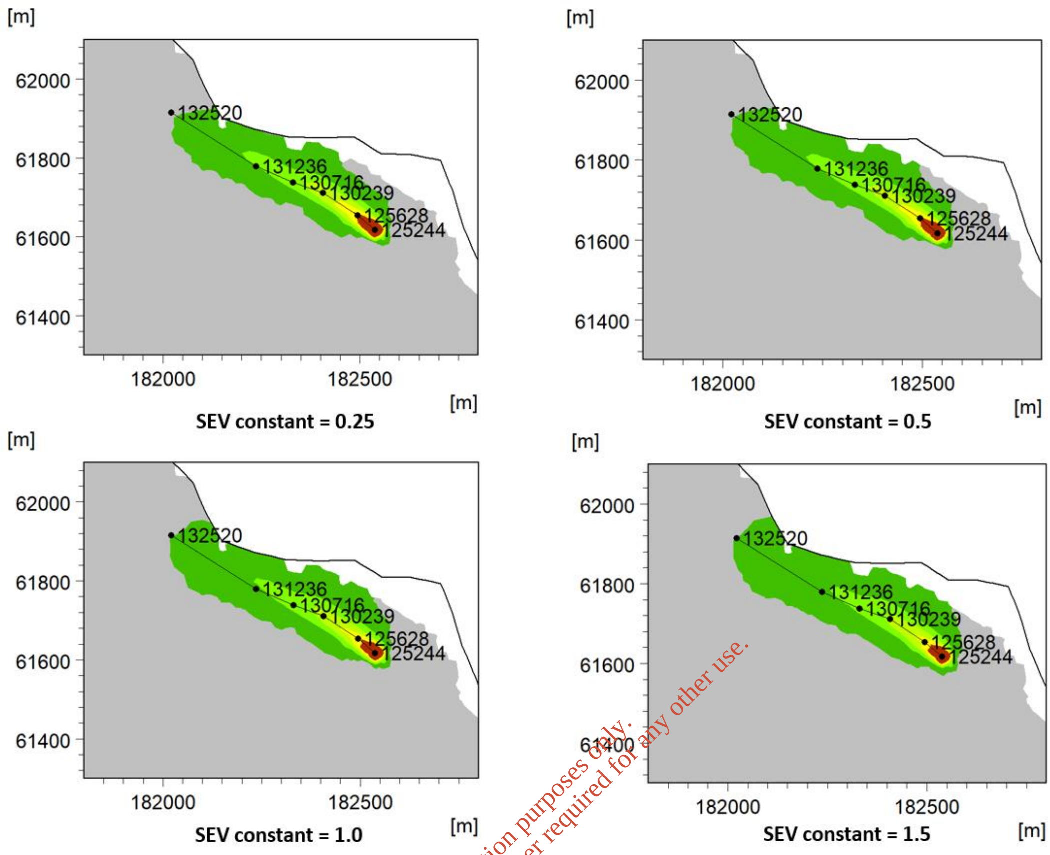


Figure 45: Spring tide conditions – flood tide release



6.3 Discharges and Background Information

The background concentrations of the modelled WQ parameters have been accounted for in the model by including coliform/nutrient discharges from three separate sources:

- All relevant WwTP and industrial outfalls in Cork Harbour;
- Primary rivers that flow into the Cork Harbour;
- Open sea boundary.

Each outfall and river source is characterised by two separate numbers:

- A flow rate in m^3/s;
- A concentration of the relevant WQ parameter in cfu/m^3 or mg/L (i.e. coliforms, nutrients etc.).

The product of these two numbers gives the total flux of either coliform or nutrient from the outfall/river in cfu/s or g/m^3.

Discharges along the open sea boundary have been included by specifying a concentration at the boundary.

6.3.1 Outfall discharges

Three outfalls presently make up the existing Whitegate/Aghada discharge to Cork Harbour. We used the information presented in the Jennings/AECOM report to determine the PE for these three outfalls. The flow rates were then estimated by multiplying the PE for each outfall by 225L/person/day[6].

We note that the flow rates derived using this method were circa 12% greater than the Dry Weather Flow (DWF) as presented in the Jennings/AECOM report [2]. For the proposed scenario at Whitegate/Aghada the design flow was calculated as the DWF * 1.3. We note that this flow rate corresponds to what was used as part of our near field modelling.

The concentrations of the various WQ parameters considered as part of the study for the different stages of treatment have been agreed with Irish Water and are based on their experience and standard values in literature. The outfall flows and concentrations are presented later in Table 23.

6.3.2 Fluvial discharges

As discussed in Section 2.5, a large number of rivers and streams discharge into Cork Harbour. These are relevant to the study in two ways:

- The rivers act as sources for the WQ parameters considered as part of the study;
- The rivers will increase the volume of water in the bay and therefore increase the dilution of a WQ parameter that is being advected in the harbour.

All the watercourses that impact on the area of interest have been included in the model. Our methodology for specifying the input flow rates for the rivers is given as:

- For gauged catchments, the 50%ile flow rate for the winter months was calculated from the gauge's flow record and used in the model. Where required, adjustments were made to the flow to account for differences in the catchment area at the gauge and the catchment area of the river where it meets with the harbour;
- For ungauged catchments, flow rates were derived from the 50% winter flow calculated for the Ballea gauge which is located on the River Owenboy upstream of Carrigaline based on differences in catchment areas;

The flows and concentrations used in the model are presented in the following section of the report.

It is noted that the specification of the river concentrations only influences the background concentrations of the model and not the existing and proposed WWtP scenarios for Whitegate/Aghada. The reduction in concentration of the relevant WQ parameter with the scheme in place (i.e. the delta value) is not impacted as the source concentration is the same for both the baseline and proposed scenario.

[6] 225L/p/d is Irish Water's assumed rate per day per person

6.3.3 Discharge locations

The fluvial and outfall discharge points in the vicinity of Whitegate/Aghada are presented in Figure 46 and Figure 47 for the existing and proposed scenarios respectively. It can be seen that a number of the fluvial discharges are located a short distance from the land boundary. This approach was adopted to avoid numerical instability in the model associated with positioning discharge points in grid cells subject to flooding and drying.

Figure 46: Existing discharges (fluvial inflows in green, outfalls in red)

Figure 47: Proposed discharges (fluvial inflows in green, outfalls in red)

Table 23 below presents the flow rates and concentrations for all discharges included in the model.

Table 23: Discharge Information

Source Type	Source Name	Flow Rate (m^3/s)	Easting (ING)	Northing (ING)	Treatment Type	WQ Parameter Concentration					
						E. Coli (cfu/100ml)	IE (cfu/100ml)	DIN (mg/l)	MRP (mg/l)	Ammonia (mg/L)	UnI Ammonia (mg/L)
River	Lee	29.3037	168380	71950	–	3000	13	1.8	0.023	0.07	0.0009
River	Glashaboy	3.3673	172720	72370	–	3000	13	3.0	0.026	0.05	0.0015
River	Douglas	0.6654	172900	69720	–	3000	13	3.0	0.026	0.05	0.0015
River	Owenacurra	3.9580	187500	71300	–	3000	13	1.4	0.017	0.04	0.0016
River	Aghada	0.3906	186650	65840	–	3000	13	1.4	0.017	0.04	0.0016
River	Owenboy	3.0258	179000	61500	–	3000	13	1.4	0.017	0.04	0.0016
River	Ardnabourkey	0.0743	183600	63700	–	3000	13	1.4	0.017	0.04	0.0016
River	Knocknamadderee	0.1467	187800	67360	–	3000	13	1.4	0.017	0.04	0.0016
River	Carrigtwohill	0.5951	180400	72420	–	3000	13	1.4	0.017	0.04	0.0016
River	Glounatouig	0.2200	175900	65100	–	3000	13	1.4	0.017	0.04	0.0016
Sea	Open Sea	-	Applied at downstream boundary		-	400	28	0.2	0.007	0.02	0.0006
Outfall	Saleen Village	0.0003	187700	67360	None	10,000,000	400,000	60.0	14	55	0.9185
Outfall	Cobh	0.0260	178243	65558	None	10,000,000	400,000	50.0	8	34	0.5678
Outfall	Whitegate/Aghada Existing	0.0052	183337	64664	None	10,000,000	400,000	25.0	4	5	0.0835
Outfall	Whitegate/Aghada Proposed	0.0085	182521	61580	Primary	1,000,000	40,000	54.0	12	50	0.8350
Outfall	North Cobh	0.0064	177535	67632	Secondary	100,000	4,000	12.6	1.38	4.3	0.07
Outfall	Carrigrennan	1.3954	176683	69726	Secondary	100,000	4,000	20.7	1.72	17.5	0.29
Outfall	Shanbally IDA	0.1622	181358	62521	Secondary	52,200	4,000	132.7	42.5	29.1	0.4860
Outfall	Midleton ID	0.0911	186177	69506	Tertiary	8,574	343	4.1	0.41	0.65	0.011
Outfall	Carrigtwohill 1	0.0271	179911	72583	Tertiary	10,000	400	7.2	0.407	1.3	0.022

Source Type	Source Name	Flow Rate (m^3/s)	Easting (ING)	Northing (ING)	Treatment Type	WQ Parameter Concentration					
						E. Coli (cfu/100ml)	IE (cfu/100ml)	DIN (mg/l)	MRP (mg/l)	Ammonia (mg/L)	UnI Ammonia (mg/L)
Outfall	Carrigtwohill 2	0.0271	180594	72283	Tertiary	10,000	400	7.2	0.407	1.3	0.022
Outfall	SKB	0.0151	178885	62710	-	0	0	25.0	2	10	0.1670
Outfall	ESB	0.0058	183266	65316	-	0	0	10.0	0	10	0.1670
Outfall	P66WR	0.1389	182596	63221	-	0	0	25.0	2	15	0.2505
Outfall	BGE	0.0069	182410	63165	-	0	0	5.0	5	5	0.0835
Outfall	M Chem	0.0035	177310	69720	-	0	0	15.0	0	10	0.1670

6.4 Overview of Design Model Runs

The design model runs were simulated with the following parameters:

- Astronomical tidal conditions for the open boundary;
- Simulation period: from 27/04/2018 09:45 to 19/05/2018 17:30 to give a total duration period of circa 23 days
- A warm up period of 6.5 hours.
- No wind forcing was used in the design runs;
- Coliform linear decay rate: T90 = 20 hours[7]
- Assume the cycling of nutrients in the harbour can be described using a linear decay function with T90 values of:
  - DIN T90 = 23 days[8]
  - MRP, TA and UiA T90 = 33 days

The T90 parameter is considered as part of the sensitivity analysis and is presented later in the report.

Spatially varying 95%ile (coliform) and 50%ile (nutrient) plots have been estimated and are presented in the following sections of the report for both the existing and proposed scenario. The difference between the existing and proposed (the 'delta' plot) is also presented.

95%ile (coliform) and 50%ile (nutrient) point concentrations at a number of EPA monitoring points are also presented and assessed. Both the spatially varying and point concentrations are used to assess compliance of the parameters with the EQS thresholds and adherence with the relevant EU water quality directives.

6.5 Design Model Results

Design model results are presented as spatially varying 95%tile (coliform) and 50%tile (nutrient) plots. The plots have been derived using DatastatisticsFM.exe tool in MIKE 21 which allows percentile calculations to be undertaken on the result files of model simulation runs.

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[7] The scientific literature outlines a range of coliform T90 values. A T90 value of 20 hours has been selected for coliforms following consultation with Irish Water. It is noted that this is a conservative estimate. The sensitivity of the T90 value is considered later in the report.

[8] The cycling of nutrients in the marine environment involved complex chemical and biological reactions. We have simplified the process by assuming that it can be represented using a linear decay function. We have conservatively used very slow decay rates in line with previous studies undertaken for Irish Water.

6.5.1 E. Coli

The spatially varying 95%ile plot for E. Coli for both the existing and proposed scenario is presented in Figure 48. The difference between the two plots (the 'delta' plot) is also presented.

From the results it can be seen that the 95%ile concentrations vary across the outer harbour and in the area of interest in Whitebay for both scenarios. For the existing scenario concentrations are greater than 150 cfu/100ml in the vicinity of Haulbowline Island, while in the area of interest in Whitebay they are generally less than 50 cfu/100ml. It can be seen from the figure that concentrations reduce considerable along the north-south direction. 95%ile concentrations are less than 10 cfu/100ml south of Whitebay towards the coastline.

For the proposed scenario the 95%ile concentrations appear broadly similar to the existing scenario plot with the only noticeable visual difference being a very significant reduction in the concentrations at the location of the existing outfalls in Whitegate/Aghada and an increase in concentrations local to the proposed outfall. With the proposed scheme in place the 95%ile concentrations are reduced from greater than 1,000 cfu/100ml to less 10 cfu/100ml at the existing Whitegate/Aghada outfalls, and concentrations at the proposed outfall are increased from below 50 cfu/100ml to over 500 cfu/100ml.

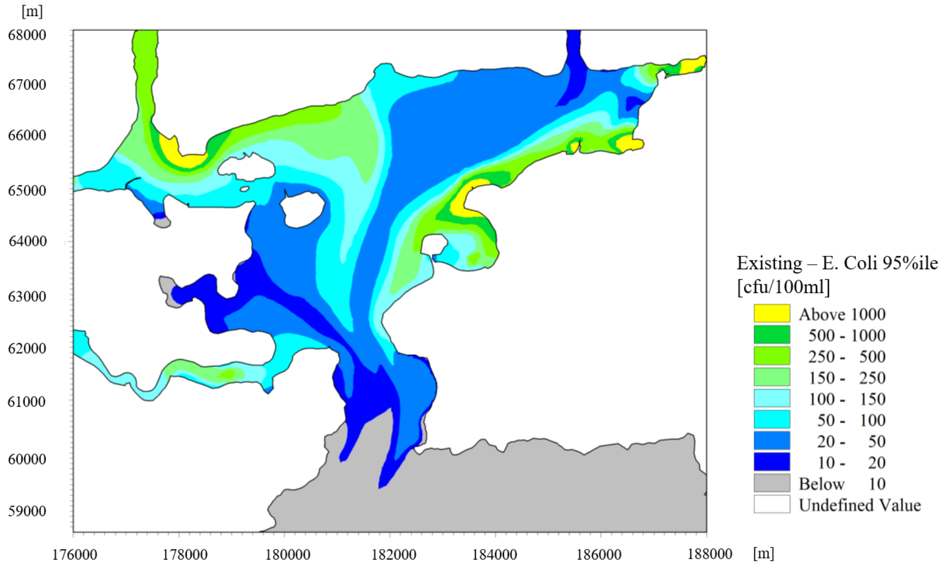
The delta plot illustrates the differences between the existing and proposed scenarios. As the existing scenario has been subtracted from the proposed scenario, reductions in 95%tile concentrations are presented as negative values, while increases in concentrations are presented as positive values. From the plot it can be seen that the proposed scheme reduces the 95%ile E. Coli concentrations across a large area of the eastern outer harbour area. For some areas of the outer harbour these reductions are in excess of 1,000 cfu/100ml which is considered very significant. 95%ile concentrations in the immediate vicinity of where the Knocknamadderee and Aghada rivers enter the harbour are however in excess of 1,000 cfu/100ml due to the coliform loading from the rivers.

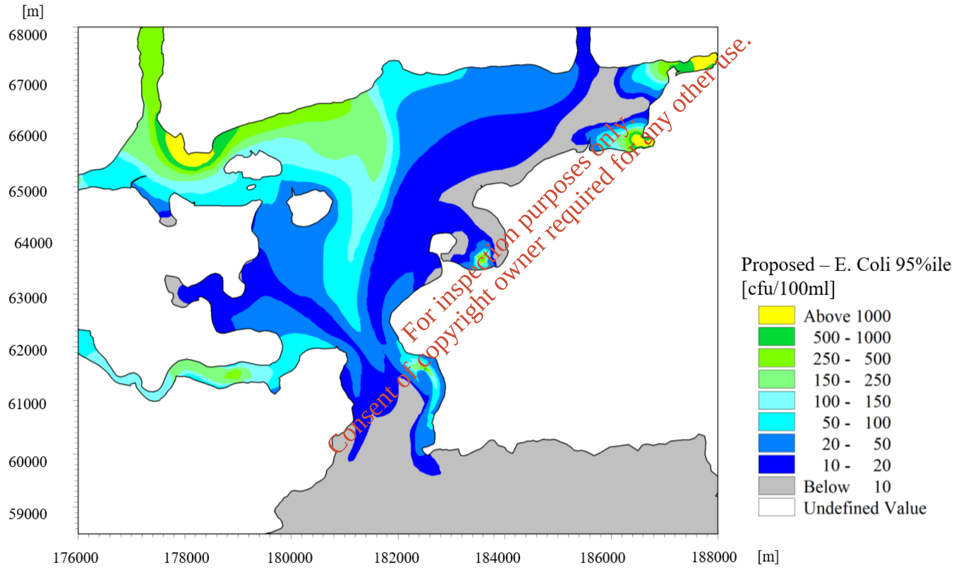
For the area around Cobh and up into West Passage the difference is minimal as these areas are not influenced by discharges from the existing Whitegate/Aghada outfall i.e. plumes from the existing outfall are not advected by the currents into these areas.

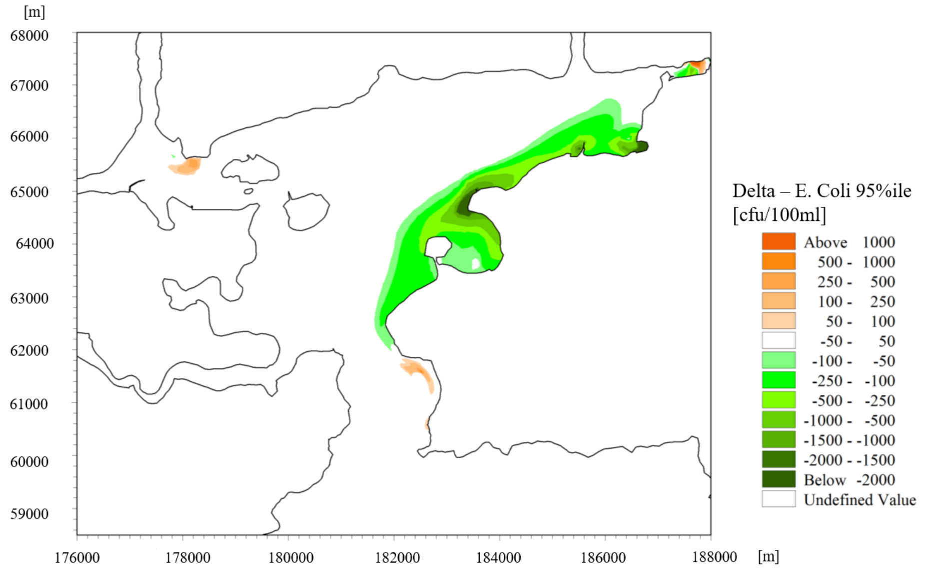
It can be seen from Figure 48 that there are small areas close to the Cobh outfall that suggest minor differences in the 95%ile concentrations for the different scenarios. These small pockets of concentrations however are not associated with changes due to the existing and proposed scenarios but are instead caused by minor errors in the model associated with the flooding and drying of grid cells in the immediate vicinity of source discharge points.

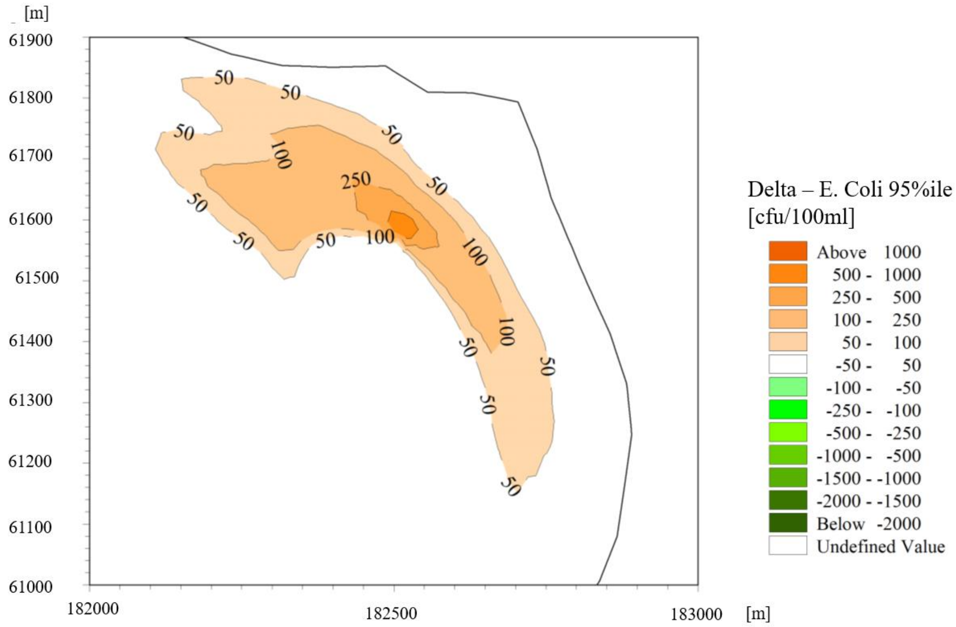
The proposed scheme results in an increase in concentration in the vicinity of the proposed outfall. It can be seen from the zoomed-in delta plot that the increase varies spatially and is highest in the immediate vicinity of the outfall where it is greater than 500 cfu/100ml. Within circa 100m of the outfall however the increase in the 95%ile E. Coli concentration is less than 250 cfu/100ml and within circa 300m the increase is less than 100 cfu/100ml.

Figure 48: E. Coli 95%ile concentration plots – existing, proposed and delta plots (including a close-up view)









Whitebay is not a designated EU bathing water area. It is however used for recreation and we have therefore considered the results in the context of the Bathing Water Regulations.

Under the Bathing Water Quality Directive (2006/7/EC), 95%ile E. Coli concentrations of 250cfu/100ml or less in coastal/transitional waters are considered "Excellent" as indicated in Table 24.

Table 24: Bathing Water Classification (Annex I of Directive 2006/7/EC)

Water Type	Parameter	Excellent	Good	Sufficient
Coastal/Transitional	E. Coli cfu/100ml	250 (*)	500 (*)	500 (**)

(*) based on a 95-percentile evaluation; (**) based on a 90-percentile evaluation

It can be seen from the results presented in Figure 48 that the 250 cfu/100ml 95%ile concentration threshold is exceeded within the mixing zone of the proposed outfall (i.e. in the immediate vicinity). The concentrations drop below the 250 cfu/100ml threshold within circa 50m from the outfall. It can therefore be concluded that the water is classified as "Excellent" as per the Bathing Water Quality Directive (2006/7/EC) within circa 50m of the outfall.

6.5.2 Intestinal enterococci 95%ile plots

The spatially varying 95%ile plot for Intestinal Enterococci for both the existing and proposed scenario is presented in Figure 49. The delta plot is also provided. The results for Intestinal Enterococci broadly follow the same pattern of concentration and changes in concentration associated with the E. Coli results as presented in the previous section: the 95%ile concentrations of Intestinal Enterococci are significantly reduced across large areas of the outer harbour but are increased locally in Whitebay.

The most significant reduction in the 95%ile concentrations is at the location of the existing discharges at Whitegate/Aghada where the reduction in coliform count is greater than 100 cfu/100ml in places. There is an increase in the 95%ile concentration of circa 32 cfu/100ml in the immediate vicinity of the proposed outfall. Within circa 400m of the outfall however the increase is less than 2 cfu/100ml which is considered to be very low.

Under the Bathing Water Quality Directive (2006/7/EC) (outlined in Table 25) 95%ile Intestinal Enterococci concentrations of 100 cfu/100ml or less in coastal/transitional waters are considered “Excellent”.

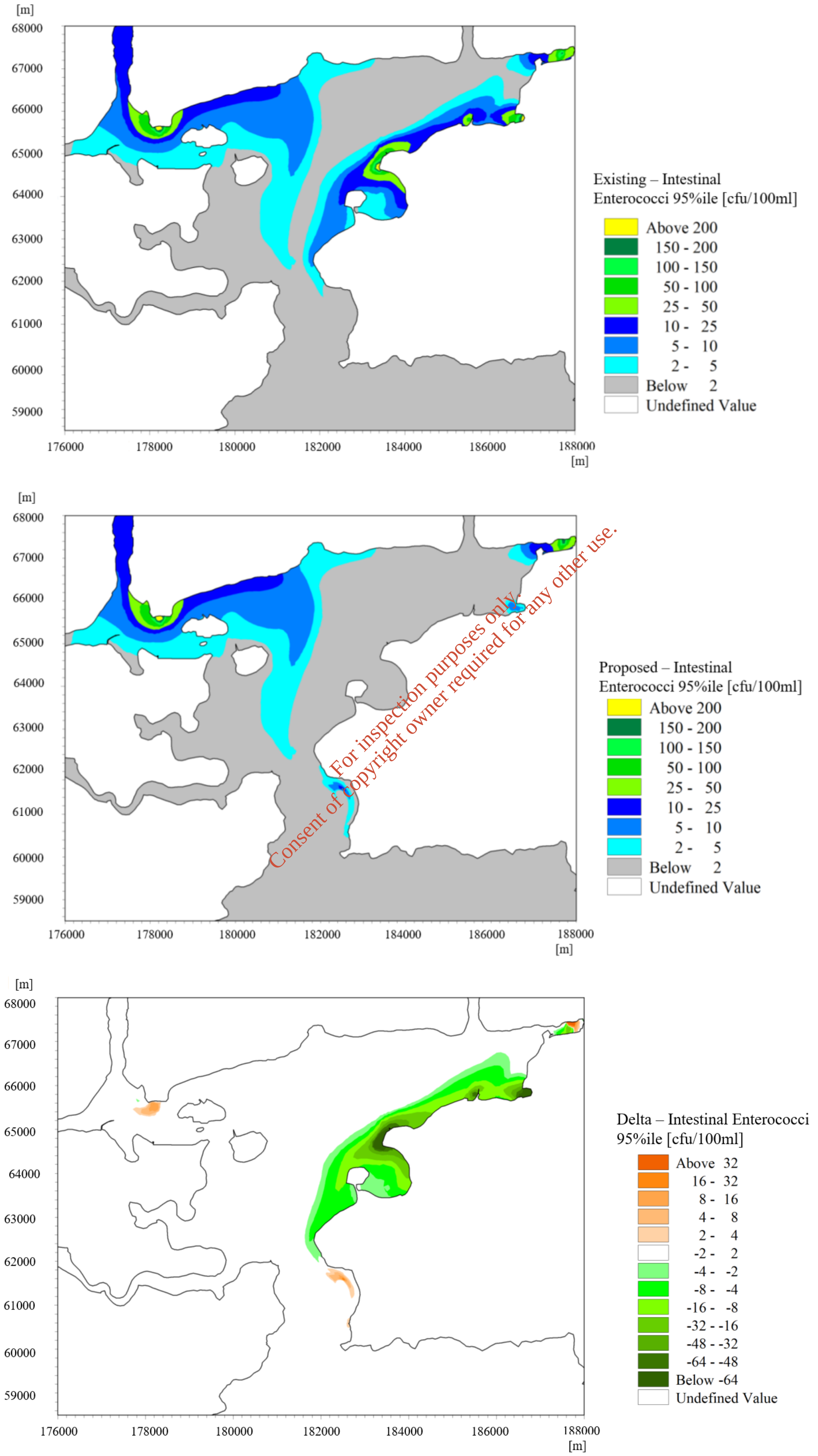
Table 25: Bathing Water Quality Directive (Annex Ⅰ of Directive 2006/7/EC)

Water Type	Parameter	Excellent	Good	Sufficient
Coastal / Transitional	Intestinal enterococci cfu/100ml	100 (*)	200 (*)	185 (**)

(*) based on a 95-percentile evaluation (**) based on a 90-percentile evaluation

For the proposed scenario the 95%ile concentration are less than 50 cfu/100ml at the outfall location and less than 25 cfu/100ml within circa 20m of the outfall. The proposed scheme therefore maintains “Excellent” status as per the Bathing Water Quality Directive for Intestinal Enterococci across the harbour.

Figure 49: IE 95%ile concentration plots – existing, proposed and delta plots.



6.5.3 DIN 50%ile plots

The spatially varying 50%ile plot for DIN for both the existing and proposed scenario is presented in Figure 50. The delta plot is also presented in the figure.

From the results it can be seen that the 50%ile concentrations vary across the outer harbour and in the area of interest in Whitebay for both scenarios, with concentrations reducing in a southerly direction towards the coastline.

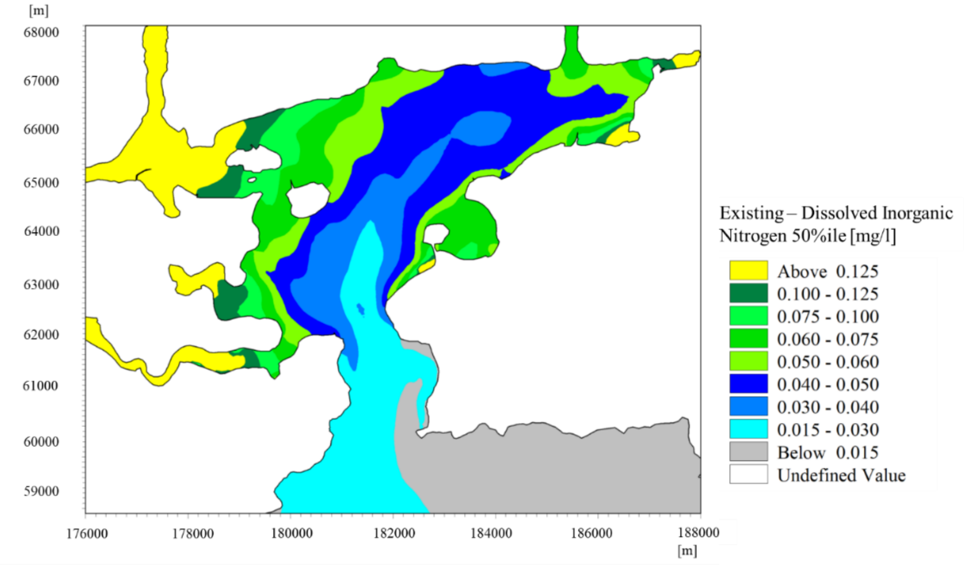
For the existing scenario concentrations exceed circa 0.03mg/l in the outer harbour area. For the proposed scenario the 50%ile concentrations appear broadly similar to the existing scenario plot. In both cases peak concentrations of over 0.125mg/l occur at the location of the river inflows. As the fluvial inflow loadings are unchanged in both scenarios the resulting concentrations in the water volume in the model are the same.

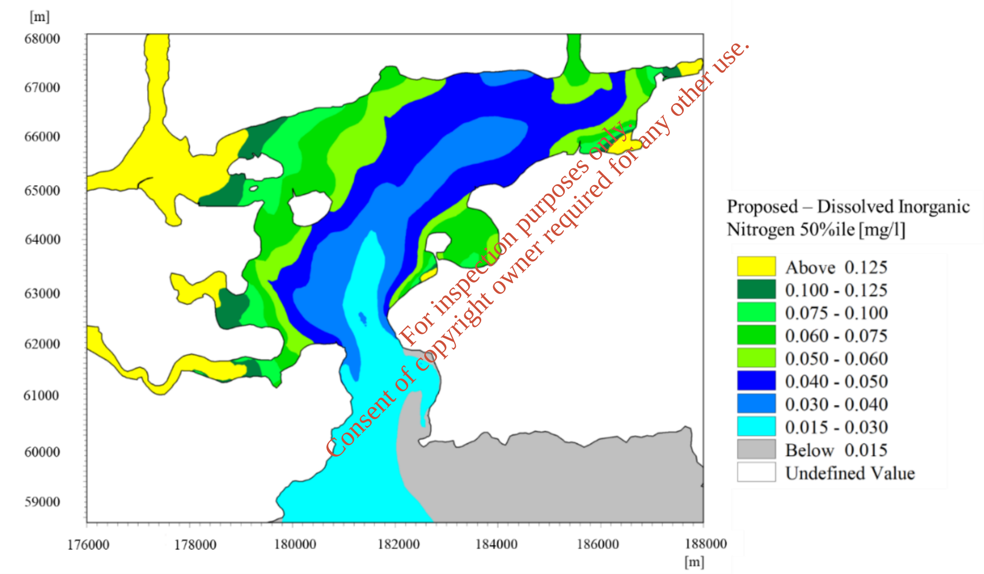
It can be seen from the delta plot that the proposed scheme reduces the 50%ile concentrations of DIN across the eastern side of the outer harbour where the existing Whitegate/Aghada discharges are. At the location of the existing Whitegate/Aghada outfalls the reduction is greater than 0.003mg/l.

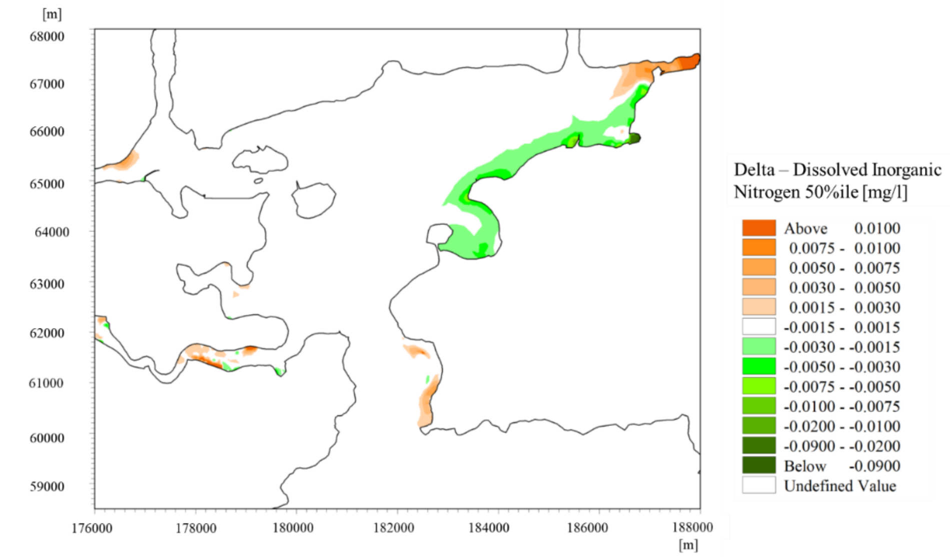
The proposed outfall discharge increases the 50%ile DIN concentrations local to the outfall in Whitebay. It can be seen from the delta plot that the concentrations local to the outfall are increased by circa 0.0015 – 0.0075mg/l with the scheme in place.

In the context of the EQSs as defined in the Surface Water Regulations, the increase in DIN associated with the proposed outfall is very minor. The target level of DIN is 0.25mg/l. The model results show that the increase associated with the proposed scheme in place in the vicinity of the outfall is considerably less that this target level. This increase in concentration is therefore deemed to be very minor.

Figure 50: DIN 50%ile concentration plots – existing, proposed and delta plot







6.5.4 MRP 50%ile plots

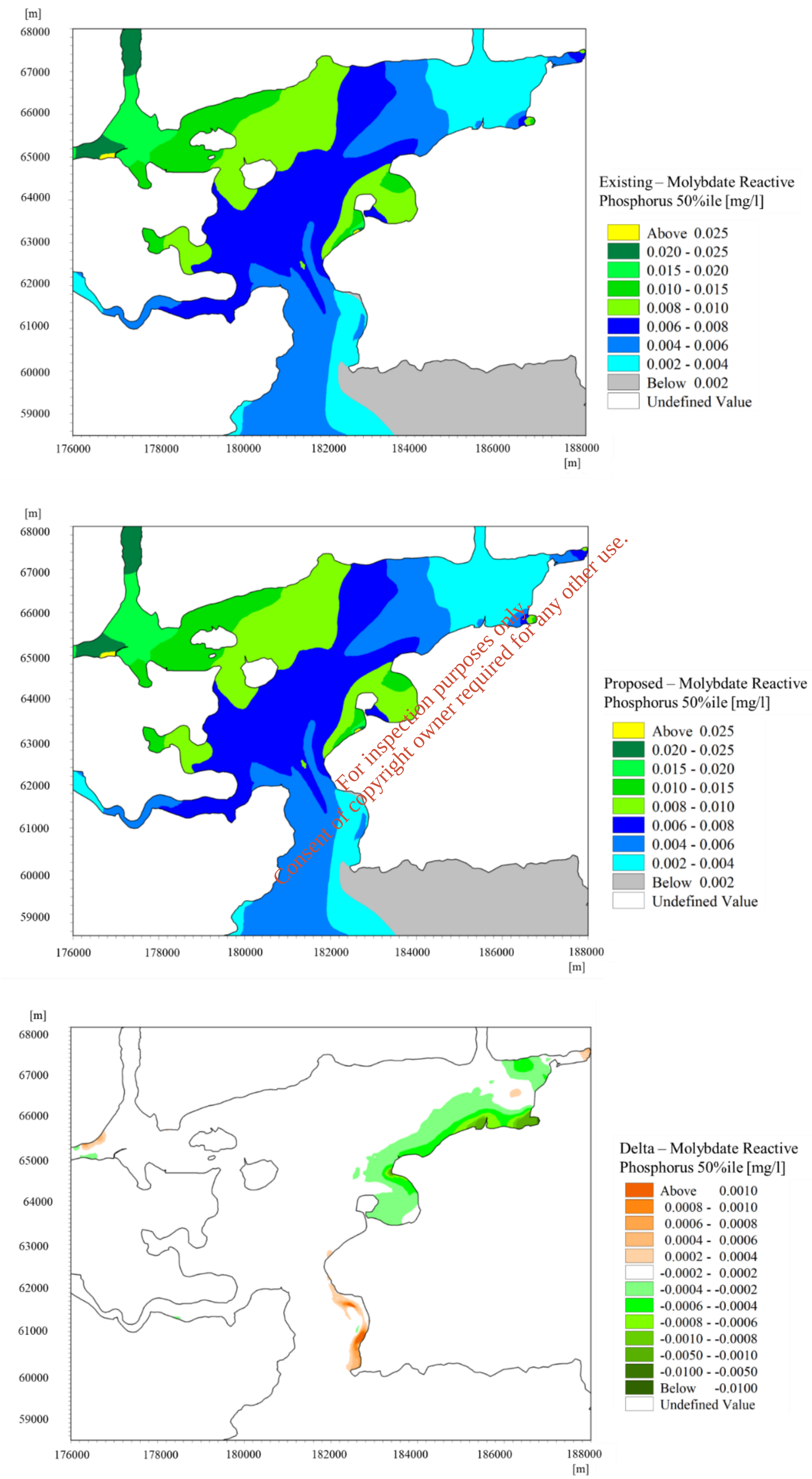
The results for MRP are presented in Figure 51. It can be seen that the general pattern of the 50%ile concentration and change in concentration associated with the proposed scheme for MRP is broadly similar to the results presented in the previous section for DIN. From the figures it is evident that there is little impact on the existing MRP levels in the outer harbour as a result of the proposed scheme.

The delta plot however shows the minor differences in MRP as a result of the scheme. The proposed scheme reduces the 50%ile concentration in the outer harbour but increases concentrations locally in the vicinity of the outfall. In the eastern side of the outer harbour concentrations are reduced by circa 0.0002 – 0.001 mg/l in the proposed scenario. In the vicinity of the proposed outfall 50%ile concentrations are increased by circa 0.0002 – 0.001 mg/l in the proposed scenario.

For both scenarios the MRP 50%ile concentrations reduce in a north-south direction due to the hydrodynamics of the harbour limiting the advection of the plume past Roches point.

The increase in the 50%ile concentration of MRP local to the outfall represents a very small fraction of the target level of 0.04mg/l as specified by the Surface Water Regulations EQSs. The results of our model indicate that the increase is less than 3% of the target level which is deemed to be very minor.

Figure 51: MRP 50%ile concentration plots – existing, proposed and delta plots

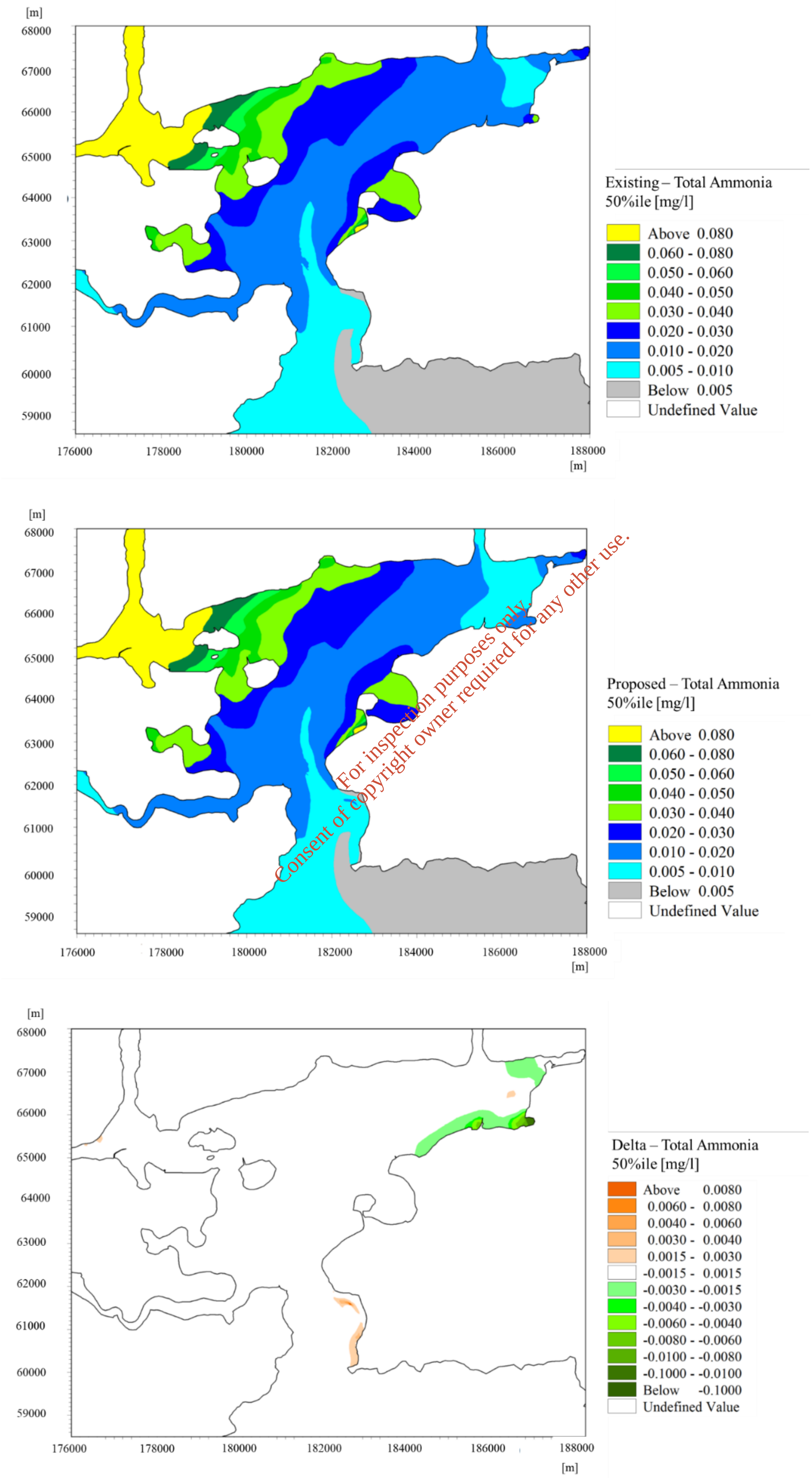


6.5.5 Total ammonia 50%ile plots

The results for Total Ammonia (TA) are presented in Figure 52. Results are similar to those for DIN and MRP, with the proposed scheme having very minor impact on the 50%tile concentrations. Implementation of the proposed scheme is seen to reduce the TA in the vicinity of existing outfalls on the eastern side of the outer harbour, where reductions of up to 0.006mg/l are observed. Increases in concentrations of up to 0.006mg/l are seen locally at the proposed outfall.

The target level of TA as per the EQSs as defined in the Salmonid Water Regulations is 1mg/l. 50%iles concentrations of TA are relatively low across the outer harbour, below the EQS threshold. In this context the increase in TA associated with the proposed outfall is deemed to be very minor.

Figure 52: TA 50%ile concentration plots – existing, proposed and delta plots

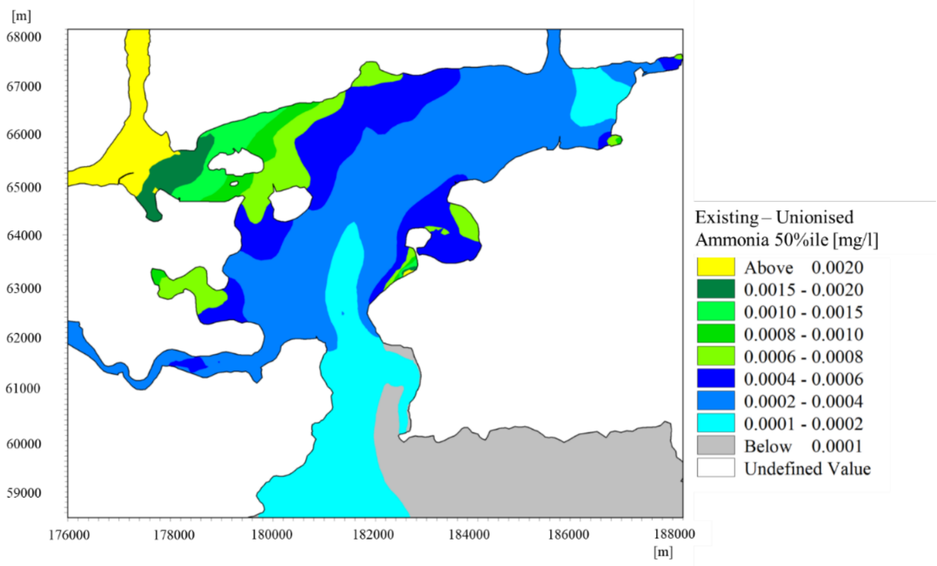


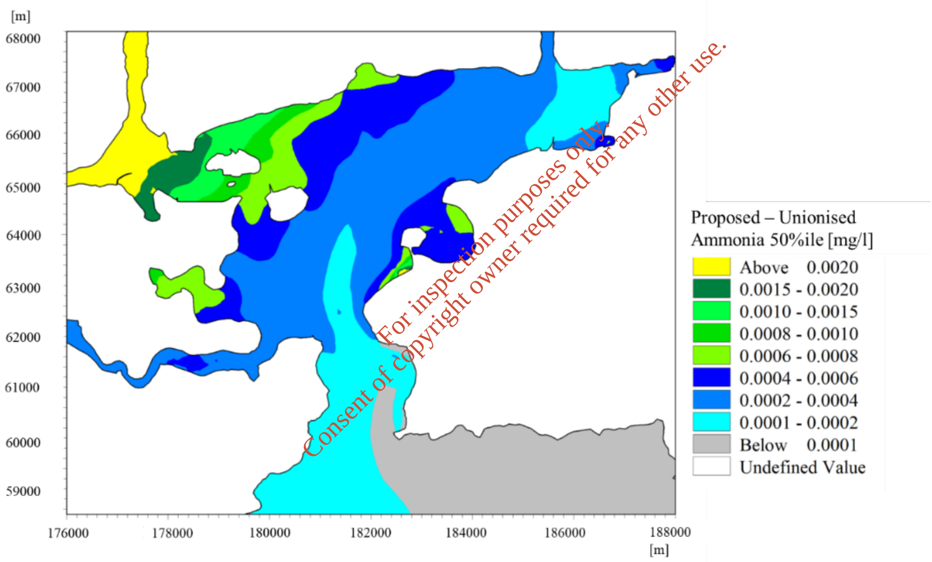
6.5.6 Unionised ammonia 50%ile plots

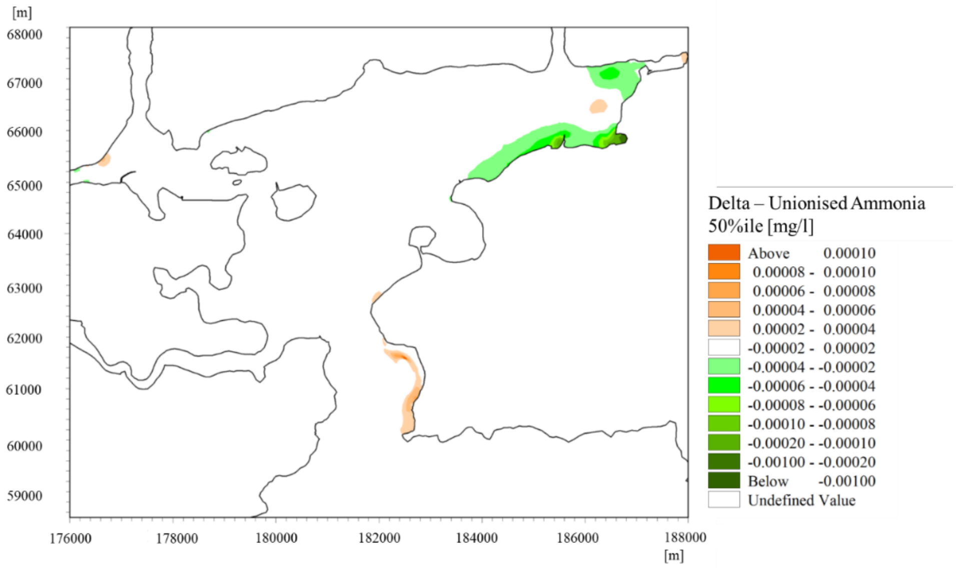
Model results for the assessment of Unionised Ammonia are presented in Figure 53. It can be seen that the general pattern of the 50%ile concentration and change in concentration associated with the proposed scheme for UiA is broadly similar to the results presented in the previous section for TA, with very low UiA concentrations observed throughout the outer harbour area. The proposed scheme has a very minor impact on concentrations at the proposed outfall locations, resulting in a marginal increase of circa 0.00002 - 0.0001mg/l.

The UIA target level as specified by the Salmonid Water Regulations EQSs is 0.02mg/l. In both the existing and proposed cases UiA levels are substantially lower than this limit.

Figure 53: UiA 50%ile concentration plots – existing, proposed and delta plots







6.6 WQ Concentrations at Monitoring Points

The 95%ile and 50%ile concentrations for the six WQ parameters considered in this study at each of the designated monitoring points in Cork Harbour are presented in Table 26. We note that these monitoring points are an amalgamation of points from the EPA's National Water Monitoring Stations as well as sampling points from the bathing water and shellfish water directives. Arup have also deemed certain points to be of interest (i.e. the bathing area at Myrtleville beach) and have included these. The location of the points is presented in Figure 54. The 95%ile and 50%ile concentrations for the six WQ parameters are also assessed for four locations within the designated shellfish waters, as shown in Figure 55.

Figure 54: Location of monitoring points

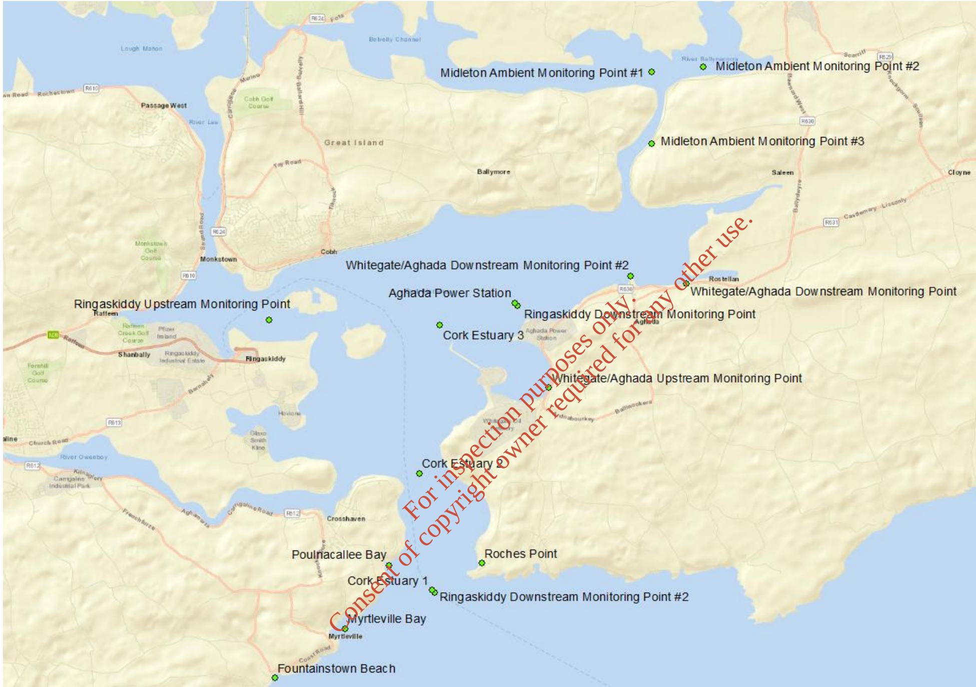


Figure 55: Location of monitoring points within shellfish waters

The difference between the existing and proposed scenario concentrations at each of the points is also presented in the delta columns of the table.

It is evident from the table that the 95%ile concentrations of both E. Coli and Intestinal Enterococci are reduced at nearly all the points across the harbour. A reduction is observed at each point within the shellfish waters, with the exception of shellfish point 1, where there is a slight increase. This increase does not however lead to EQS thresholds being exceeded at this point. The only noticeable increase is at Roches Point which is considered a comparatively minor increase with regard to the EQS threshold for E. Coli.

The differences in the 50%ile concentrations of the various nutrients at the various monitoring points are also considered minor.

Only two concentrations presented in the table (highlighted in yellow) exceed their EQS for the proposed scenario: the E. Coli and DIN concentrations at the Whitegate Aghada Downstream Monitoring Point 1. The concentrations of both of these parameters are above their relevant EQS thresholds of 500cfu/100ml and 0.25mg/l respectfully.

The Whitegate Aghada Downstream Monitoring Point 1 is located adjacent to the River Aghada's source discharge in the model and is therefore very sensitive to discharges from the river, which elevate concentrations locally. The proposed scheme however still results in a significant improvement in water quality at this monitoring point due to the removal of the untreated discharge from Rostellan. This improvement is demonstrated by the reduction in the E. Coli 95%ile concentration at this point from 3182 to 883cfu/100ml. The exceedance of the EQS threshold is therefore on account of the background concentration in the model and is not as a result of the impact of the proposed scheme.

From the results it appears as if the proposed scheme results in a reduction in the DIN 50%ile concentration at this same monitoring point (-0.02mg/l).

The model predicts that discharges from the proposed WwTP for Whitegate/Aghada are therefore in compliance with the relevant EU regulations.

Table 26: Coliform (95%ile) and nutrient (50%ile) concentrations at monitoring points

Label	95%ile						50%ile											
	E. Coli (cfu/100ml)			Intestinal Enterococci (cfu/100ml)			Dissolved Inorganic Nitrogen (mg/l)			Molybdate Reactive Phosphorus (mg/l)			Total Ammonia (mg/l)			Unionised Ammonia (mg/l)		
	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta
Roches Point	6	27	21	0	1	1	1E-02	9E-03	-5E-03	3E-03	2E-03	-9E-04	5E-03	4E-03	-1E-03	1E-04	7E-05	-3E-05
Cork Estuary 1	7	5	-2	0	0	0	2E-02	2E-02	3E-04	5E-03	5E-03	4E-05	7E-03	7E-03	2E-04	1E-04	1E-04	3E-06
Cork Estuary 2	36	36	0	1	1	0	3E-02	3E-02	1E-04	6E-03	6E-03	6E-05	1E-02	1E-02	3E-04	2E-04	2E-04	4E-06
Cork Estuary 3	45	44	-1	2	2	0	4E-02	4E-02	1E-04	8E-03	8E-03	3E-05	2E-02	2E-02	4E-04	3E-04	3E-04	8E-06
Aghada Power Station	39	12	-28	2	1	-1	4E-02	4E-02	-1E-03	6E-03	5E-03	-1E-04	2E-02	2E-02	-8E-04	3E-04	3E-04	-2E-05
Poulnacallee Bay	6	5	0	0	0	0	2E-02	2E-02	2E-04	5E-03	5E-03	4E-05	9E-03	9E-03	3E-04	2E-04	2E-04	5E-06
Fountainstown Beach	0	0	0	0	0	0	7E-03	7E-03	9E-05	2E-03	2E-03	2E-05	3E-03	3E-03	1E-04	5E-05	5E-05	2E-06
Myrtleville Bay	1	1	0	0	0	0	2E-02	2E-02	1E-04	4E-03	4E-03	4E-05	7E-03	7E-03	3E-04	1E-04	1E-04	4E-06
Ambient Monitoring Pt 1	18	18	0	0	0	0	9E-02	9E-02	-7E-04	3E-03	3E-03	-8E-05	9E-03	9E-03	-2E-04	2E-04	2E-04	-5E-06
Ambient Monitoring Pt 2	234	230	-4	1	1	0	2E-01	2E-01	-8E-04	5E-03	5E-03	-6E-05	1E-02	1E-02	-2E-04	4E-04	4E-04	-4E-06
Ambient Monitoring Pt 3	23	23	0	1	0	0	8E-02	8E-02	-8E-04	3E-03	3E-03	-8E-05	1E-02	1E-02	-3E-04	2E-04	2E-04	-5E-06
Ringaskiddy Upstream Monitoring Pt	116	116	0	5	5	0	1E-01	1E-01	2E-04	1E-02	1E-02	3E-05	9E-02	9E-02	1E-04	1E-03	1E-03	3E-06
Ringaskiddy Downstream Monitoring Point 1	53	11	-42	2	1	-2	4E-02	4E-02	-1E-03	6E-03	6E-03	-2E-04	2E-02	2E-02	-8E-04	3E-04	3E-04	-1E-05
Ringaskiddy Downstream Monitoring Pt 2	8	5	-3	0	0	0	2E-02	2E-02	2E-04	5E-03	5E-03	4E-05	7E-03	7E-03	2E-04	1E-04	1E-04	3E-06

Label	95%ile						50%ile											
	E. Coli (cfu/100ml)			Intestinal Enterococci (cfu/100ml)			Dissolved Inorganic Nitrogen (mg/l)			Molybdate Reactive Phosphorus (mg/l)			Total Ammonia (mg/l)			Unionised Ammonia (mg/l)		
	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta	Existing Scenario	Proposed Scenario	Delta
Whitegate/ Aghada Upstream Monitoring Pt	275	2	-272	11	0	-11	6E-02	6E-02	-5E-03	9E-03	8E-03	-8E-04	3E-02	3E-02	-2E-03	6E-04	6E-04	-3E-05
Whitegate/ Aghada Downstream Monitoring Pt 1	3182	883	-2298	95	4	-91	3E-01	3E-01	-2E-02	8E-03	6E-03	-2E-03	2E-02	2E-02	-7E-03	6E-04	5E-04	-1E-04
Whitegate/ Aghada Downstream Monitoring Pt 2	648	27	-620	25	0	-25	7E-02	7E-02	-4E-03	4E-03	3E-03	-9E-04	1E-02	9E-03	-3E-03	2E-04	2E-04	-6E-05
Shellfish point 1	89	93	4	3	4	0	6E-02	5E-02	-7E-03	3E-03	3E-03	-2E-04	1E-02	9E-03	-9E-04	2E-04	2E-04	-2E-05
Shellfish point 2	10	10	0	0	0	0	7E-02	7E-02	-6E-04	2E-03	2E-03	-2E-05	6E-03	6E-03	-2E-05	1E-04	1E-04	-1E-06
Shellfish point 3	77	33	-44	2	0	-2	7E-02	7E-02	-3E-04	3E-03	3E-03	-2E-04	1E-02	9E-03	-4E-04	2E-04	2E-04	-5E-06
Shellfish point 4	111	4	-107	4	0	-4	5E-02	4E-02	-8E-04	3E-03	3E-03	-2E-04	1E-02	1E-02	-8E-04	2E-04	2E-04	-1E-05

6.7 Mixing Zones

The mixing zone for the proposed outfall has been estimated as part of the study. Our methodology for calculating the mixing zone is:

- Run the proposed scenario model with all background concentrations included (i.e. the normal proposed conditions) for the entire simulation period;
- Calculate the 95%ile of the relevant WQ parameter;
- Present the 95%ile results with the colour palette set to the relevant target values of the relevant EU water directive.

As per Section 11.3 of the IW technical guidelines for marine modelling [1], mixing zones have been delineated for all water quality parameters considered in this study. The mixing zone for each WQ parameter has been defined based on the relevant EQS threshold, where the mixing zone is the area at which the percentile standard exceeds the EQS threshold for that parameter.

The results are presented in Figure 56 - Figure 61 with the target values set to those defined in the relevant EU directives.

For E.Coli, it can be seen that the mixing zone is limited to the immediate vicinity of the outfall and that the Whitebay shoreline maintains excellent water quality. The zone that exceeds the 500 cfu/100ml threshold is approximately 2,500m^2 in size.

For IE, DIN, MRP, TA and UIA, no mixing zone envelope is shown, indicating that the EQS threshold levels are not exceeded at the outfall location for any of these WQ parameters.

The mixing zone for each WQ parameter is in compliance with the targets outlined in Table 11-3 of the IW guidelines [1]. It can be concluded that the proposed scenario excellent water quality is maintained at the outfall location.

Figure 56: E. Coli Mixing Zone for outfall (outfall location indicated)

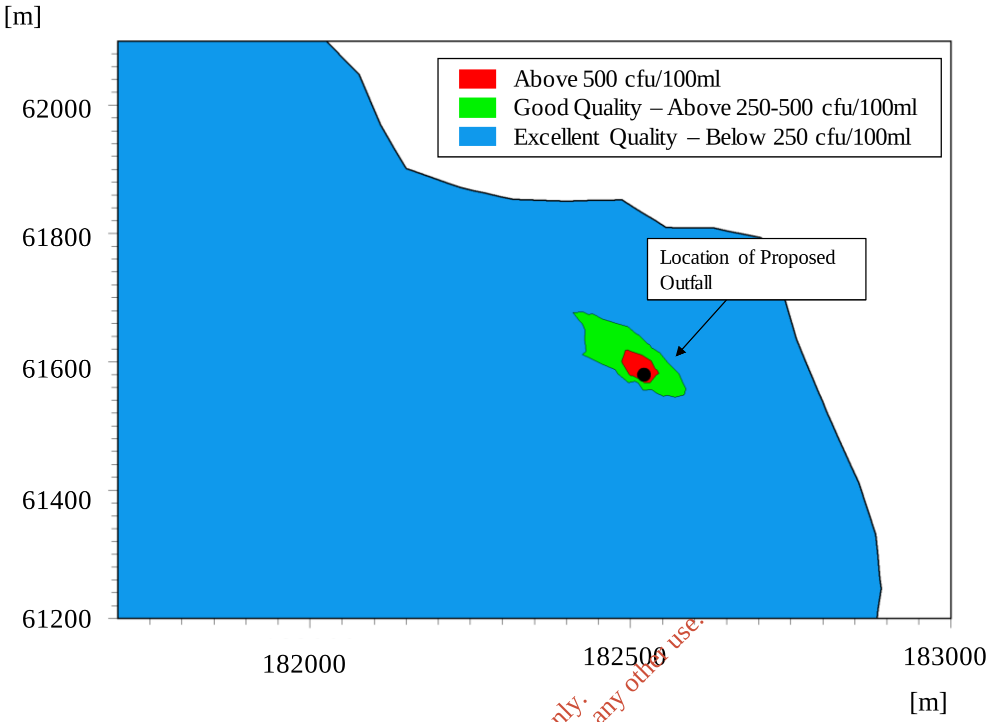


Figure 57: IE Mixing Zone for outfall (outfall location indicated)

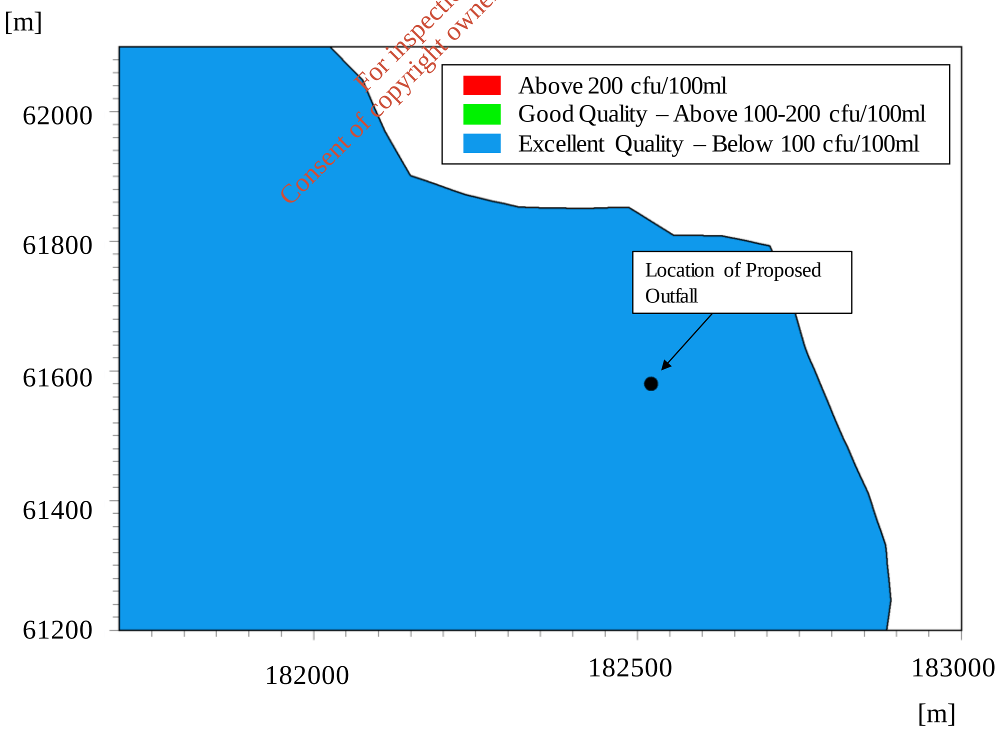


Figure 58: DIN Mixing Zone for outfall (outfall location indicated)

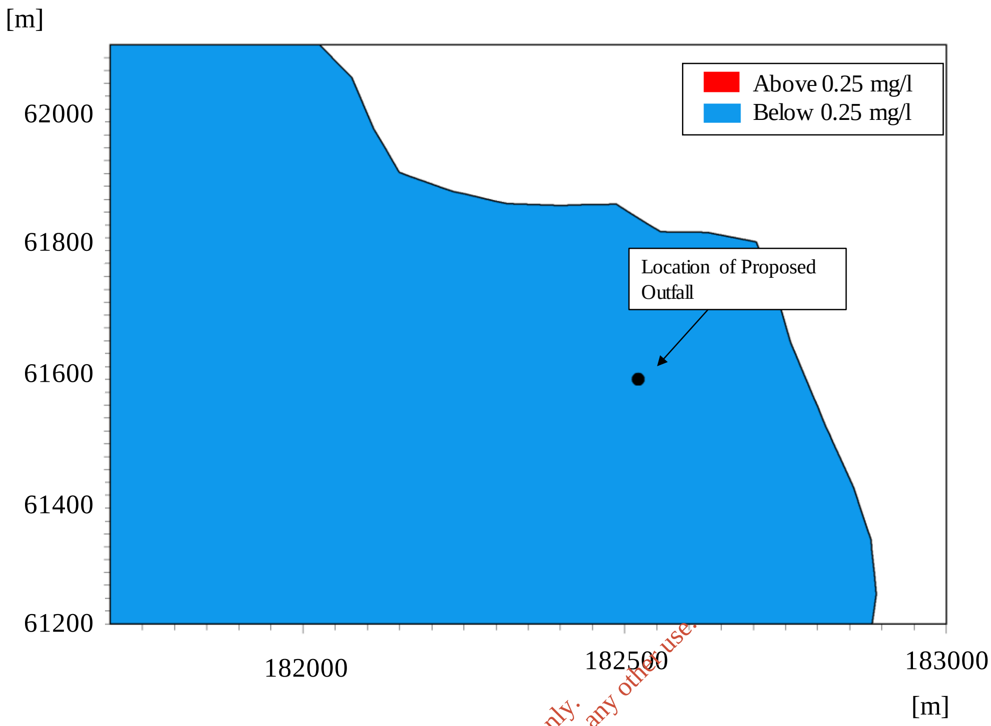


Figure 59: MRP Mixing Zone for outfall (outfall location indicated)

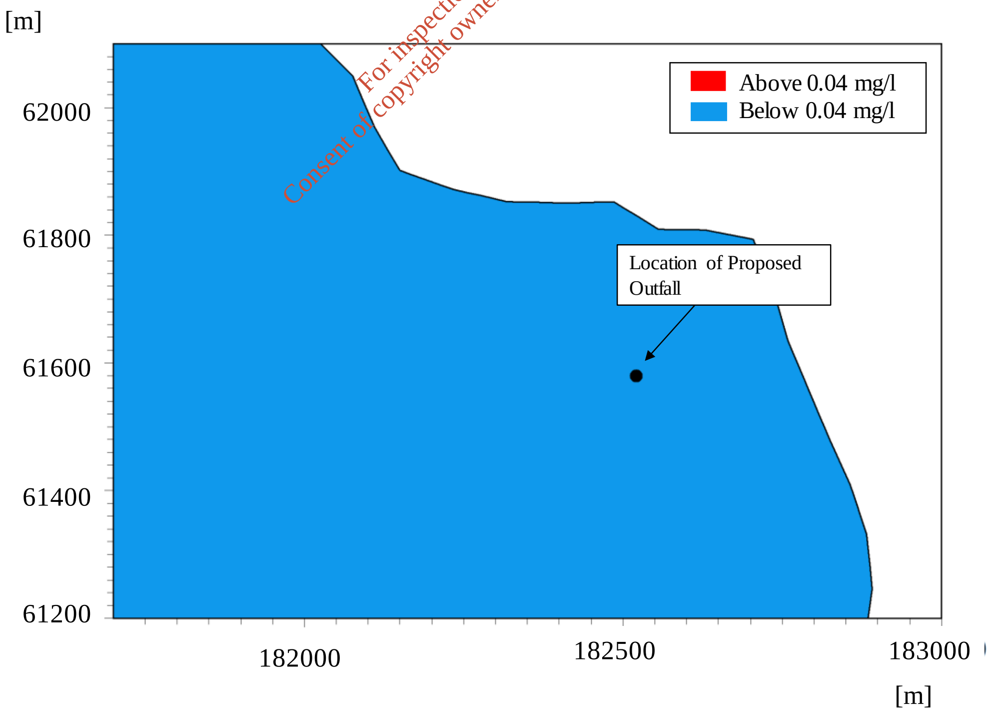


Figure 60: TA Mixing Zone for outfall (outfall location indicated)

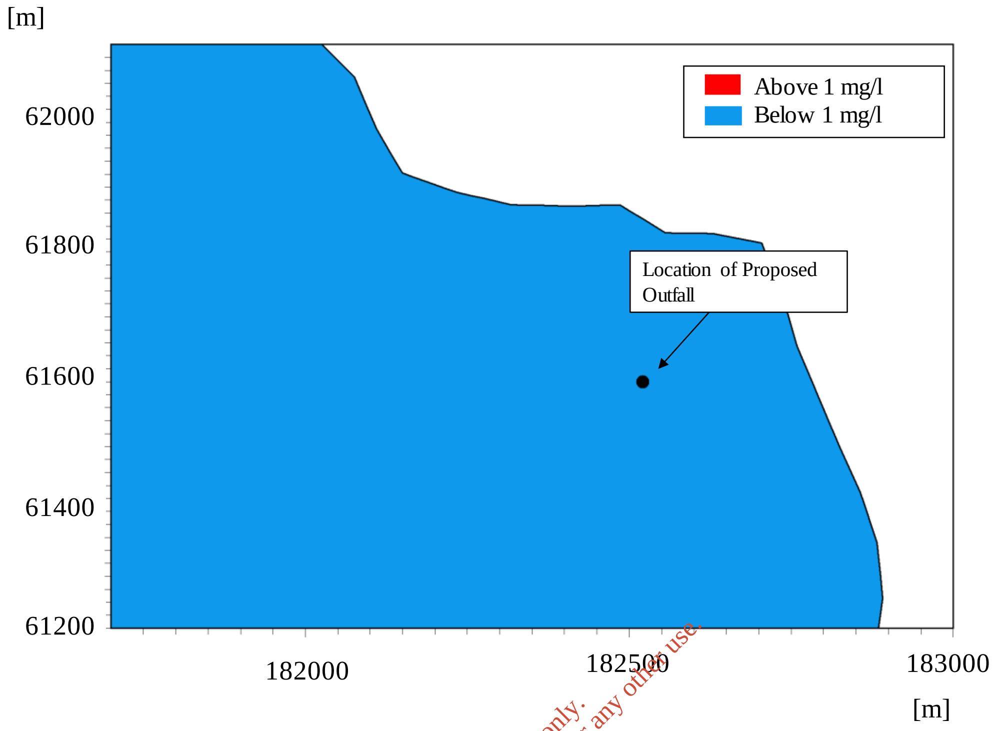
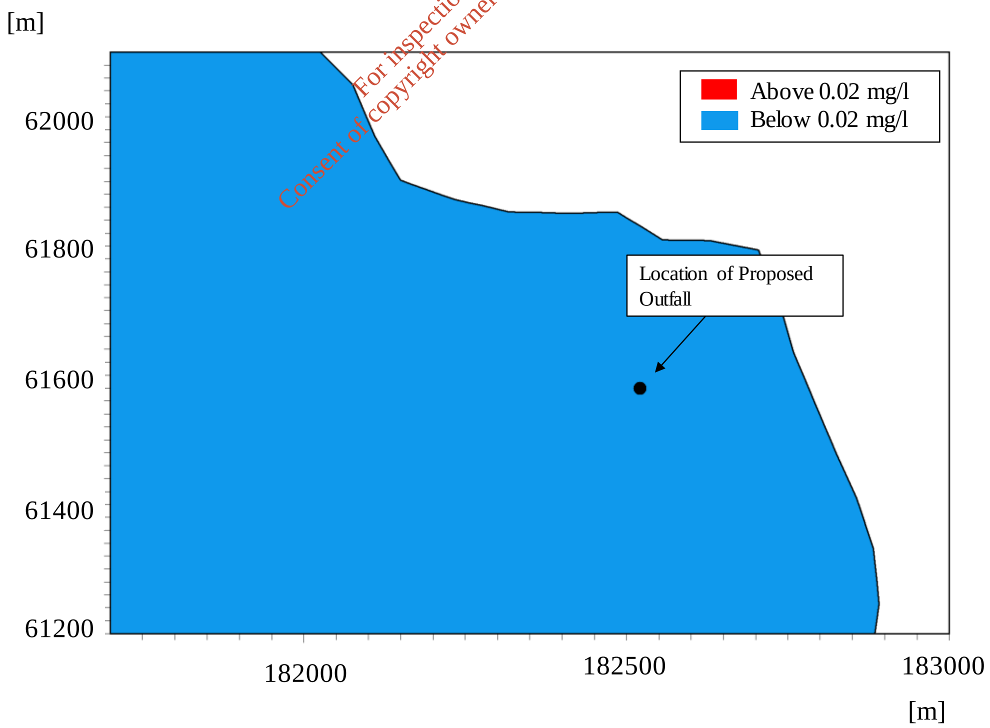


Figure 61: UIA Mixing Zone for outfall (outfall location indicated)



6.8 Discussion

The results of the model show that the 95%ile concentrations of both E. Coli and Intestinal Enterococci are significantly reduced in the outer harbour as a result of the scheme but are increased local to the outfall in Whitebay.

While Whitebay is not a designated EU Bathing Water area, we have considered our results in the context of the EQSs specified in the Bathing Water Directive in order to inform on the water quality. In the context of the EQS's, the increase in both E. Coli and Intestinal Enterococci are considered minor and excellent water quality will be achieved in Whitebay with the proposed scheme in place. The model results also indicate that the proposed scheme reduces the 95%ile concentrations of E. Coli and Intestinal Enterococci within the designated shellfish waters in Cork Harbour. The Bathing Water EQS thresholds are also are also not exceeded within these Shellfish areas.

The results of our model also show that the proposed scheme has a very minor impact on the existing 50%ile concentrations of DIN, MRP, TA and UiA in Cork Harbour. The results indicate a minor reduction in existing nutrient concentrations at the location of the existing untreated Whitegate/Aghada discharges in the outer harbour. There is also a minor increase in the 50%ile nutrient concentrations local to the outfall.

In context of the regulations, the results demonstrate that the proposed scheme does not cause any of the EQS thresholds in the harbour to be exceeded and the discharges from the proposed WwTP for Whitegate/Aghada are in full compliance with the EU water regulations.

7 Dispersion model sensitivity analysis

7.1 Overview

Four separate sensitivity analysis (SA) simulations runs were undertaken as part of work to assess the impact of the proposed scheme. These are:

- SA1: Decay Sensitivity –T90 value of both E. Coli and Intestinal Enterococci was increased from 20 hours to 40 hours;
- SA2: Wind Sensitivity – a Constant wind speed of 5.1m/s blowing from the South West (240 degrees). We note that this wind speed represents the 50%ile wind speed blowing from the predominate south westerly wind direction based on hourly data from Cork Airport from a single calendar year
- SA3: Dispersion coefficient sensitivity – Model run with an increased Scaled Eddy Viscosity Formulation factor of 1.5.
- SA4: Dispersion coefficient sensitivity – Model run with a decreased Scaled Eddy Viscosity Formulation factor of 0.5.

7.2 Sensitivity Analysis Results

The findings of the analysis are presented in the following tables.

Table 27: Sensitivity Analysis – 95%ile Escherichia Coliform concentrations

	Escherichia Coliforms (95%ile)				
	Proposed Scenario	**SA1 - Decay**		**SA2 - Wind**	
	(cfu/100ml)	**(cfu /100ml)**	**Delta**	**(cfu/100ml)**	**Delta**
Roches Point	28	32	4	24	-4
Cork Estuary 1	5	10	5	5	0
Cork Estuary 2	36	68	32	35	-1
Cork Estuary 3	44	95	51	45	1
Aghada Power Station	12	33	21	12	0
Poulnacallee Bay	5	13	8	4	-1
Fountainstown Beach	0	1	1	0	0
Myrtleville Bay	1	3	2	1	0
Midleton Monitoring Pt. 1	18	40	22	19	0
Midleton Monitoring Pt. 2	230	424	194	227	-3
Midleton Monitoring Pt. 3	23	45	23	23	0
Ringaskiddy Upstream Monitoring Point	116	264	148	117	1
Ringaskiddy Downstream Monitoring Pt. 1	11	31	20	12	0
Ringaskiddy Downstream Monitoring Pt. 2	5	10	5	5	0
Whitegate/Aghada Upstream Monitoring Point	2	9	6	18	15
Whitegate/Aghada Downstream Monitoring Pt. 1	883	1097	214	555	-328
Whitegate/Aghada Downstream Monitoring Pt. 2	27	52	25	6	-21

It can be seen from Table 27 that there is an increase in E. Coli concentrations at all monitoring points as a result of the slower T90 decay rate. In the context of the EQS thresholds, the increases in concentration do not result in the E. Coli threshold of 500cfu/100ml to be exceeded at any of the monitoring locations.

The 95%ile concentrations are not sensitive to the inclusion of wind forcing with the exception of the Whitegate/Aghada Downstream Monitoring Pt. 1. At this location the inclusion of the wind forcing reduces the E. Coli concentration.

Table 28: Sensitivity Analysis – 95%ile Escherichia Coliform concentrations

	Escherichia Coliforms (95%ile)				
	Proposed Scheme - Eddy Viscosity Scaling Factor of 1	SA3 - Eddy Viscosity Scaling Factor of 1.5		SA4 - Eddy Viscosity Scaling Factor of 0.5	
	(cfu/100ml)	(cfu/100ml)	Delta	(cfu/100ml)	Delta
Roches Point	28	27	0	24	-4
Cork Estuary 1	5	5	0	5	0
Cork Estuary 2	36	35	-1	35	-1
Cork Estuary 3	44	42	-2	48	5
Aghada Power Station	12	12	1	11	-1
Poulnacallee Bay	5	5	0	5	0
Fountainstown Beach	0	0	0	0	0
Myrtleville Bay	1	1	0	1	0
Midleton Monitoring Pt. 1	18	19	1	17	-1
Midleton Monitoring Pt. 2	230	239	9	220	-10
Midleton Monitoring Pt. 3	23	23	0	23	1
Ringaskiddy Upstream Monitoring Point	116	121	5	107	-9
Ringaskiddy Downstream Monitoring Pt. 1	11	12	1	10	-1
Ringaskiddy Downstream Monitoring Pt. 2	5	5	0	6	0
Whitegate/Aghada Upstream Monitoring Point	2	3	1	2	0
Whitegate/Aghada Downstream Monitoring Pt. 1	883	854	-30	976	92
Whitegate/Aghada Downstream Monitoring Pt. 2	27	26	-1	28	0

It can be seen that the model's results are not sensitive to the changes in the scaling factor on the dispersion coefficient, with the exception of the Whitegate/Aghada Downstream Monitoring Point 1 where there are minor changes in the modelled concentrations.

Table 29: Sensitivity Analysis – 95%ile Intestinal Enterococci concentrations

	Intestinal Enterococci (95%ile)				
	Proposed	**SA1 - Decay**		**SA2 - Wind**	
	(cfu/100ml)	**(cfu/100ml)**	**Delta**	**(cfu/100ml)**	**Delta**
Roches Point	1	1	0	1	0
Cork Estuary 1	0	1	0	0	0
Cork Estuary 2	1	3	1	1	0
Cork Estuary 3	2	4	2	2	0
Aghada Power Station	1	1	1	1	0
Poulnacallee Bay	0	0	0	0	0
Fountainstown Beach	0	0	0	0	0
Myrtleville Bay	0	0	0	0	0
Midleton Monitoring Pt. 1	0	1	0	0	0
Midleton Monitoring Pt. 2	1	2	1	1	0
Midleton Monitoring Pt. 3	0	1	1	0	0
Ringaskiddy Upstream Monitoring Point	5	11	6	5	0
Ringaskiddy Downstream Monitoring Pt. 1	1	1	1	1	0
Ringaskiddy Downstream Monitoring Pt. 2	0	1	0	0	0
Whitegate/Aghada Upstream Monitoring Point	0	0	0	0	0
Whitegate/Aghada Downstream Monitoring Pt. 1	4	5	1	2	-1
Whitegate/Aghada Downstream Monitoring Pt. 2	0	0	0	0	0

It can be seen from Table 29 that the slower decay rate for SA1 results in some minor increases in IE concentrations. The change with inclusion of the wind forcing is negligible. In the context of the EQS threshold, these increases do not result in the exceedance of the IE threshold of 200cfu/100ml at any of the monitoring locations.

Table 30: Sensitivity Analysis – 95%ile Intestinal Enterococci concentrations

	Intestinal Enterococci (95%ile)				
	Proposed-Eddy Viscosity Scaling Factor of 1	**SA3 - Eddy Viscosity Scaling Factor of 1.5**		**SA4 - Eddy Viscosity Scaling Factor of 0.5**	
	(cfu/100ml)	**(cfu/100ml)**	**Delta**	**(cfu/100ml)**	**Delta**
Roches Point	1	1	0	1	0
Cork Estuary 1	0	0	0	0	0
Cork Estuary 2	1	1	0	1	0
Cork Estuary 3	2	2	0	2	0
Aghada Power Station	1	1	0	1	0
Poulnacallee Bay	0	0	0	0	0
Fountainstown Beach	0	0	0	0	0
Myrtleville Bay	0	0	0	0	0
Midleton Monitoring Pt. 1	0	0	0	0	0
Midleton Monitoring Pt. 2	1	1	0	1	0
Midleton Monitoring Pt. 3	0	0	0	0	0
Ringaskiddy Upstream Monitoring Point	5	5	0	4	0
Ringaskiddy Downstream Monitoring Pt. 1	1	1	0	1	0
Ringaskiddy Downstream Monitoring Pt. 2	0	0	0	0	0
Whitegate/Aghada Upstream Monitoring Point	0	0	0	0	0
Whitegate/Aghada Downstream Monitoring Pt. 1	4	4	0	4	0
Whitegate/Aghada Downstream Monitoring Pt. 2	0	0	0	0	0

It can be seen from Table 30 that the results are not sensitive to the changes in the dispersion coefficient.

7.3 Discussion

A number of sensitivity model runs have been undertaken which have examined changes to the decay rates, wind forcing and dispersion coefficient. The results for E. Coli and Intestinal Enterococci have been presented and demonstrate that none of the sensitivity runs would result in changes to the outcome of this modelling study. In the context of the regulations, the differences in concentrations as a result of the sensitivity runs do not lead to an exceedance of the relevant EQS thresholds at any of the monitoring points. The other WQ parameters were included in the sensitivity model runs but are not presented as they have similar findings.

It can be concluded that the model results are not sensitive to changes in decay rates, wind forcing or the dispersion coefficient.

8 Cumulative Impact Scenario

With the Lower Harbour Main Drainage Scheme project in place, untreated wastewater from Cobh will be collected and treated at the Shanbally WwTP. This scenario has been considered as part of the study and incorporated in two separate future scenarios:

- 10-year future scenario;
- 30-year future scenario.

The WwTP discharges for these future scenarios were estimated based on Irish Water's predicted growth rates for each of the agglomerations. Only the Midleton WwTP is projected to exceed its design capacity (as given by the most recent AER). It has been assumed as part of these future scenarios that additional capacity will be added to the plant. These flow rates for the future scenarios are presented in Table 31.

Table 31: Future estimated WwTP discharges

WwTP Outfall	Proposed scenario discharges (m^3/s)	Projected 2030 future scenario discharges (m^3/s)	Projected 2050 future scenario discharges (m^3/s)
Saleen Village	0.0003	0.00033	0.00039
Proposed outfall	0.0085	0.0101	0.0133
North Cobh	0.0064	0.0080	0.0115
Carrigrennan (Cork City)	1.395	1.7303	2.6356
Shanbally/IDA	0.1622	0.2160	0.2780
Midleton/ID	0.28	0.3820	0.5740
Carrigtwohill 1	0.0271	0.038	0.064
Carrigtwohill 2	0.0271	0.038	0.064

The fluvial river inflows and industrial outfall source discharges are unchanged for the future scenario model runs. The concentrations of the various WQ parameters for both the treated effluent and river inflows were left unchanged for these future scenarios.

The exception to the above are the Shanbally/IDA and Midleton/ID outfalls, which are a combination of WwTP and industrial flows. The future flows and WQ parameter concentrations for these discharges were provided by Irish Water.

Table 32 and Table 33 below present the 95%ile concentrations for E. Coli and Intestinal Enterococci for the future scenarios. The differences between the future scenario and the proposed scenario are also displayed. It can be seen that there are decreases in the 95%ile concentration at the monitoring points closer to Cobh which can be attributed to the removal of untreated waste being discharged at Cobh. There are also however some increases in the 95%ile concentration in the vicinity of the Shanbally outfall due to the increased loading from the outfall.

Table 32: E. Coli 95%ile concentrations at monitoring points for the future scenarios

	E. Coli				
	Proposed	2030		2050	
	(cfu/100ml)	(cfu/100ml)	Diff	(cfu/100ml)	Diff
Roches Point	28	33	5	44	16
Cork Estuary 1	5	7	2	10	5
Cork Estuary 2	36	7	-29	10	-26
Cork Estuary 3	44	13	-31	18	-26
Aghada Power Station	12	9	-3	12	1
Poulnacallee Bay	5	4	-1	5	-1
Fountainstown Beach	0	0	0	0	0
Myrtleville Bay	1	1	0	1	0
Midleton Monitoring Pt. 1	18	19	1	22	3
Midleton Monitoring Pt. 2	230	230	0	230	0
Midleton Monitoring Pt. 3	23	24	1	27	4
Ringaskiddy Upstream Monitoring Point	116	78	-38	119	3
Ringaskiddy Downstream Monitoring Pt. 1	11	9	-3	12	1
Ringaskiddy Downstream Monitoring Pt. 2	5	7	2	10	5
Whitegate/Aghada Upstream Monitoring Point	2	2	0	2	0
Whitegate/Aghada Downstream Monitoring Pt. 1	883	883	-1	881	-3
Whitegate/Aghada Downstream Monitoring Pt. 2	27	27	0	28	0

There are minor changes to the 95% Intestinal Enterococci concentrations (Table 33) which are minor and not deemed significant. In the context of the EU water quality regulations, the predicted increase of WwTP hydraulic loads for these future scenarios do not lead to an exceedance of the relevant EQS thresholds at any of the monitoring points.

Table 33: Intestinal Enterococci 95%ile concentrations at monitoring points for the future scenarios

	Intestinal Enterococci				
	Proposed	**2030**		**2050**	
	(cfu/100ml)	**(cfu/100ml)**	**Diff**	**(cfu/100ml)**	**Diff**
Roches Point	1	1	0	2	1
Cork Estuary 1	0	1	0	1	0
Cork Estuary 2	1	1	-1	1	-1
Cork Estuary 3	2	1	-1	1	-1
Aghada Power Station	1	1	0	1	0
Poulnacallee Bay	0	0	0	0	0
Fountainstown Beach	0	0	0	0	0
Myrtleville Bay	0	0	0	0	0
Midleton Monitoring Pt. 1	0	0	0	0	0
Midleton Monitoring Pt. 2	1	1	0	1	0
Midleton Monitoring Pt. 3	0	0	0	0	0
Ringaskiddy Upstream Monitoring Point	5	3	-2	5	0
Ringaskiddy Downstream Monitoring Pt. 1	1	1	0	1	0
Ringaskiddy Downstream Monitoring Pt. 2	0	1	0	1	0
Whitegate/ Aghada Upstream Monitoring Point	0	0	0	0	0
Whitegate/ Aghada Downstream Monitoring Pt. 1	4	4	0	4	0
Whitegate/ Aghada Downstream Monitoring Pt. 2	0	0	0	0	0

9 Discussion and Conclusions

A high-resolution MIKE 21 Water Quality model of Cork Harbour has been developed as part of the study to assess the concentrations of E. Coli, Intestinal Enterococci, DIN, MRP, Ammonia and Unionised Ammonia in the harbour with the proposed WwTP at Whitegate/Aghada in place.

The results of the model show that the 95%ile concentrations of both E. Coli and Intestinal Enterococci are significantly reduced in the eastern part of the Outer Harbour with the proposed scheme in place. The results also show that the 50%ile concentrations of DIN, MRP, TA and UiA are also considerably reduced.

The results also indicate that the 95%ile concentrations of both E. Coli and Intestinal Enterococci as well as the 50%ile concentrations of the other modelled nutrients are increased in the vicinity of the proposed outfall location. The increases however do not lead to the EQS at any of the designated EPA Surface Water Regulation monitoring points to be exceeded and the Whitebay shoreline still retains excellent water quality with the proposed outfall in place.

The proposed scheme therefore does not cause any of the EQS thresholds in Cork harbour to be exceeded and the discharges from the proposed WwTP for Whitegate are in full compliance with the relevant EU water regulations.

A number of sensitivity model runs have been undertaken which have examined changes to the decay rate, wind forcing, and dispersion coefficient. None of the sensitivity runs cause any of the EQS thresholds to be exceeded at any of the monitoring points.

Two future scenarios were also assessed as part of the project for 2030 and 2050. These model runs increased the outfall flow rates at all the relevant outfalls in Cork Harbour based on projected population growth rates. Neither of these future scenarios resulted in the coliform EQS thresholds being exceeded at the monitoring points within the harbour.

It can therefore be concluded that the proposed WwTP at Whitegate/Aghada is fully compliant with all the relevant Water Quality legislation.

References

[1] Irish Water, "Technical Standards - Marine Modelling Rev 1.0," IW, 2018.

[2] AECOM & Jennings O'Donovan, "Cork UTAS Design Reports and Technical Notes for Whitegate/Aghada," 2016.

[3] Scottish Environment Protection Agency (SEPA), "Supporting Guidance (WAt-SG-11) Modelling Coastal and Transitional Discharges, Version V3.0," 2013.

[4] Statutory Instruments No. 254 of 2001, "Irish Statutory Requirements, 2001. S.I. No. 254/2001 - Urban Waste Water Treatment Regulations," SI, 14 June 2001.

[5] European Union, "Environmental Objectives (Surface Waters) (Amendment) Regulations. S.I. No. 77 of 2019," EU, 2019.

[6] European Union, "Directive 2006/7/EC of the European Parliment and of the Council of 15 Fenruary 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC," EU, 2006.

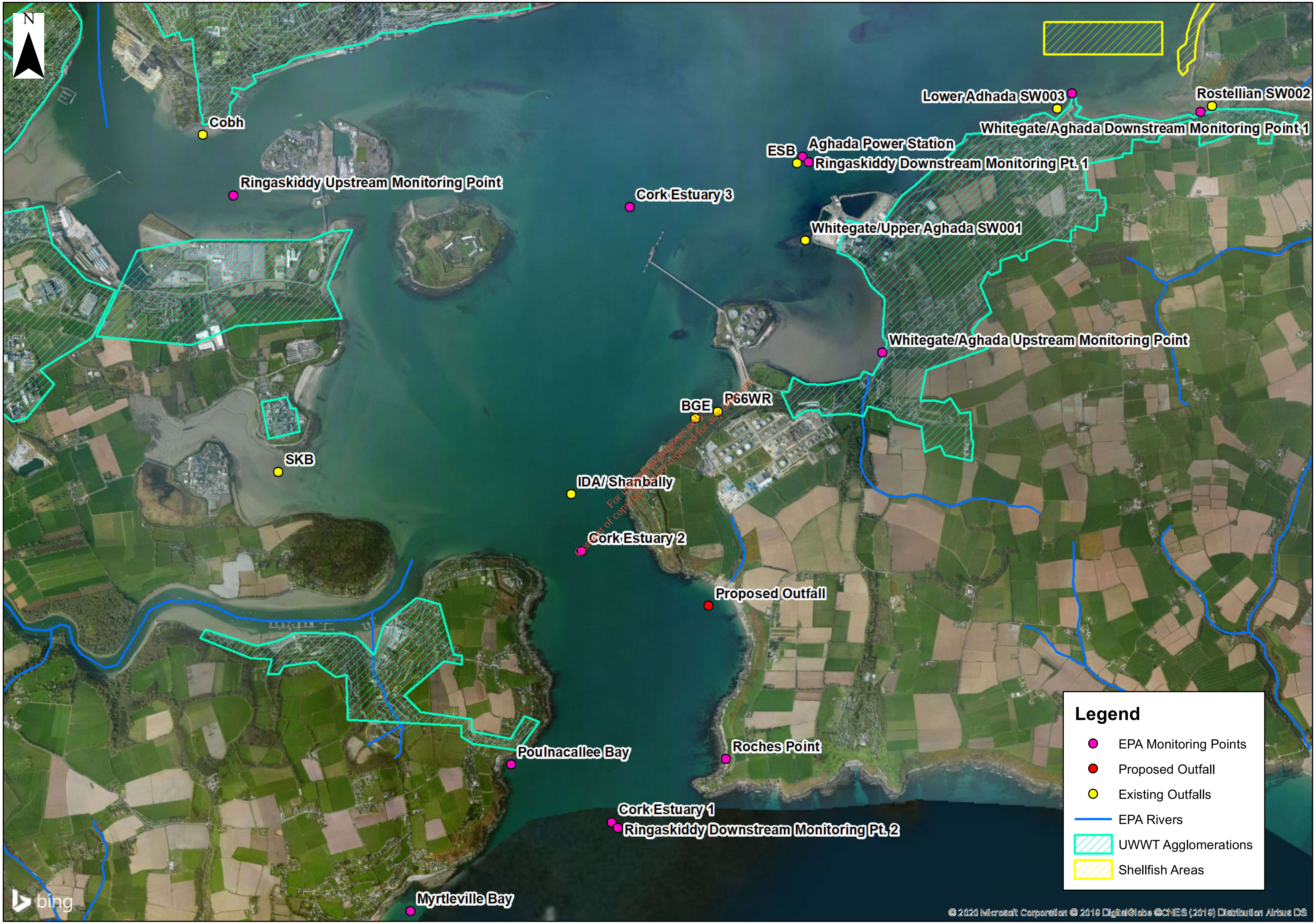
[7] Irish Statutory Requirements No 79 of 2008, "Irish Statutory Instruments, 2006 European Communities (Quality of Shellfish Waters) Regulations," SI, 22nd May 2006.

[8] Arup, "Cork UTAS, Whitegate/Aghada Phase 1 Dispersion Modelling Report," 16th December 2019.

[9] Irish Water, "Technical Standards - Marine Modelling, Revision 1.86," IW, 2019.

Appendix A

Area of Interest Map


N
Cobh
Ringaskiddy Upstream Monitoring Point
Cork Estuary 3
ESB
Aghada Power Station
Ringaskiddy Downstream Monitoring Pt. 1
Lower Adhada SW003
Rostellian SW002
Whitegate/Aghada Downstream Monitoring Point 1
Whitegate/Upper Aghada SW001
Whitegate/Aghada Upstream Monitoring Point
BGE
P66WR
SKB
IDA/ Shanbally
Cork Estuary 2
Proposed Outfall
Poulnacallee Bay
Roches Point
Cork Estuary 1
Ringaskiddy Downstream Monitoring Pt. 2
Myrtleville Bay
Legend
EPA Monitoring Points
Proposed Outfall
Existing Outfalls
EPA Rivers
UWWT Agglomerations
Shellfish Areas
bing
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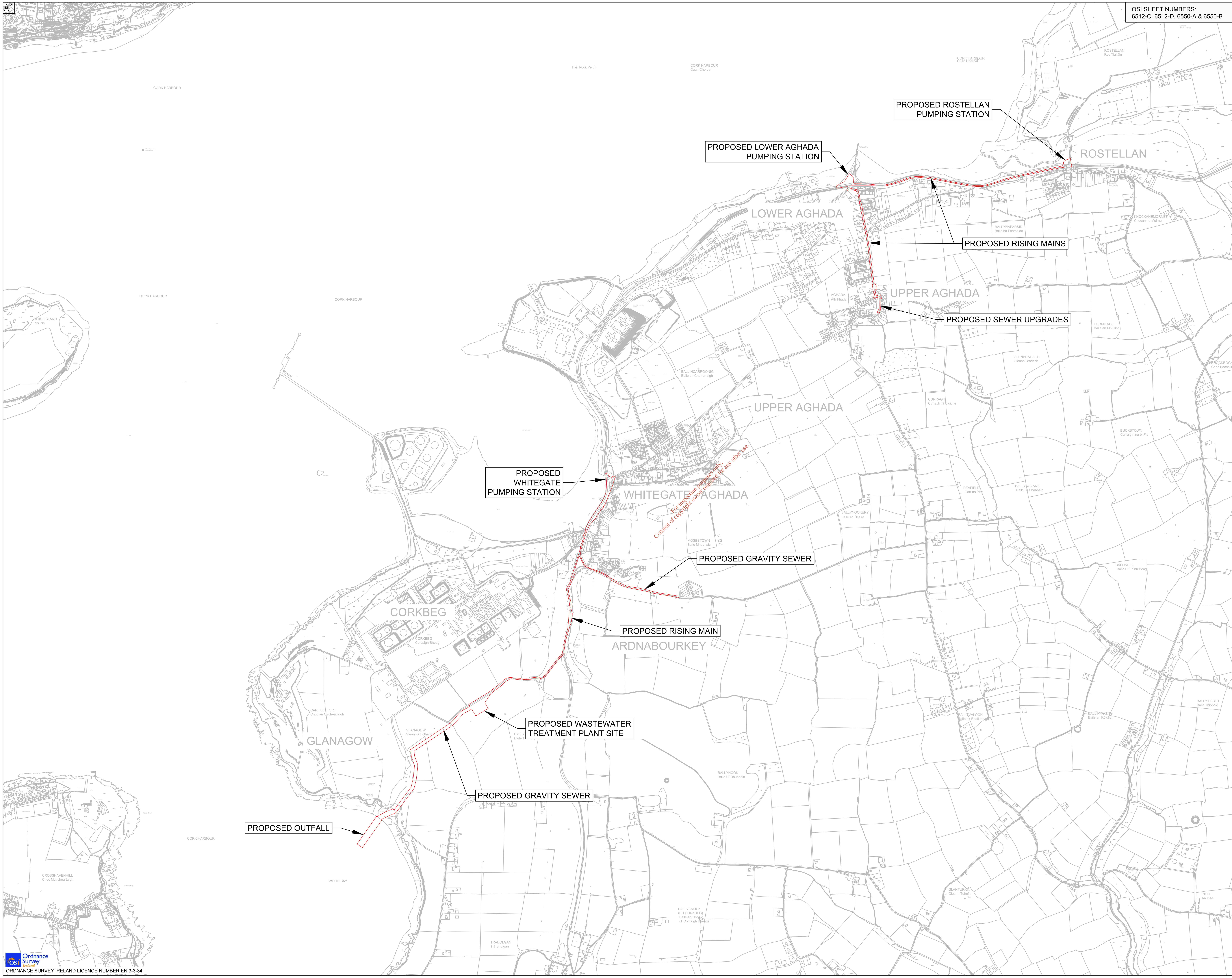
Appendix B

Proposed Scheme



GENERAL NOTES

N W E S

LEGEND:

PROPOSED SITE BOUNDARY

NOTES:

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS AND SPECIFICATIONS.
2. ANY QUERIES OR DISCREPANCIES ARE TO BE REFERRED TO THE EMPLOYER'S REPRESENTATIVE IMMEDIATELY.

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Rev	Date	Description	By	Chk	App
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PROJECT

WHITEGATE - AGHADA SEWERAGE SCHEME
UTAS - CORK BUNDLE

DRAWING TITLE

LOCATION MAP

STATUS

FOR PLANNING

Date: 12/07/19	Scale: 1:10560@A1	Drawn: TD	Chk: AM	App: KOS
Project No: 257589-00	Drg. No: IW-10015229-03-01-001			Rev: P1

Appendix C

Phase 1 - Near Field Modelling Report

Irish Water

Cork UTAS

Whitegate/Aghada Phase 1 Dispersion Modelling Report

Issue 1 | 16 December 2019

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 257589-00

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Document Verification

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			Prepared by	Checked by	Approved by
		Name	Daniel Walsh	Kevin Barry	Donal O Connor
		Signature			
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		Name	Daniel Walsh	Kevin Barry	Evelyn McAuliffe
		Signature			
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		Description			
			Prepared by	Checked by	Approved by
		Name	Daniel Walsh	Kevin Barry	Kevin O'Sullivan
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

1 Introduction

1.1 Background

As part of the Cork UTAS project, Arup has been commissioned by Irish Water to undertake dispersion modelling for the proposed Whitegate/Aghada Wastewater Treatment Plant (WWTP) in order to assess the compliance of the effluent discharge from the site with the relevant water quality legislation. The site in consideration is located in Whitebay in Cork Harbour.

At present, sewage from Whitegate/Aghada is currently discharging untreated into Cork Harbour. It is proposed to build a new WWTP and network in to provide primary treatment for the effluent. The proposed WWTP will be located to the south of Whitegate with treated effluent to be discharged via a proposed outfall pipeline to the mouth of Cork Harbour in a south-westerly direction. The proposed outfall location near the mouth of Cork Harbour is shown in Figure 1 below.

Figure 1: Location of proposed outfall

Following guidance from Irish Water, the work is being undertaken in two distinct phases:

- **Phase 1:**
  - Data gathering and quality assurance;
  - Screening assessment to determine the relevant Water Quality (WQ) parameters at the site;

  - Near-field[1] dispersion modelling to calculate concentrations of the relevant WQ parameters in the immediate vicinity of the outfall where the buoyancy and momentum of the effluent discharge dominate the mixing process;
  - Make recommendations for the scope of Phase 2.

- **Phase 2:**
  - Where required, procure and manage a marine hydrographic survey which has been recommended and scoped as part of Phase 1;
  - Where required, undertake far-field[2] dispersion modelling of the relevant WQ parameters at the site;
  - Undertake a compliance assessment for the relevant minimum Environmental Quality Standards (EQS) at the site;
  - Where the EQS's are exceeded, advise on what level of additional treatment and/or dilution is required in order to meet with the requirements.

This report details the findings of Phase 1 of the study and provides recommendations on Phase 2. The findings of Phase 2 are presented in a separate far-field modelling report.

1.2 Guidance documents

The following guidance documents have been assessed as part of the study:

- DRAFT Irish Water Technical Standards for Marine Modelling;
- UTAS Design Reports and Technical Notes for the site (AECOM/Jennings O'Donovan);
- Scottish Environment Protection Agency, Modelling Coastal and Transitional Discharges, Supporting Guidance (WAT-SG-11);
- Relevant Regulatory Framework documents:
  - Urban Waste Water Treatment Regulations 2001;
  - Surface Water Regulations 2009;
  - The Bathing Water Directive 2006/7/EC;
  - The Shellfish Directive 2006/113/EC.

[1] The near field relates to the initial mixing zone area immediately adjacent to the outfall where the buoyancy and momentum of the outfall discharge is dominant
[2] The far field relates to the mixing zone outside the near field where the outfall discharge loses all its initial buoyancy and momentum and becomes passive

2 Water Quality Legislation

2.1 Irish Water Standards

The DRAFT Irish Water Technical Standards for Marine Modelling lists the parameters that are to be modelled as part of marine outfall compliance assessments to "demonstrate compliance with Surface Water, Bathing Water and Shellfish legislation".

These parameters are listed as:

- Temperature;
- Salinity;
- Biochemical Oxygen Demand (BOD);
- Dissolved Oxygen (DO);
- Escherichia Coli (EC);
- Intestinal Enterococci (IE);
- Norovirus;
- Molybdate-Reactive Phosphorus (MRP);
- Dissolved Inorganic Nitrogen (DIN);
- Nitrate;
- Nitrite;
- Ammonia;
- Chlorophyll-a.

Irish Water have noted to Arup that this list is not exhaustive and, if necessary, other water quality parameters that are not listed may also need to be assessed in order to demonstrate compliance.

2.2 Screening Assessment

A screening assessment has been undertaken to determine which Water Quality Legislation is enacted at the site. From this the WQ parameters that need to be assessed at the site to demonstrate compliance with the relevant legislation can be determined.

The findings of the screening assessment are presented in Table 1. The table is colour coded to aid the reader in determining which legislation is governing the inclusion of each of the water quality parameters. We note that in addition to the legislative requirements, Arup have consulted with Irish Water on the list of water quality parameters that are to be assessed as part of the study.

Table 1: WQ modelling parameters

Whitegate
Temperature
Salinity
BOD
DO
-
MR Phosphorus
Intestinal Enterococci
DI Nitrogen
Faecal Coliforms and E Coli
Relevant Legislation
Surface Water Regulations 2009
Bathing Water Directive
Shellfish Directive

3 Near Field Dispersion

3.1 Background

The near-field concentrations of the WQ parameters listed in Table 1 have been calculated. The modelling has been undertaken using Visjet which is an industry standard software for undertaking near field modelling[3]. Visjet allows for the buoyancy and momentum of the effluent discharge, as well as the hydrodynamic conditions of receiving water, to be considered as part of the near-field modelling.

3.2 Data requirements

The data requirements and data sources for the near-field modelling are listed in Table 2.

Table 2: Near field data requirements

Site	Data	Sources
Whitegate/Aghada	Ambient background WQ conc.	EPA monitoring data and Irish Water Agglomeration Annual Environmental Report
	Tidal data and datums	2018 survey data and UK/Ireland Admiralty Tide Tables
	Outfall configuration	We have assumed a single horizontal diffuser port outfall with a diameter of 80mm
	Bed elevation at outfall	Bathymetric data from 2018 survey
	Current speed	Current speed data from 2018 survey
	Effluent loadings and concentrations	Calculated by Arup design team and instruction from Irish Water
	Target levels	Relevant WQ regulations

The temporal resolution of the EPA water quality dataset is relatively coarse and peak concentrations in the water column may therefore not be captured by the dataset.

[3] The Springer Handbook of Ocean Engineering 2016 lists Visjet (which is also known as Jetlag) as an industry standard near-field software on page 15 (Section C).

As part of this report we have not assessed the implications of this and how as a consequence the background concentrations of the WQ parameters may vary throughout the year.

Further we note that background concentrations of MRP in Whitegate/Aghada are not available from the EPA database. The background concentration of MRP for Whitegate Aghada has therefore been set equal to zero for the near field dispersion modelling. It will however be considered in greater detail as part of the Phase 2 of the study.

3.3 Loadings from the outfall

Table 3 presents the loadings from the proposed outfall.

Table 3: Effluent concentrations (with primary treatment)

Parameter	Whitegate/Aghada
Mean Flow (m^3/s)	0.00845
BOD (mg/l O2)	280
DO (mg/l)	0
SS (mg/l)	-
DIN (mg/l)	41
MR Phosphorous (mg/l)	9
Intest. Enterococci (cfu/100ml)	4x104
EC and FC (cfu/100ml	1x106

3.4 Diffuser port configuration assessment

As part of this study, a high-level assessment of the diffuser port configuration was undertaken in order to assess the sensitivity of different port configurations on the near field dilutions and exit velocities from the ports.

The Springer Book of Ocean Engineering[4] notes that there is a risk of seawater intrusion into sewage outfalls as the effluent density is less than the density of seawater.

To mitigate this risk a Froude number greater than 1.6 is recommended for port discharges to ensure the exit velocity from the ports are high enough to prevent intrusion. Wood et al[5] also recommend a minimum port diameter of 65mm for a port diffuser.

[4] The Springer Handbook of Ocean Engineering 2016
[5] I.R. Wood, R.G. Bell, D.L. Wilkinson, Ocean Disposal of Waste (World Scientific, Singapore 1993)

A single port diffuser of 80mm diameter is recommend as the preferred configuration for the outfall at the site. This approach is justified:

- Given the relatively low design effluent flow the scope for including a number of port diffusers at the outfall is limited as additional ports will result in the reduction of the port exit velocity and therefore increase the risk of seawater intrusion.
- The 80mm diameter exceeds the minimum recommended by Wood.

The outfall arrangement will need to be confirmed as part of the detailed design of the outfall.

3.5 Near-field dispersion modelling results

3.5.1 Overview of initial dilution

The dilution at the water surface was calculated at hourly intervals for both Spring and Ebb tidal cycles. The 95%ile and 50%ile exceedance values were then calculated from these dilutions. The findings of the analysis are presented in Table 4 below.

Table 4: Number of dilutions at water surface

Scenario	Whitegate/Aghada
95%ile scenario	119
50%ile scenario	533

For compliance with SEPA guidelines, an initial dilution of 100 is recommended for primary treated effluents in the near-field. It is evident from the results that the Whitegate/Aghada outfall has achieved this guideline for the 95%ile scenario with a dilution value of 119.

3.5.2 Whitegate/Aghada near field concentrations

The near-field concentration results for Whitegate/Aghada are presented in Table 5 (95%ile scenario) and Table 6 (50%ile scenario). The concentrations have been calculated by dividing the effluent concentration by the number of dilutions and subsequently adding the background concentration values. The highlighted parameters in each percentile table are the parameters whose EQS relates to the that particular percentile.

It can be seen from Table 5 that concentrations of BOD and DO are below the EQS target levels for the 95%ile scenario in the near field. Discharges of BOD and DO from the proposed Whitegate/Aghada outfall are therefore in full compliance with all the relevant legislation in the near field.

No further assessment of their impact in the far field is therefore required. It can also be seen that concentrations of IE and EC/FC are above their EQS target levels.

Table 5: 95%ile scenario: Initial Dilution of 119

Parameter	Treated Eff. Conc.	Background Conc.	Conc. After I.D.	Target Level	Additional Far Field Dilution Required
BOD (mg/l O2)	280	0.5	2.8	4.0	0
DO (%Saturation)	0	105	104.1	80-120	0
DIN (mg/l)	41	0.10	0.44	0.25	1
MR Phosphorus (mg/l)	9	0	0.08	0.04	1
Intest. Entercocci (cfu/100ml)	40,000	349	682	100	6
E-Coli and FC (cfu/100ml)	1,000,000	943	9324	250	37

Table 6: 50%ile scenario: Initial Dilution of 533

Parameter	Treated Eff. Conc	Backgroun d Conc.	Conc. After I.D.	Target Level	Additiona l Far Field Dilution Required
BOD (mg/l O2)	280	0.5	1.0	4.0	0
DO (%Saturation)	0	105	104.8	80-120	0
DIN (mg/l)	41	0.10	0.18	0.25	0
MR Phosphorus (mg/l)	9	0	0.02	0.04	0
Intest. Entercocci (cfu/100ml)	40,000	349	423	100	4
E-Coli and FC (cfu/100ml)	1,000,000	943	2817	250	11

It can be seen from **Table 6** that concentrations of DIN and MRP are below the 50%ile EQS target levels and are therefore in full compliance with all the relevant legislation in the near field. No further assessment of their concentrations in the far field is therefore required.

As the concentrations of IE and EC/FC for the Whitegate/Aghada outfall exceed their respective EQS target values in the near field it is necessary to assess their impact in the far field as they have an adverse impact on sensitive receptors. This work will be undertaken as part of Phase 2 of the project as discussed in Section 5.

4 Recommendations

The findings of our near-field dispersion modelling indicate that a number of the WQ parameters considered as part of the study exceed their respective EQS thresholds in the near field. There is therefore a risk that the transport of these parameters in the far field may have an adverse impact on the sensitive receptors in the far field and a Phase 2 study is therefore required. Recommendations for Phase 2 are presented in the following sections.

An assessment of the impact of the following WQ parameters in the far field of Cork Harbour is required in order to assess the compliance of the discharge from the outfall on sensitive receptors:

- Intestinal Enterococci;
- Escherichia coli/Faecal Coliforms.

Following advice from Irish Water, Molybdate Reactive Phosphorus and Dissolved Inorganic Nitrogen are also to be assessed in the far field as part of Phase 2 of the study.

5 Far field Dispersion Modelling

5.1 Proposed models

We propose to construct far field dispersion models for Whitegate/Aghada in order to simulate the transport and decay of the WQ parameters listed the previous section. The model will be developed in MIKE 21 and consist of two separate components:

- **Hydrodynamic (HD) module** – simulates the depth-averaged time-varying water level, current speed and direction for the model domain under varying tidal, wind and river flow forcing. The salinity and temperate gradient will also be included in the HD model.
- **Ecolab (EL) module** – simulates the release, transport and decay of the relevant WQ parameters in response the hydrodynamics and dispersion characterise of the site of interest.

Both modules will be fully coupled and run together as a single integrated model. As detailed in the following section, the hydrodynamic model will be calibrated and validated against recorded data before being utilised to simulate a range of design scenarios.

5.2 Data requirements

Far-field dispersion models require extensive datasets in order to develop, calibrate, validate and run the models. We have undertaken a detailed review of all the available datasets and the findings of our analysis is presented in Table 7.

Table 7: Available datasets

Bathymetry	Hydrographic (water level, current speed & direction, temperature & salinity)	Drogue/Dye release data	WQ parameter background concentration data
Whitegate/Aghada			
Port of Cork surveyed the site of interest in 2017 and the dataset is deemed suitable for use in the study. The data will be integrated with additional survey and Infomar data to form a complete composite bathymetric dataset for the harbour and area outside Roches Point.	No suitable data available for the site of interest. New survey data therefore required.	No suitable data available for the site of interest. New survey data therefore required.	EPA WQ dataset is deemed suitable. We note however that the temporal resolution of the dataset is relatively coarse. Peak concentrations in the water column may therefore not be captured by the dataset.

5.3 New Marine Surveys

We propose to appoint a hydrographic surveyor to collate the data listed in the table below. Once Irish Water have approved the scope of the surveys, Arup will confirm the fees and programme for undertaking the works.

5.3.1 Whitegate/Aghada Marine Survey

We propose collecting:

- **HD model development –** Single beam bathymetric survey at the site of interest.
- **HD calibration data –** Measurement of water level at surface, current speed & direction at different locations in the water column at a high temporal frequency at the site of interest. The data will be collected for two separate 12hr periods: a spring tide period and a neap tide period. We note that this data will be collected from a boat.
- **HD boundary condition data –** Measurement of water level at surface for the same periods as noted above at a distance from the site of interest.
- **WQ calibration data –** Drogue release survey for spring tide conditions and neap tide conditions (i.e. two separate surveys). Drogues to be released at the location of the outfall at the surface and below water surface.

The indicative fee for this survey is circa €8,900 ex. VAT.

5.4 Hindcast data

We note that Arup may utilise hindcast data (i.e. Deltares ISM model, Proundman CS3 model etc.) as part of the study in order to derive design water level and/or flux boundary conditions of the various models.

5.5 Scope of the far field modelling

Our proposed methodology for undertaking the far-field modelling for Whitegate/Aghada has been developed following consultation with Irish Water and referring to the DRAFT Irish Water Technical Standards for Marine Modelling.

Our scope of work is summarised as:

- Develop a hydrodynamic model for the site of interest with sufficient spatial resolution to accurately resolve the hydrodynamics. Our model will be developed using a flexible mesh.
- The boundary condition of the model will be located at a sufficient distance from the key area of interest in order to ensure boundary effects do not influence the performance of the model in the area of interest and that no concentrations are lost through the open boundary.

- The hydrodynamic model will be calibrated against the spring tide water level, current speeds and current direction data. The model will be validated against the equivalent neap tide data.
- The water quality dispersion model will be calibrated against both the salinity data and the findings of the drogue spring tide release survey. The water quality model will be validated against the neap tide datasets.
- Once calibrated and validated a number of design runs will be undertaken which will consider various forcing's of tide, wind, river flow and different decay rates of the water quality parameters.
- Undertaking a compliance assessment at the key area of interest to determine if the effluent discharge is in exceedance of the minimum EQS for the WQ parameters considered as part of the far-field modelling.
- Consult with the design team and, if required, advise on the need for greater removal efficiency in the WWTP and/or relocation of the marine outfall. Alterative configurations of the outfall diffuser will also be considered.
- A final report will be produced which will detail all aspects of the model development and calibration and the findings of the Water Quality modelling.

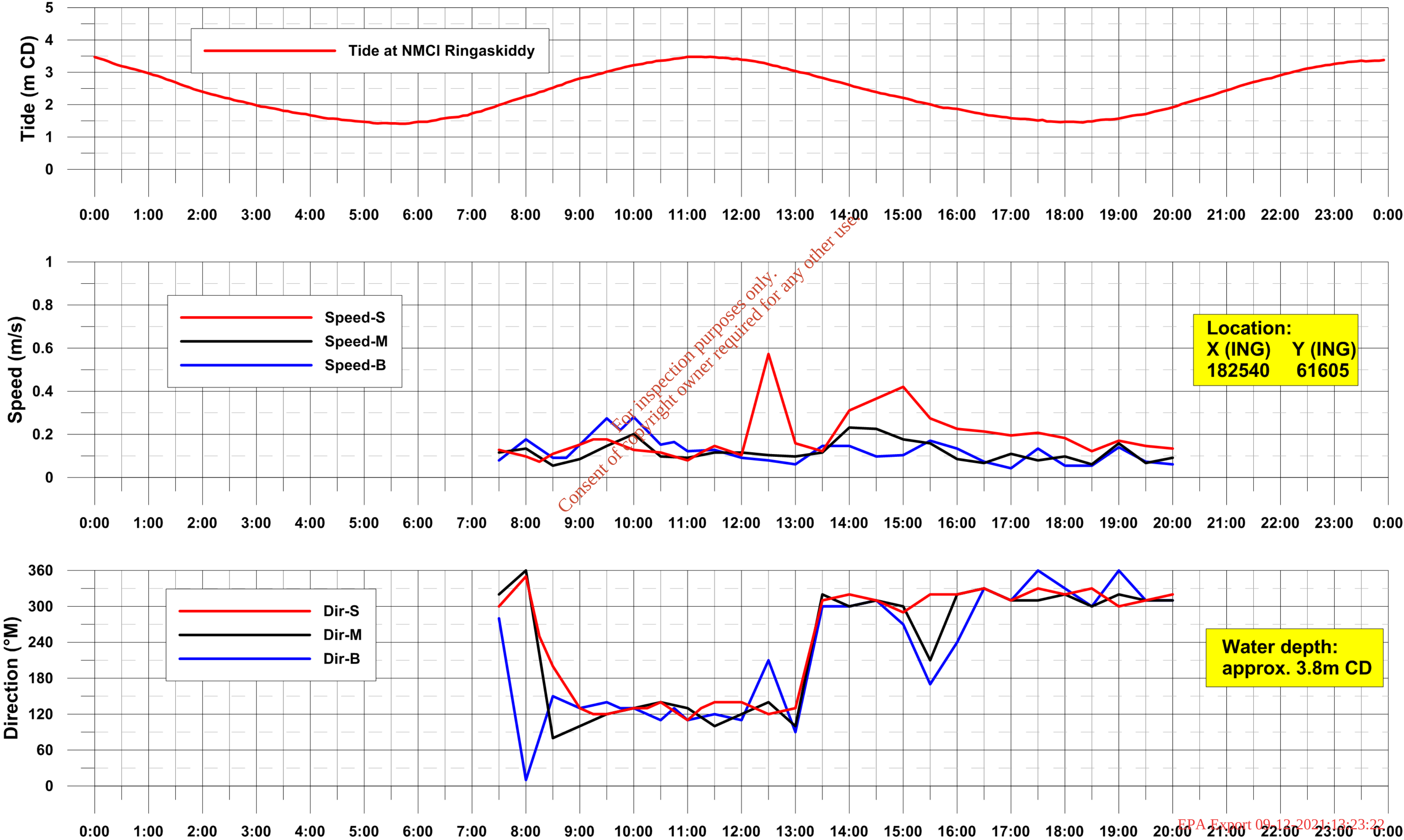
Appendix D

Marine Survey Data

UTAS Surveys for Arup & Irish Water

Cork Harbour - White Bay

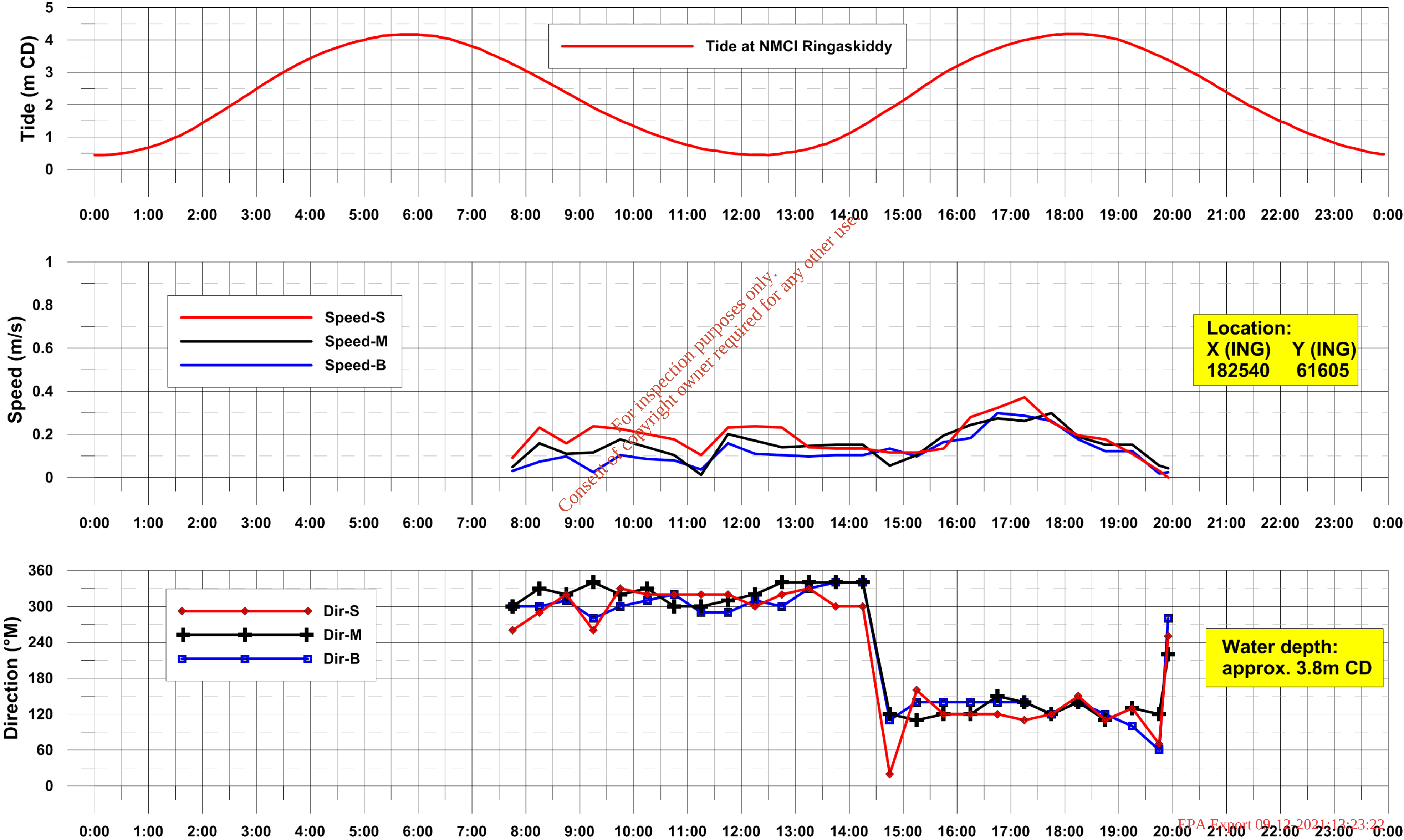
Fixed Station Current Speed and Direction - April 8th 2018



UTAS Surveys for Arup & Irish Water

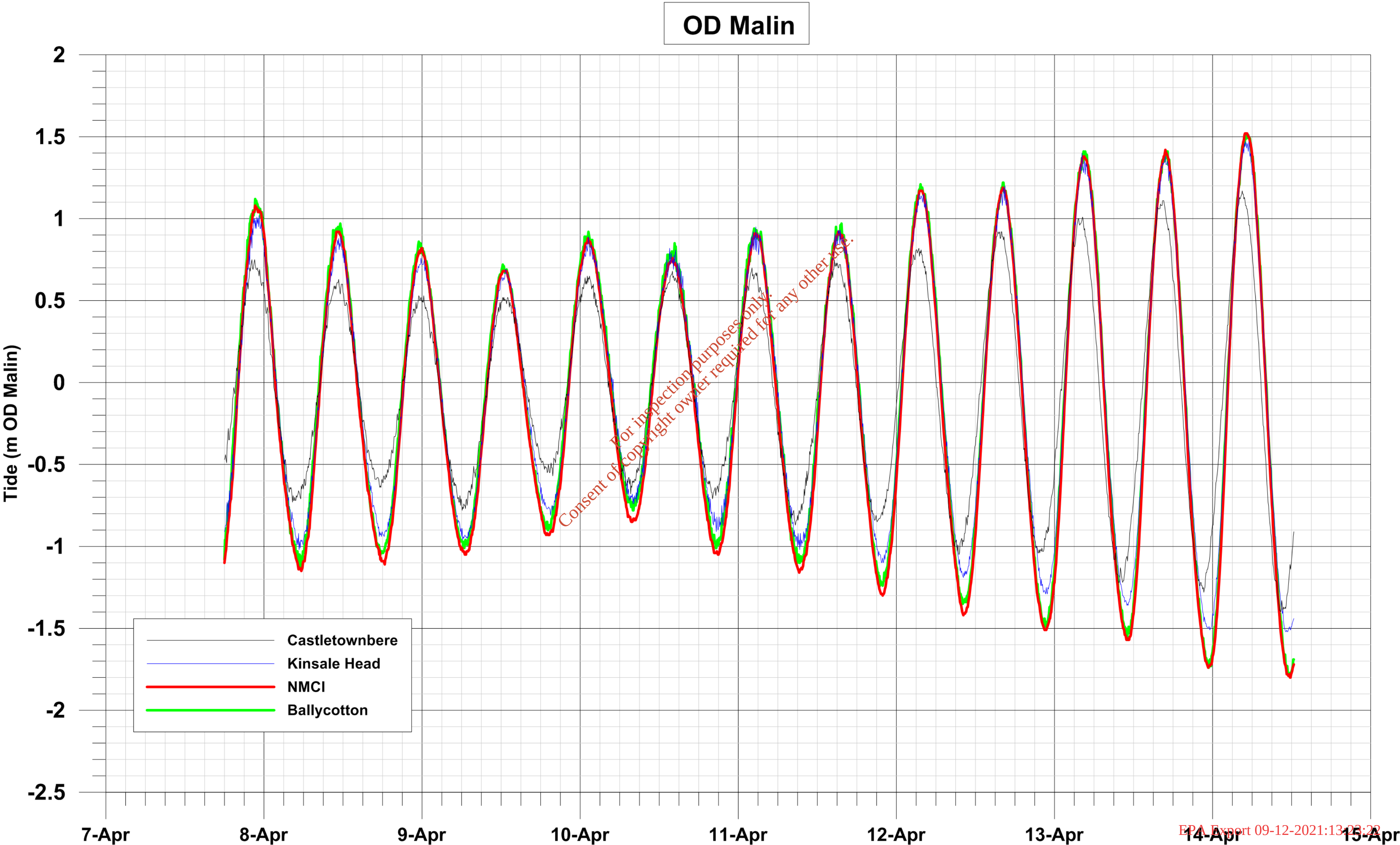
Cork Harbour - White Bay

Fixed Station Current Speed and Direction - April 29th 2018



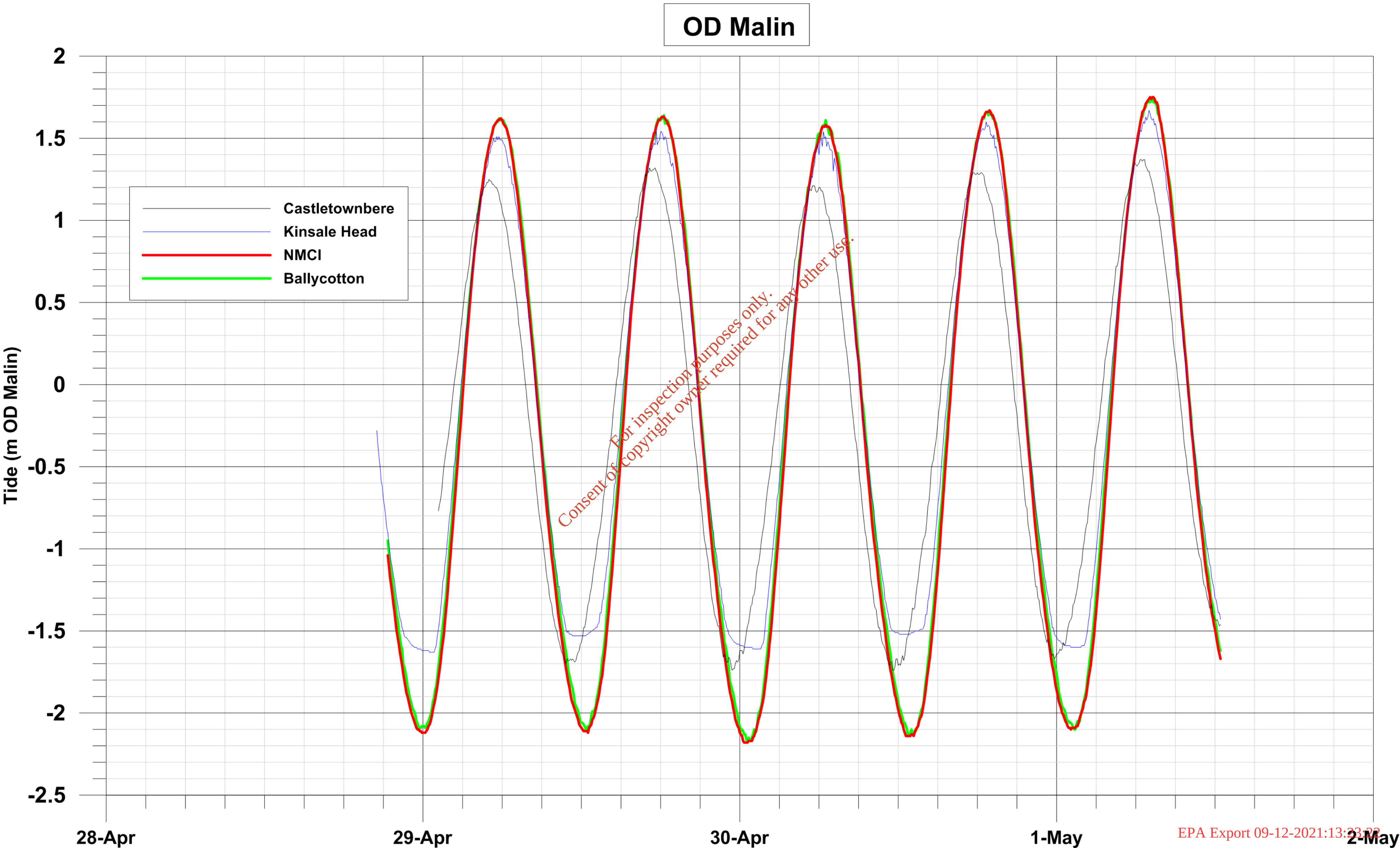
UTAS Surveys for Arup & Irish Water

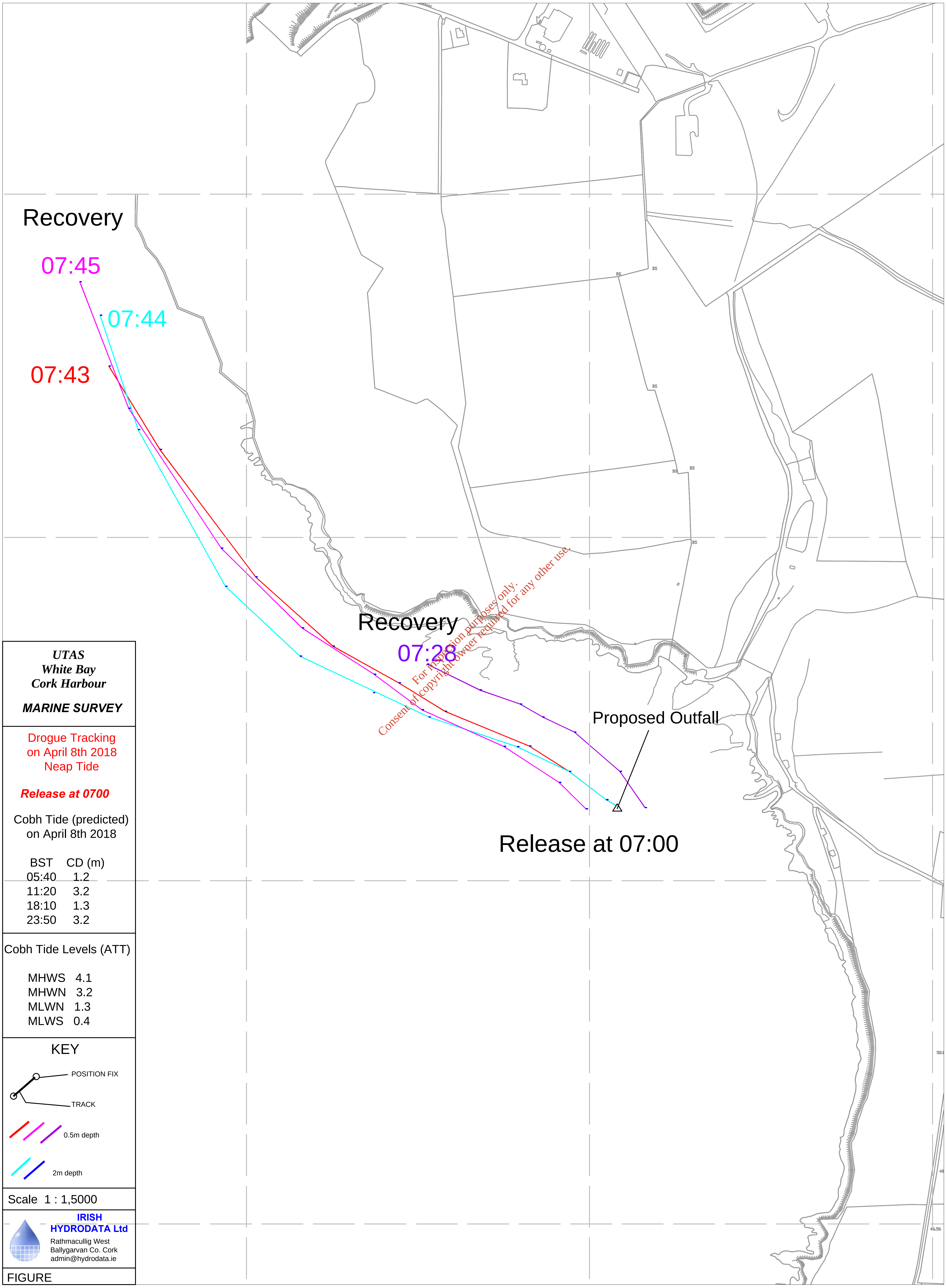
Tide at Kinsale Head - April 7th to 14th 2018

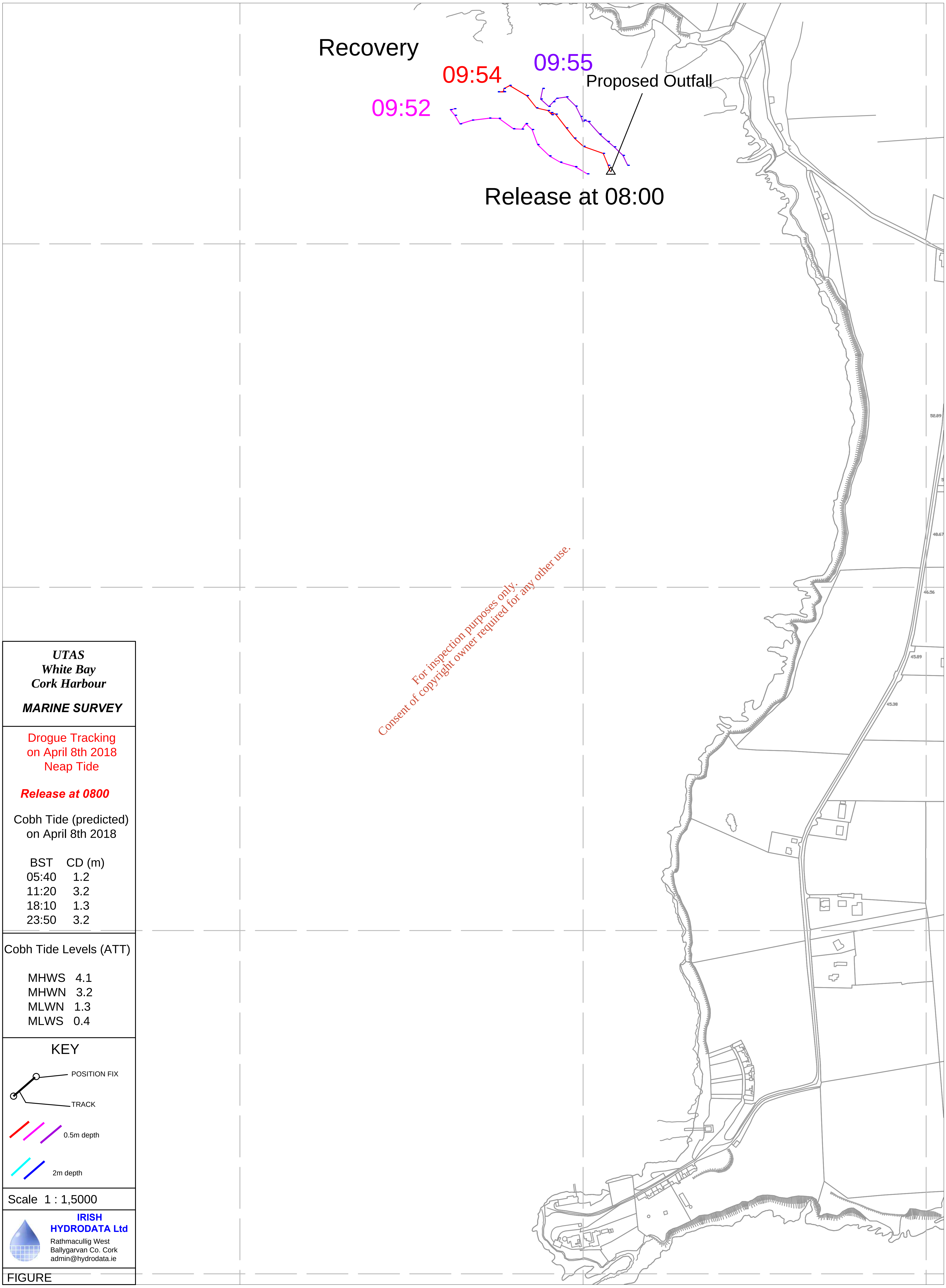


UTAS Surveys for Arup & Irish Water

Tide at Kinsale Head - April 28th to May 1st 2018




Recovery
07:45
07:44
07:43
Recovery
07:28
Proposed Outfall
Release at 07:00
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 0700
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 8th 2018
Neap Tide

Release at 0800

Cobh Tide (predicted)
on April 8th 2018

BST	CD (m)
05:40	1.2
11:20	3.2
18:10	1.3
23:50	3.2

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

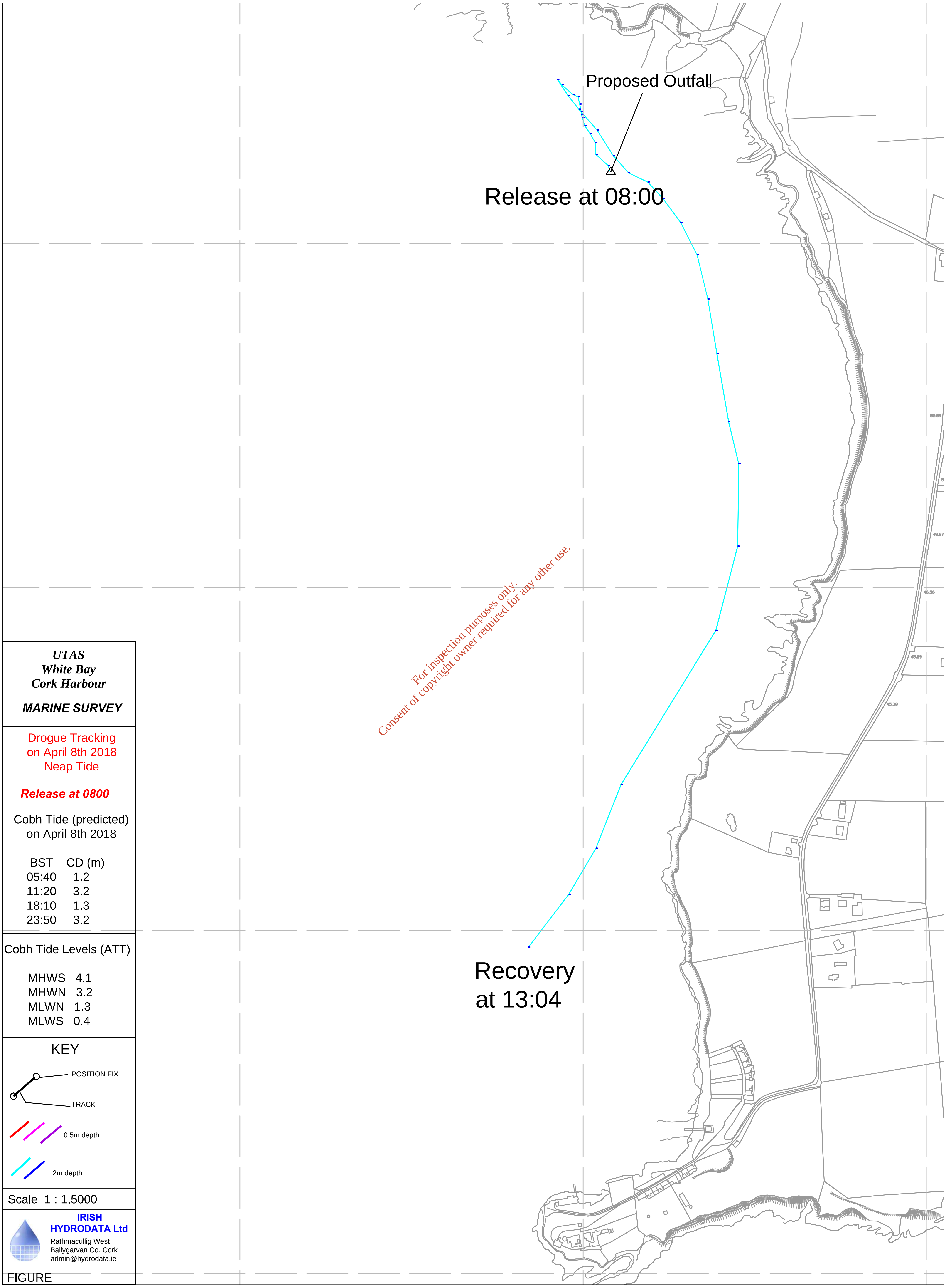
KEY

POSITION FIX
TRACK
0.5m depth
2m depth

Scale 1 : 1,5000

IRISH HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie

FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 8th 2018
Neap Tide

Release at 0800

Cobh Tide (predicted)
on April 8th 2018

BST	CD (m)
05:40	1.2
11:20	3.2
18:10	1.3
23:50	3.2

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

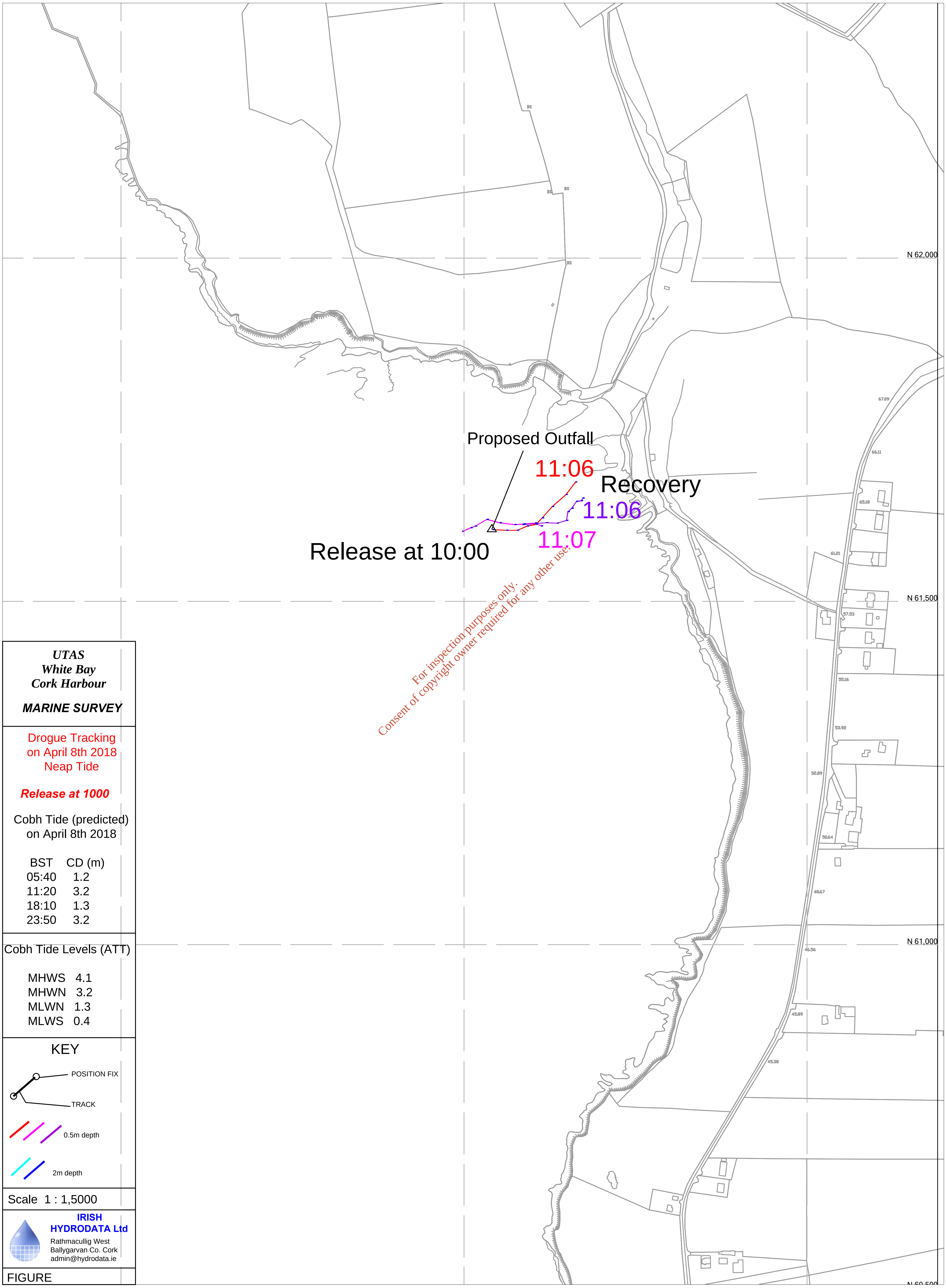
KEY

POSITION FIX
TRACK
0.5m depth
2m depth

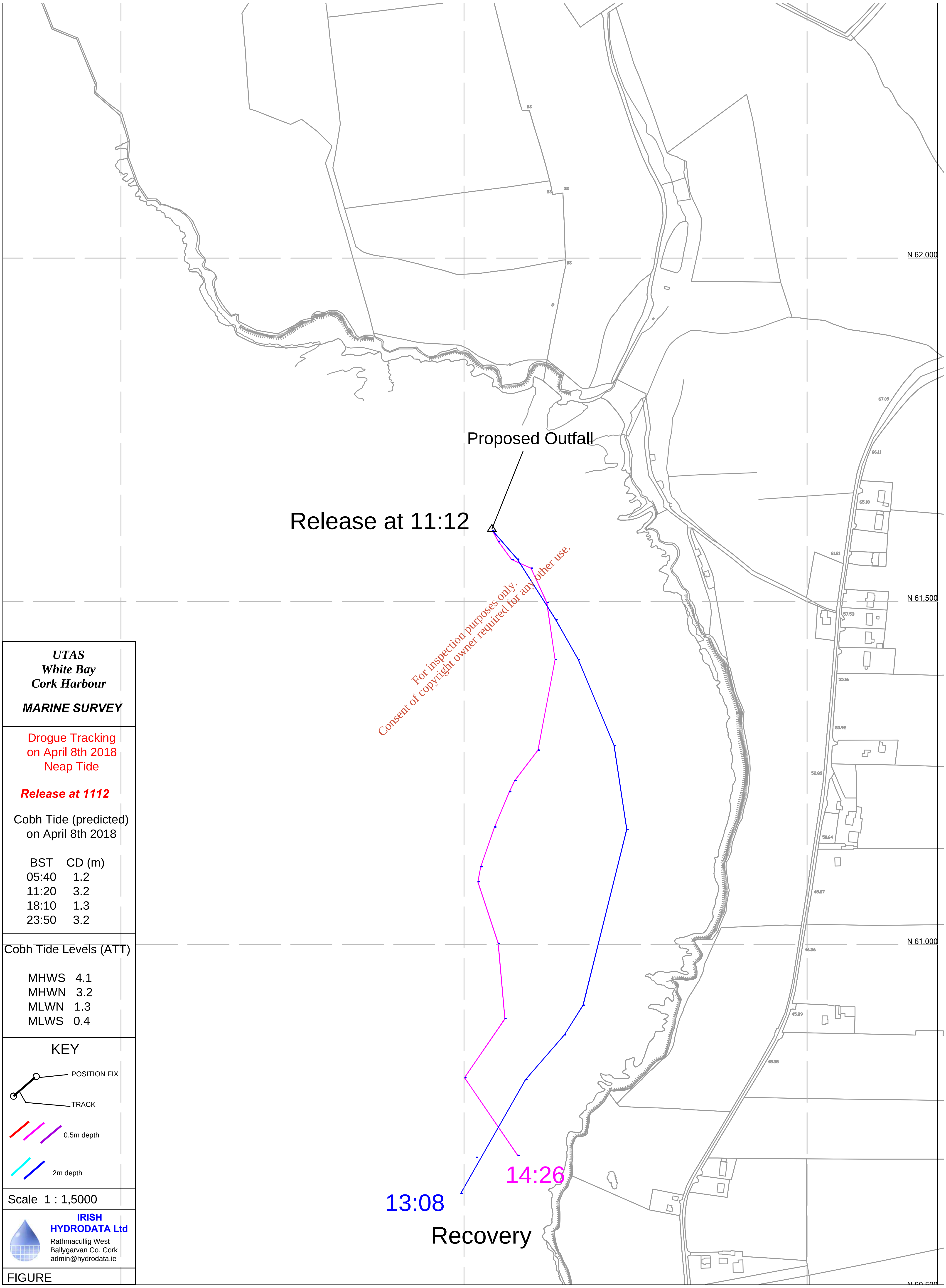
Scale 1 : 1,5000

IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie

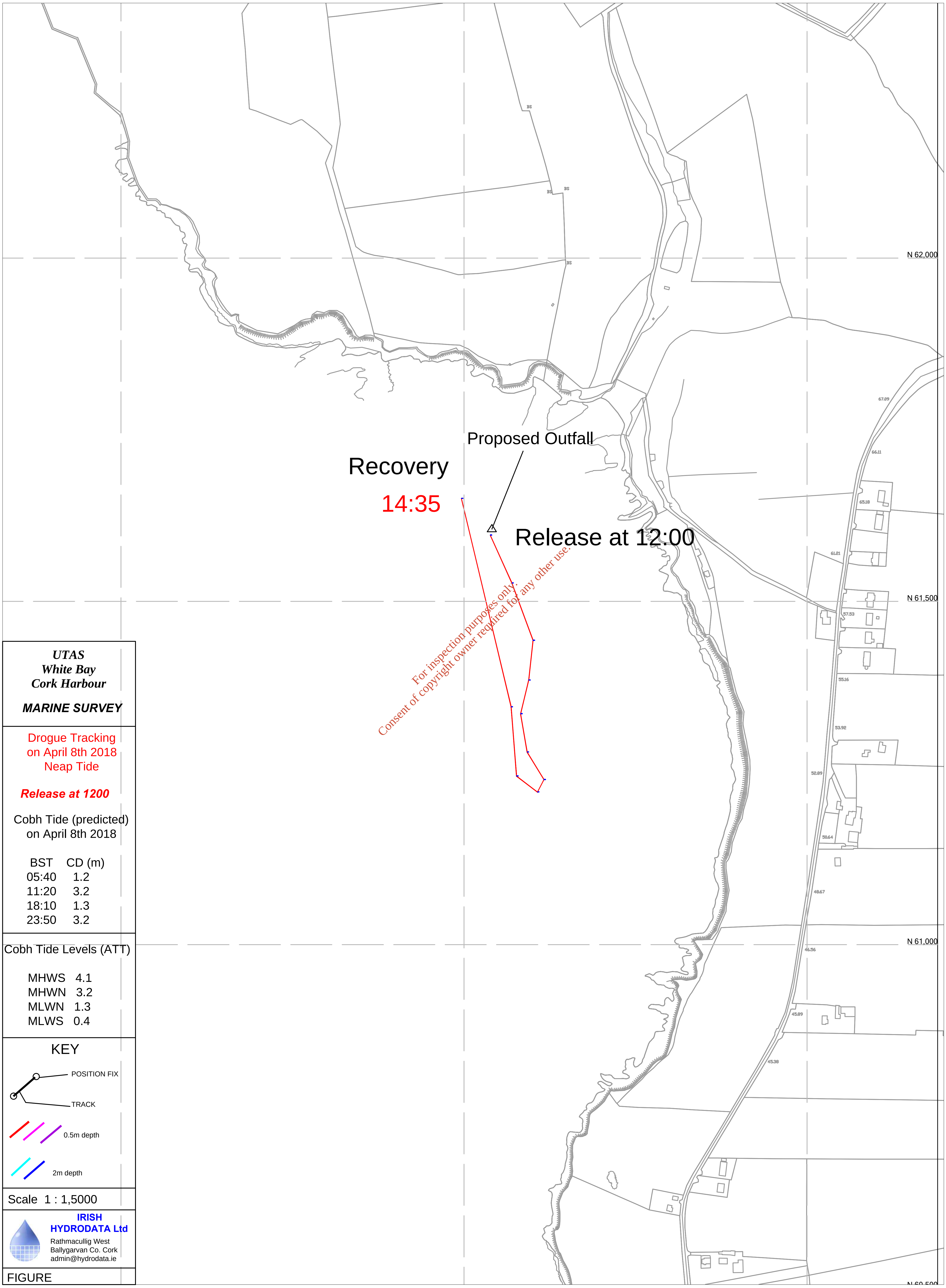
FIGURE



Proposed Outfall
11:06
Recovery
11:06
11:07
Release at 10:00
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 1000
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



Proposed Outfall
Release at 11:12
14:26
13:08
Recovery
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 1112
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 8th 2018
Neap Tide

Release at 1200

Cobh Tide (predicted)
on April 8th 2018

BST	CD (m)
05:40	1.2
11:20	3.2
18:10	1.3
23:50	3.2

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

KEY

POSITION FIX
TRACK
0.5m depth
2m depth

Scale 1 : 1,5000

IRISH HYDRODATA Ltd
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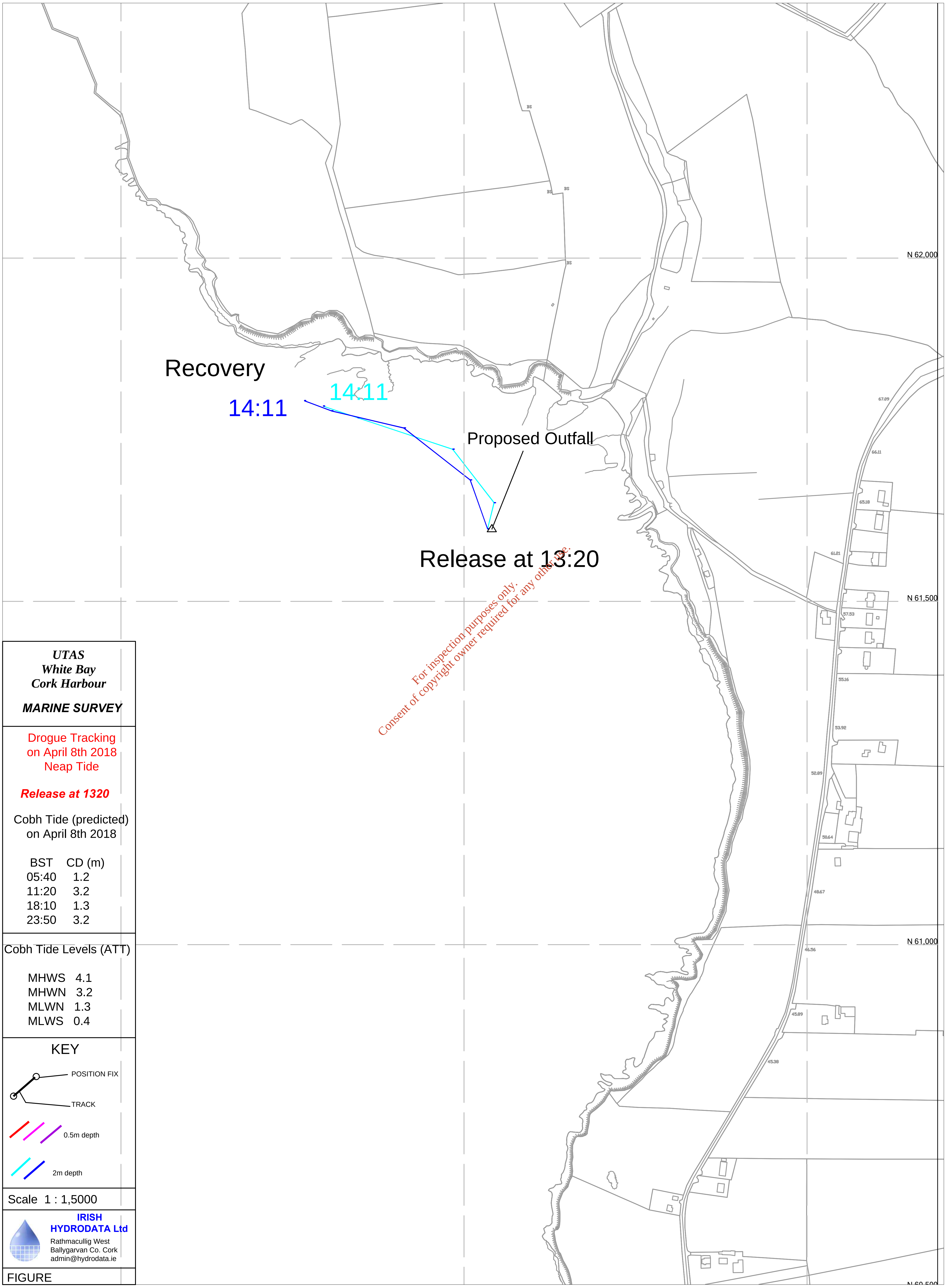
admin@hydrodata.ie

FIGURE


Recovery
14:11
14:11
Proposed Outfall
Release at 13:20
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 1320
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
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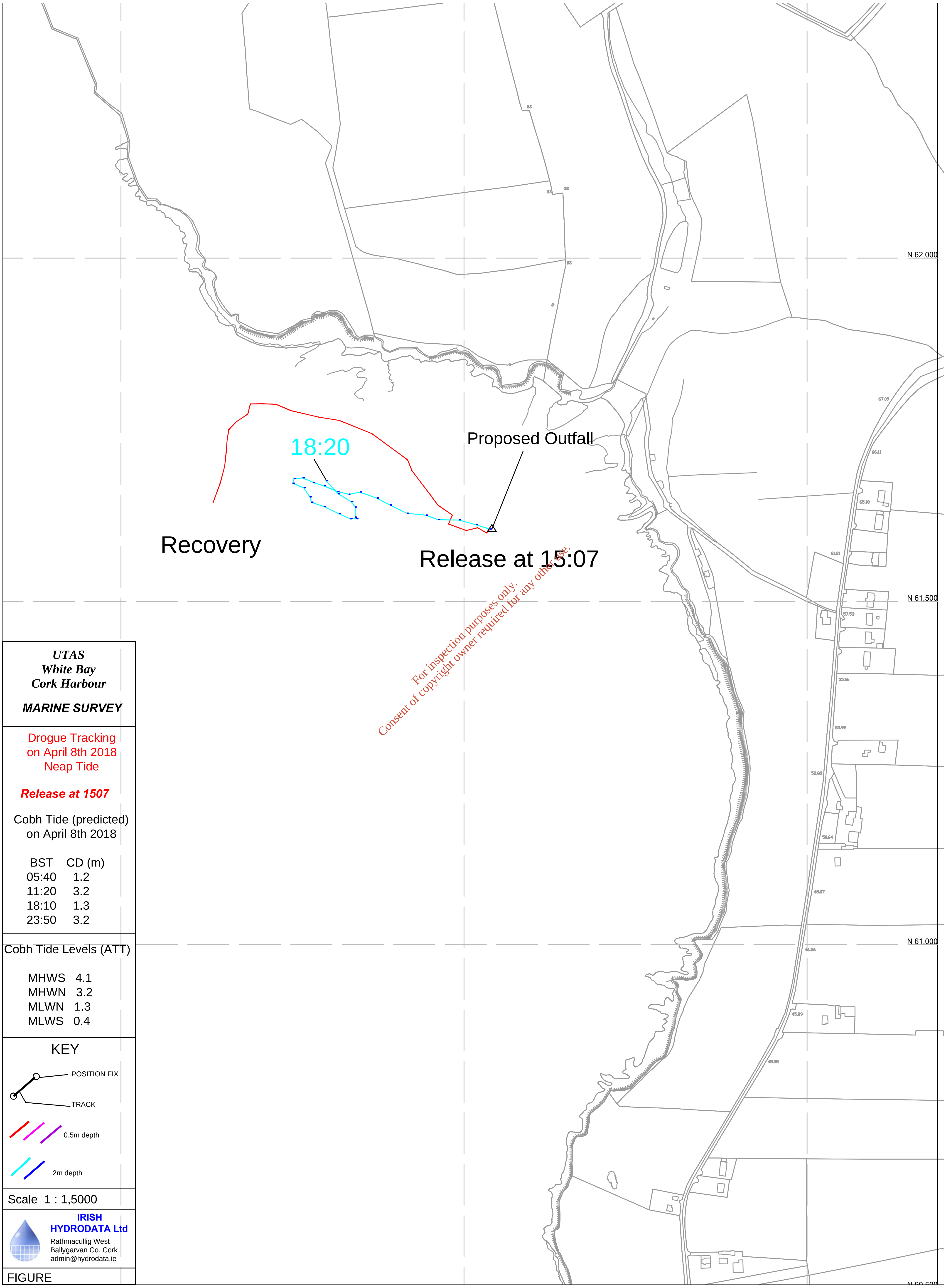
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



18:20
Proposed Outfall
Recovery
Release at 15:07
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 1507
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
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IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
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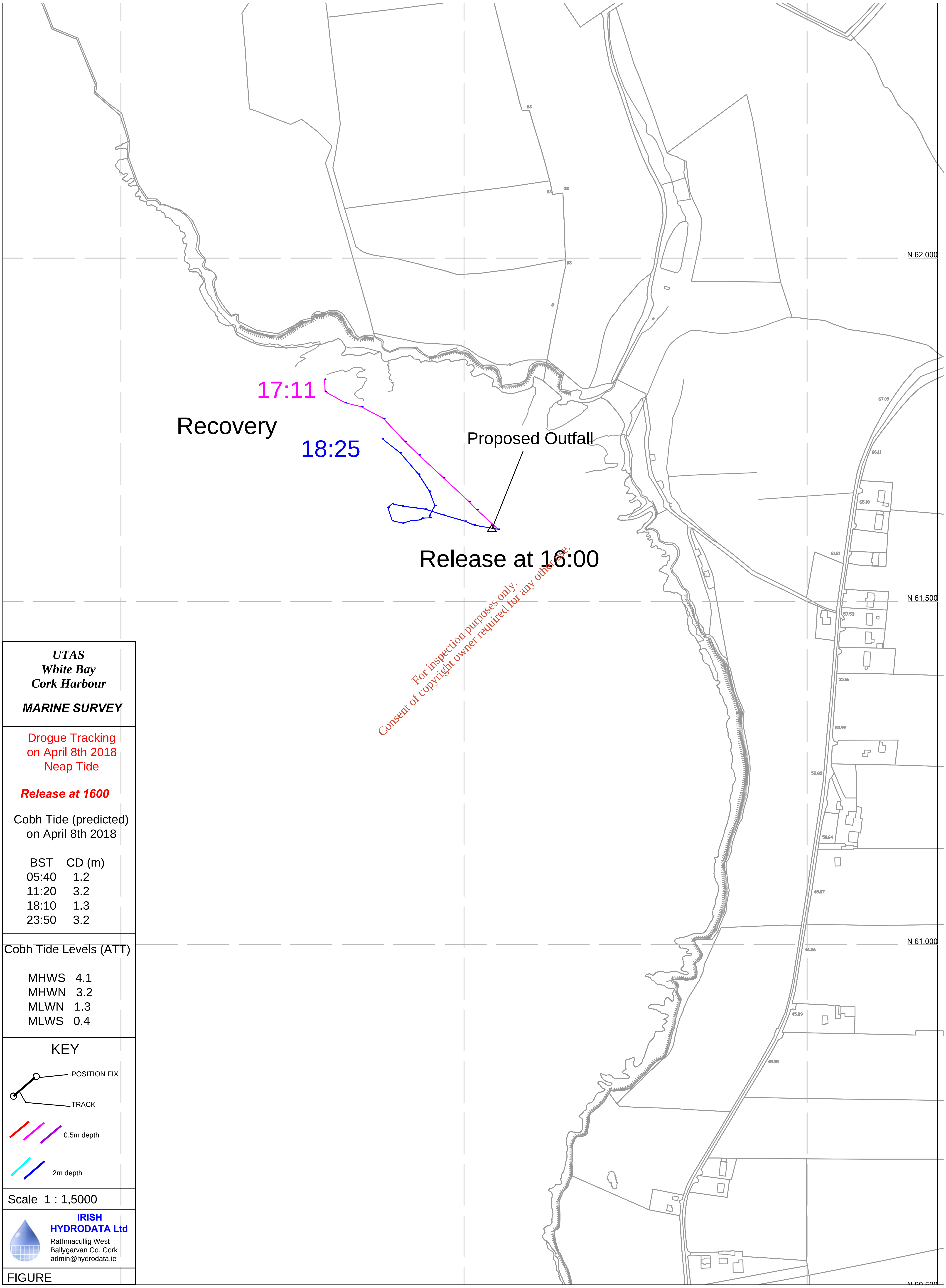
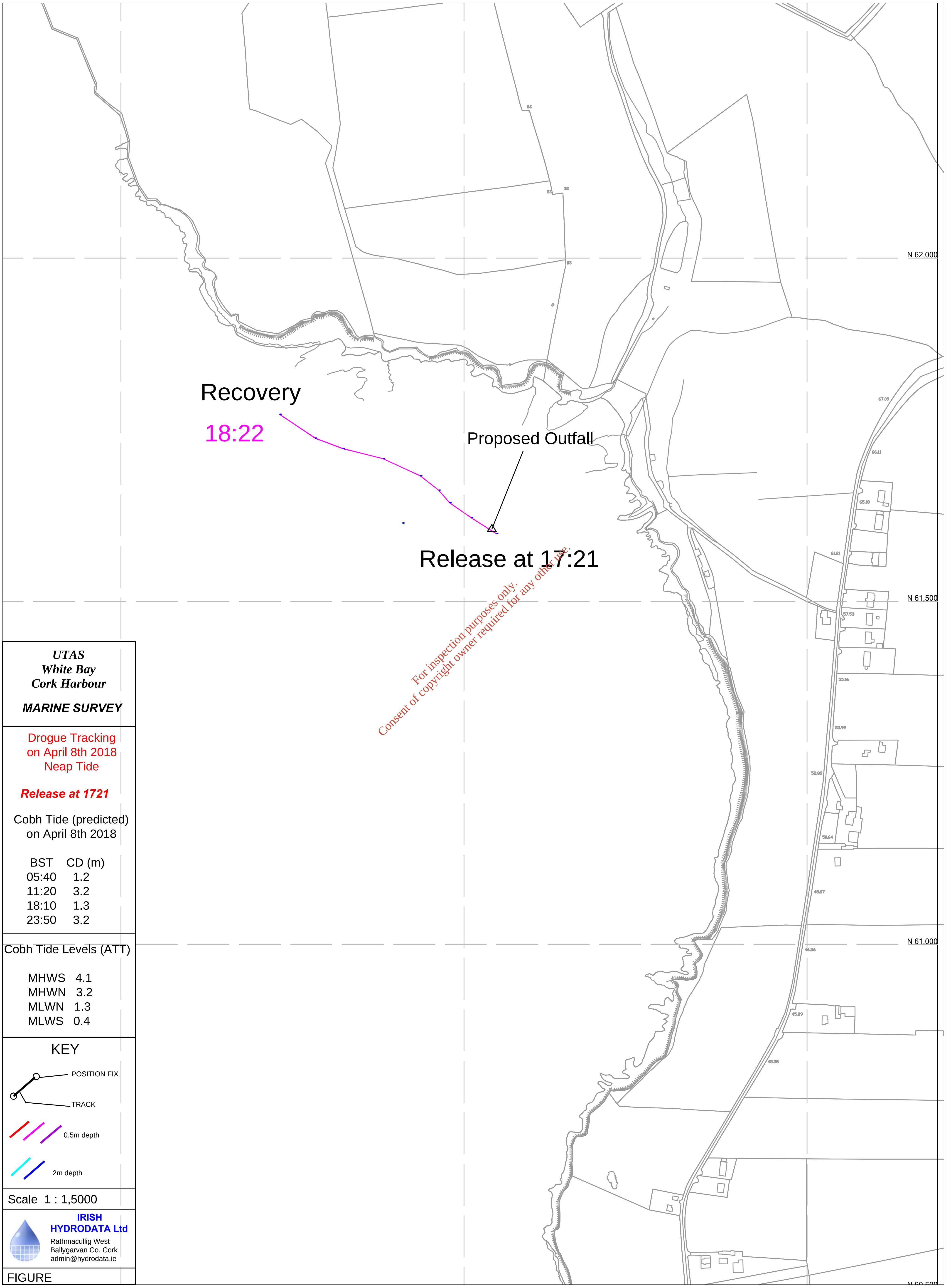
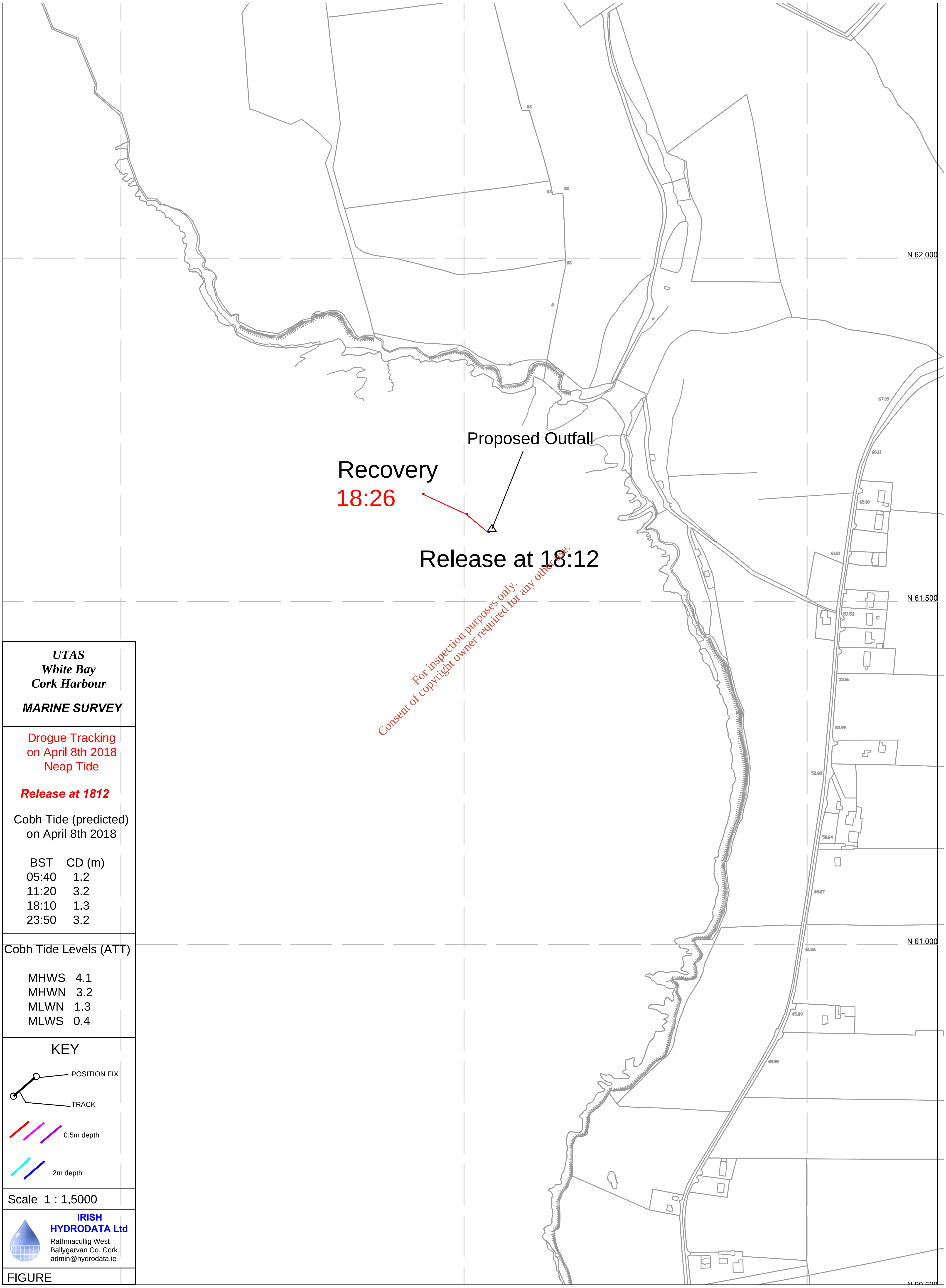


17:11
Recovery
18:25
Proposed Outfall
Release at 16:00
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 1600
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE


Recovery
18:22
Proposed Outfall
Release at 17:21
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 8th 2018
Neap Tide
Release at 1721
Cobh Tide (predicted)
on April 8th 2018
BST CD (m)
05:40 1.2
11:20 3.2
18:10 1.3
23:50 3.2
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 8th 2018
Neap Tide

Release at 1812

Cobh Tide (predicted)
on April 8th 2018

BST	CD (m)
05:40	1.2
11:20	3.2
18:10	1.3
23:50	3.2

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

KEY

POSITION FIX
TRACK
0.5m depth
2m depth

Scale 1 : 1,5000

IRISH
HYDRODATA Ltd
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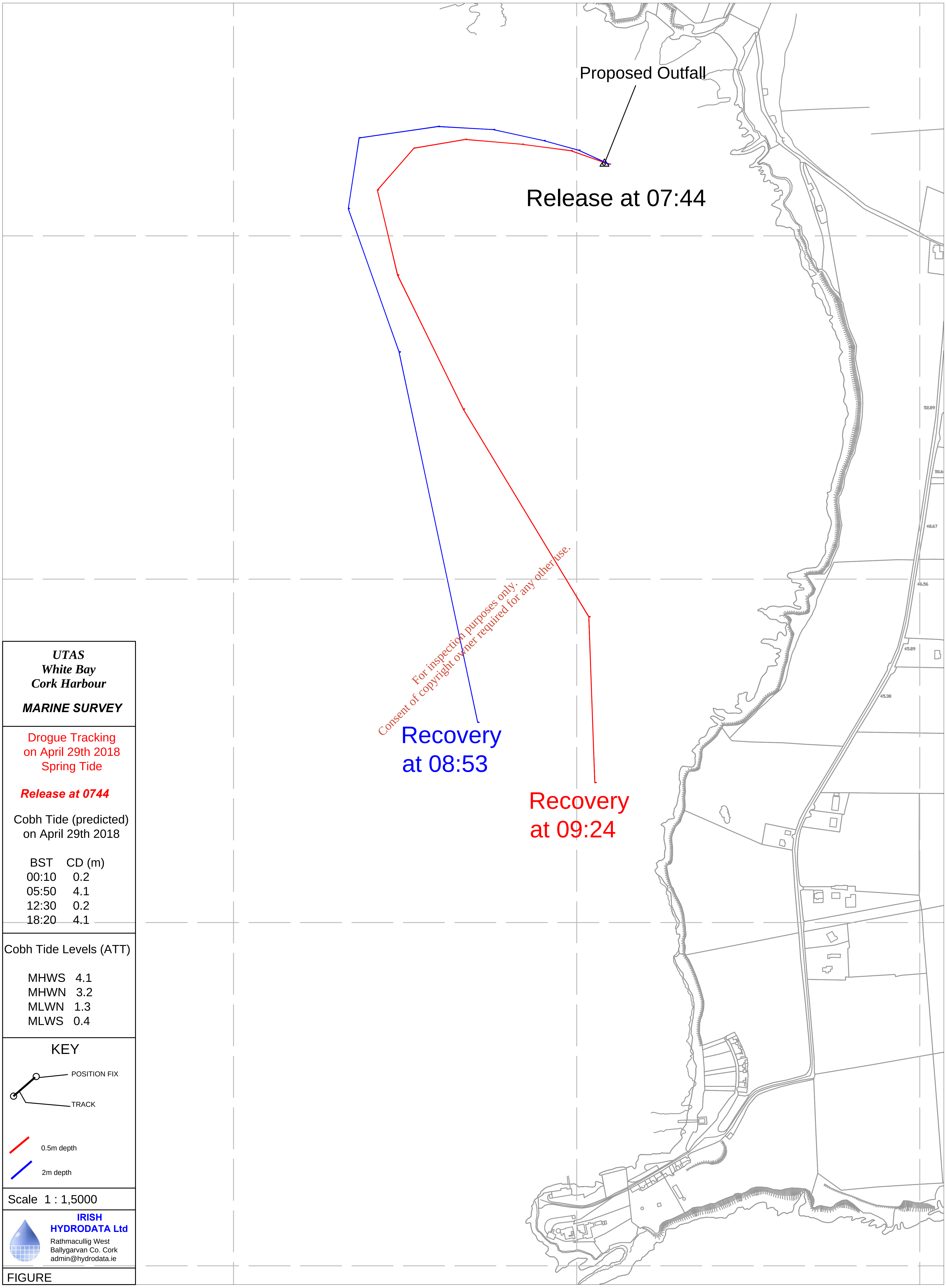
Ballygarvan Co. Cork
admin@hydrodata.ie

FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 29th 2018
Spring Tide

Release at 0744

Cobh Tide (predicted)
on April 29th 2018

BST	CD (m)
00:10	0.2
05:50	4.1
12:30	0.2
18:20	4.1

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

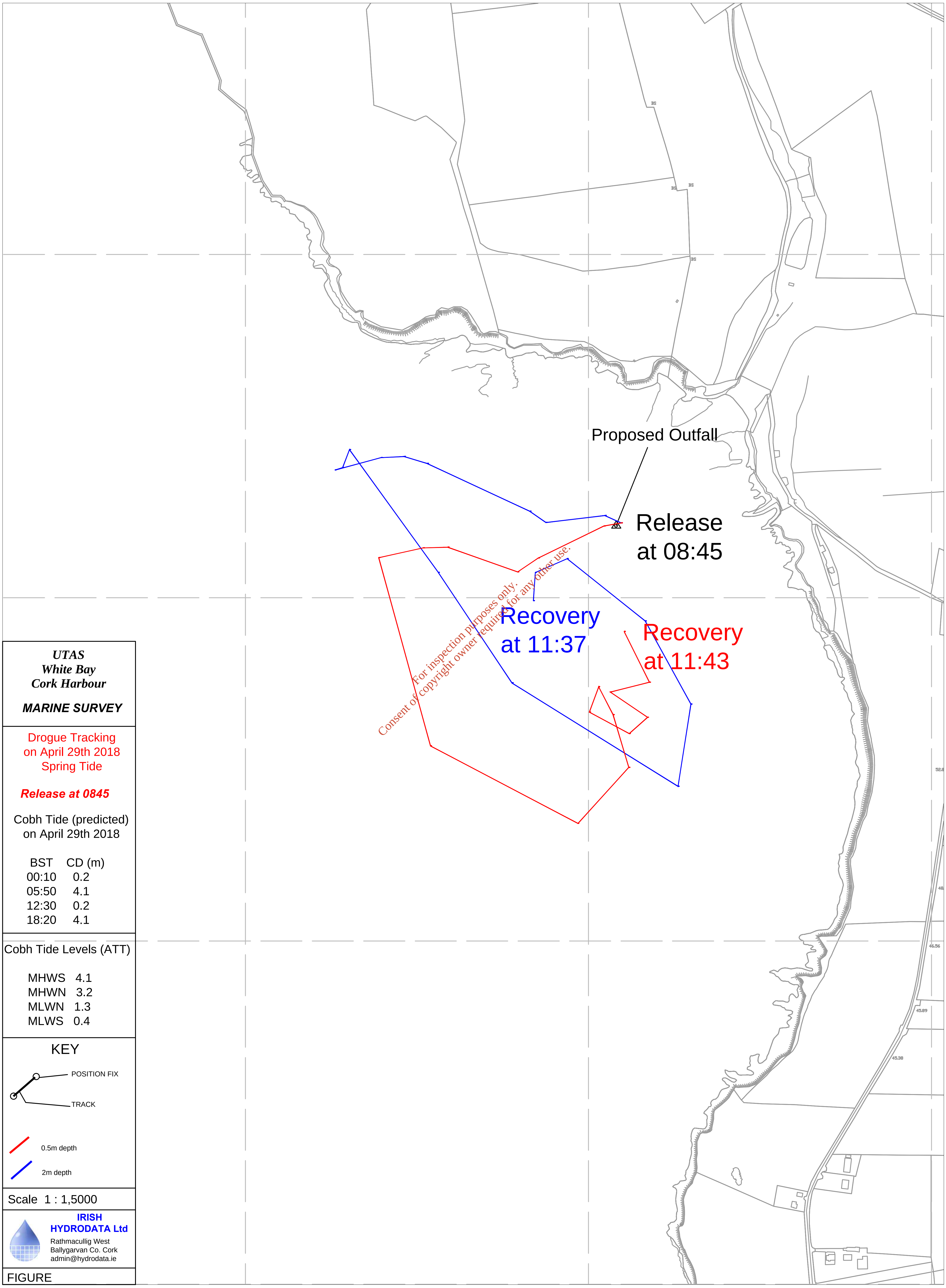
KEY

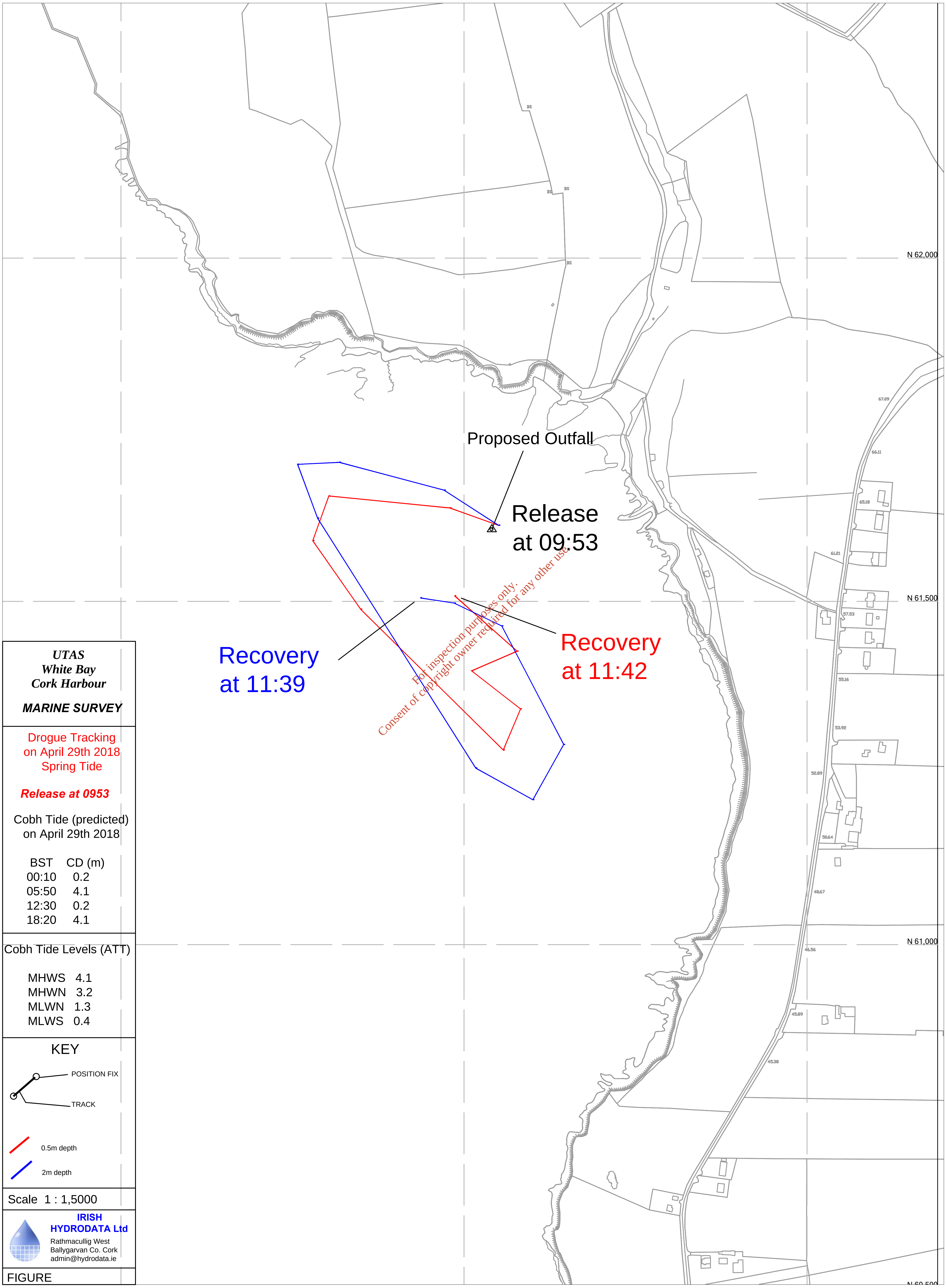
POSITION FIX
TRACK
0.5m depth
2m depth

Scale 1 : 1,5000

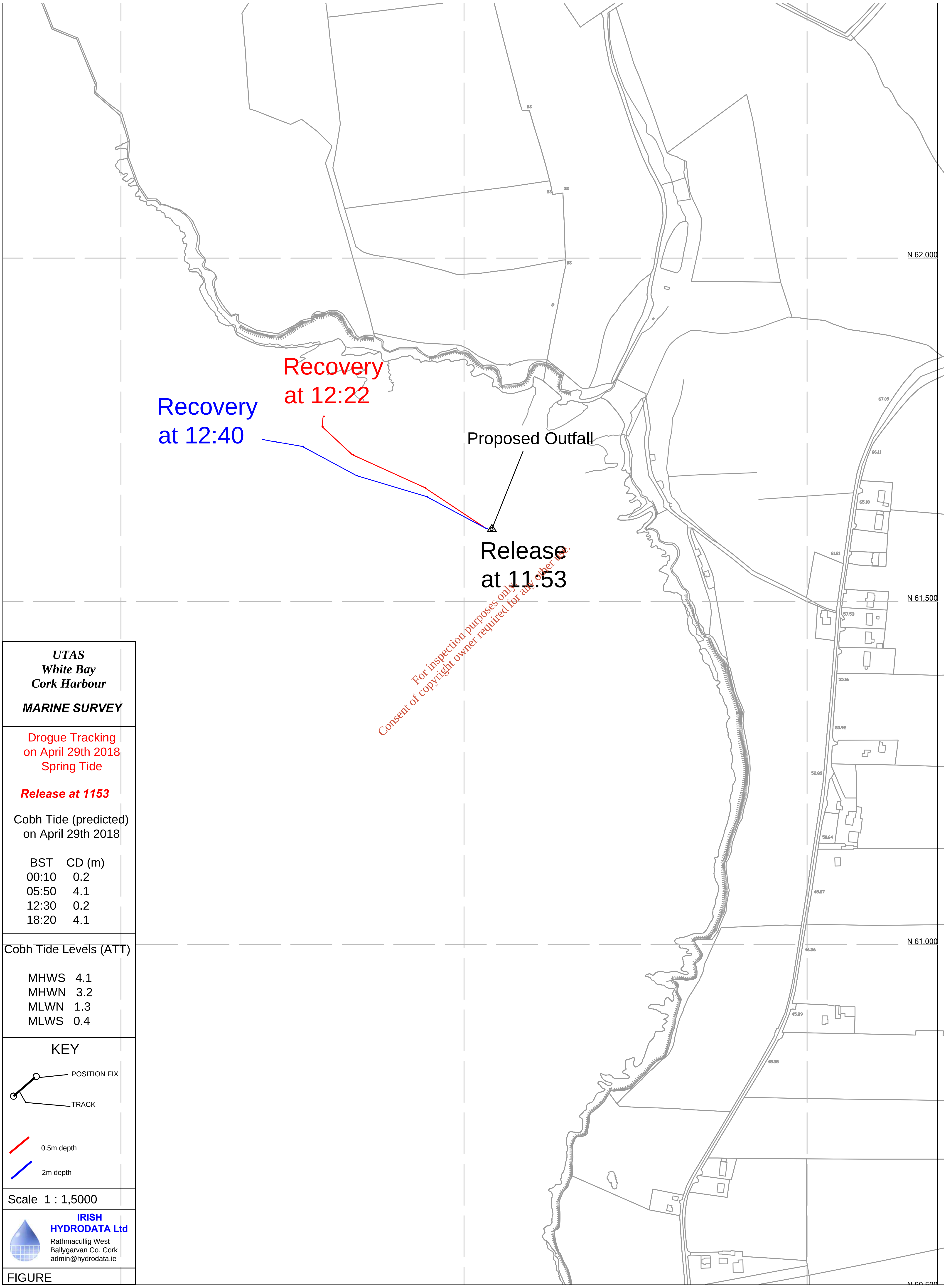
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie

FIGURE


Proposed Outfall
Release
at 08:45
Recovery
at 11:37
Recovery
at 11:43
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 29th 2018
Spring Tide
Release at 0845
Cobh Tide (predicted)
on April 29th 2018
BST CD (m)
00:10 0.2
05:50 4.1
12:30 0.2
18:20 4.1
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



Proposed Outfall
Release
at 09:53
Recovery
at 11:39
Recovery
at 11:42
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 29th 2018
Spring Tide
Release at 0953
Cobh Tide (predicted)
on April 29th 2018
BST CD (m)
00:10 0.2
05:50 4.1
12:30 0.2
18:20 4.1
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 29th 2018
Spring Tide

Release at 1153

Cobh Tide (predicted)
on April 29th 2018

BST	CD (m)
00:10	0.2
05:50	4.1
12:30	0.2
18:20	4.1

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

KEY

Scale 1 : 1,5000

IRISH
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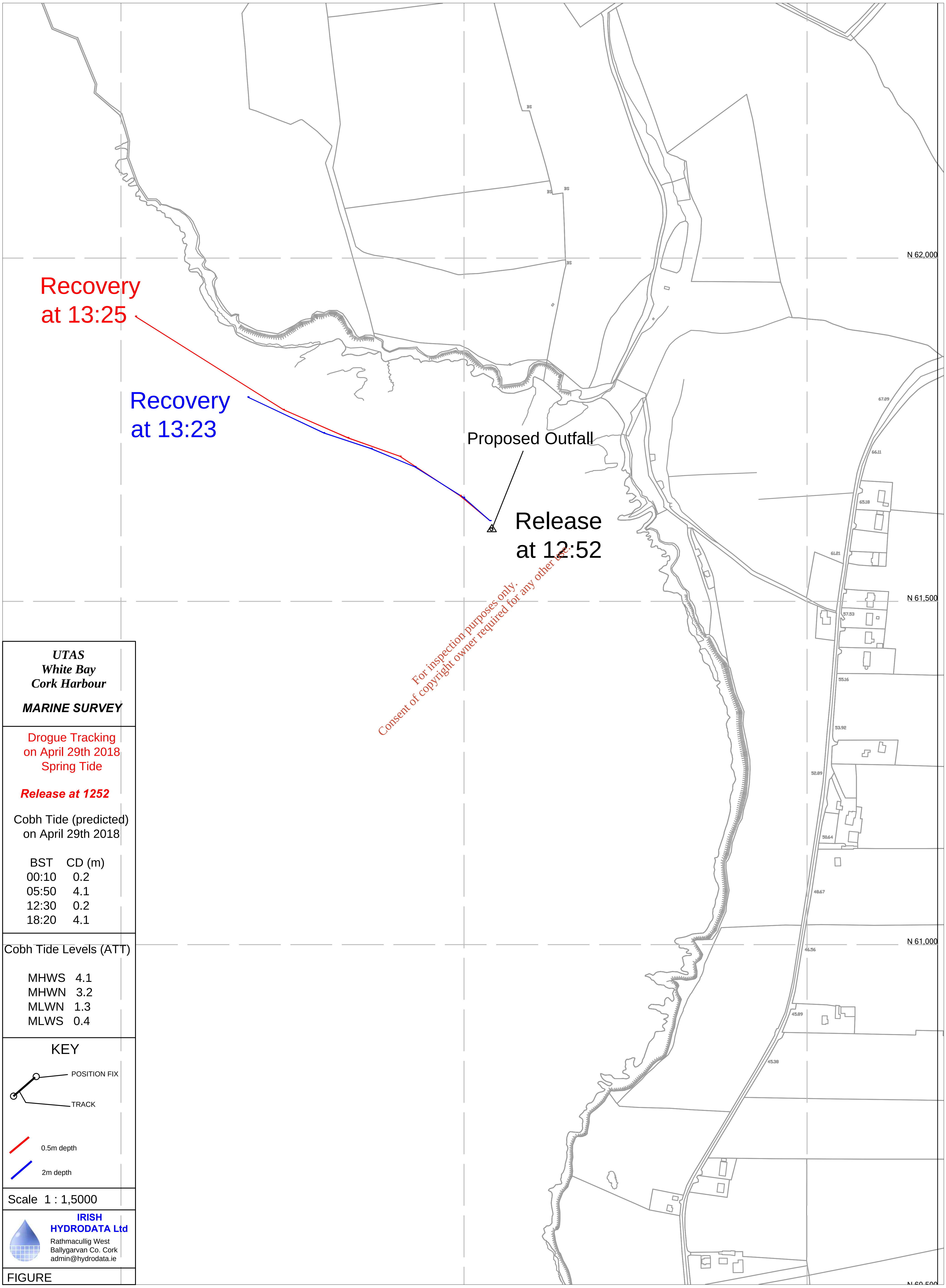
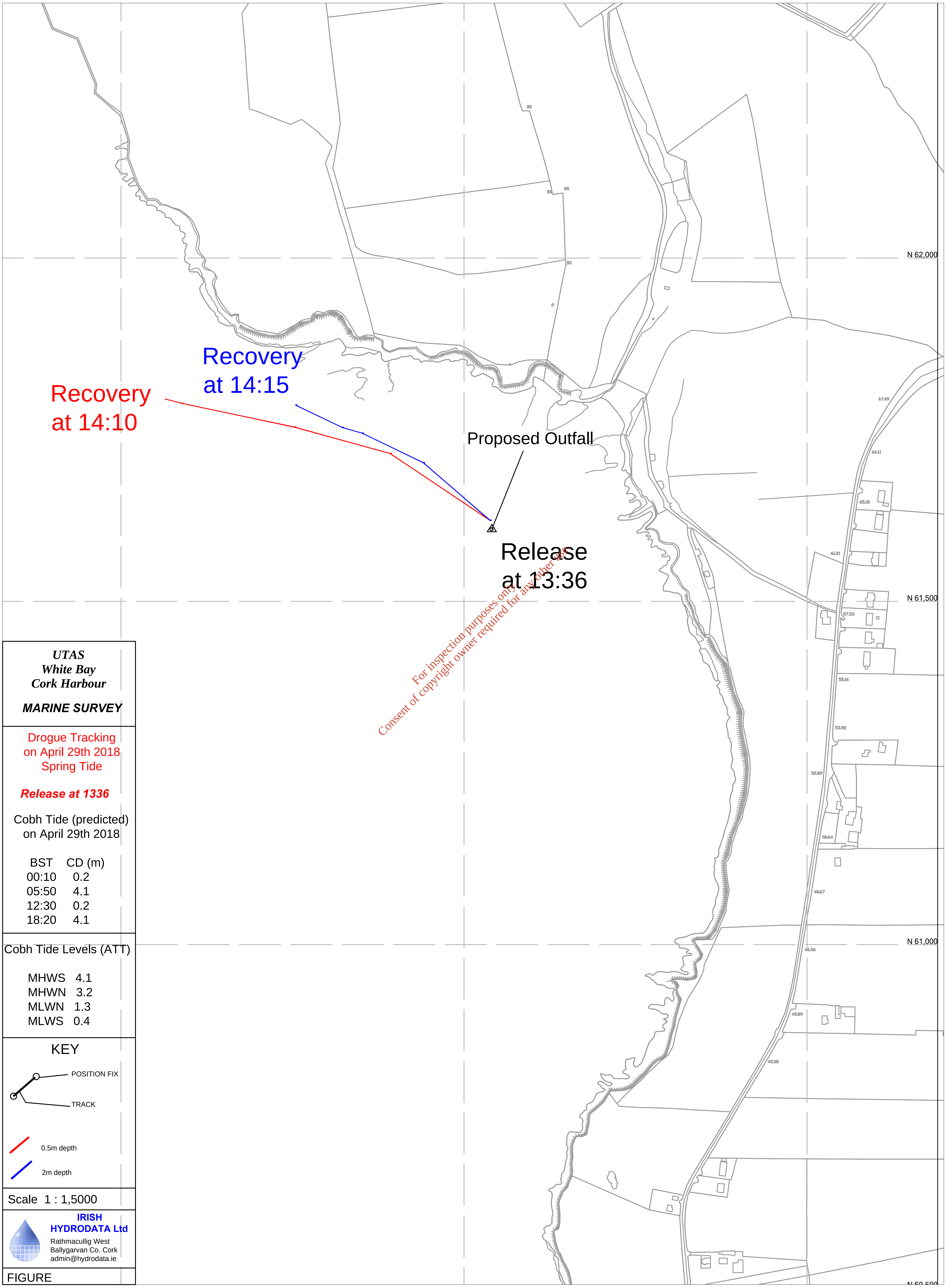
Ballygarvan Co. Cork
admin@hydrodata.ie

FIGURE


Recovery at 13:25
Recovery at 13:23
Proposed Outfall
Release at 12:52
N 62,000
N 61,500
N 61,000
N 60,500
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking on April 29th 2018 Spring Tide
Release at 1252
Cobh Tide (predicted) on April 29th 2018
BST CD (m)
00:10 0.2
05:50 4.1
12:30 0.2
18:20 4.1
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



UTAS
White Bay
Cork Harbour

MARINE SURVEY

Drogue Tracking
on April 29th 2018
Spring Tide

Release at 1336

Cobh Tide (predicted)
on April 29th 2018

BST	CD (m)
00:10	0.2
05:50	4.1
12:30	0.2
18:20	4.1

Cobh Tide Levels (ATT)

MHWS	4.1
MHWN	3.2
MLWN	1.3
MLWS	0.4

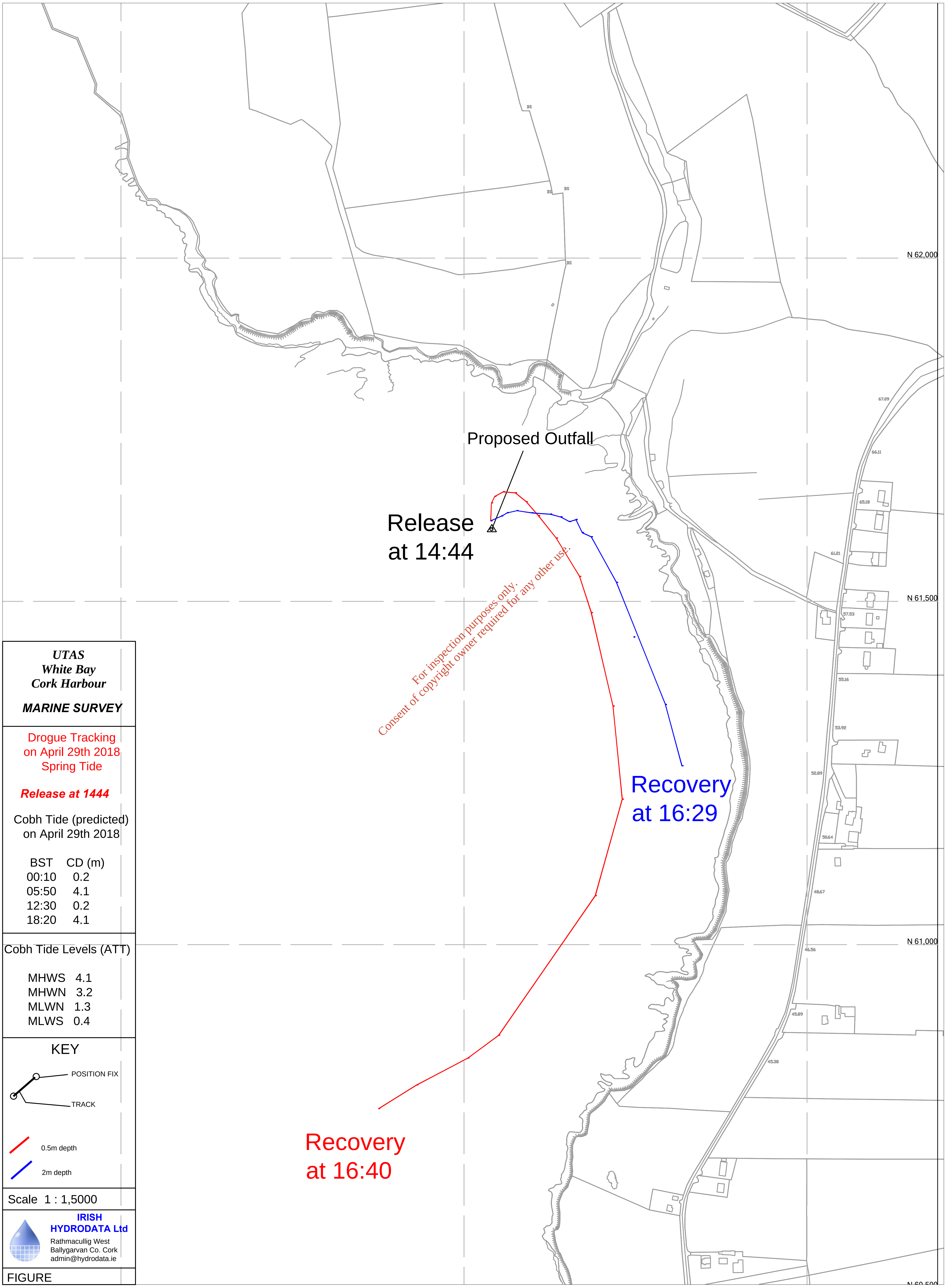
KEY

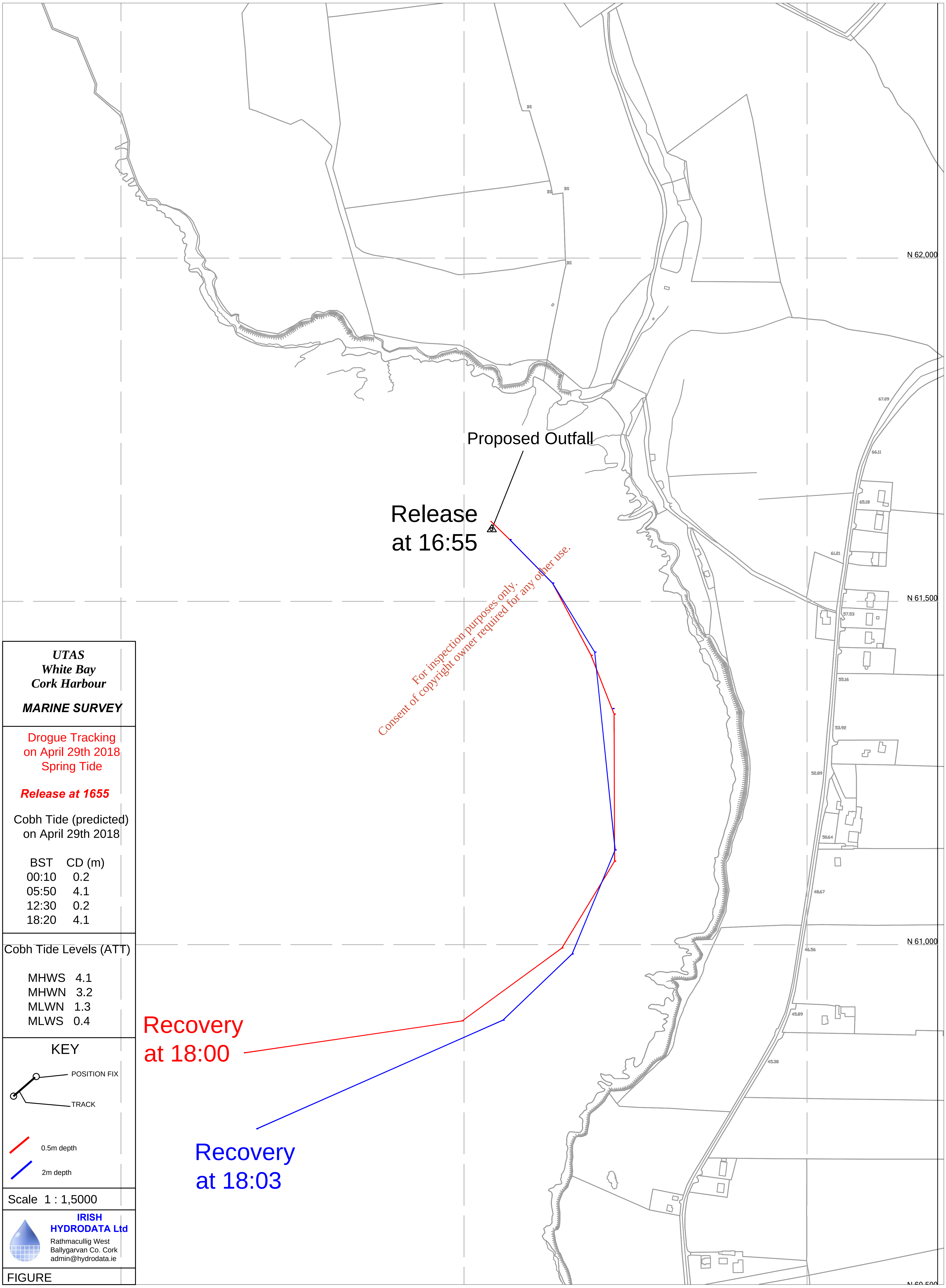
POSITION FIX
TRACK
0.5m depth
2m depth

Scale 1 : 1,5000

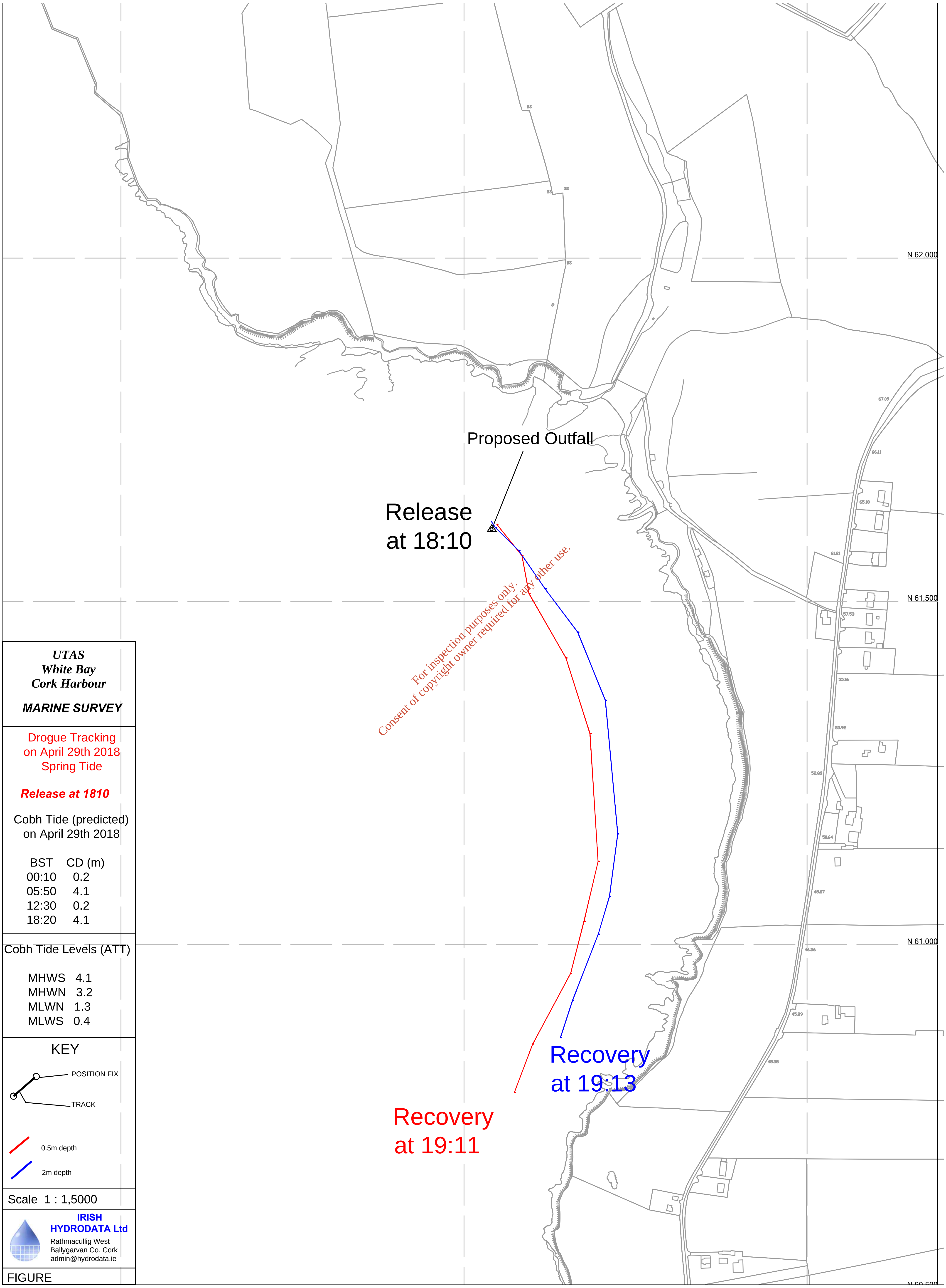
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie

FIGURE


N 62,000
N 61,500
N 61,000
N 60,500
Proposed Outfall
Release
at 14:44
Recovery
at 16:29
Recovery
at 16:40
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 29th 2018
Spring Tide
Release at 1444
Cobh Tide (predicted)
on April 29th 2018
BST CD (m)
00:10 0.2
05:50 4.1
12:30 0.2
18:20 4.1
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



N 62,000
N 61,500
N 61,000
Proposed Outfall
Release
at 16:55
Recovery
at 18:00
Recovery
at 18:03
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 29th 2018
Spring Tide
Release at 1655
Cobh Tide (predicted)
on April 29th 2018
BST CD (m)
00:10 0.2
05:50 4.1
12:30 0.2
18:20 4.1
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
HYDRODATA Ltd
Rathmacullig West
Ballygarvan Co. Cork
admin@hydrodata.ie
FIGURE



Proposed Outfall
Release
at 18:10
Recovery
at 19:13
Recovery
at 19:11
N 62,000
N 61,500
N 61,000
UTAS
White Bay
Cork Harbour
MARINE SURVEY
Drogue Tracking
on April 29th 2018
Spring Tide
Release at 1810
Cobh Tide (predicted)
on April 29th 2018
BST CD (m)
00:10 0.2
05:50 4.1
12:30 0.2
18:20 4.1
Cobh Tide Levels (ATT)
MHWS 4.1
MHWN 3.2
MLWN 1.3
MLWS 0.4
KEY
POSITION FIX
TRACK
0.5m depth
2m depth
Scale 1 : 1,5000
IRISH
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admin@hydrodata.ie
FIGURE

Appendix G

CEMP

Irish Water

Whitegate-Aghada Sewerage Scheme- UTAS Cork Bundle

Construction Environmental Management Plan (CEMP)

Issue | 27 October 2020

Job number 257589-00

Ove Arup & Partners Ireland Ltd

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D04 T6X0
Ireland
www.arup.com

Document verification

ARUP
BYRNELOOBY

Job title		Whitegate-Aghada Sewerage Scheme- UTAS Cork Bundle			**Job number** 257589-00
Document title		Construction Environmental Management Plan (CEMP)			**File reference**
Document ref					
Revision	**Date**	**Filename**	WTG_CEMP_Issue 27.01.20.docx		
Draft	27 Jan 2020	**Description**	Issue		
			Prepared by	Checked by	Approved by
		Name	Aine Delany	Fiona Patterson	Clodagh O'Donovan
		Signature			
Issue	27 Oct 2020	**Filename**	257589_WTG_CEMP_Issue 20201027.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Áine Delany	Kevin O'Sullivan	Evelyn McAuliffe
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document verification with document ✓

Contents

1 Introduction

1.1 Overview

This Construction Environmental Management Plan (CEMP) has been prepared by Arup to support Irish Water's planning application for the proposed Whitegate and Aghada Sewerage Scheme (hereafter referred to as 'the proposed development'). The proposed development comprises the following elements (see also Figure 1 below):

A) A proposed wastewater treatment plant (WWTP) at Ballytigeen TD, with associated and ancillary development works including an access road, tanks, storage facilities, inlet works, all associated site development works, boundary fencing around the perimeter of the WWTP, a gravity sewer and long sea outfall to convey treated discharge effluent from the WWTP to White Bay through Glanagow TD and Trabolgan TD.

B) A proposed underground wastewater pump station and associated infrastructure in Rostellan at the Thomas Kent Memorial Park at Rostellan TD, including an underground pump sump, underground stormwater storage tank, valve and flowmeter chambers, manholes, pipework, access road and gate, control kiosks and vent stack.

C) A proposed rising main at Rostellan TD, Ballynafarsid TD and Aghada TD, to convey flows from the proposed Rostellan pump station to a proposed pump station in Lower Aghada.

D) A proposed underground wastewater pump station and associated infrastructure at Lower Aghada located west of the pier at Aghada TD, including an underground pump sump, underground stormwater storage tank, valve and flowmeter chambers, manholes, pipework, access road, gate, control kiosks, a surge vessel, a vent stack and the decommissioning of an existing package wastewater treatment plant.

E) A proposed rising main to convey flows from the proposed Lower Aghada pump station to an existing sewer in the Upper Aghada sewerage network at Aghada TD.

F) A proposed upgrade to the existing sewerage system by the replacement of an existing 150mm diameter sewer with a proposed 225mm diameter sewer at Aghada TD and Curragh TD.

G) A proposed underground wastewater pump station and associated infrastructure at the Square in Whitegate village including an underground pump sump, underground stormwater storage tank, valve and flowmeter chambers, manholes, pipework, control kiosks and vent stack, and decommissioning of existing pump station, in Mosestown TD and Ballincarroonig TD.

H) A proposed rising main to convey flows from the proposed Whitegate pump station to the proposed WWTP at Mosestown TD, Corkbeg TD, Ardnabourkey TD and Ballytigeen TD.

I) A proposed 225mm diameter gravity sewer in Ardnabourkey TD and decommissioning of an existing septic tank.

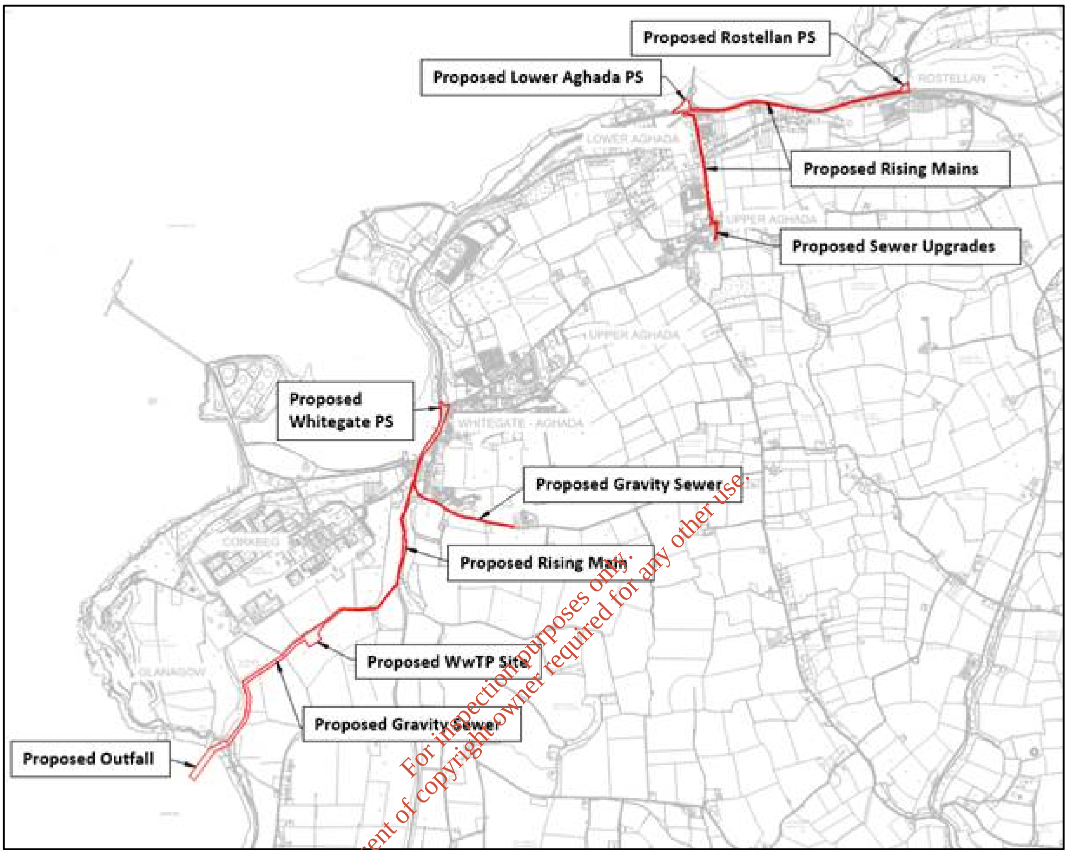

Figure 1: Proposed Development

1.2 Objective

The objective of the CEMP is to provide a framework for how Irish Water and any contractor(s) appointed will manage and where practicable minimise negative environmental effects during the construction of the proposed development. Construction is considered to include all site preparation, enabling works, demolition, materials delivery, waste removal, construction activities and associated engineering works.

Irish Water intends to procure the proposed development using a design and build type contract. Under this type of contract, the contractor will be responsible for the detailed design of the proposed development, within the constraints set out in the planning permission, NIS, etc.

The contractor will, as necessary, develop this CEMP further following appointment and prior to commencing works on site. Implementation of the CEMP will ensure disruption and nuisance are kept to a minimum.

This CEMP identifies the minimum requirements with regard to the appropriate mitigation, monitoring, inspection and reporting mechanisms that need to be implemented throughout construction. Compliance with this CEMP does not absolve the contractor or its sub-contractors from compliance with all legislation and bylaws relating to their construction activities.

This CEMP has been produced to accompany the planning application to ensure compliance with legislative requirements and the environmental reports that have been prepared for the proposed development. This CEMP must be read in conjunction with the following reports for specific details and requirements in relation to certain construction aspects and specific environmental controls (where appropriate):

- Whitegate-Aghada Archaeological Impact Assessment Reports (including Archaeological Impact Assessment, Site Investigation Monitoring, Site Investigation Testing and Underwater Archaeological Impact Assessment Report);
- Whitegate-Aghada EIA Screening Report;
- Whitegate-Aghada Natura Impact Statement (NIS), which includes, as appendices, an Ecological Impact Assessment Report and associated appendices and an Invasive Alien Species Report.

1.3 Structure

This CEMP is structured as follows:

- Section 1 provides and introduction to the proposed development and outlines the objective of the CEMP.
- Section 2 outlines management, including training, communications, monitoring, record keeping, etc.
- Section 3 sets out the operational control requirements and procedures to be employed during construction to manage environmental aspects; and also describes measures to be implemented to minimise likely significant negative effects, as far as practicable, during the construction of the proposed development.
- Section 4 outlines emergency response requirements and procedures.
- Section 5 sets out requirements for site demobilisation.

2 Environmental Management

2.1 Environmental Policy

The environmental policy of this project is to carry out the works in full compliance with all applicable environmental regulations, Irish Water regulations and any other requirements that are specified in this document.

Prevention of pollution from activities through a system of operational controls that include written instructions and staff training appropriate to the environmental requirements of their work.

Implementing this environmental policy shall be undertaken through the successful operation of the CEMP.

2.2 Training Awareness and Competence

Site staff shall be competent to perform tasks that have the potential to cause a significant environmental impact. Competence is defined in terms of appropriate education, training and experience. Environmental awareness and training will be achieved by:

- Site induction, including relevant environmental issues.
- Environmental posters and site notices.
- Method statements and risk assessment briefings.
- Toolbox talks, including instruction on incident response procedures.
- Key project specific environmental issues briefings.

All managers and supervisors will be briefed on the CEMP.

Method statements shall be prepared for specific activities prior to the works commencing and shall include environmental protection and mitigation measures and emergency preparedness appropriate to the activity covered. The contractor's environmental ecologist shall review key method statements prior to their issue.

Method Statement briefings will be given before personnel carry out key activities for the first time.

2.3 Communication

The CEMP will be distributed to the project team, including sub-contractors, to ensure that the environmental requirements are communicated effectively. Key activities and environmentally sensitive operations shall also be briefed to staff and Contractors. Project, client and company environmental policies, where available, will be displayed on site.

The Contractor will define procedures for internal and external communication. The client may require that any communication with external parties such as environmental regulators or the public is undertaken through a nominated representative.

The agreed CEMP may be published on the project website.

During the construction phase, internal communication will include regular progress meetings, which shall cover:

- Training undertaken;
- Progress report;
- Inspections, audits and non-conformance;
- Complaints received;
- Visits by external bodies and the outcome or feedback from such visits;
- Objective/target achievement, including reporting on environmental performance.

External communication, including letter drops or meetings, and liaison with statutory authorities shall be overseen by the Client Project Manager.

2.4 Monitoring, Audit and Inspections

Periodic inspections by the Contractor shall address environmental issues including dust, litter, noise, traffic, surface water, waste management and general housekeeping.

An inspection audit of the construction site shall be carried out. Environmental aspects of this audit shall be documented. The frequency of these audits (weekly/ monthly/other) will be based on the nature of Contractor activity.

2.5 Keeping of Records

The Construction Manager shall ensure that fully detailed records are maintained of any ‘incident/event’ likely to cause non-compliance and / or harm to the environment. Environmental Incidents/Near Miss Reports will be reported and recorded.

Complaints and follow up actions on the construction site will be managed by the construction management team and the Contractor shall ensure that all complaints are recorded according to requirements.

The Contractor shall be responsible for ensuring that a full record and copy of all Safety Data Sheets (SDS) pertaining to their works is kept on file and up to date in their site offices.

The Contractor’s construction management team shall be responsible for monitoring the movement and treatment of all waste during the construction phase of the project. Monitoring will be carried out to record the nature, quantities and off-site destination of wastes.

2.6 Non-Conformance and Corrective and Preventative Action

Procedures for addressing non-conformance and corrective actions are to be provided. These may include, for example:

- A Non-Conformance Report (NCR) that will be raised to record any environmental incident and work that has not been carried out in accordance with the CEMP or Method Statement.
- A Corrective Action Report (CAR) that will be raised where a deficiency is identified as a result of monitoring, inspection, surveillance and valid complaints.
- Any actions identified shall nominate an owner to follow through the action to be taken, along with a specified timescale for it to be closed out.

2.7 Incident Preparedness and Response

The likelihood of an incident can be minimised by effective planning through development of Emergency Response Procedures (see Section 4 of this document). These procedures will identify the on-site risks and appropriate responses. Suitable equipment, such as spill kits, oil booms and absorbent material, shall be held at appropriate locations on site. Effective pollution incident response procedures rely on the following elements:

- Identification of all possible emergency scenarios;
- Effective planning, e.g. availability of booms, spills kits at appropriate locations;
- Identification of receptors/pathways (e.g. surface water drains);
- Identification and dissemination of contact numbers;
- Definition of site-based staff responsibilities;
- Appropriate site-based staff training;
- Exercise of incident scenarios – spill drills;
- Availability of suitable spill kits at appropriate locations on the site; and
- Implement lessons learnt from previous incidents.

All appropriate site staff will be made aware of the company's site emergency procedure(s) (e.g. spillage, leakage, fire, explosion and flooding). They will be made aware that drain covers and spill kits are available and training will be provided to ensure that staff know how to use the available equipment.

3 Operational Control Requirements and Procedures

3.1 Site Establishment

3.1.1 Access

The Contractor will define the method of delivery/removal of material and plant from the sites, including the identification of access routes for deliveries and personnel. These routes are to be clearly signed.

No machinery is to enter lands not within the site and no unauthorised personnel are to be allowed access the construction site.

3.1.2 House Keeping

A ‘good housekeeping’ policy shall be adopted across the site. This will include the following requirements:

- No fires on site;
- Considerate behaviour of all site staff, including on the local roads;
- Removal of food waste and other rubbish at frequent intervals;
- Site access roads shall be regularly cleaned and maintained as appropriate. Hard surface road shall be swept to remove mud and aggregate material from their surface as a result of the development. Any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road in the vicinity of the development that has the potential to give rise to dust must be regularly watered, as appropriate, during extended dry and/or windy conditions;
- Temporary portable toilet facilities shall be provided for staff during the construction period. These units will be maintained regularly, and the waste disposed of by an appropriate contractor;
- Any fuel stored on site shall be stored in double skinned, bunded containers and shall be located in a designated work compound;
- Temporary site offices shall be provided for staff during the construction period. These units are to be maintained regularly.

3.2 Waste Management

All waste generated during construction will be appropriately managed and disposed of or re-used offsite in accordance with the waste hierarchy and relevant waste management guidance and legislation.

A Construction and Demolition Waste Management Plan (CDWMP) plan will be required to be developed by the contractor following appointment and prior to commencing works on site.

The CDWMP shall address waste generation and the arrangements made for prevention, reuse, recycling disposal and collection of recyclables and wastes.

3.3 Invasive Plant Species

An Invasive Alien Species (IAS) survey and report was undertaken for Whitegate-Aghada Sewerage Scheme. This report is included in Appendix E of the NIS.

Section 11 of the Invasive Species Survey Report states that prior to the commencement of works, the works area will be re-surveyed to accurately assess any changes in distribution in the intervening period. In addition, an Invasive Species Management Plan will be prepared in accordance with best practice guidelines and all work related to invasive species at construction stage will be in accordance to this Management Plan. The report identified that Japanese Knotweed and Himalayan knotweed were recorded at various locations within the study area. The route has been designed to avoid the largest area of Japanese Knotweed/Himalayan knotweed at White Bay and standard measures will be implemented to ensure there is no spread of this species from stands located in other areas, in accordance with the Management Plan. A buffer zone of seven metres will be put in place in respect of each stand of Japanese Knotweed were possible. This zone will be clearly fenced, and no works will proceed within these buffer zones. The extent of the infestation will be determined by the supervising ecologist. The various control methods which can be utilised for invasive alien species are outlined in the Whitegate-Aghada IA survey report.

3.4 Traffic and Transportation

The Contractor is required to implement the following measures in relation to traffic and transportation during construction:

- Adequate parking will be provided at the proposed Lower Aghada Pump Station site;
- Trucks required to wait on sites will switch off engines to avoid unnecessary fuel usage and noise;
- Wheel washes and lances will be provided by the Contractor as required, to ensure that wheels, bodies and sides of trucks are clean prior to leaving Pump Stations sites and the WWTP site;
- Roads outside the sites will be visually inspected on a daily basis and power swept and washed as and when required;
- All site staff including truck drivers will be required to abide by the normal rules of the road;
- The Contractor shall prepare a Detailed Construction Traffic Management Plan (CTMP) covering all construction stages that takes into account other potential construction works. CTMP will demonstrate how pedestrians, cyclists and motorised vehicles can pass through the works areas safely and that measures are in place which ensure traffic operates in as an efficient manner as possible;

- The CTMP will include a detailed consultation plan to deal with third party queries from both residents and retail/ commercial operators. The CTMP will require agreement with both Cork County Council and An Garda Síochána.
- The Contractor will appoint a single point of contact to facilitate the communication of the various traffic management plans and the preparation of a project specific website to aid communications would also be beneficial.

3.5 Noise and Vibration

Noise and vibration monitoring will be undertaken at the start of each new activity to determine the compliance with limit values. This may involve monitoring on a daily basis during the first weeks of the construction works, but subject to satisfactory results, this could be relaxed to once a week/twice-weekly depending upon the site activities. The frequency will be increased again if particularly noisy activities (such as pile driving) are undertaken.

Continuous noise and vibration monitoring will take place at the nearest sensitive receptor to the works. Environmental noise and vibration monitoring is to be undertaken only by suitably-trained and experienced staff.

Specific mitigation measures, which will be adopted where appropriate to demonstrate best practicable means (BPM), including;

- Careful selection of equipment, construction methods and programming with the objective of reducing noise and vibration where possible. Only equipment, including road vehicles, conforming to relevant national or international standards, directives and recommendations on noise and vibration emissions, will be used;
- Using noise-control equipment such as jackets, shrouds, hoods, and doors, and ensuring they are closed;
- Locating plant, as far as is reasonably practicable, away from receptors or as close as possible to noise barriers or hoardings where these are located between the source and receptor;
- Ensuring that all plant is maintained regularly to comply with relevant national or international standards;
- Ensuring that air lines are maintained and checked regularly to prevent leaks;
- Operating plant in the mode of operation that minimises noise emissions;
- Ensuring that plant is shut down when not in use;
- Prohibiting works vehicles waiting or queuing on the public highway;
- Constructing temporary infrastructure (e.g. haul roads) of materials that minimise noise and vibration;
- Avoiding percussive piling, except where there is an overriding justification;
- Rotary drills and bursters actuated by hydraulic or electrical power will be used for excavating hard material.

In some instances, chemical bursting can be used where nearby sensitive structures are particularly vulnerable to vibration from pneumatic breakers, etc.;

- Handling all materials, particularly steelwork, in a manner that minimises noise. For example, storing materials as far as possible away from sensitive receptors and using resilient mats around steel handling areas;
- Designing all audible warning systems and alarms to minimise noise. Non-audible warning systems can be used in preference, i.e. Cab-mounted CCTV or the use of banksmen. If required, ensure that audible warning systems are switched to the minimum setting required by the health and safety authority (HSA), and where practicable use 'white noise' reversing alarms in place of the usual 'siren' style reversing alert;
- Designing haul routes to minimise the amount of reversing required;
- Selecting electrically powered plant that is quieter than diesel or petrol- driven plant, if interchangeable; and
- Fitting suitable anti-vibration mountings where practicable, to rotating and/or impacting equipment;
- Unnecessary revving of engines will be avoided, and equipment will be switched off when not required;
- Rubber linings shall be used in chutes and dumpers etc. to reduce impact noise;
- Drop heights of materials shall be minimised;
- Construction plant and activities to be employed on site shall be reviewed to ensure that they are the quietest available for the required purpose;
- Regular and effective maintenance by trained personnel shall be carried out to reduce noise and/or vibration from plant and machinery;
- Site activities shall be limited to 7am - 7pm, Monday to Friday; and 8am - 2pm, Saturday. It may be necessary in exceptional circumstances to undertake some certain types of activities outside of normal construction core working hours.

  Any such working hours outside the normal construction core working hours will be agreed with the Employer's Representative. The planning of such works will have regard to nearby sensitive receptors.

3.6 Archaeological Monitoring

The Contractor will be required to implement the following measures in relation to archaeology during construction:

- All ground excavations associated with the proposed development will be monitored by a suitably qualified archaeologist. This will enable the identification of any previously unrecorded features/ deposits of archaeological significance.

Full provision will be made to ensure the preservation by record of any such features, should that be deemed the most appropriate manner in which to proceed, following consultation with the DCHG.

- All archaeological works will be carried out under the supervision of a project archaeologist, appointed on behalf of Irish Water, to ensure all mitigation measures are implemented.
- All excavations associated with the marine outfall will be monitored by a suitably qualified underwater archaeologist. Works will be carried out under licence to the DCHG and full provision will be made to ensure the preservation by record of any features that may be identified, should that be deemed the most appropriate manner in which to proceed, following consultation with the DCHG.

3.7 Air Quality

3.7.1 Emissions and Odours

Any works that risk creating odours shall be planned appropriately so as to minimise any effect. Any processes that emit fumes, odours or smoke is to comply with manufacturer's and, if appropriate, regulatory limits to prevent nuisance or a regulatory breach. All plant and vehicles shall comply with European Union (EU) emission limits for their vehicle class as a minimum and are to be regularly maintained. A programme of maintenance checks shall be developed for plant on site and adhered to.

Any plant and equipment emitting black smoke will be taken out of service immediately and the defect rectified. Plant shall be located a maximum distance from sensitive receptors. Where possible use mains or battery powered equipment over diesel powered.

3.7.2 Dust

Fine spraying of water (e.g. using a bowser) is the most effective way to suppress dust. Repeat spraying shall be provided regularly, especially during warm, sunny and dry weather when water will evaporate quickly. It will be ensured that the works do not create excessive mud or a flow of dirty water that can run off into watercourses. Areas that would need to be considered for spraying include;

- Unpaved work areas subject to traffic or wind;
- Site haul roads;
- Sand, spoil and aggregate stockpiles; and
- During the loading and unloading of dust generating materials.

Non-potable water will be used for damping down where possible, e.g. rainwater captured on site. Other effective measures to reduce the dust impact on nearby receptors include, control of vehicle speeds and speed restrictions and sweeping of hard surface roads.

- Vehicle speed restrictions will be followed to reduce dust impact on nearby receptors.
- Sweeping of hard surface roads will be carried out to reduce dust impact on nearby receptors.

3.8 Nature Conservation

3.8.1 Ecological Impact Assessment (EcIA) Report Mitigation Measures

Specific mitigation measures are detailed in the Ecological Impact Assessment Report (EcIA) included in the planning application (Appendix C of the NIS). Refer directly to this report for further details. These measures are also included below:

- It is possible that some root damage to the existing sycamore tree located in the Thomas Kent Memorial Park, Rostellan may arise during the construction works. It is intended to retain the tree if at all possible. An aboriculturalist will assess the condition of the tree during and following the completion of site works. The aboriculturalist may specify a crown reduction to minimise the risk of wind blow or in worst-case scenario may specify removal. It is proposed that three evergreen oaks (*Quercus ilex*) will be planted within the memorial park to ensure that tree cover is maintained.
- Works in close proximity to or within the Cork Harbour SPA will avoid the wintering bird season (September to March). Refer to Figure 1 below in relation to NIS mitigation measures and to Section 8.2 of the NIS. This will minimise the disturbance to any wintering/migratory bird species utilising the harbour during this period. During operation there will not be a significant increase in noise or activity associated with the development.

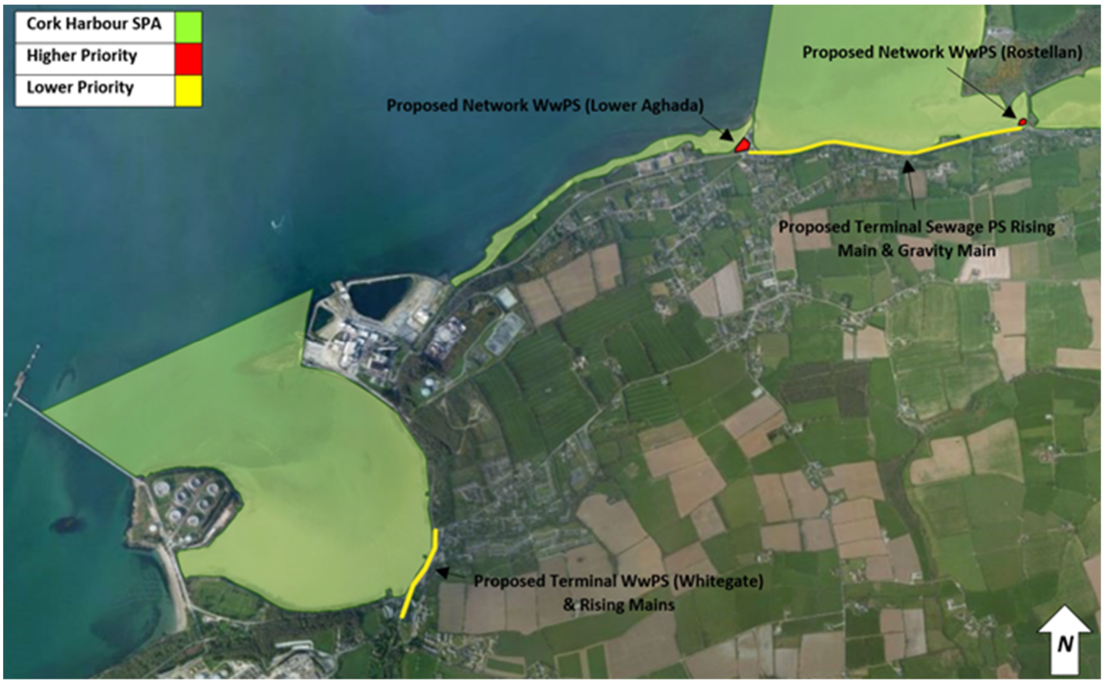

Figure 2: Construction works will be avoided during the winter bird season at the areas outlined above. The most sensitive areas (Rostellan PS and Lower Aghada PS), which will require hoarding between the works and the water's edge, is shaded red.

3.8.1.1 Construction measures – general guidelines

All personnel involved with the project will receive an on-site induction relating to operations and the environmentally sensitive nature of European sites and to re-emphasise the precautions that are required as well as the precautionary measures to be implemented. All staff and subcontractors have the responsibility to:

- Work to agreed plans, methods and procedures to eliminate and minimise environmental impacts;
- Understand the importance of avoiding pollution on-site, including noise and dust, and how to respond in the event of an incident to avoid or limit environmental impact;
- Respond in the event of an incident to avoid or limit environmental impact;
- Report all incidents immediately to their line manager;
- Monitor the work place for potential environmental risks and alert the immediate line manager if any are observed; and
- Co-operate as required, with site inspections.

The following measures will be implemented:

- The supervising ecologist who will be employed by the Contractor will liaise with the Contractor and will be responsible for dealing with any specific ecological issues which may arise during the works and liaising with statutory bodies if required.

- The employment of good construction management practices will minimise the risk of pollution of soil, storm water run-off, river water or groundwater.
- The Construction Industry Research and Information Association (CIRIA) in the UK has issued a guidance note on the control and management of water pollution from construction sites, Control of Water Pollution from Construction Sites, guidance for consultants and contractors (Masters-Williams et al 2001). Relevant measures which will be implemented are outlined below:
    - Hazardous material will be bunded to be able to contain 110% volume to guard against potential accidental spills.
    - Mobile settlement tanks discharging via silt socks will be utilised if required to filter surface water emissions from the site to any drains or watercourses
    - Works will not be undertaken during periods of heavy rainfall.
    - Wash down and washout of concrete transporting vehicles will not be permitted at the location of construction. Such wash down and washout activities will take place at an appropriate facility offsite or at the location where concrete was sourced.
    - Spill kits are retained to ensure that all spillages or leakages are dealt with immediately and staff are trained in their proper use. Any such spills, in the unlikely event of their occurrence would be minor.

3.8.1.2 Construction works – water quality

- The working area used during construction will be clearly outlined prior to the commencement of works and will be kept to the minimum area necessary to effectively complete the works. Vegetation will be retained where possible.
- All site personnel will be trained and aware of the appropriate action in the event of an emergency, such as the spillage of potentially polluting substances. In the event of spillage of any polluting substance and/or pollution of a watercourse, Cork County Council, Inland Fisheries Ireland and the NPWS shall be notified.
- A silt curtain will be installed downgradient of the site works and between the works and sensitive aquatic receptors during construction. The use of Terrastop Premium Silt Fence (or similar) will provide effective protection during construction works.
- It is noted that all vehicles used on site will be inspected on a daily basis to ensure there are no minor leaks of hydrocarbons. All site personnel will be trained and aware of the appropriate action in the event of an emergency, such as the spillage of potentially polluting substances.
- Concrete pouring will not take place during heavy rain when run off is likely due to excess water. Shuttering will be designed to accommodate small increases in the volume of material contained within the shuttered area due to rainfall.

- Construction of the long sea outfall will generally be restricted to the period April – October, with the period between November - February generally avoided. In this manner, the months with normally worst wave and wind conditions, which lead to higher levels of sediment suspension and transport, will be avoided. The Contractor should be aware of tidal and wind forecasts and should monitor these closely.

3.8.1.3 Construction works - protection of habitats

- To prevent incidental damage by machinery or by the deposition of spoil during site works, any habitats earmarked for retention in close proximity will be securely fenced or sign posted early in the construction phase. These will be clearly visible to machine operators.
- Habitats that are damaged and disturbed will be left to regenerate naturally or will be rehabilitated and landscaped, as appropriate, once construction is complete. Disturbed areas will be seeded or planted using appropriate native grass or species native to the areas where necessary.
- Mature trees will be avoided. Any hedgerows/scrub habitat disturbed during construction will be replanted using a suitable mix of native species.
- One sycamore tree is located within an area of amenity grassland at the proposed Pump Station at Rostellan. This tree lacks the structural elements that would provide potential bat roosts and as an isolated non-native species is considered of low ecological value. However, it is a locally important visual element in the context of the local landscape. Works in proximity to the tree will be minimised, however due to exposed location and as there will be some root damage, an aboriculturalist will assess the condition of the tree during and following the completion of site works (see earlier in this Section for further detail).

3.8.1.4 Construction works – storage and waste

- Oil, petrol and other fuel containers will be double-skinned and bunded to be able to contain 110% volume to guard against potential accidental spills or leakages entering local watercourses linked to the European sites. Bund specification will conform to the current best practice for oil storage such as Enterprise Irelands Best Practice Guidelines. Construction materials will be stored in a secure compound to prevent the potential for vandalism and theft of material.
- Dedicated fuel storage areas will be introduced on-site or fuelling should take place offsite.

3.8.1.5 Construction works – Ecology

Works will primarily take place during hours of daylight to minimise disturbance to any roosting birds or feeding nocturnal mammal species.

3.8.1.6 Construction works – noise

- Best practice noise and vibration control measures will be employed by the Contractor. The best practice measures set out in BS 5228 (2009) Parts 1 and 2 will be complied with. This includes guidance on several aspects of construction site environmental measures, including, but not limited to the following:
  - The potential for any item of plant to generate noise will be assessed prior to the item being brought onto the site. The least noisy item should be selected.
  - If replacing a noisy item of plant is not a viable or practical option, consideration will be given to noise control "at source".
    This refers to the modification of an item of plant or the application of improved sound reduction methods in consultation with the supplier. For example, resonance effects in panel work or cover plates can be reduced through stiffening or application of damping compounds; rattling and grinding noises can often be controlled by fixing resilient materials in between the surfaces in contact.
  - Mobile plant will be switched off when not in use and will not be left idling.
  - All items of plant will be subject to regular maintenance. Such maintenance can prevent unnecessary increases in plant noise and can serve to prolong the effectiveness of noise control measures.

3.8.1.7 Invasive species

Measures for dealing with invasive species are outlined in Appendix E of the NIS (Invasive Species Survey). The Report on this survey states that prior to the commencement of works, the works area will be re-surveyed to accurately assess any changes in distribution in the intervening period. In addition, an Invasive Species Management Plan will be prepared in accordance with best practice guidelines and all work related to invasive species at construction stage will be in accordance to this Management Plan. The method for the elimination of Japanese knotweed on the site will be implemented with reference to the relevant codes of practice and guidelines: Best Practice Management Guidelines – Invasive Species Ireland (Maguire et al. 2008), NRA (2010) and EA (2007) Managing Japanese Knotweed on Development Sites: The Knotweed Code of Practice.

3.8.1.8 Bird Mitigation Measures

See Section 3.7.2 below, Natura Impact Statement – Mitigation Measures.

3.8.1.9 Otter Mitigation Measures

A pre-construction otter survey will be carried out prior to the commencement of site works. Any holts found to be present will be subject to monitoring and mitigation as set out in the NRA Guidelines for the Treatment of Otter prior to the Construction of National Road Schemes (2006b). If found to be inactive, exclusion of holts may be carried out during any season.

No wheeled or tracked vehicles (of any kind) will be used within 20m of active, but non-breeding, otter holts. Light work, such as digging by hand or scrub clearance will also not take place within 15m of such holts, except under license. The prohibited working area associated with otter holts will be fenced and appropriate signage erected. Where breeding females and cubs are present no evacuation procedures of any kind will be undertaken until after the otters have left the holt, as determined by a specialist ecologist. Breeding may take place at any season, so activity at a holt must be adjudged on a case by case basis. The exclusion process, if required, involves the installation of one-way gates on the entrances to the holt and a monitoring period of 21 days to ensure the otters have left the holt prior to removal.

3.8.2 Natura Impact Statement - Mitigation Measures

Specific mitigation measures are detailed in the NIS and include all of those already provided in the EcIA above. In addition, the following specific measures are also included in the NIS:

3.8.2.1 Bird Mitigation Measures

- Works in close proximity to the Cork Harbour SPA will avoid the wintering bird season (September to March) as indicated in Figure 1 of this Report. This will minimise the disturbance to any wintering/migratory bird species utilising the harbour during this period. Hoarding will be required between the works area and the adjoining shoreline habitats at the proposed Pump Station at Lower Aghada during works during the summer period as this area is used by feeding birds during the summer months.
- The Wildlife Act 1976, as amended, provides that it is an offence to cut, grub, burn or destroy any vegetation on uncultivated land, or any such growing in any hedge or ditch from the 1st of March to the 31st of August. Exemptions include the clearance of vegetation in the course of road or other construction works or in the development or preparation of sites on which any building or other structure is intended to be provided. Nonetheless, it is recommended that vegetation be removed outside of the breeding season.

3.9 Surface Water Runoff

In addition to the water quality measures detailed above, the following is a list of the best practice construction measures for managing surface water run-off that will be implemented for the duration of the construction phase:

- All fuels/chemicals or other materials classified as hazardous will be kept stored within a bunded enclosed spillage tray or cabinet. A folder with an inventory of the chemicals along with their applicable SDS sheets and shall be kept within the designated fuel storage area.
- Fuelling and lubrication of machinery is not to be carried out within 50m of the shoreline.
- Machinery must not be leaking oil when carrying out the work.

- Any spillage of fuels, lubricants of hydraulic oils is to be immediately contained and the contaminated soil removed for proper disposal.
- No vehicles shall be left unattended when refuelling and a spill kit including an oil containment boom and absorbent pads shall be on site at all time;
- All vehicles shall be regularly maintained, washed and checked for fuel and oil leaks;
- Dewatering of excavations will be treated prior to discharge of water to a watercourse. Prior to discharge into White Bay, a number of measures will be implemented to intercept and treat silt laden surface water run-off. These measures will include, as a minimum, a boundary swale complete with "Sedimats" or equivalent and check dams, settlement ponds including a forebay and a siltbuster to be used by the Contractor to promote settlement and filtration. A boundary silt fence as a redundancy measure to retain any remaining silt and sediment.
- There shall be no direct pumping of contaminated water from the works to a watercourse at any time;

The following standard practices shall be implemented to reduce the generation of silt-laden run-off:

- All stockpiles of excavated material shall be covered to prevent run off of silt;
- Silt fences shall be provided at all locations where the works (including temporary works and haul roads) are within 10m of the shore;
- Silt fences/swales shall be provided at all locations where surface water run-off may enter/leave the working areas, and adjacent to the haul roads;
- The short-term storage and removal / recovery or disposal of excavated material shall be considered and planned such that risk of pollution from these activities is minimised.

The following measures will be implemented to reduce the impact on existing drainage:

- Stockpiles of topsoil and/or materials shall not obstruct existing drainage routes. Existing drains outside the development area will not be interfered with or blocked during the construction phase.

The following measures will be implemented to reduce the impact on the existing hydrological regime of the study area:

- Temporary works, such as material storage will be located to not significantly change flood flow paths anywhere within the study area.

3.10 Coastal Processes

The following mitigation measure is proposed with respect to effects on coastal processes from construction of the long sea outfall:

- Construction of the outfall will generally be restricted to the period April – October, with the period between November - February generally avoided. In this manner, the months with normally worst wave and wind conditions, which lead to higher levels of sediment suspension and transport, will be avoided. The Contractor should be aware of tidal and wind forecasts and should monitor these closely.

3.11 Other mitigation measures

During construction of the proposed Rostellan Pumping Station located in the Thomas Kent Memorial Park, the existing sculpture, commemorative plaque, flag pole, outdoor tables and seats, information sign at the entrance and the bollard and chain fencing will be removed and stored safely off-site. They will be placed back approximately in their current position on the completion of construction works. Topsoil will be reinstated, and grass seeded, to ensure that the finished Memorial Park would be similar to the existing Park.

4 Emergency Response Requirements and Procedures

A description of an Emergency Response Plan (ERP) is presented in this section of the CEMP. It provides details of procedures to be adopted in the event of an emergency in terms of site health and safety and environmental protection.

4.1 Environmental Emergency Procedure

The site-specific Emergency Response Plan (ERP) includes details on the response required and the responsibilities of all personnel in the event of an emergency. The ERP in terms of health and safety will require updating and submissions from the various contractors and suppliers as the proposed project progresses.

4.2 Spill Control Measures

Every effort will be made to prevent an environmental incident during the construction and operational phase of the proposed project.

Oil/Fuel spillages are one of the main environmental risks that will exist on the proposed site which will require an emergency response procedure. The importance of a swift and effective response in the event of such an incident occurring cannot be over emphasised.

The following steps provide the procedure to be followed in the event of such an incident.

- Stop the source of the spill and raise the alarm to alert people working in the vicinity of any potential dangers;
- If applicable, eliminate any sources of ignition in the immediate vicinity of the incident;
- Contain the spill using the spill control materials, track mats or other material as required. Do not spread or flush away the spill;
- If possible, cover or bund off any vulnerable areas where appropriate such as drains, watercourses or sensitive habitats;
- If possible, clean up as much as possible using the spill control materials;
- Contain any used spill control material and dispose of used materials appropriately using a fully licensed waste contractor with the appropriate permits so that further contamination is limited;
- Notify the Environmental Manager immediately giving information on the location, type and extent of the spill so that they can take appropriate action;
- The Environmental Manager will inspect the site and ensure the necessary measures are in place to contain and clean up the spill and prevent further spillage from occurring; and

- The Environmental Manager will notify the appropriate regulatory body such as Cork County Council, National Parks & Wildlife Service, Environmental Protection Agency (EPA) and Inland Fisheries Ireland (IFI), if deemed necessary.

Environmental incidents are not limited to just fuel spillages. Therefore, any environmental incident must be investigated in accordance with the following steps.

- The Environmental Manager must be immediately notified;
- If necessary, the Environmental Manager will inform the appropriate regulatory authority. The appropriate regulatory authority will depend on the nature of the incident;
- The details of the incident will be recorded on an Environmental Incident Form which will provide information such as the cause, extent, actions and remedial measures used following the incident. The form will also include any recommendations made to avoid reoccurrence of the incident;
- If the incident has impacted on a sensitive receptor such as an archaeological feature the Environmental Manager will liaise with the Project Archaeologist;
- A record of all environmental incidents will be kept on file by the Environmental Manager and the Main Contractor. These records will be made available to the relevant authorities such as Cork County Council, and DHPLG if required;
- In the event of any incident occurring which may impact significantly on the environment during the carrying out of the works, or during operations following the completion of these works, that incident will be reported to the relevant authority (e.g. Irish Coast Guard, NPWS, etc.) immediately by telephone.

The Contractor is responsible for any corrective actions required as a result of the incident e.g. an investigative report, formulation of alternative construction methods or environmental sampling, and will advise the Main Contractor as appropriate.

By carrying out the above steps, a proper system will be in place to investigate, record and report any potential accidents or incidents.

4.3 Fire Control Measures

Every effort shall be made to prevent the outbreak of a fire during the construction and operational phase of the proposed project. Fire extinguishers and first aid supplies will be available in the work area. In the event of such an incident, the health and safety of all personnel will be a priority.

The Contractor must ensure that there are:

- adequate fire escape routes;

- adequate measures for the prevention of internal and external spread of fire; and
- access and facilities for the fire safety services.

4.4 Emergency Flood Measures

The Contractor is required to prepare a comprehensive plan for managing the works that are being undertaken within areas susceptible to flooding.

The plan is required to outline proposed work methods, risk assessments and the emergency response measures and protocols that will be established to ensure the works can be carried out in a safe manner.

5 Site Demobilisation

In clearing the site, it is vital that wastes are managed in accordance with legislation, including avoiding burning of any clearance materials. Before a project is considered to be complete, the Contractor is required to clear away, and remove from the site, all equipment and materials. Any materials removed during the site demobilisation are still subject to transport management plans, loading procedures, waste management etc. This includes unused materials stored or taken to another site.