

## SECTION D – EXISTING ENVIRONMENT & IMPACT OF THE DISCHARGE(S)

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### Attachment D1: Marine Modelling Study Report

- Attachment D.1a: Phase 1 Model Scoping report
- Attachment D.1b: Phase 2 Survey Interpretative report
- Attachment D.1c: Phase 3 Model Calibration report
- Attachment D.1d: Phase 4 Modelling report

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# Youghal Marine Modelling Study

Survey Interpretive Report

Irish Water

Project number: 60619448

2<sup>nd</sup> July 2020

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## Table of Contents

1.	Introduction .....	6
2.	Data collected .....	7
2.1	Locations and instruments .....	7
2.2	Processing .....	11
2.3	Units .....	11
3.	Meteorological Station.....	11
4.	River flows .....	15
5.	Water level.....	20
5.1	Introduction.....	20
5.2	Youghal.....	20
5.3	Camphire Bridge.....	21
5.4	Cappoquin .....	22
6.	Salinity and temperature .....	24
7.	ADCP Transects .....	28
8.	Water Quality Sampling .....	35
9.	Conclusion .....	38
10.	Bathymetric Survey.....	11
11.	References .....	38
	Appendix A Document copies.....	39
A.1	App heading 2.....	
	Appendix B Survey specification .....	40
	Appendix C Fixed Station CTDs.....	41
	Appendix D CTD Profiles .....	43
	Appendix E Comparison of Youghal Met Station Data with Met Éireann data for Roches Point .....	61
	Appendix F Youghal Tide Gauge data.....	
	Appendix G ADCP Current data.....	68
	Appendix H Water quality sampling results .....	93

## Figures

Figure 1-1.	Tidal curve for the months of January and February showing the timing of each of the surveys.....	6
Figure 2-1.	Survey locations for ADCP and CTD Meters and Water Quality Sampling (note that no drogoue releases were undertaken).....	8
Figure 2-2.	Locations of each sample for the Youghal Bay 1, 2 and 3 locations and excluded samples. ....	10
Figure 3-1.	Bathymetric survey of Youghal Harbour area. ....	12
Figure 4-1.	Observed meteorological data at Youghal WwTP .....	14
Figure 5-1.	Derived rating curves for Ballyduff (top) and Mogeely (bottom).....	16
Figure 5-2.	Calculated flow rates at Mogeely and Ballyduff for the survey period.....	17
Figure 5-3.	Locations of tributaries to the Youghal Estuary showing the tributaries for which flow duration curves are available (blue) and not available (red).....	18
Figure 6-1.	Observed water level data for Youghal tide gauge (top) and the OPW gauge (bottom). ....	21
Figure 6-2.	Observed water levels at Camphire Bridge.....	22

Figure 6-3. Investigation of the low water rating curve based on the flow at Ballyduff and the survey tide gauge at Cappoquin.....	23
Figure 7-1. Temperature and salinity values recorded at Youghal. ....	26
Figure 7-2. Example of the plots for the CTD Profiles showing data for Youghal Bridge on 21 <sup>st</sup> January 2020 .....	27
Figure 8-1. Transect locations for all surveys.....	29
Figure 8-2. Example of scatter plot of currents using U and V vectors .....	31
Figure 8-3. Example of vertical profile and depth averaged current.....	32
Figure 8-4. Depth averaged current speed and direction at the intersection of Transect E with Transects A to D on 17 <sup>th</sup> January.....	33
Figure 8-5. Depth averaged current speed and direction at the intersection of Transect E with Transects A to D on 21 <sup>st</sup> January.....	34
Figure 8-6. Depth averaged current speed and direction at the intersection of Transect E with Transects A to D on 28 <sup>th</sup> January.....	35
Figure 9-1. Water Quality Monitoring Results .....	37

## Tables

Table 2-1. Details of physical parameters measured .....	9
Table 5-1. Flow duration curves for all tributaries [ $m^3/s$ ].....	19
Table 7-1. Statistics for temperature and salinity at each fixed station CTD .....	24
Table 7-2. Summary statistics for each profile station.....	25

## Glossary

ADCP	Acoustic Doppler Current Profiler
CTD	Conductivity-Temperature-Depth
MSL	Mean Sea Level
OD	Ordnance Datum Malin Head
PSU	Practical Salinity Units

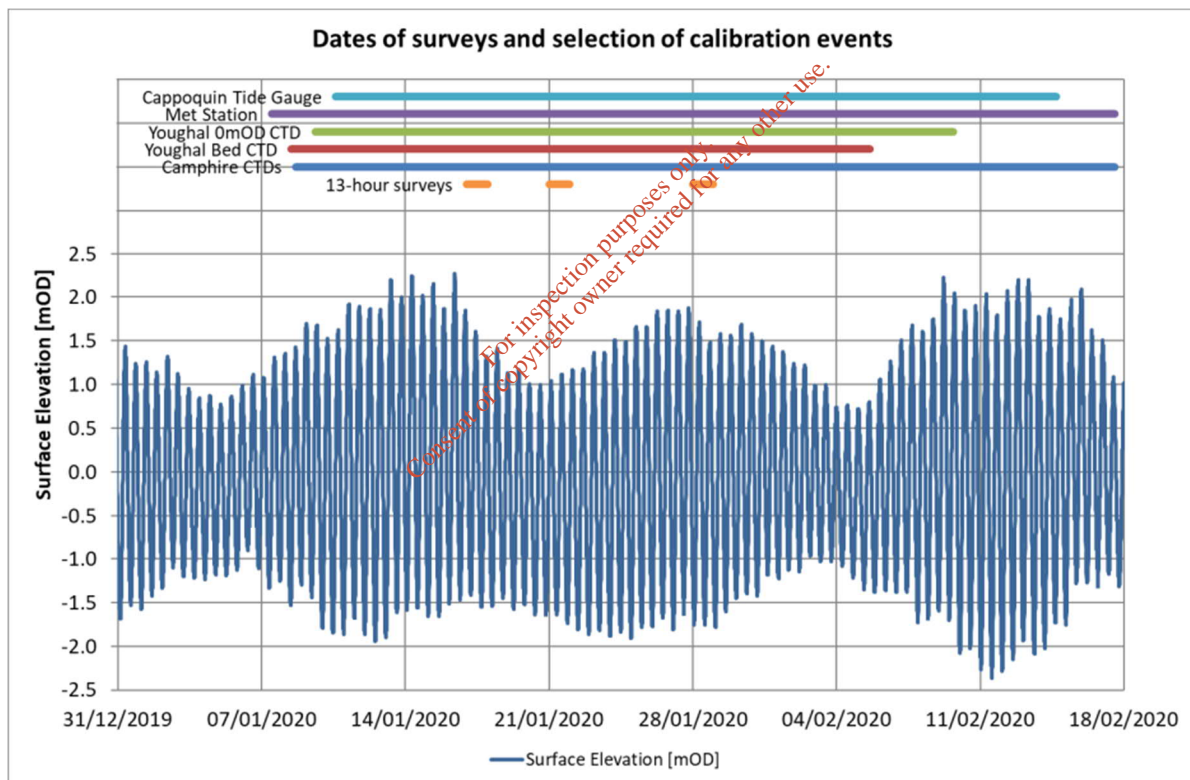
# 1. Introduction

A metocean survey has been commissioned in support of the Youghal WwTP water quality modelling project. The objective of the survey is to collect data to aid the understanding of the physical and water quality processes in the estuary and to facilitate the setup, calibration and validation of a numerical model of the water quality around Youghal and associated with the WwTP at Youghal.

The specification for the survey was presented in the Model Scoping Report (AECOM, 2019) for the project. The scope provided to the contractor is in Appendix B. The specification has been modified during the survey to meet the constraints of the project including:

- No instruments to be placed on the sea or river bed;
- Weather preventing collection of data outside of the estuary.

The surveys were undertaken in January and February 2020 with three 13-hour surveys covering an intermediate tide on 17<sup>th</sup> January, a spring tide on 21<sup>st</sup> January and a neap tide on 28<sup>th</sup> January as shown in Figure 1-1.



**Figure 1-1. Tidal curve for the months of January and February showing the timing of each of the surveys.**

## 2. Data collected

### 2.1 Locations and instruments

Locations for the surveys undertaken are shown in Figure 2-1. Additional observed water levels by the OPW at Youghal Quay have also been downloaded from the OPW website (Waterlevel.ie). Details of the data collected are provided in Table 2-1.

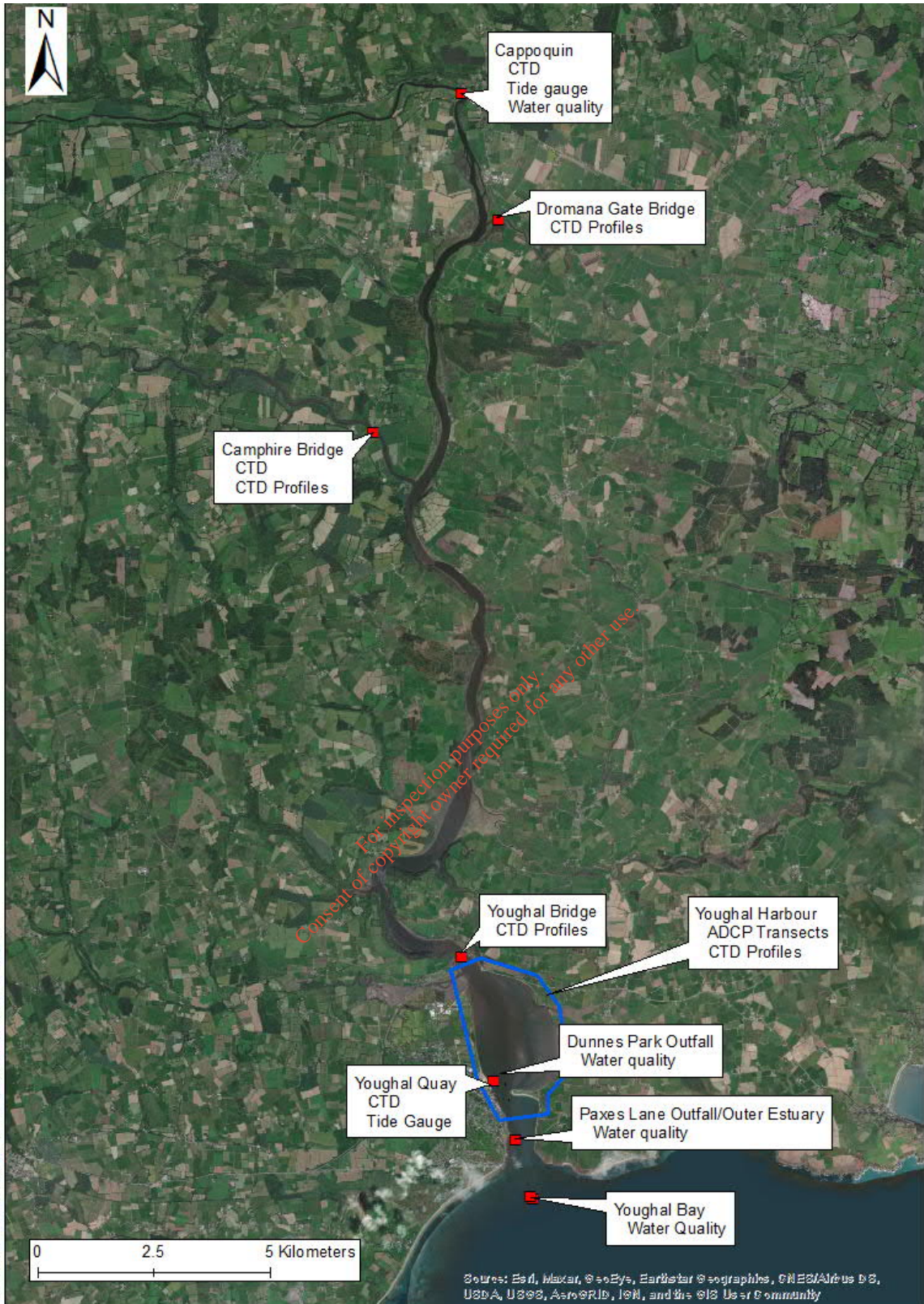
The instruments deployed at the Cappoquin station were not all co-located due to access issues and concerns over safety (security) of instruments exposed above the water line. The instruments were deployed as follows:

- CTD profiles from the road bridge
- CTD attached to the underside of the pontoon on the left bank downstream of the road bridge
- A tide gauge and CTD at the bed attached to the old Railway Bridge.

Each drop for the 13-hour profiles at Youghal Bridge was undertaken close to the bridge when possible, but not all profiles were taken at the same location, e.g. if the survey vessel could not make it back to the bridge due to logistics. This has resulted in three separate locations to be defined as Youghal Bay 1, 2 and 3. Youghal Bay 1 is immediately downstream of the bridge. Youghal Bay 2 is between Ferry Point and the bridge and Youghal Bay 3 is downstream of Ferry Point. In addition, some drops were made in locations where there was no repeated survey. These have been identified and classified as 'excluded profiles'. The locations of each of the drops and the locations are shown in Figure 2-2.

Water samples were taken at five locations (Cappoquin, near the Paxes Lane and Dunnes Park outfalls and in Youghal Bay) for subsequent analysis of ammonia, BOD, DIN, DO, nitrate, nitrite, phosphate, pH, salinity, E Coli and Intestinal Enterococci.

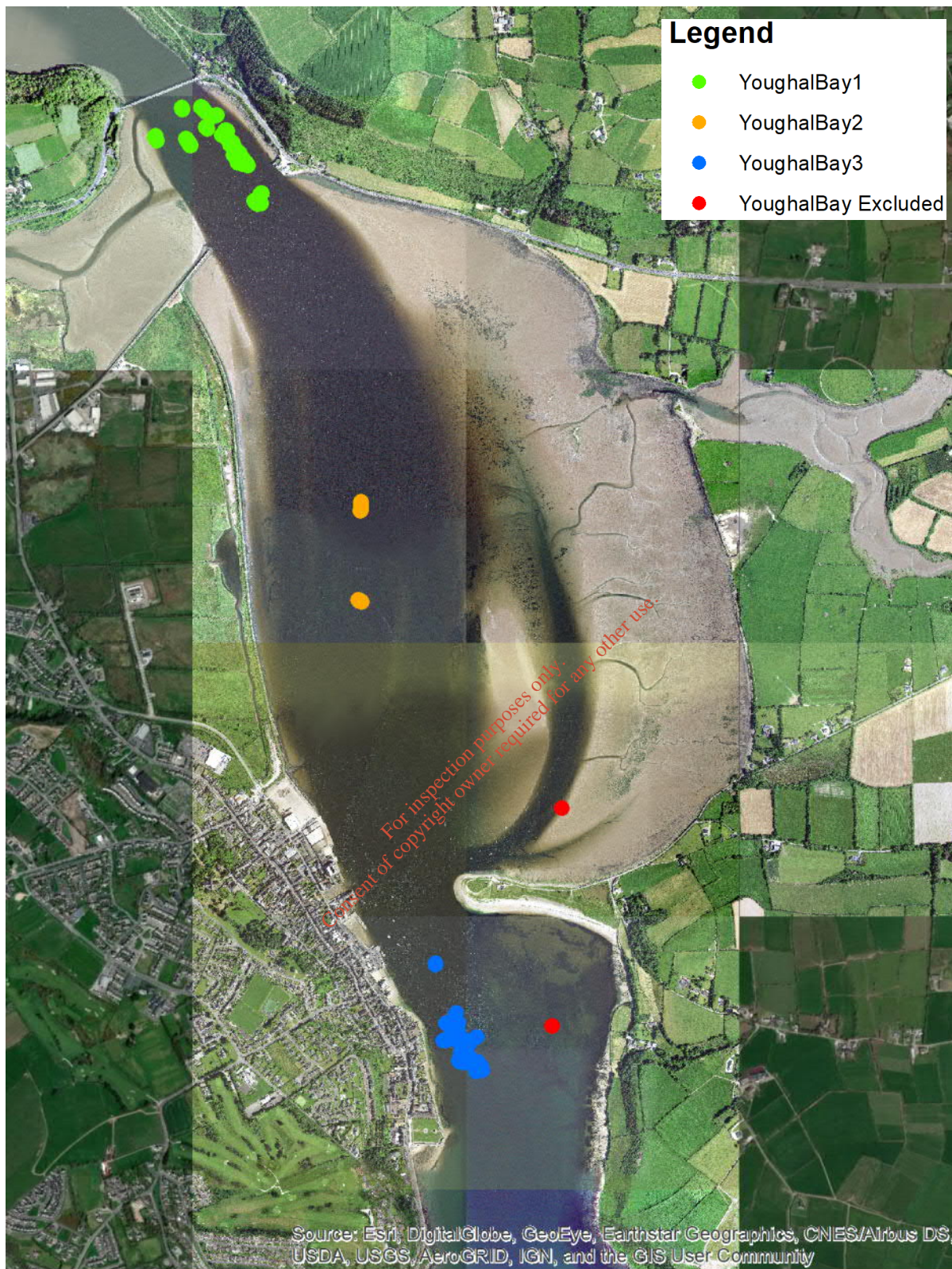




**Figure 2-1. Survey locations for ADCP and CTD Meters and Water Quality Sampling (note that no drogue releases were undertaken).**

**Table 2-1. Details of physical parameters measured**

Location	Gauge	Parameters
Youghal WwTP	Met Station	Temperature, wind speed and direction, wind gust speed, atmospheric pressure, precipitation
Cappoquin	Fixed Tide	Water level
	Fixed CTD Pontoon	Temperature, salinity
	Fixed CTD Bed	Water level, temperature, salinity
	3 x CTD Profile	Temperature, salinity
Dromana Gate	3 x CTD Profile	Temperature, salinity
Camphire Bridge	Fixed CTD 0mOD	Water level, temperature, salinity
	Fixed CTD Bed	Water level, temperature, salinity
	3 x CTD Profile	Temperature, salinity
Youghal Bay 1	3 x CTD Profile	Temperature, salinity
Youghal Bay 2	3 x CTD Profile	Temperature, salinity
Youghal Bay 3	3 x CTD Profile	Temperature, salinity
Youghal Quay	Fixed tide gauge	Water level, temperature, salinity
	Fixed CTD 0mOD	Water level, temperature, salinity
	Fixed CTD Bed	Water level, temperature, salinity



**Figure 2-2. Locations of each sample for the Youghal Bay 1, 2 and 3 locations and excluded samples.**

## 2.2 Processing

The survey data and appropriate data downloaded from the OPW website is presented for each location. All data for a single survey location is presented together with a comment on the quality of the data and a brief description of the physical environment described by the data.

The CTD instruments have all recorded water pressure that has been converted to surface elevations. The conversion has corrected the pressure using the observed atmospheric pressure from the met station and the surveyed elevation of the device. The fixed station CTDs have recorded data at 2Hz and have therefore been averaged to provide one value every 5 minutes.

## 2.3 Units

The units used for all parameters are presented below. Salinity is dimensionless, however for avoidance of doubt the units are defined as “Practical Salinity Units” or PSU; the older notation of parts per thousand, ppt or ‰ are not used.

Parameter	Units
Atmospheric pressure	hPa (= mbar)
Depth	m
Precipitation	mm/day
Salinity	PSU
Temperature	°C
Water level	mOD Malin, abbreviated to mOD
Wind direction	°N (cardinal points of 22.5°)
Wind speed	m/s

## 3. Bathymetric Survey

A bathymetric survey was completed on the 3<sup>rd</sup> and 4<sup>th</sup> January 2020. The survey was conducted in fair weather with a light westerly wind. The survey used a single beam echo sounder mounted on a shallow draft vessel and was completed over the periods of high tide. The results of the survey are shown in Figure 3-1. The data was provided in text files of xyz data reduced to OD Malin Head and in ING coordinates.

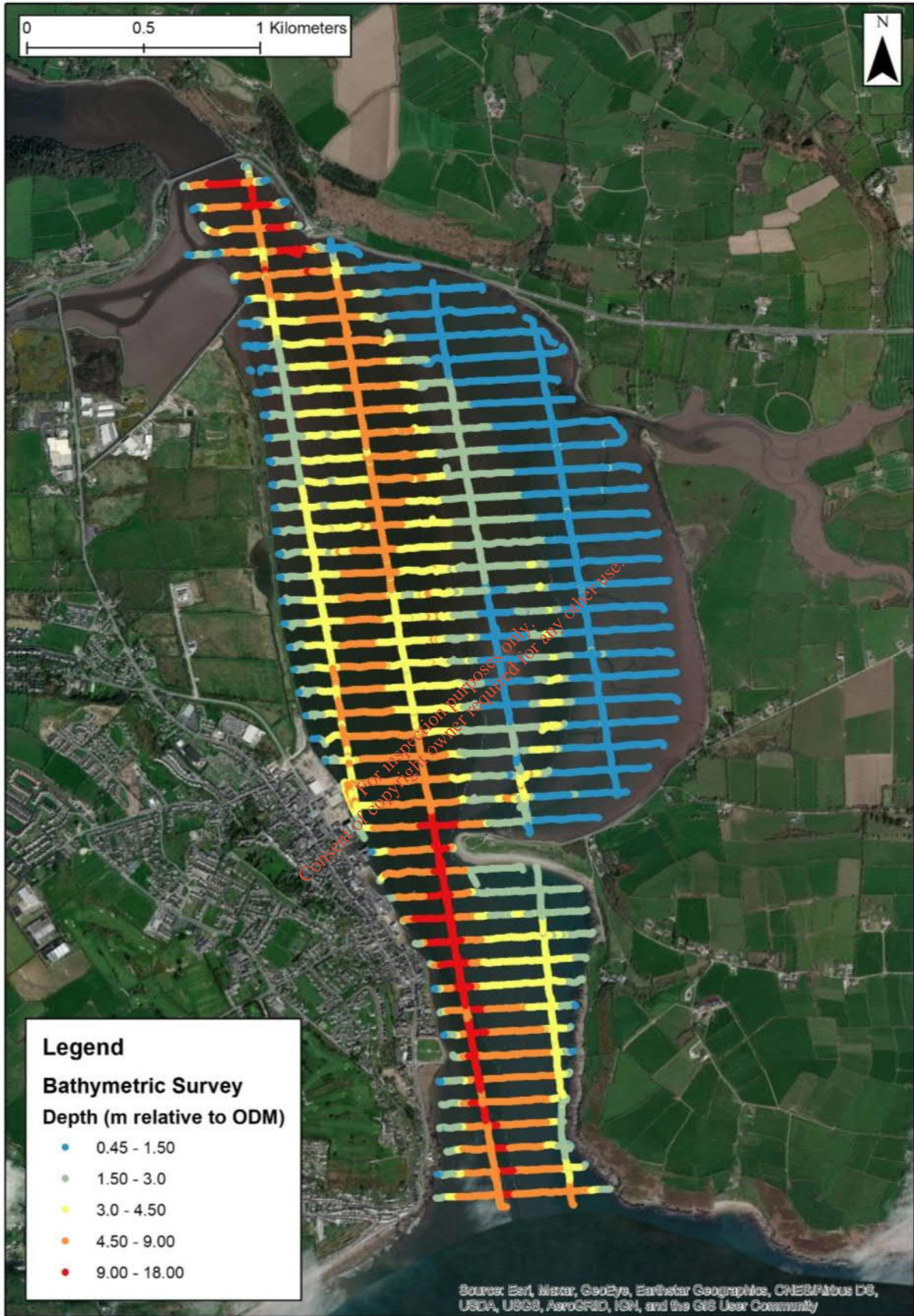


Figure 3-1. Bathymetric survey of Youghal Harbour area.

## 4. Meteorological Station

A meteorological station (met station) was installed at the Youghal WwTP for the duration of the survey. The data provided has been plotted and compared to similar data from the Met Éireann station at Roches Point at the entrance to Cork Harbour. The recorded atmospheric pressure, daily rainfall, air temperature and wind speed and direction are all shown in Figure 4-1.

A comparison of the observed data with the Met Éireann data for Roches Point (Met Éireann, 2020) is provided in Appendix E. The comparison shows that the Youghal WwTP met station has recorded similar values and is consistent with the patterns in the weather seen at Roches Point.

The weather data shows two high pressure systems and several low-pressure systems during the 35-day survey period. There is decreased rainfall and strong diurnal variation in the air temperature during the periods of high pressure; which is consistent with the weather systems affecting the area.

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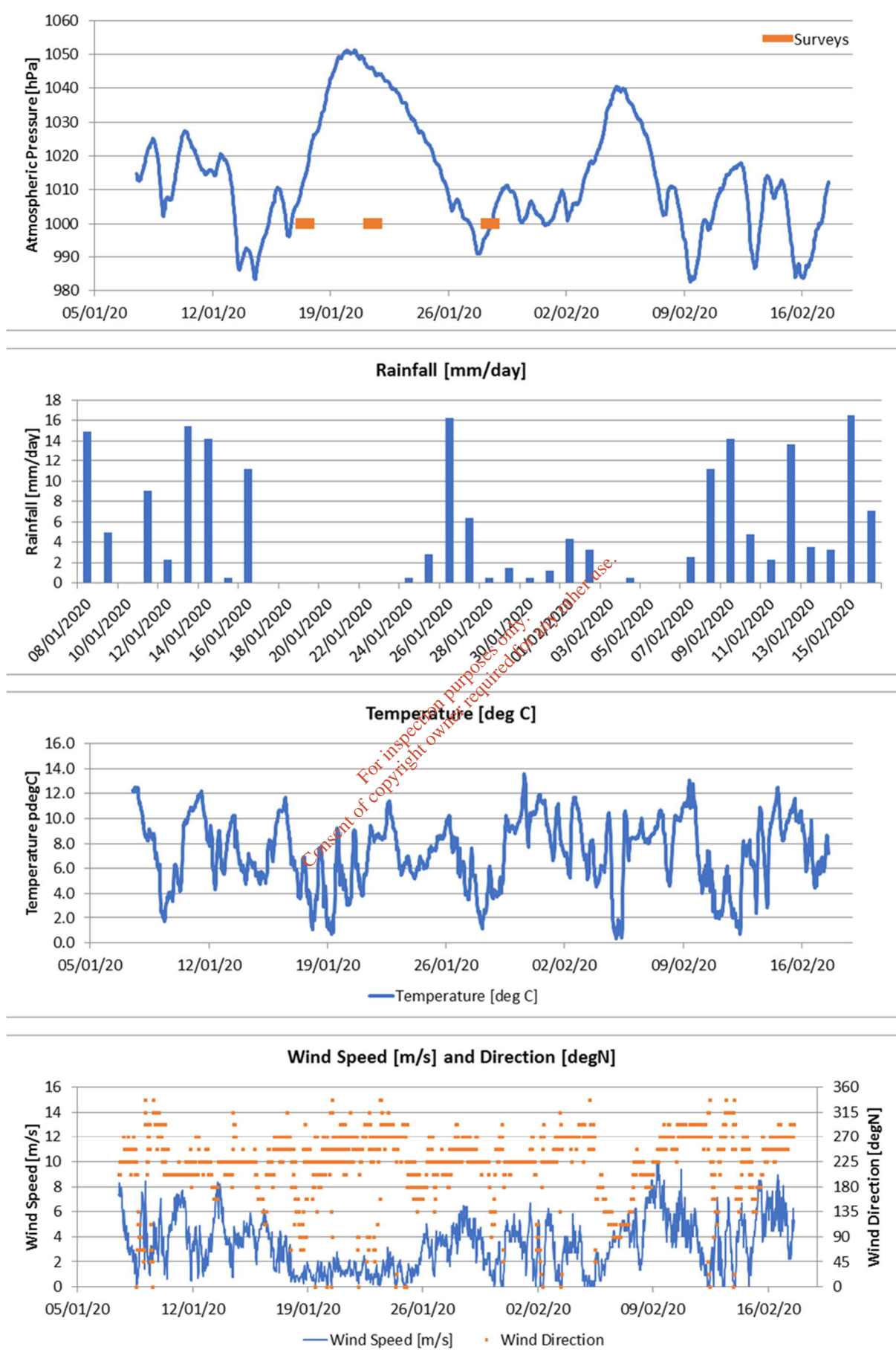


Figure 4-1. Observed meteorological data at Youghal WwTP

## 5. River flows

The two main rivers flowing into the Youghal estuary are the River Blackwater and the River Bride. Both rivers have OPW hydrometric stations Ballyduff (18002) on the River Blackwater and Mogeely (18001) on the River Bride. The water level is available for both sites for the survey period with historic level and discharge data also available. The water level and discharge data have been downloaded from the [WaterLevel.ie](http://WaterLevel.ie) website (OPW, 2020).

Rating curves for gauging stations are normally estimated through the *in-situ* measurement of stage and discharge over a range of flow conditions. A relationship is then estimated that may be either a lookup (graphical) or an algebraic function. This relationship is then used by the OPW to convert easily measured stage into discharge. The actual relationship at each site may change over time and an update to the rating curve implemented.

The historic flow and stage data have been used to identify the stage-discharge relationship, effectively reversing the rating curve process at each of the two sites (Figure 5-1). The relationship for Ballyduff is based on data from 2015 to 2020.

Flow rates for the Mogeely site are only available up to 1999. The relationship appears to have changed during 1998, possibly due to a datum shift. The curve used to determine the discharge from the water levels for January and February 2020 has used pre 1998 relationship. The relationship is referred to as the “derived relationship” within the remainder of this report.

Based on the use of the derived relationships and observed water level data, the estimated flow rates during the survey period are shown below in Figure 5-2.

**Additionally, all the minor tributaries to the estuary have been identified from the EPA hydrometric system (EPA, 2020). The flow duration curve for each tributary for which data is available has been downloaded and are reproduced in**

Table 5-1. The tributaries that this includes are shown in blue in Figure 5-3 with the tributaries for which there is no data shown in red (less than 5 km<sup>2</sup>). Only the downstream parts of the tributaries (the lowest reach on the river for which data was available) are highlighted, close to where the water would flow into the model.

Analysis of the mean flows, (assumed to be the Q30 flow rate - [https://www.epa.ie/pubs/reports/water/flows/Hydrological Data Book 1995.pdf](https://www.epa.ie/pubs/reports/water/flows/Hydrological_Data_Book_1995.pdf)), suggests that the River Blackwater contributes approximately 68% of the total fluvial flow in the Blackwater Estuary, the River Bride 16% and all other tributaries 16%. This suggests that whilst individually the flows are small, with Q30 flows generally less than 1 m<sup>3</sup>/s, collectively they are a significant part of the total freshwater flow into the estuary.

The flow rate at the tidal limit has been estimated from the Ballyduff flow rate and scaled to account for the slight increase in catchment area to the tidal limit using the flow duration curve data from the EPA hydrometric website (EPA, 2020). The flow rates in all other tributaries have then been estimated by using the flow duration curves for each tributary.



The tributary flow rate is assumed to be the same percentage exceedance as the River Bride at Mogeely.

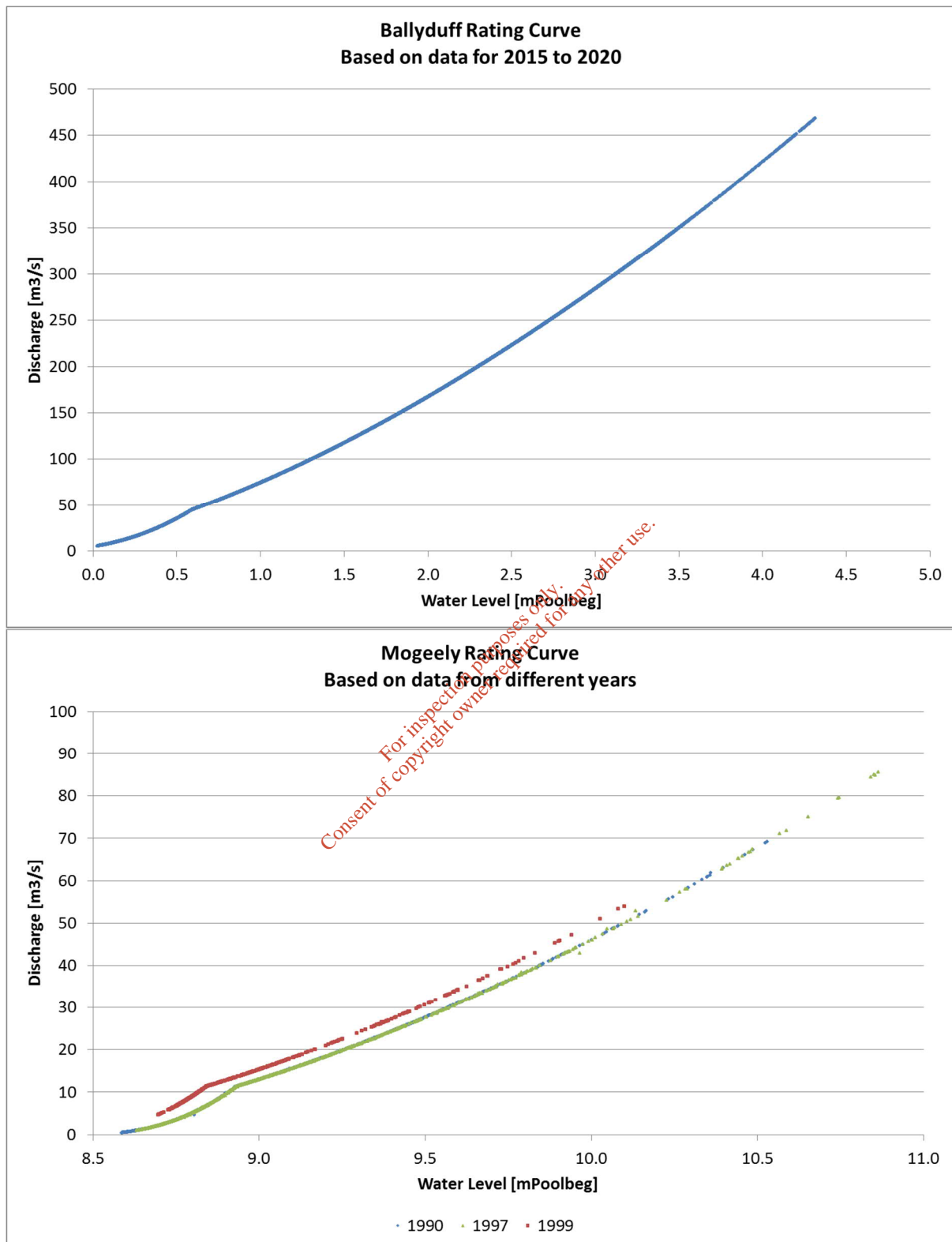


Figure 5-1. Derived rating curves for Ballyduff (top) and Mogeely (bottom)

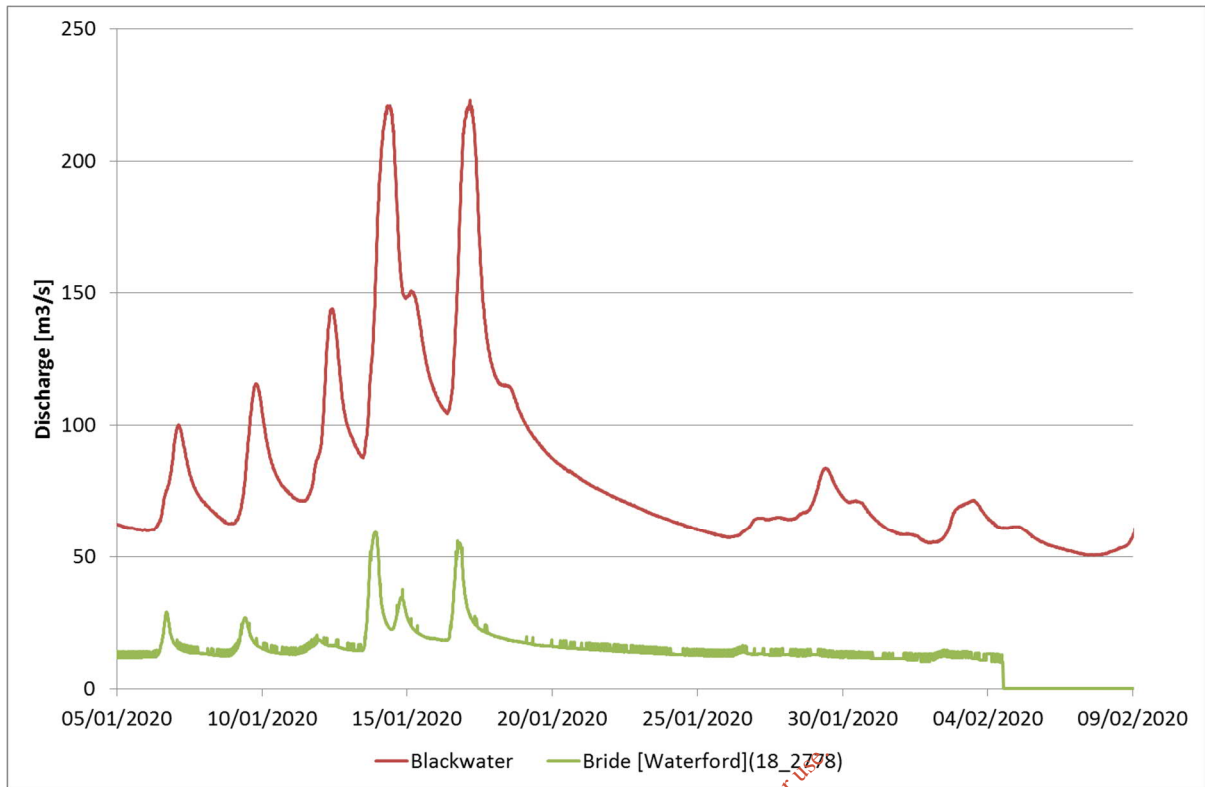
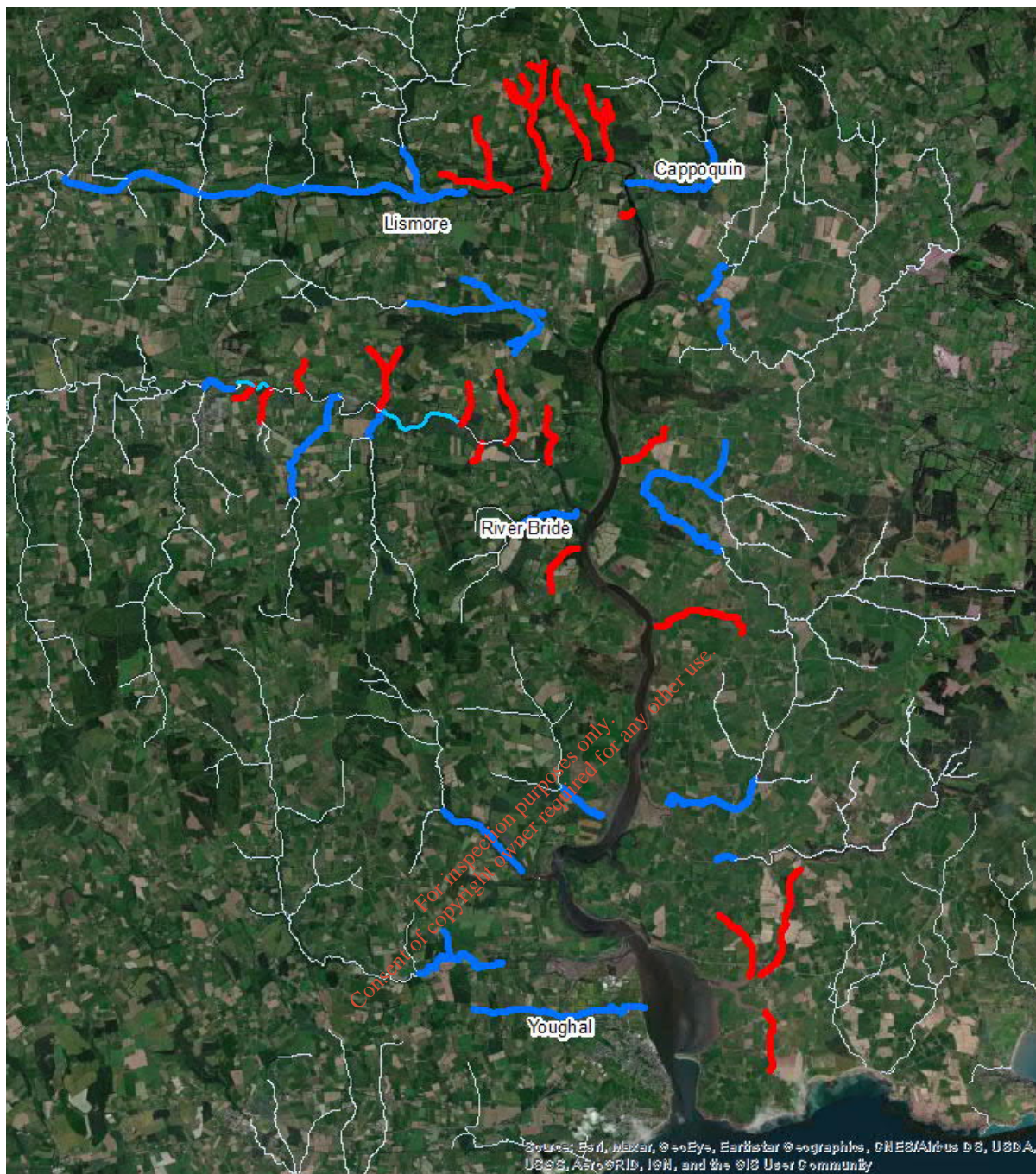


Figure 5-2. Calculated flow rates at Mogeely and Ballyduff for the survey period

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**Figure 5-3. Locations of tributaries to the Youghal Estuary showing the tributaries for which flow duration curves are available (blue) and not available (red).**

**Table 5-1. Flow duration curves for all tributaries [m<sup>3</sup>/s]**

River	Percentile										
	5	10	20	30	40	50	60	70	80	90	95
Blackwater [Munster](18_2755)	118.4	91.1	62.5	47.5	37.3	38.4	29.5	21.7	16.5	11.0	8.3
GLENNAFALLIA 18(18_2766)	3.8	2.9	1.9	1.3	1.0	0.8	0.7	0.5	0.4	0.3	0.2
MONEYGORM(18_2772)	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Finisk(18_2770)	7.9	5.8	3.7	2.5	1.9	1.5	1.2	0.9	0.7	0.4	0.3
Owbeg [Waterford](18_2776)	0.9	0.7	0.5	0.4	0.5	0.4	0.3	0.3	0.2	0.1	0.1
COOLAHEST(18_2805)	1.0	0.5	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1
Goish(18_2808)	2.3	1.7	1.2	0.8	0.6	0.4	0.3	0.2	0.2	0.1	0.1
HEADBOROUGH(18_2800)	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0
MONATRIM_LOWER(18_2790)	1.1	0.8	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.0	0.0
Kilbeg Stream(18_2786)	1.2	0.9	0.6	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.0
Bride [Waterford](18_2778)	26.5	20.3	14.3	11.0	8.3	7.2	5.2	3.6	2.4	1.5	1.1
ABARTAGH(18_2818)	1.1	0.8	0.6	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Licky(18_2820)	3.6	2.8	1.9	1.4	1.1	0.6	0.5	0.3	0.2	0.1	0.0
HARROWHILL(18_2814)	1.1	0.8	0.6	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1
Glendine [Blackwater](18_2822)	1.4	1.1	0.7	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1
Tourig(18_2824)	3.5	2.7	1.8	1.4	1.1	0.8	0.6	0.4	0.3	0.2	0.1
MUCKRIDGE(18_967)	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Blackwater (tidal limit)	118.4	91.1	62.5	47.5	37.3	38.4	29.5	21.7	16.5	11.0	8.3
Bride (Mogeely)	26.5	20.3	14.3	11.0	8.3	7.2	5.2	3.6	2.4	1.5	1.1
Others	30.5	22.9	15.2	11.0	8.6	6.4	4.8	3.6	2.5	1.6	1.2
Total flow	175.4	134.3	92.0	69.5	54.2	52.0	39.5	28.9	21.5	14.0	10.6
As % of Total flow											
Blackwater	68%	68%	68%	68%	69%	74%	75%	75%	77%	78%	79%
Bride	15%	15%	16%	16%	15%	14%	13%	12%	11%	10%	10%
Others	17%	17%	17%	16%	16%	12%	12%	13%	12%	11%	11%

## 6. Water level

### 6.1 Introduction

Tide gauges were installed at Youghal and Cappoquin and the CTDs at Camphire bridge have also been used to provide water levels there. Additionally, the data for the OPW tide gauge at Youghal Quay has been downloaded from WaterLevel.ie (OPW, 2020).

### 6.2 Youghal

The tide gauge at Youghal returned data at 5-minute intervals between 3<sup>rd</sup> January and 14<sup>th</sup> February. There were several points at which the instrument was reset, and it was not operating for approximately 10 days. However, for the period that the gauge was operating the data return is good quality (Figure 6-1). The OPW gauge data has also been downloaded and provides a continuous water level for the entire survey period and therefore the OPW gauge should be used for calibration.

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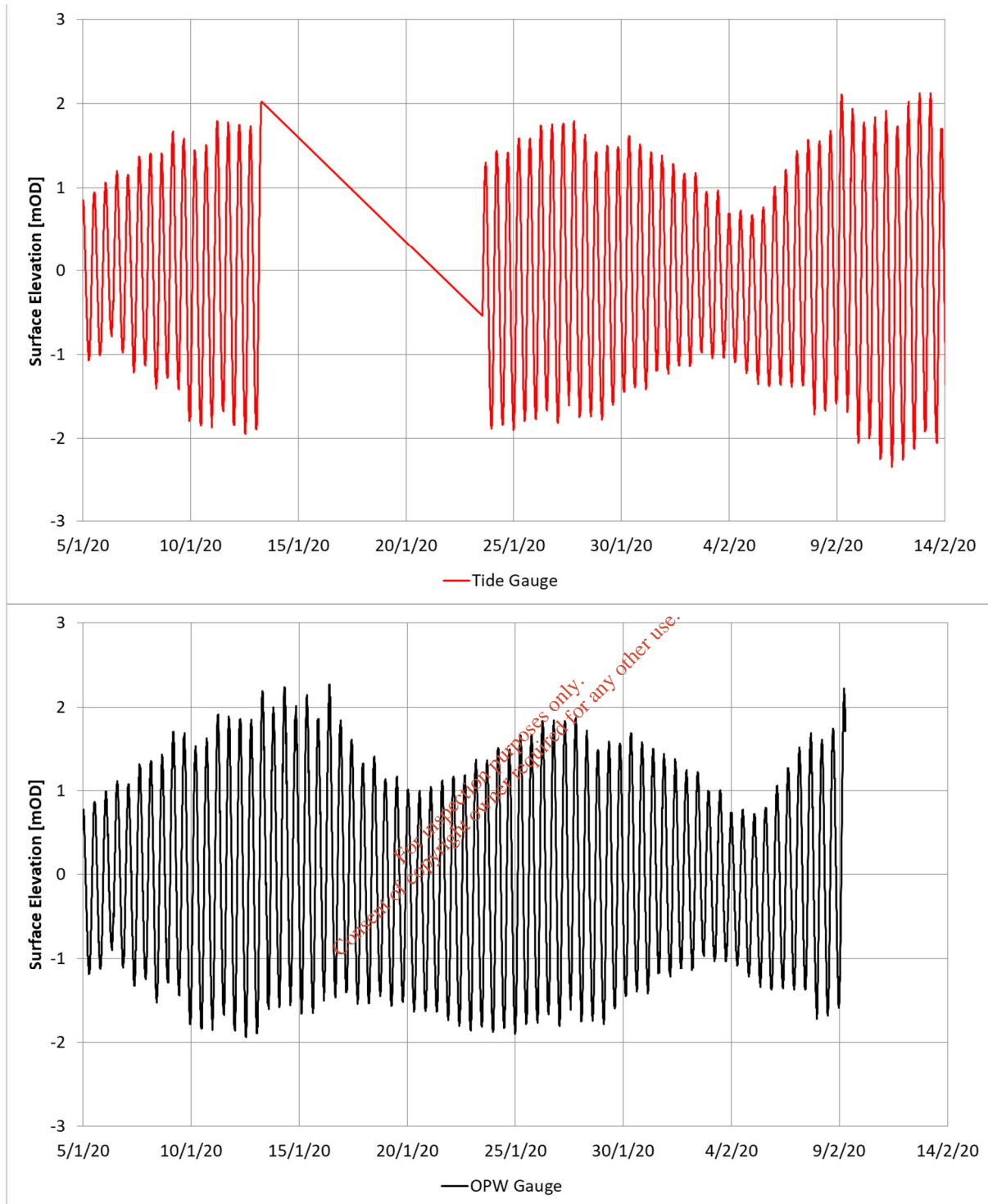


Figure 6-1. Observed water level data for Youghal tide gauge (top) and the OPW gauge (bottom).

### 6.3 Camphire Bridge

The surface elevation from the CTD on the bed at Camphire Bridge is shown in Figure 6-2.

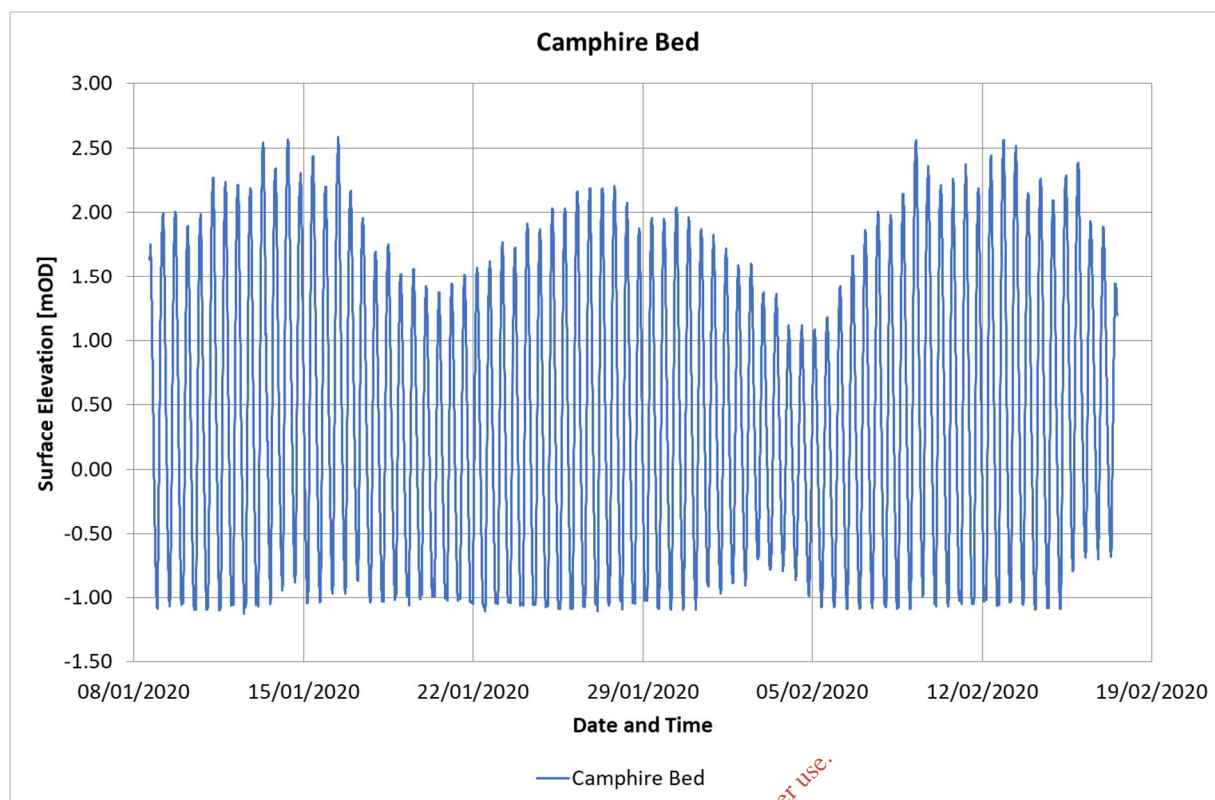
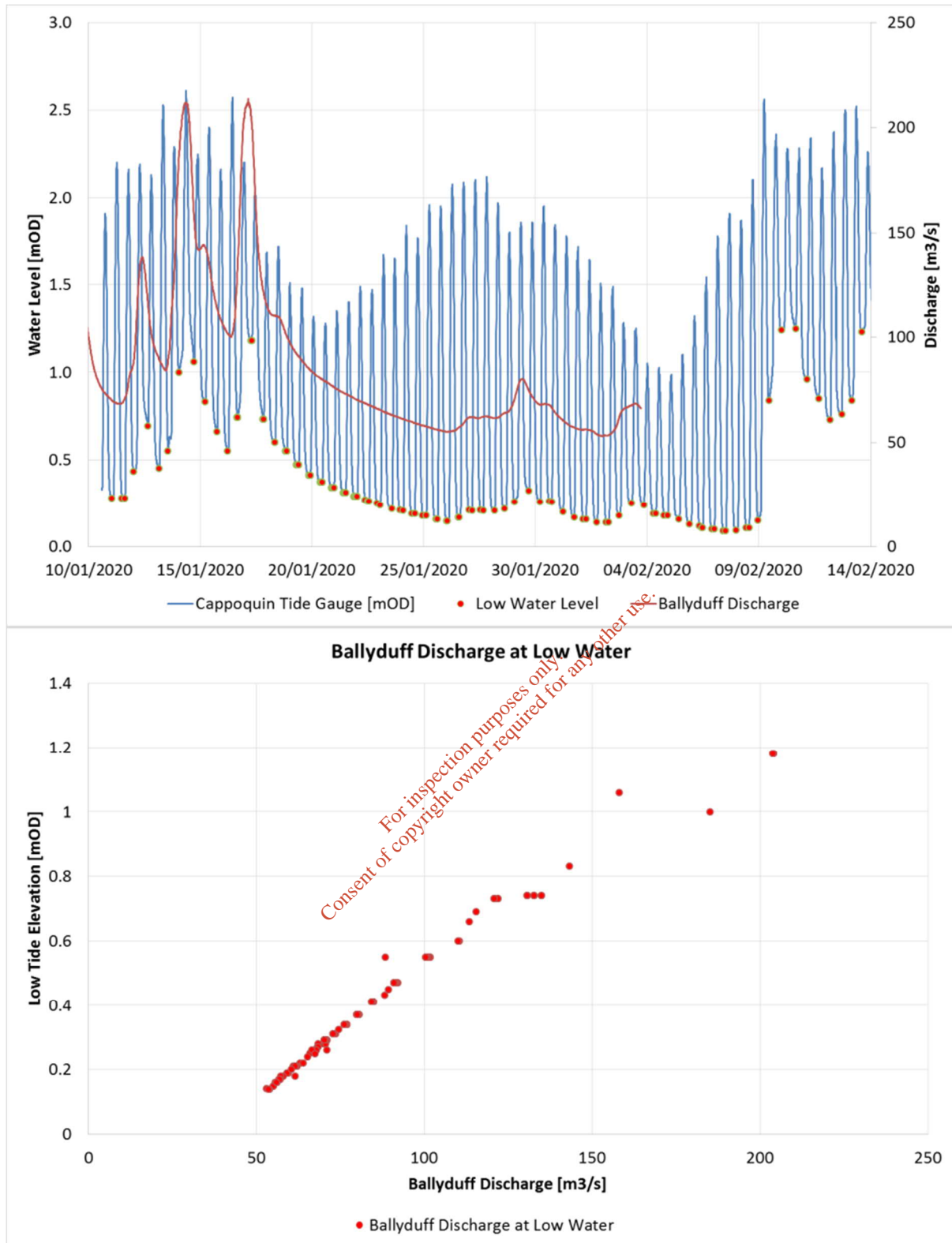


Figure 6-2. Observed water levels at Camphire Bridge.

## 6.4 Cappoquin

The tide gauge at Cappoquin has been used to provide measured water level data over the survey period (Figure 6-3 **Error! Reference source not found.**). This data has been inspected and analysed and is deemed reliable and should be used for model calibration.

The tide gauge at Cappoquin has been analysed to identify the tidal low water level. This has then been combined with the flow rate for the Blackwater to investigate the low water rating curve. The data is shown in Figure 6-3 and shows that for the majority of flow rates the low water level is described very well by the flow rate in the River Blackwater.



**Figure 6-3. Investigation of the low water rating curve based on the flow at Ballyduff and the survey tide gauge at Cappoquin.**



## 7. Salinity and temperature

Salinity and temperature have been measured at three fixed stations for 35 days and four spot locations for three separate 13-hour profile measurements. Table 7-1 shows the minimum, mean and maximum recorded temperature and salinity at each of the fixed station CTDs. This table shows that the water at Camphire Bridge and Cappoquin is effectively fresh water (salinities are <0.5 PSU) throughout the tidal cycle and at all levels. However, the values for Youghal show that there is a variation in salinity and suggests that the location is in an area of tidal influence and mixing. The minimum salinity for the instrument on the bed is lower than the one at 0mDD suggesting that the area can be almost fully fresh water over the period of low tide.

Figure 7-1 shows the observed time series of the salinity and temperature at Youghal both at 0m ODM and at the sea bed. The figures show that there is a clear tidal signal at both levels. Similar figures for the other sites are provided in Appendix C.

**Table 7-1. Statistics for temperature and salinity at each fixed station CTD**

Location	Salinity				Temperature			
	Min	Mean	Max	St dev	Min	Mean	Max	St dev
Cappoquin Railway Bridge Bed	0.1	0.1	0.2	0.0	5.1	7.1	9.1	1.0
Cappoquin Pontoon	0.1	0.1	0.2	0.0	5.1	7.3	9.1	1.0
Camphire Bed	0.0	0.2	0.7	0.7	-3.8	7.2	11.6	1.4
Camphire 0mOD	0.1	0.2	0.7	0.0	5.2	7.3	9.2	1.0
Youghal Bed	1.0	26.3	34.6	9.0	6.0	8.7	10.1	0.7
Youghal 0mOD	14.6	31.4	34.6	3.7	6.1	9.0	9.9	0.4

Three 13-hour surveys at four locations were undertaken. The data collected shows the variation in temperature and salinity throughout a tidal cycle and the vertical profile. The purpose of the surveys is to identify the degree of mixing between fresh and saline water within the estuary and whether or not there is a significant variation in the vertical profile.

The summary statistics for each location and parameter are shown below in Table 7-2. Figure 7-2 shows the variation of temperature and salinity through the tidal cycle and with depth for Youghal Bridge on 21<sup>st</sup> January 2020. The plots for each location and day are provided in Appendix C. The plots are intended to show the variation of temperature and salinity through the tidal cycle and with depth. The top image shows the variation of temperature and salinity through time (all depths). The middle image shows the variation with depth and the bottom image shows the T-S diagram.

The data for Cappoquin Bridge, Dromanna Gate and Camphire Bridge show that all three of the sites are freshwater (salinities <0.5 PSU) throughout the tidal cycle. The data for the three Youghal Bay sites cannot be compared on a like for like basis as all three sites were not surveyed in a temporally consistent manner throughout any tidal cycle. They do however provide a wide spread sample of temperature and salinity profiles in an area of strong mixing between the fresh and saline water.

**Table 7-2. Summary statistics for each profile station.**

Location	Temperature				Salinity			
	Min	Mean	Max	St dev	Min	Mean	Max	St dev
Cappoquin Bridge	3.6	6.7	7.8	0.8	0.0	0.1	0.2	0.0
Dromana Gate	5.2	6.7	8.0	0.5	0.1	0.1	0.2	0.0
Camphire Bridge	5.5	6.7	7.9	0.8	0.1	0.1	0.2	0.0
Youghal Bay1	6.3	8.6	9.9	0.7	0.3	22.3	40.0	12.0
Youghal Bay2	9.2	9.6	9.9	0.2	25.2	35.6	36.8	2.0
Youghal Bay3	6.2	8.6	9.6	0.7	4.6	26.8	40.0	9.4

The data for Youghal Bay shows a significant range of salinity values indicating that the mixing of fresh and salt water is occurring in this location through the tidal cycle and water column. It is notable that the minimum salinity measured at Youghal Bridge is 0.3 and maximum salinity measured at Youghal Bridge approaches 40 and that this is a high value. The instrument used for some of the profiles was later found to be faulty by the surveyor and has been sent back to the vendor for checking. The profiles undertaken using this device affects the surveys on 21<sup>st</sup> and 28<sup>th</sup> January and will be excluded in the analysis for model calibration.

The measurements of salinity and temperature do show that there is significant mixing within the Youghal Harbour area. The mixing appears to be such that there is strong vertical mixing; however, there are also some periods when the surface few metres appear to be stratified. It is possible that a 2D model will be able to replicate the overall mixing; however, it is also possible that a 3D model will be required. It is recommended that the calibration and validation of the model identifies whether 3D modelling is required.

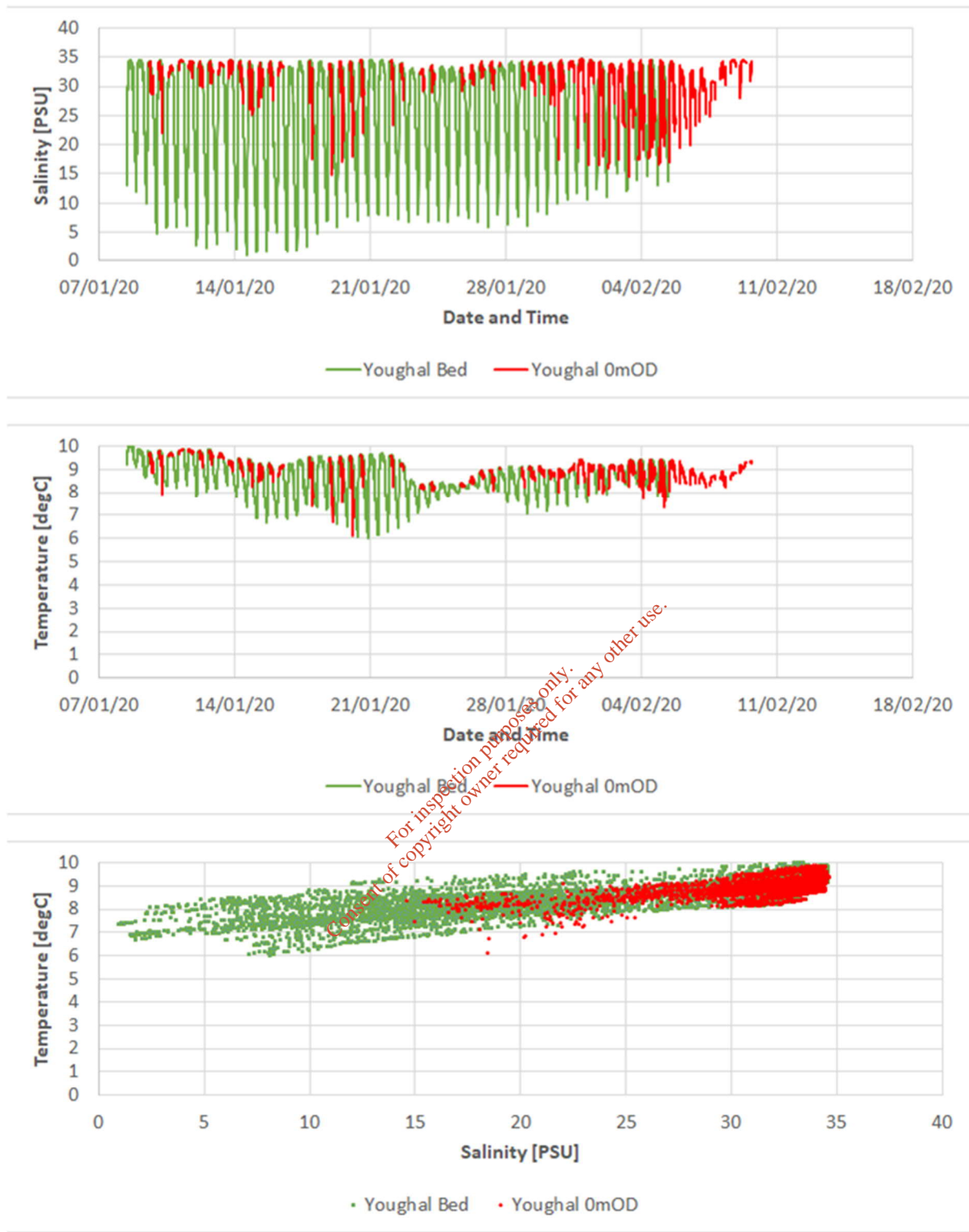
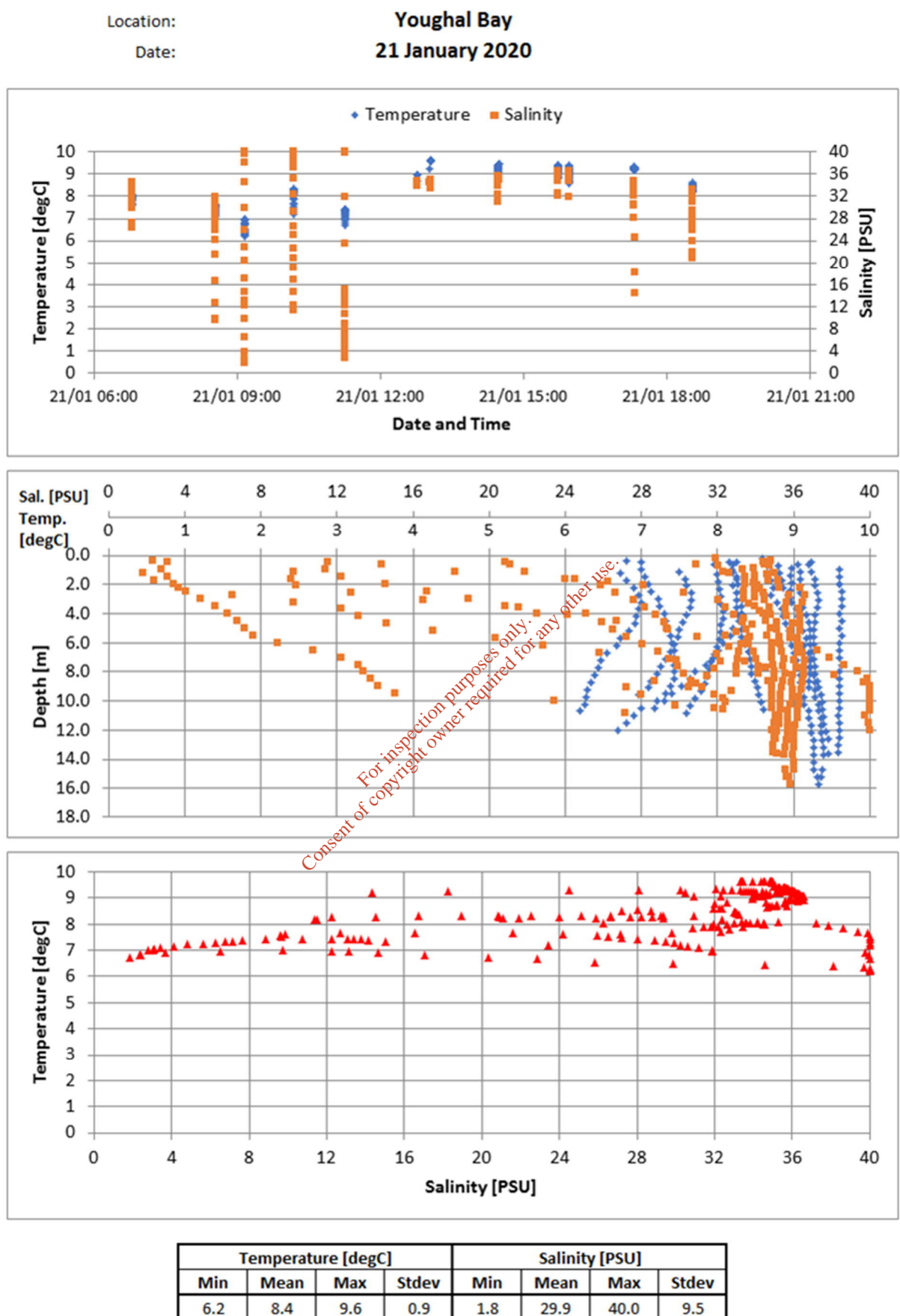


Figure 7-1. Temperature and salinity values recorded at Youghal.



**Figure 7-2. Example of the plots for the CTD Profiles showing data for Youghal Bridge on 21<sup>st</sup> January 2020**

## 8. ADCP Transects

Four ADCPs transects (A to D) were undertaken across the estuary and an additional transect (E) whilst the vessel travelled between the other four transects (Figure 8-1). This provided data at approximately hourly intervals throughout the estuary downstream of the Youghal Bridge. The data has been analysed and the currents at the points where Transect E crosses Transects A to D have been analysed to provide currents at specific points and the currents through time.

The currents at each point have been presented as a scatter plot of the vector components U and V and also as vertical profiles. Examples of each type are shown in Figure 8-2 and Figure 8-3 respectively. The plots for all data are provided in Appendix F.

There is not a clear pattern in any of the plots to show consistent current formation within the vertical profile at any of the locations. Few of the profiles exhibit the classic shape of slower currents on the bed and faster currents near the surface; either as a vertically homogeneous or any form of power law or logarithmic profile. This could be due to high levels of turbulence in the water; however, the ADCP should still detect the larger advection current in all of the turbulence. There is also variability in the direction of the current at a specific point through the vertical profile.

The general pattern of the depth averaged current speed through the tidal cycle is shown in Figure 8-4 to Figure 8-6. These show that the strongest current speeds occur during the flood and ebb tides, although the current does not reduce to zero at high and low water. Also, these plots show that the current direction reverses with the tide, as expected.

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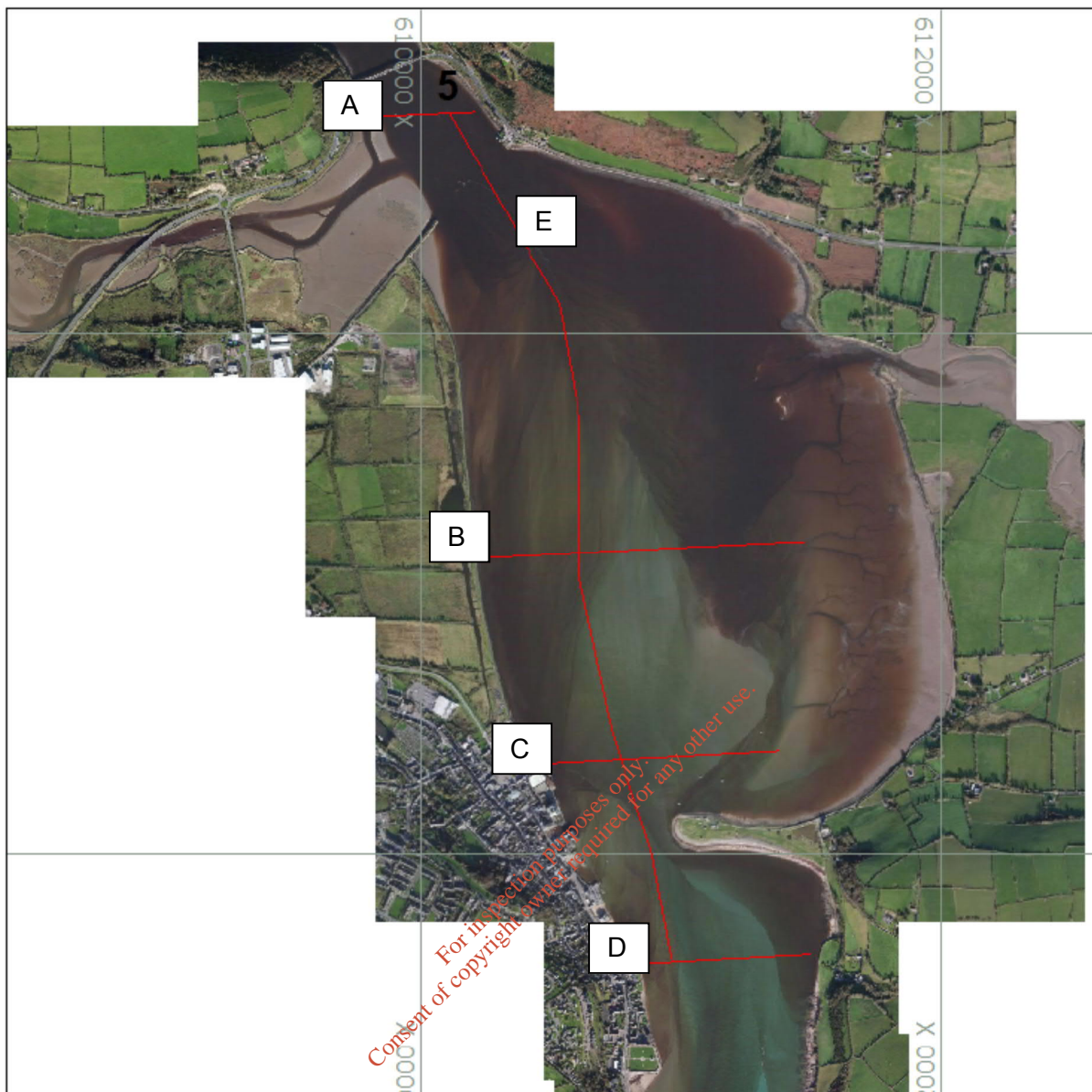


Figure 8-1. Transect locations for all surveys.

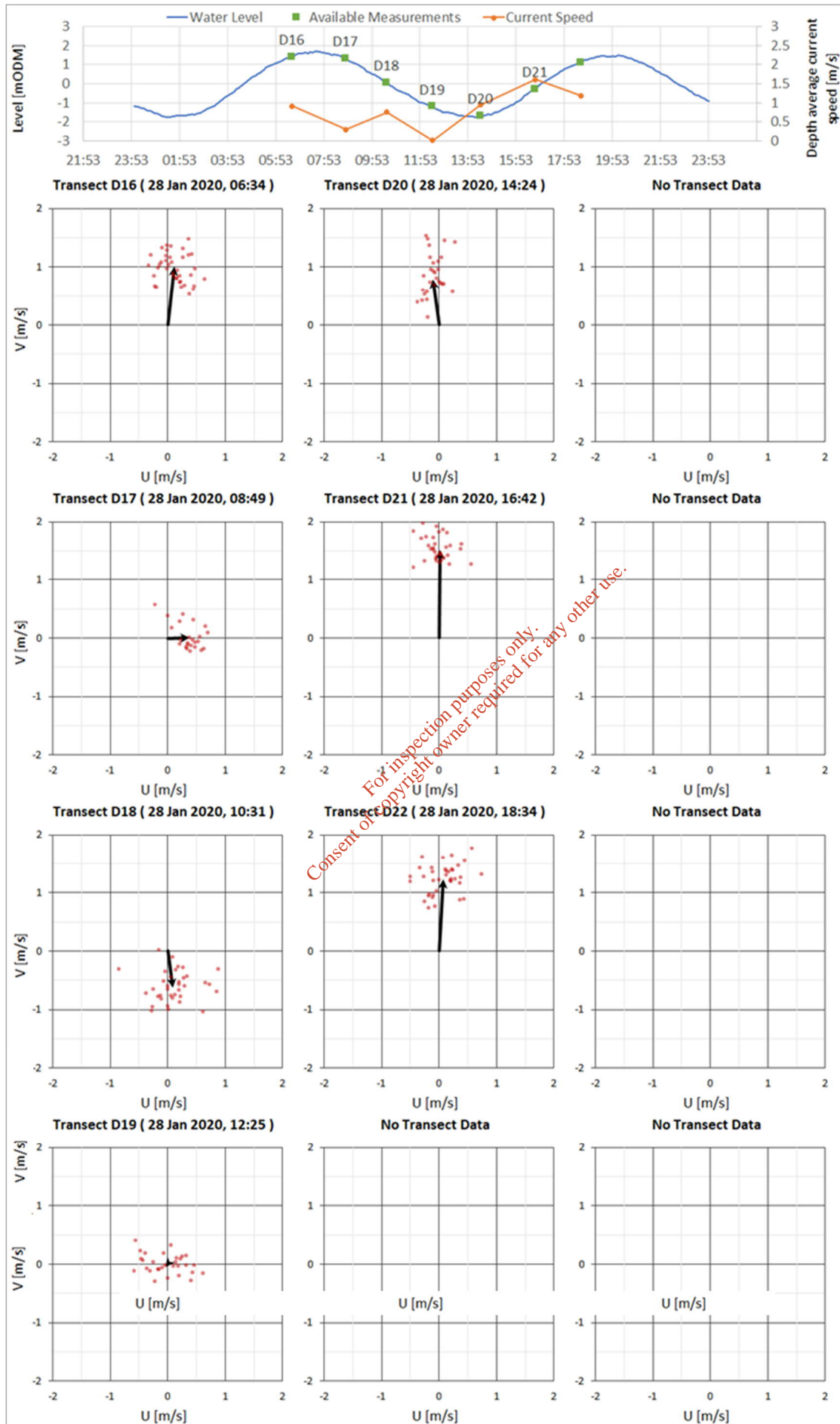


Figure 8-2. Example of scatter plot of currents using U and V vectors

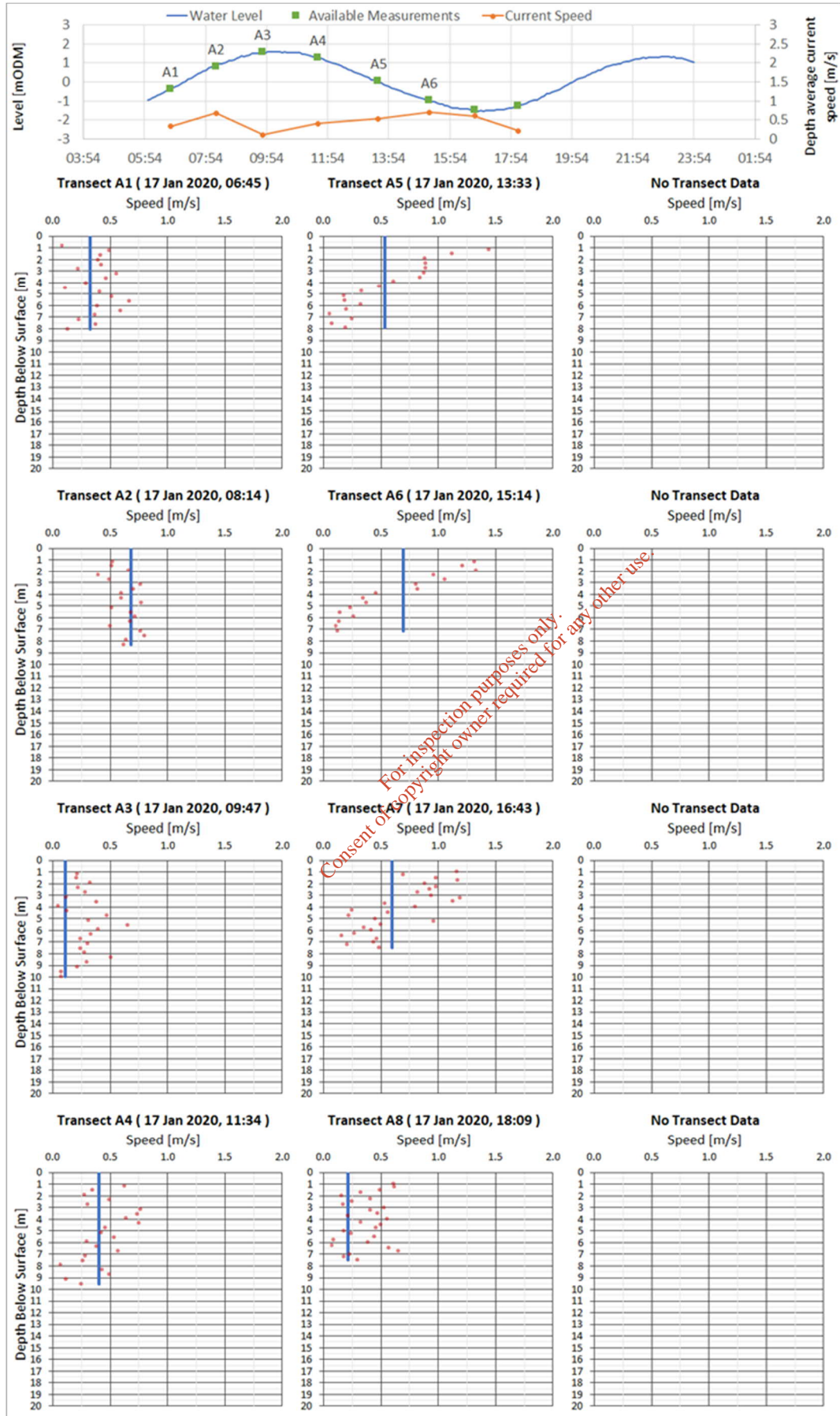




Figure 8-3. Example of vertical profile and depth averaged current

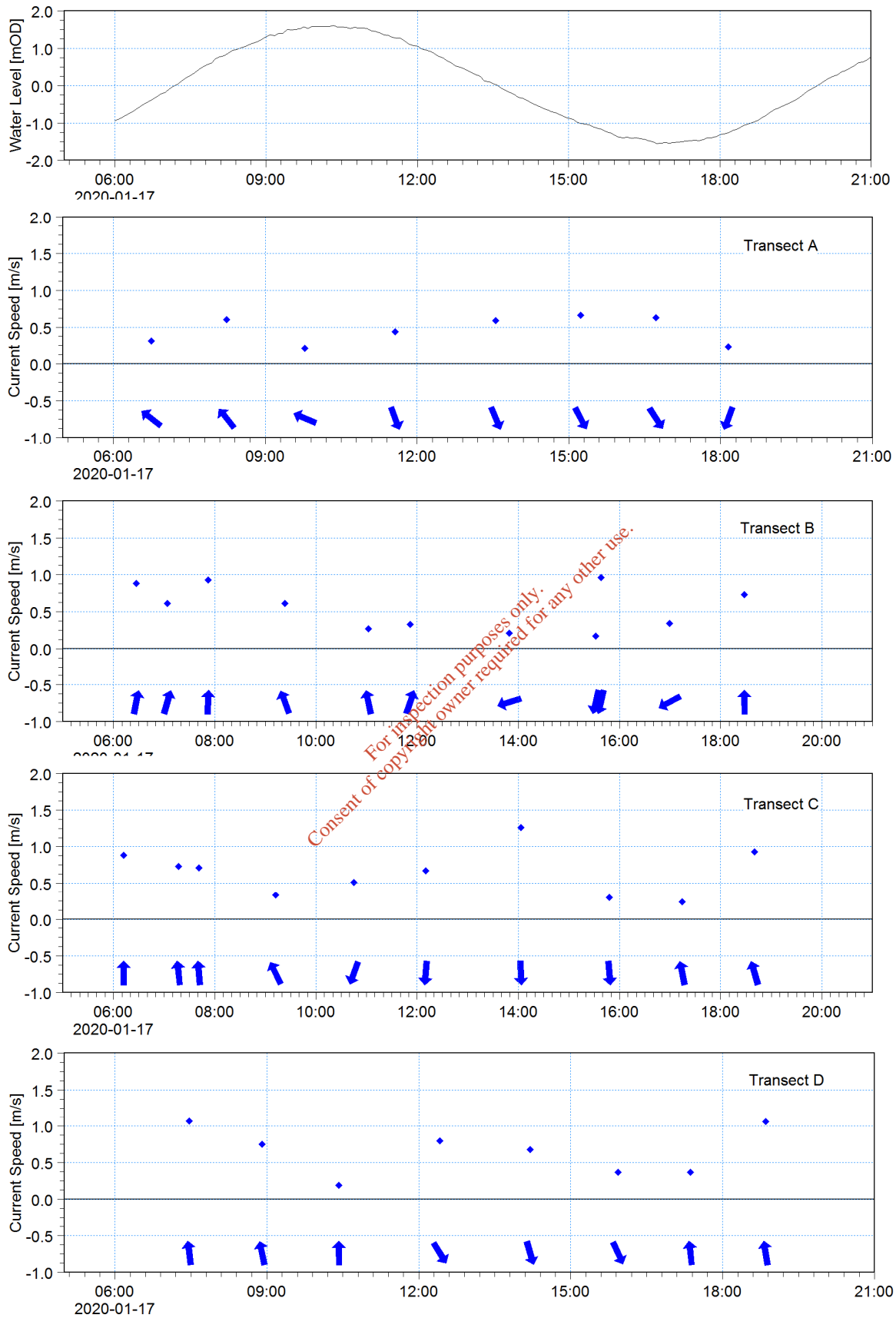


Figure 8-4. Depth averaged current speed and direction at the intersection of Transect E with Transects A to D on 17<sup>th</sup> January.

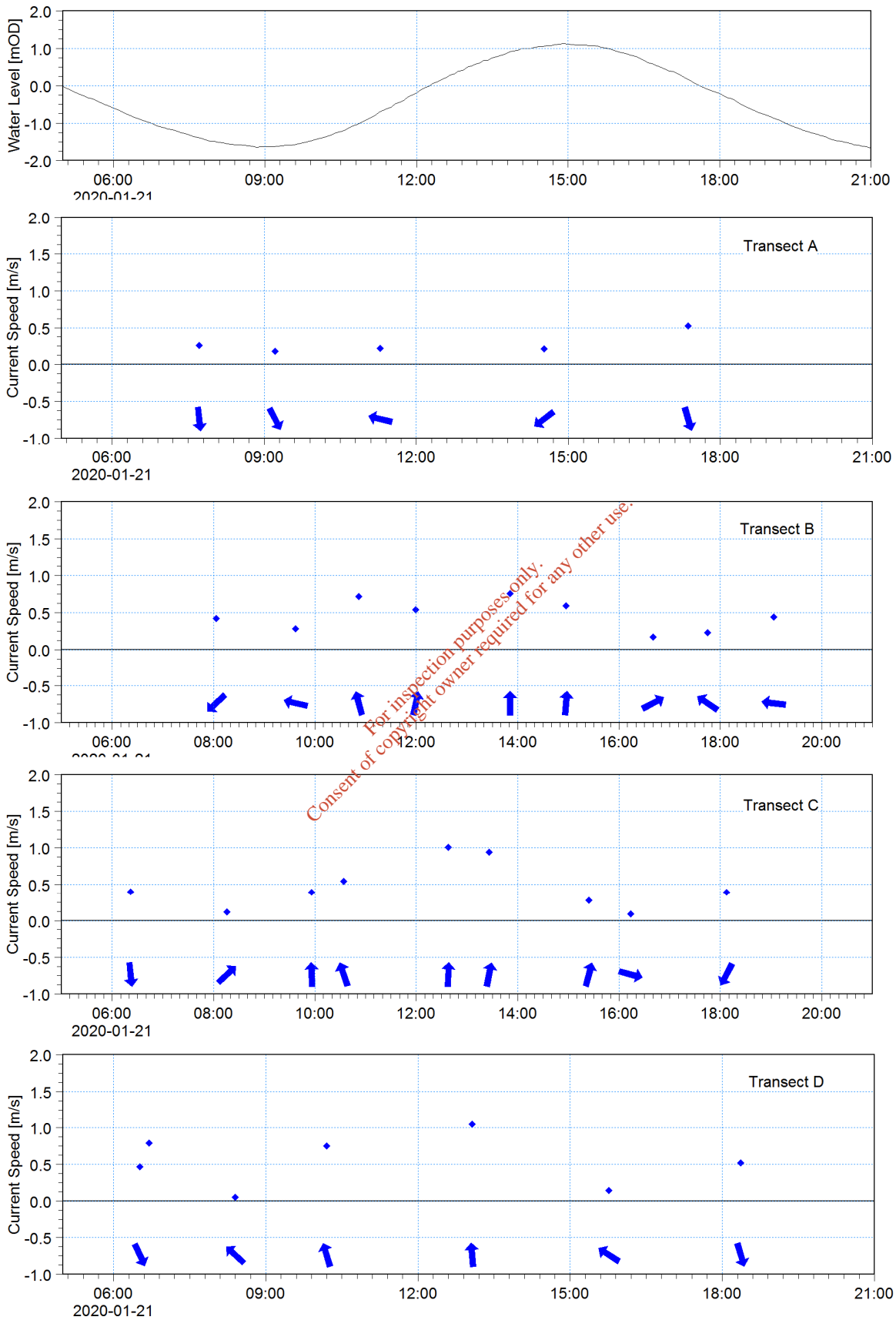
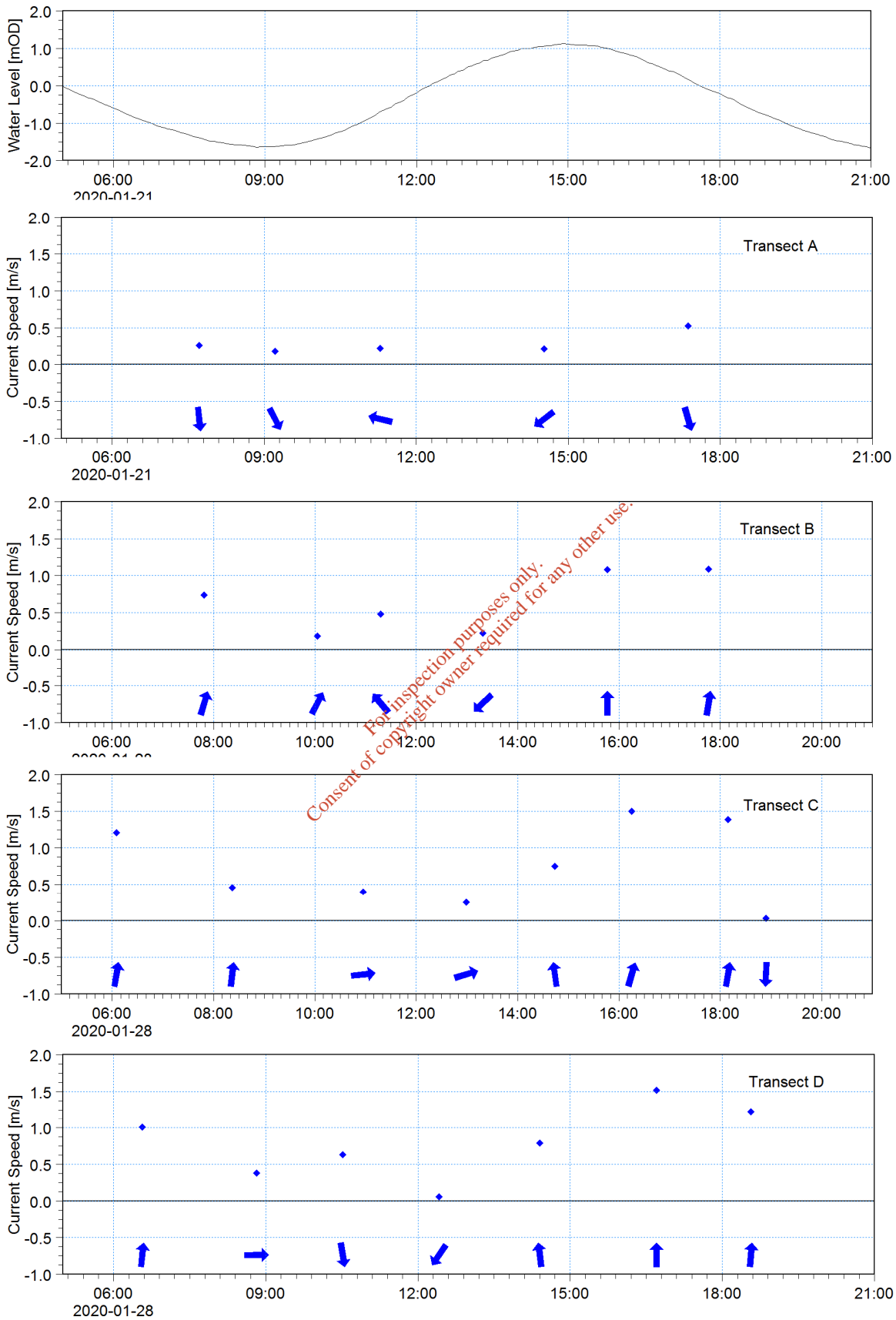


Figure 8-5. Depth averaged current speed and direction at the intersection of Transect E with Transects A to D on 21<sup>st</sup> January.



**Figure 8-6. Depth averaged current speed and direction at the intersection of Transect E with Transects A to D on 28<sup>th</sup> January.**

## 9. Water Quality Sampling

Water quality sampling was carried out at five locations (Cappoquin, near the Paxes Lane and Dunnes Park outfalls and in Youghal Bay) at the same time as water quality sampling of the final treated effluent at Youghal WwTP. The samples were also timed to coincide with the time of the hydrodynamic surveys in the Blackwater Estuary. The aim of the sampling was to allow sufficient data to be collected to calibrate the model for the baseline (current) scenario. The quality of the treated effluent shall be used as an input to the model for calibration purposes and, along with the other water quality monitoring data and hydrodynamic survey data, to check that the model is able to reproduce acceptable results.

The samples were collected on 17<sup>th</sup>, 21<sup>st</sup> and 28<sup>th</sup> January 2020, although no samples were collected at Cappoquin on the 17<sup>th</sup> and weather conditions precluded sampling in Youghal Bay on the 28<sup>th</sup>. Seven samples, collected at two-hour intervals, were collected in the estuary and Youghal Bay sample points, while three samples were collected each day from the WwTP effluent. The samples were collected by the on-site staff using the auto-sampler and passed to the surveyor for forwarding to the lab for analysis.

The samples were analysed for ammonia, BOD, DIN, DO, nitrate, nitrite, phosphate (as orthophosphate), pH, salinity, E Coli and Intestinal Enterococci. The results for all parameters are presented in Appendix G, and for key parameters in Figure 9-1 below.

Key findings are as follows:

- Concentrations of ammonia, DIN, BOD and phosphate (measured as orthophosphate) are generally significantly higher in the treated effluent than in the receiving waters. This is as expected, however the data also show that DIN and Ammonia levels in the estuary can be similar to effluent concentrations and two extremely high phosphate concentrations were recorded at Cappoquin. These high concentrations were queried with the analysing laboratory but no additional information was provided that might show why concentrations were so high on 28<sup>th</sup> January. Similar levels were not seen downstream and the rainfall records in Section 3 shows no large rainfall event on that day which might have resulted in activation of stormwater overflows or other pollution events.
- Dissolved oxygen concentrations in the treated effluent are slightly lower than in the Blackwater Estuary and Youghal Bay.
- Very high levels of bacteria are present in the treated effluent, but low levels in the estuary and in Youghal Bay.
- The results in App Figure G-13 show that the effluent is slightly more acid (pH 7-7.5) than the receiving waters (pH 8) and contains lower levels of suspended solids.

These results show that for the periods sampled, the indicative quality of the transitional waters at Cappoquin, Paxes Lane and Dunes Park is HIGH in terms of both BOD and phosphate, although water quality at Cappoquin would fail to meet GOOD indicative quality for phosphate if the two anomalous results are included. The sampled water quality in Youghal Bay meets GOOD indicative quality for BOD, and is at MODERATE indicative water quality for DIN. It is not possible to compare the water quality data with Environmental Quality Standards (EQS) for Dissolved Oxygen as the data have been provided in terms of mg/l while the EQS are in terms of % saturation. Converting between the two requires the temperature of the water at the time of sampling, which was not recorded.

The data collected as part of this study is in line with the bathing water compliance data collected at nearby beaches which show the beaches achieving GOOD to EXCELLENT status.

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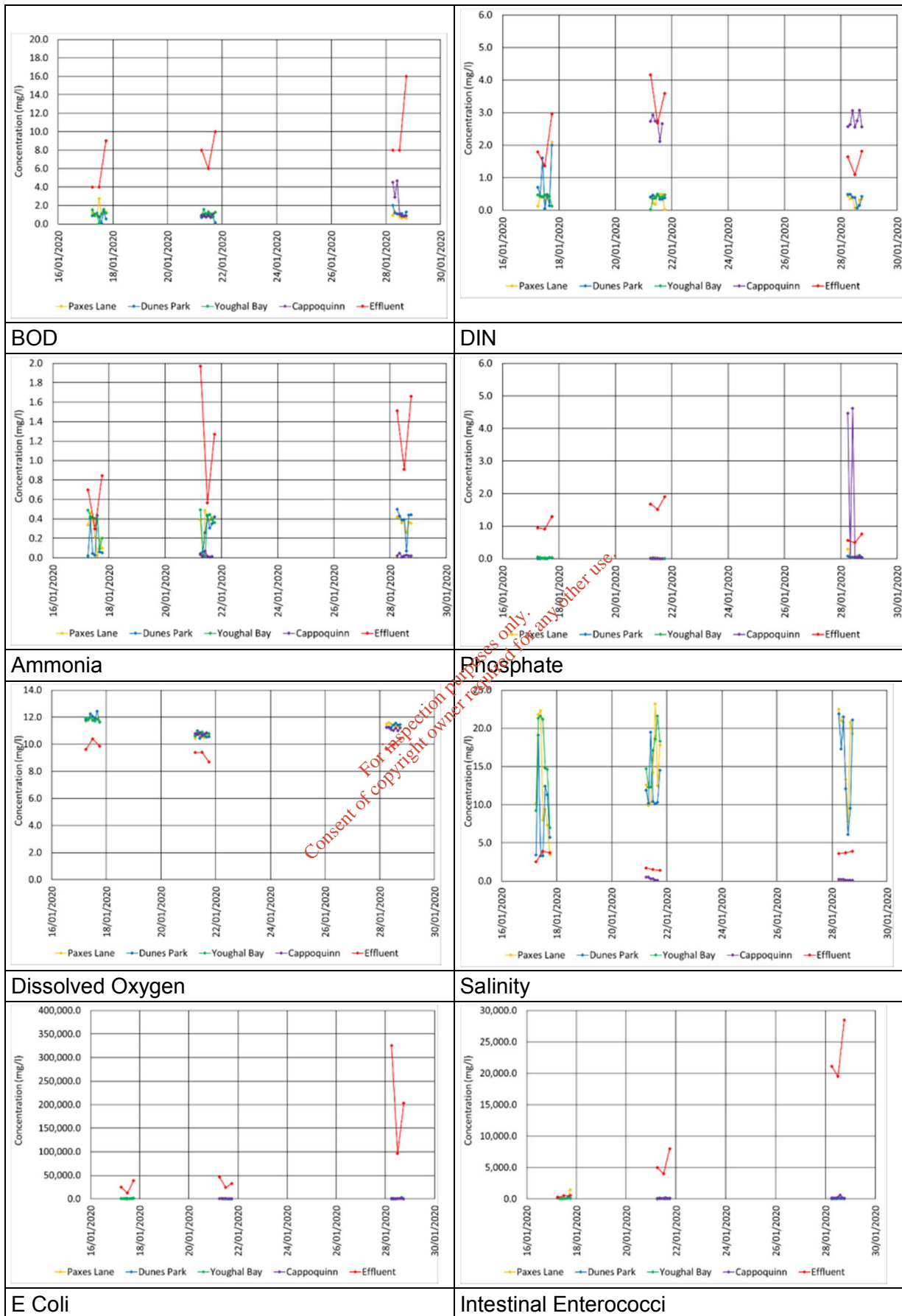


Figure 9-1. Water Quality Monitoring Results

## 10. Conclusion

A survey of the Blackwater River, tributaries and Youghal Harbour has been successfully completed over a period covering 7<sup>th</sup> January to 18<sup>th</sup> February 2020. The survey included continuous recording of water levels, salinity and temperature at different sites and three 13-hour surveys covering spring, neap and intermediate tides. Throughout the period there was a range of weather including periods of rainfall increasing the river flows.

There were several difficulties encountered during the survey that included winter storms preventing any access to the survey points outside of the estuary.

The measurement of currents using an ADCP mounted on a moving vessel to collect transects appears to have collected very variable data. The only data that has been used is where the transects intersect. However, the restriction of not placing any instruments on the bed meant that a mobile solution was required.

In general, the data is considered reasonable for use in calibration of a numerical model. Specifically, the salinity and temperature data does show possible stratification and therefore consideration as to whether a 2D or 3D model will be required is recommended at the calibration stage.

## 11. References

AECOM, 2019, "Youghal Marine Modelling Study: Model Scoping Report".

EPA, 2020,

<http://watermaps.wfdireland.ie/HydroTool/Viewer.aspx?Site=Hydro&reloadkey=true>  
accessed throughout January 2020.

Met Eireann, 2020, <https://www.met.ie/climate/available-data/historical-data> accessed 24 March 2020.

OPW, 2020, <https://waterlevel.ie/> accessed during January and February 2020.

## Appendix A Document copies

### Numbered copies

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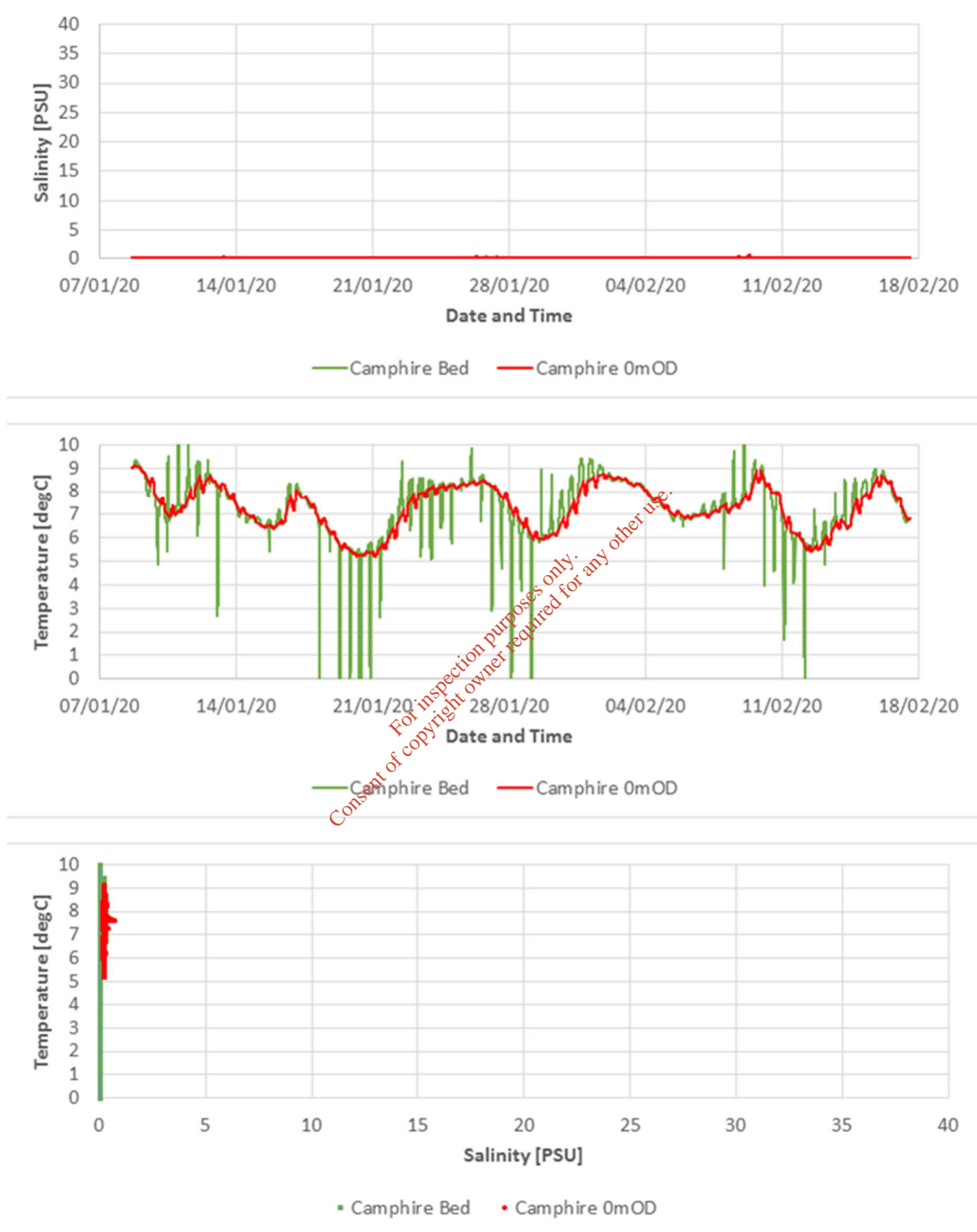
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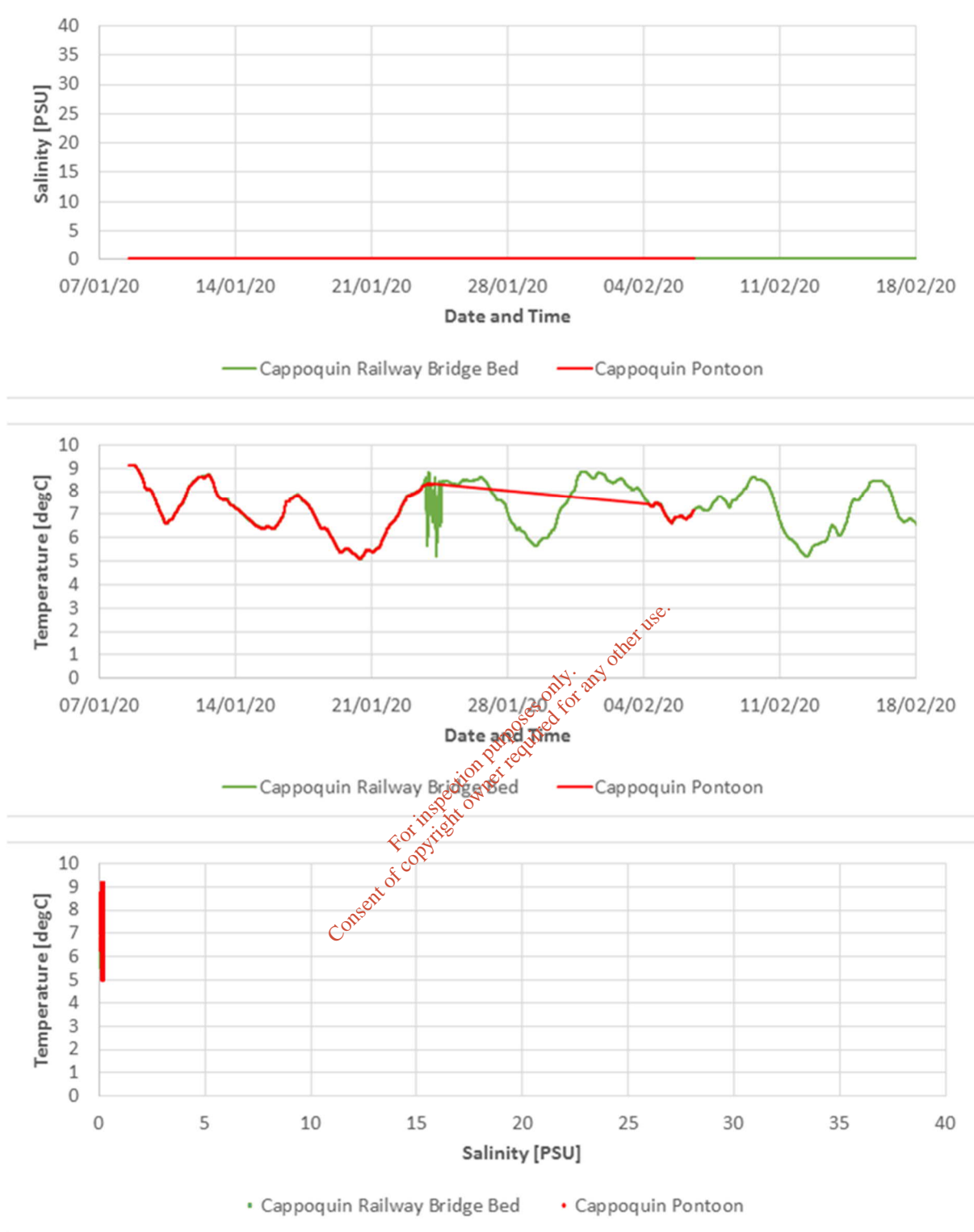
## Appendix B Survey specification

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## Appendix C Fixed Station CTDs



App Figure C-1. Temperature and salinity at Camphire Bridge

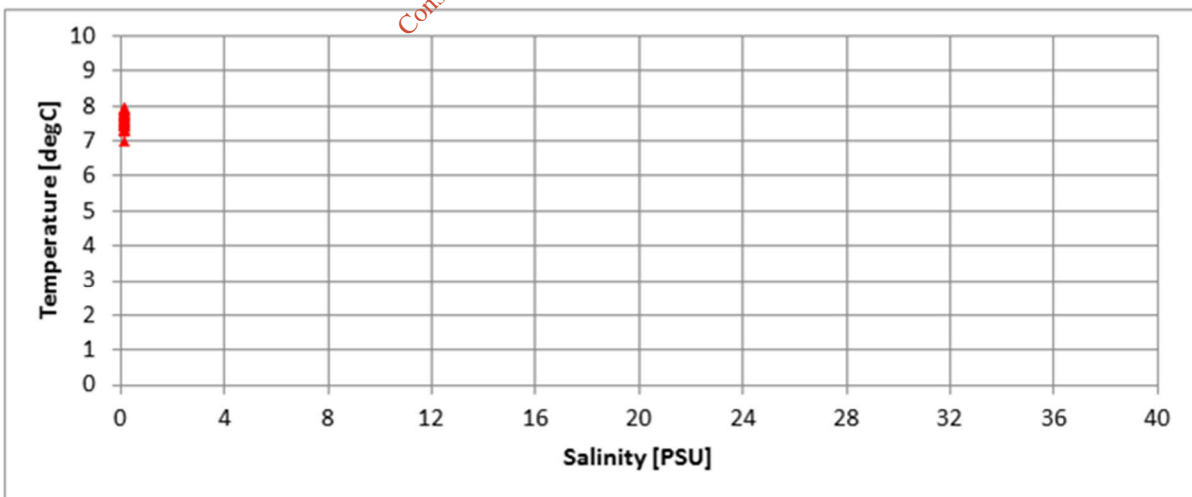
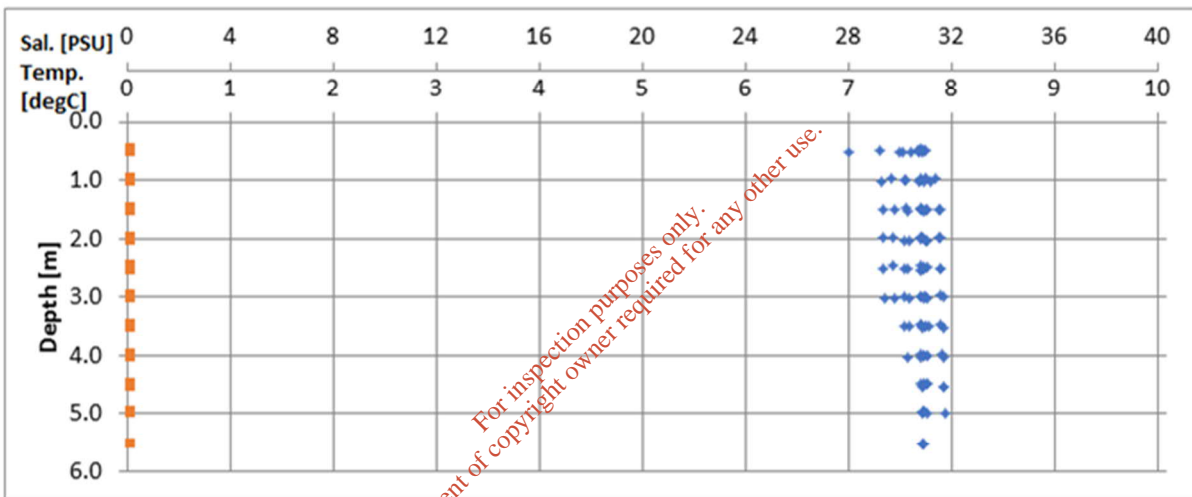
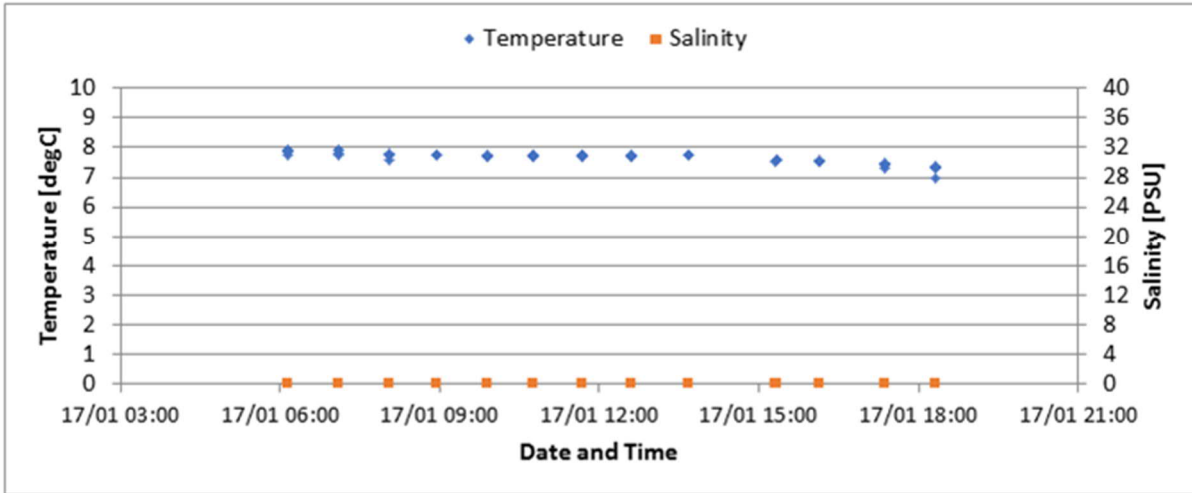


App Figure C-2. Temperature and salinity at Cappelquin

## Appendix D CTD Profiles

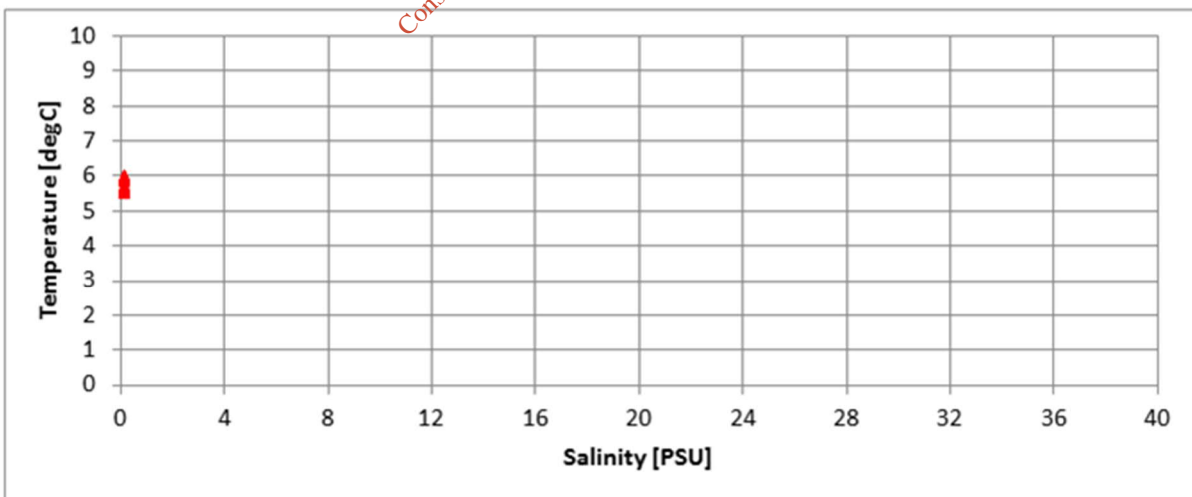
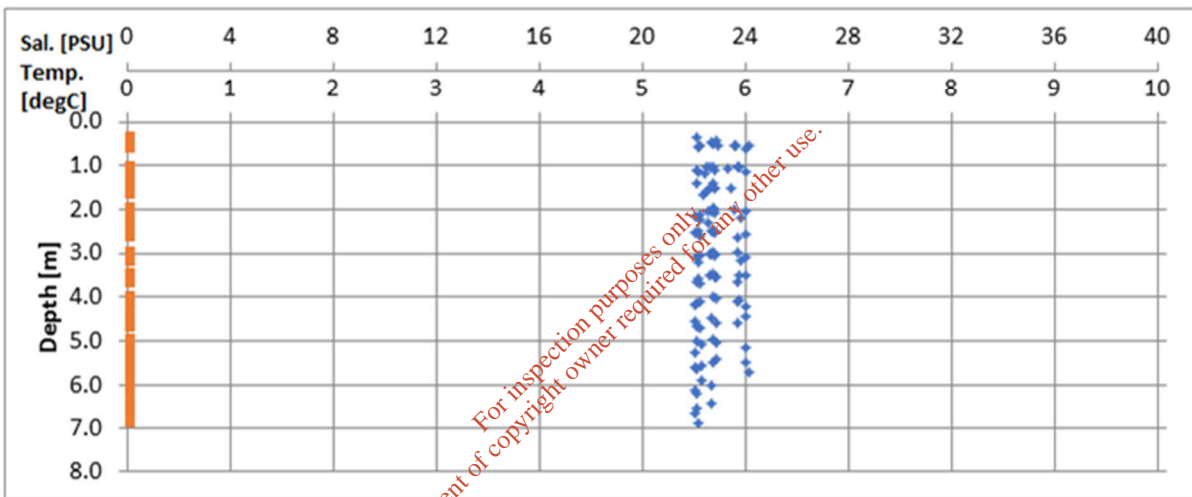
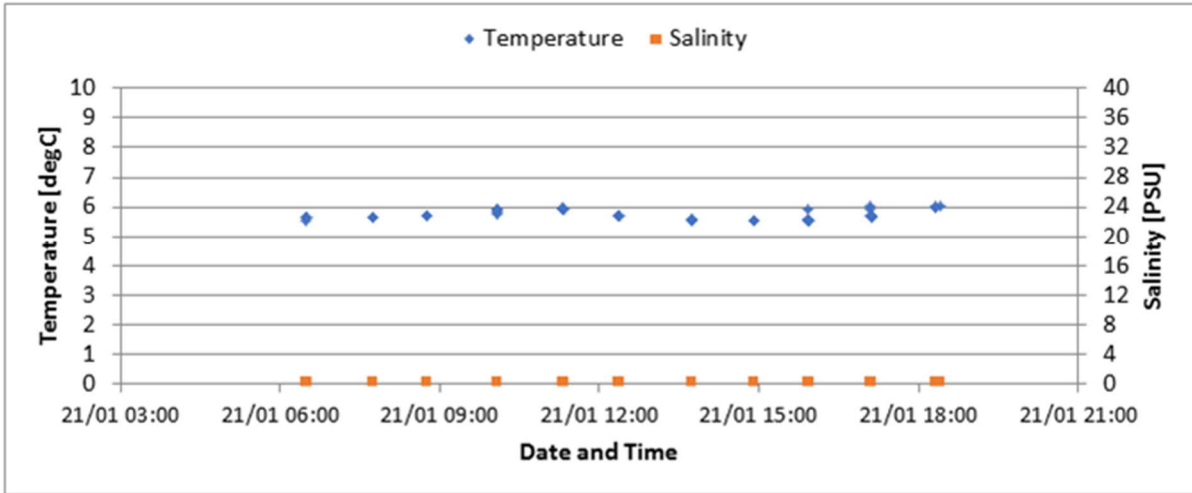
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Location: **Camphire Bridge**  
 Date: **17 January 2020**



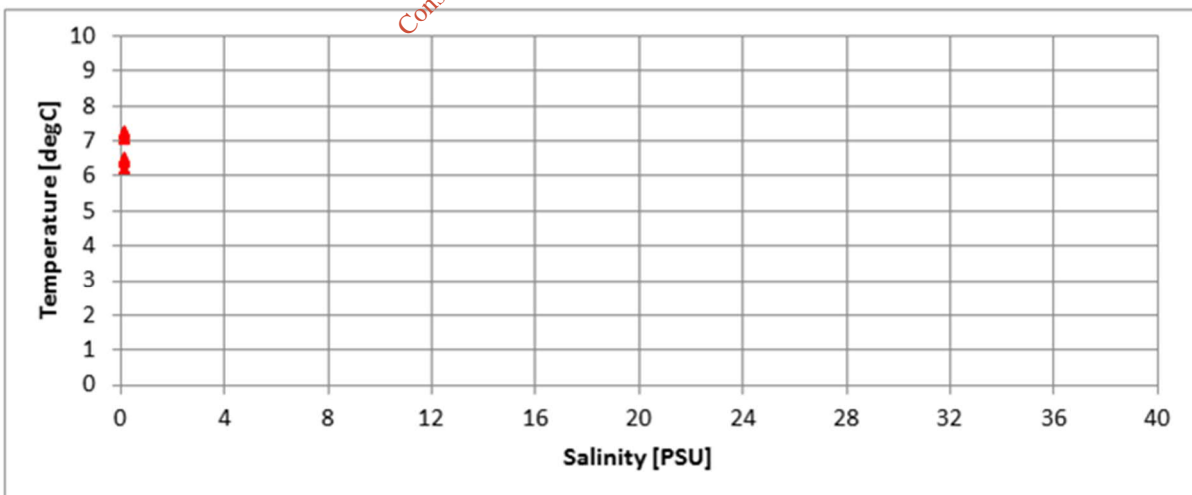
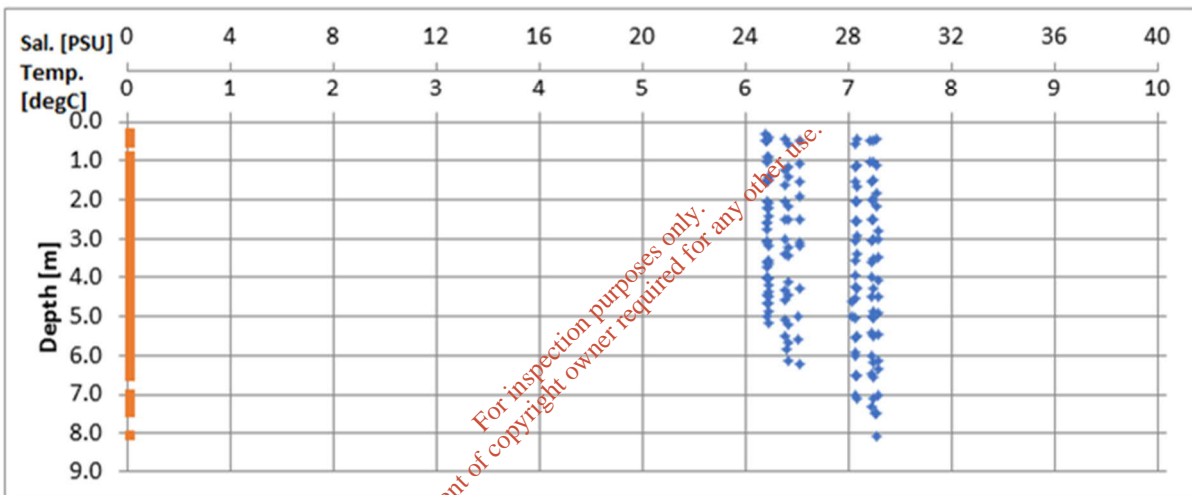
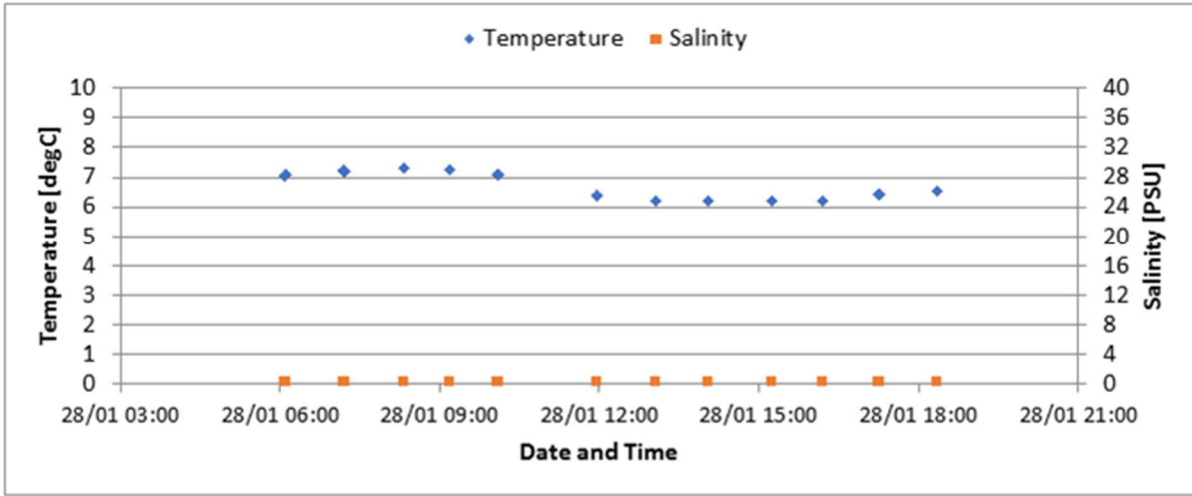
Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
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Location: **Camphire Bridge**  
 Date: **21 January 2020**



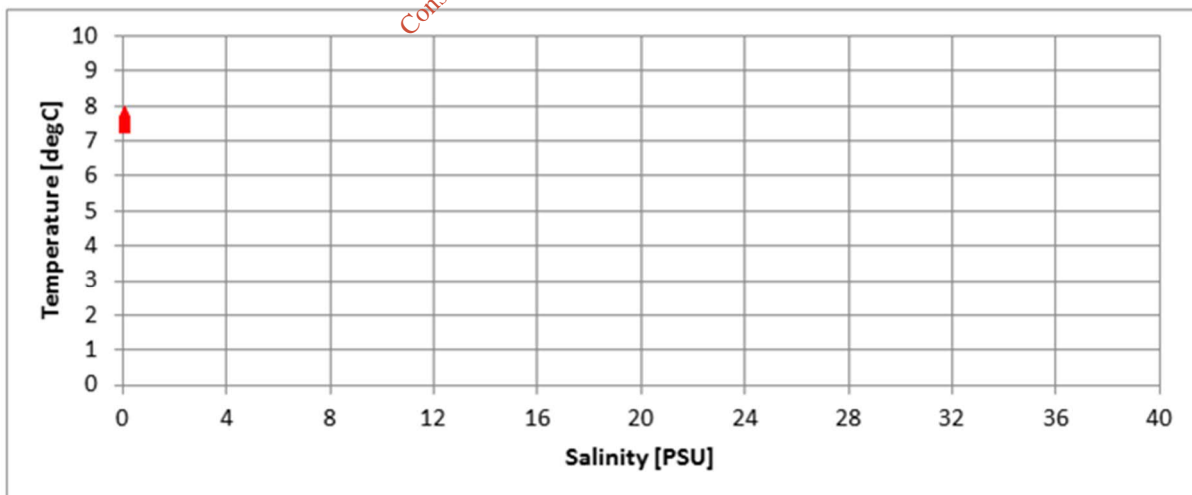
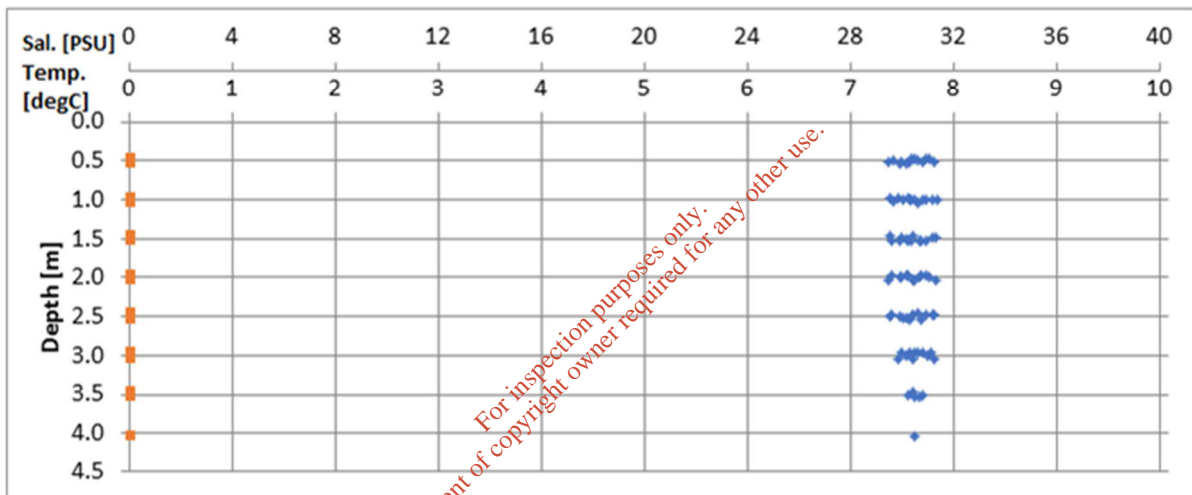
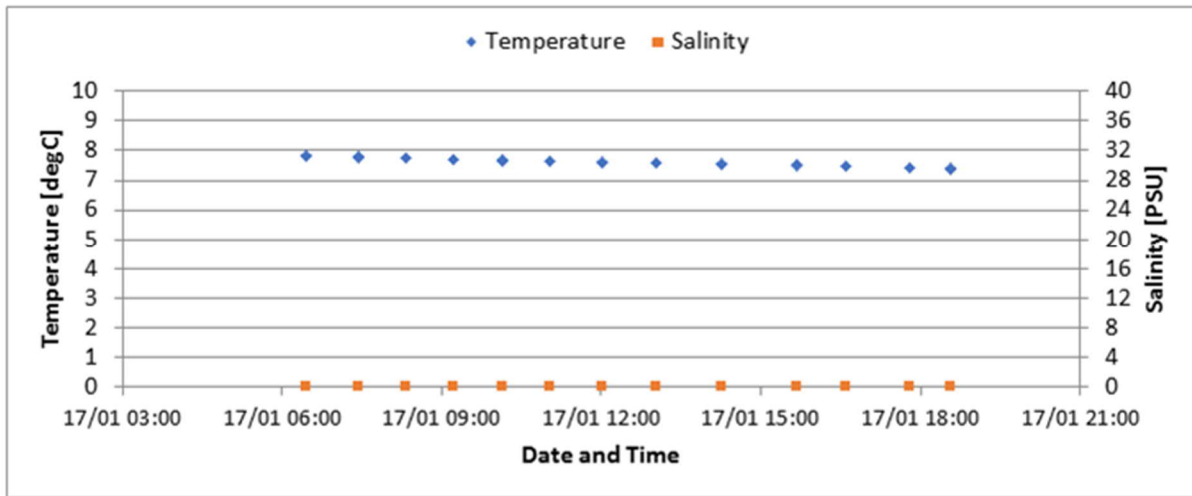
Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
5.5	5.7	6.0	0.2	0.1	0.1	0.2	0.0

Location: **Camphire Bridge**  
 Date: **28 January 2020**



Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
6.2	6.8	7.3	0.4	0.1	0.2	0.2	0.0

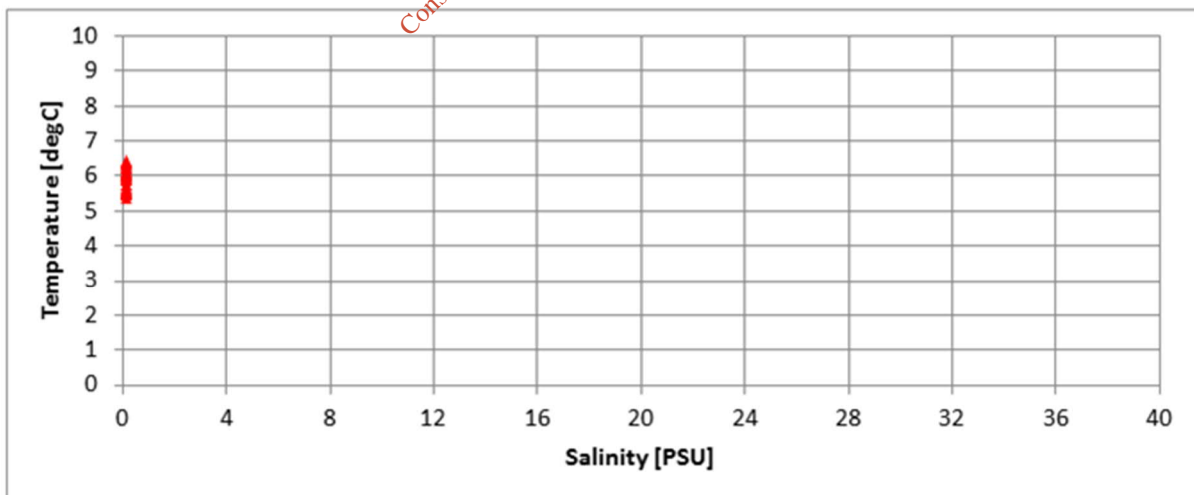
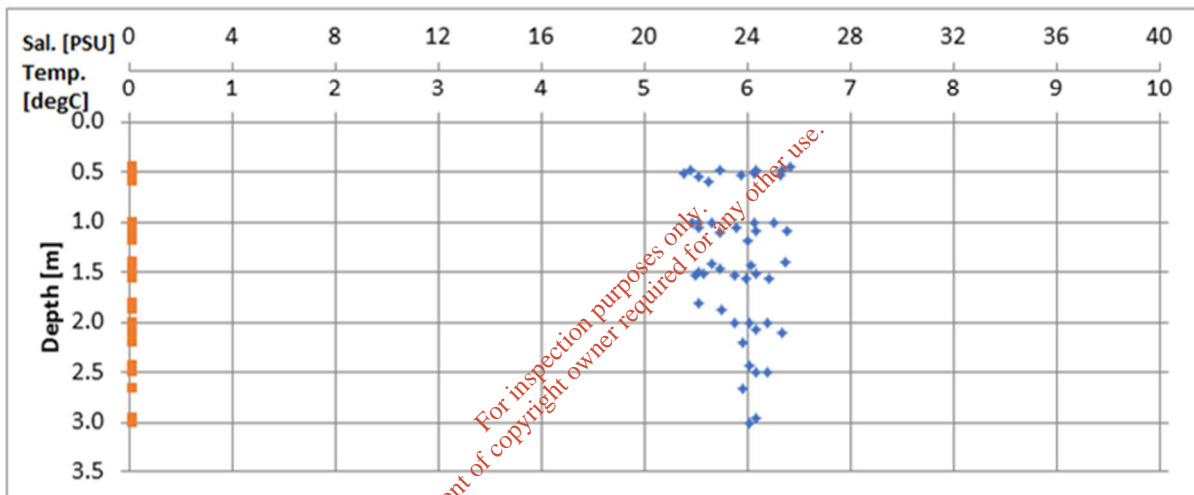
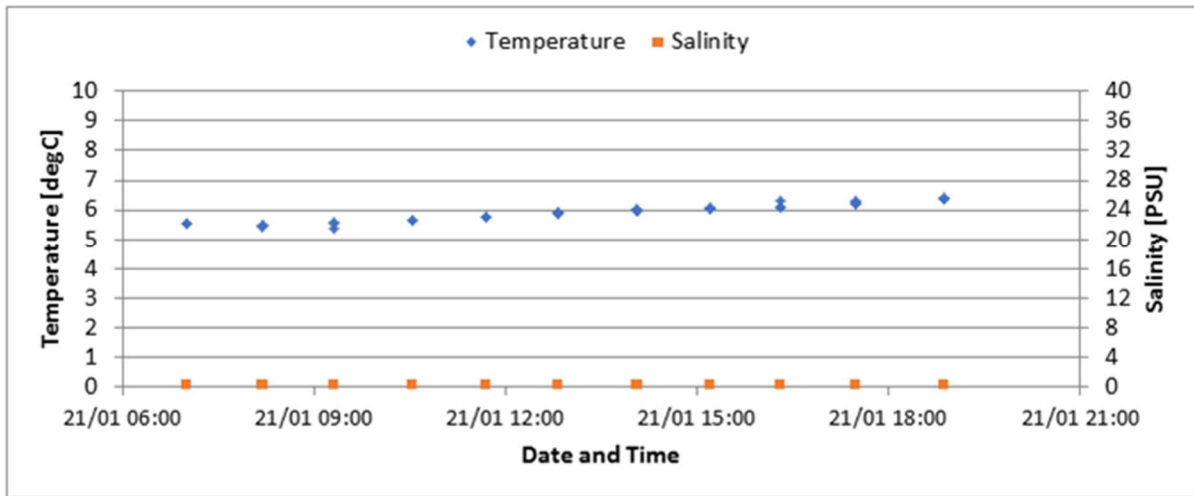
Location: **Cappoquin Bridge**  
 Date: **17 January 2020**



Temperature [degC]				Salinity [PSU]			
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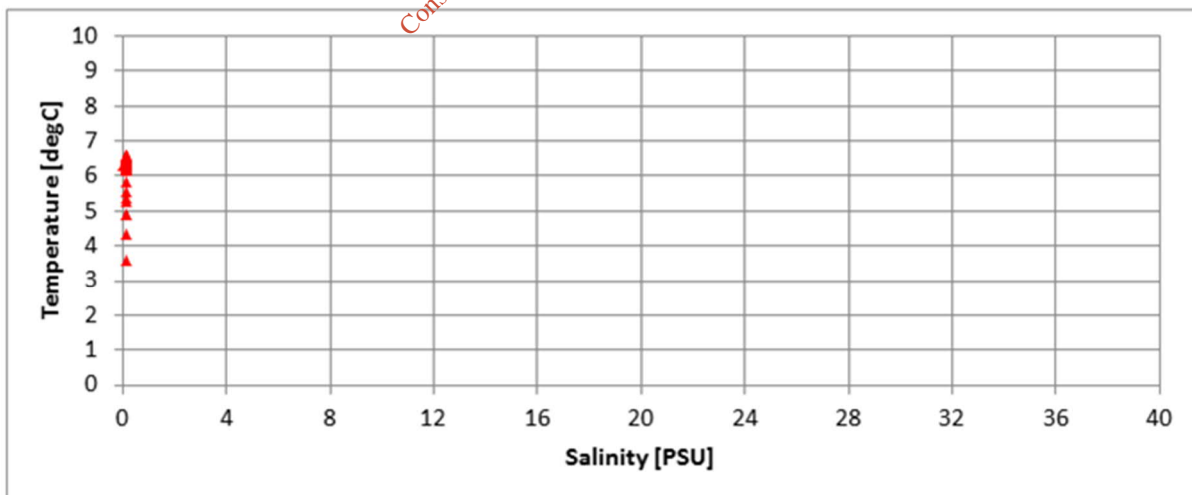
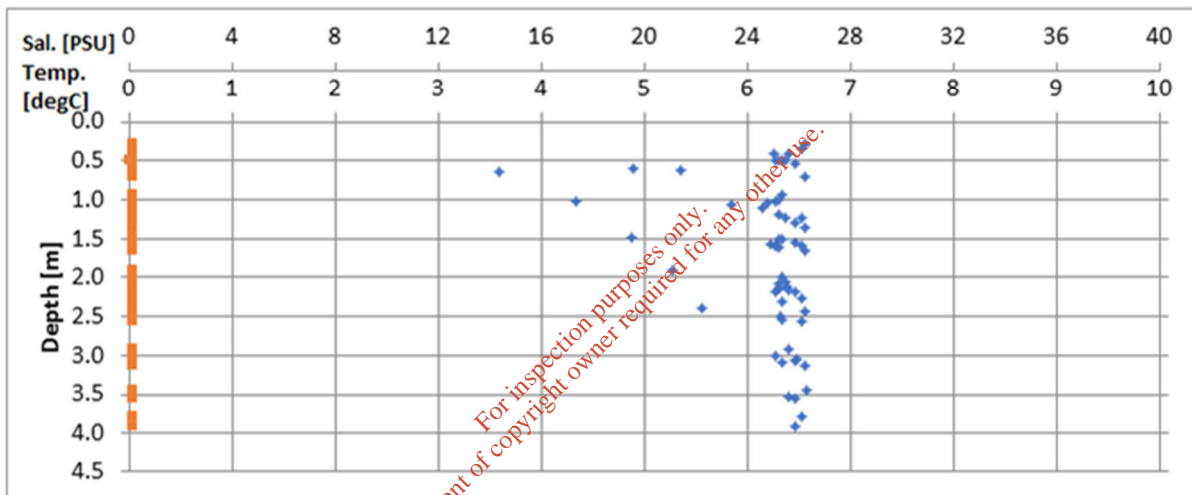
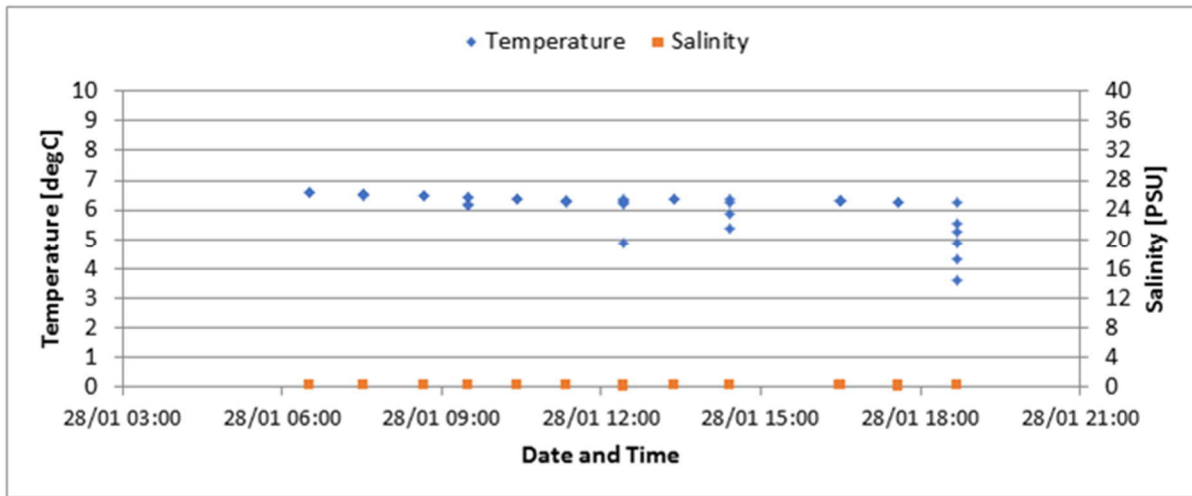


Location: **Cappoquin Bridge**  
 Date: **21 January 2020**



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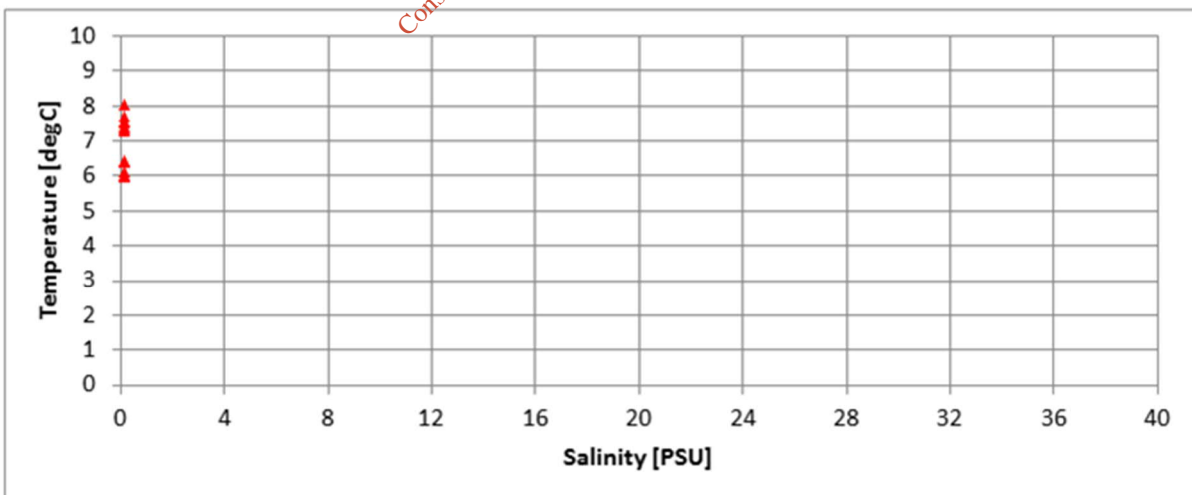
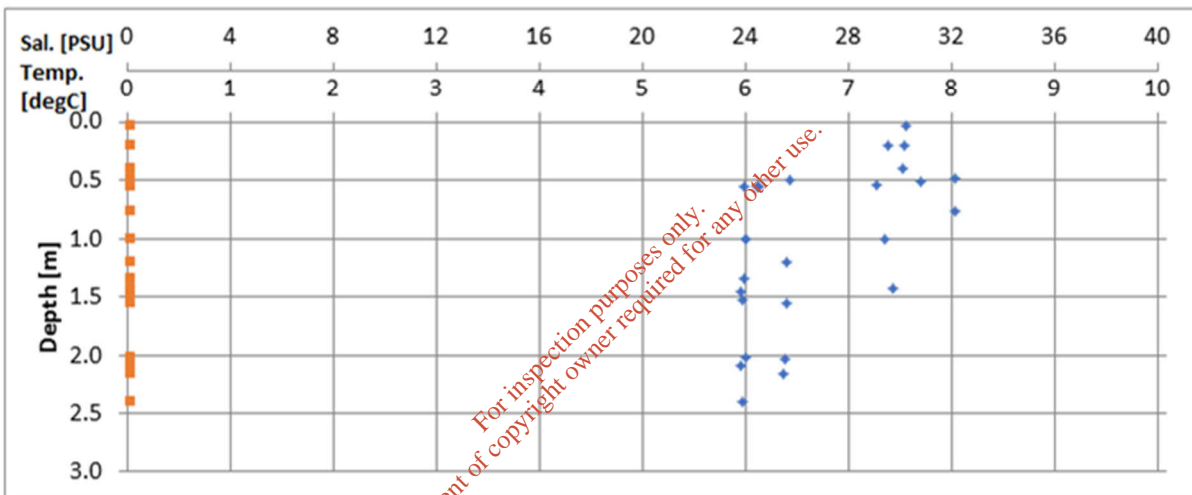
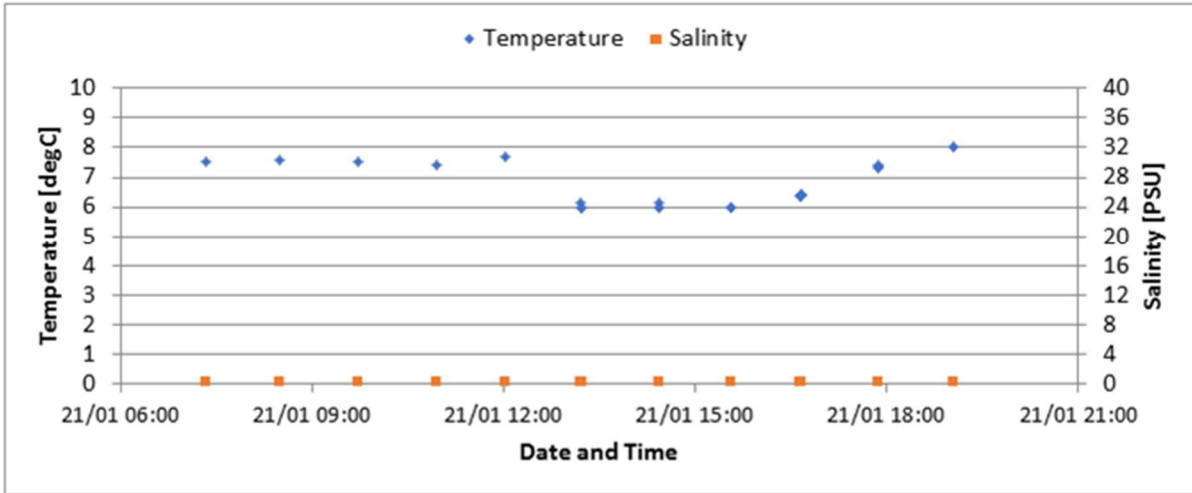
Location: **Cappoquin Bridge**  
 Date: **28 January 2020**



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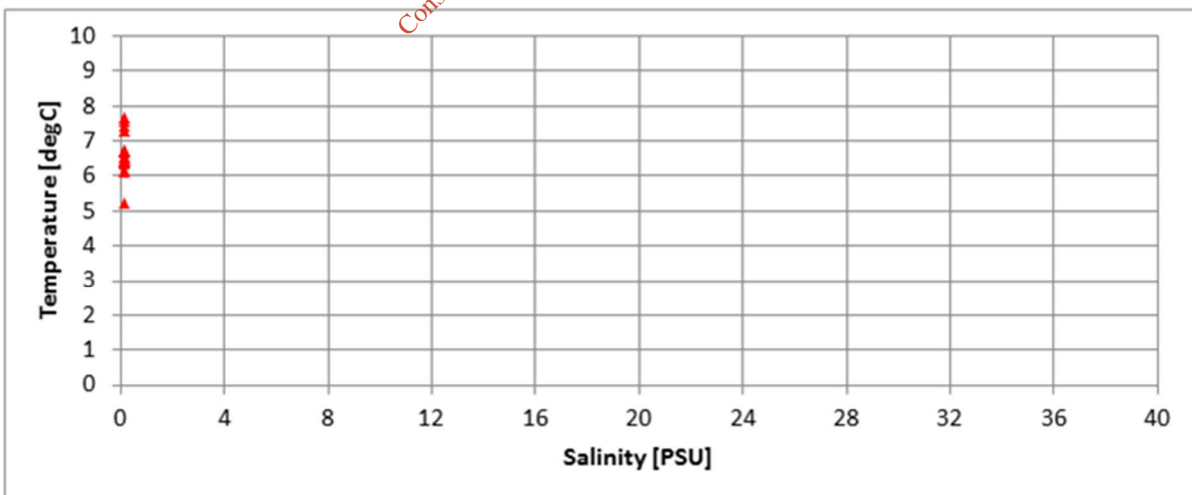
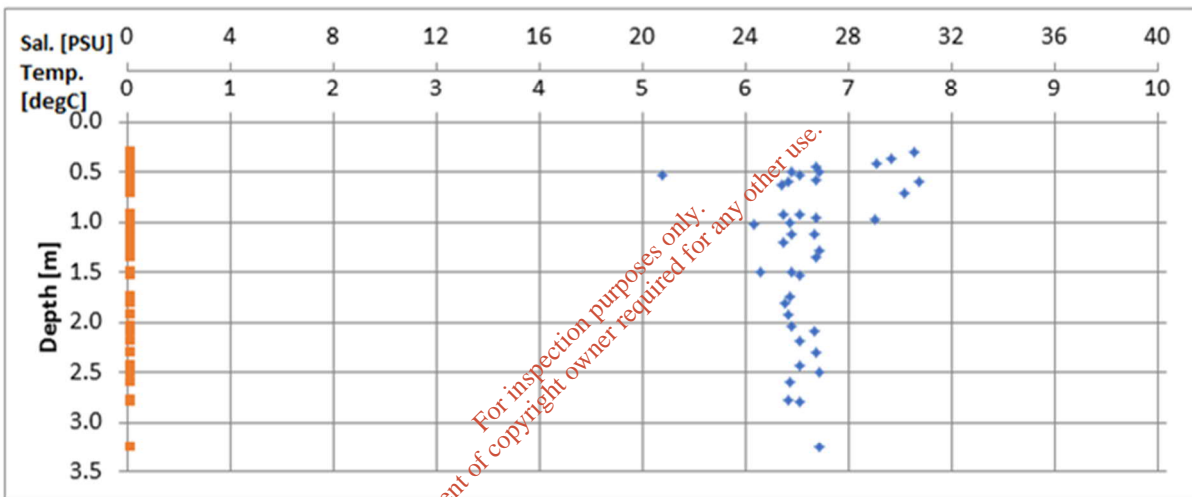
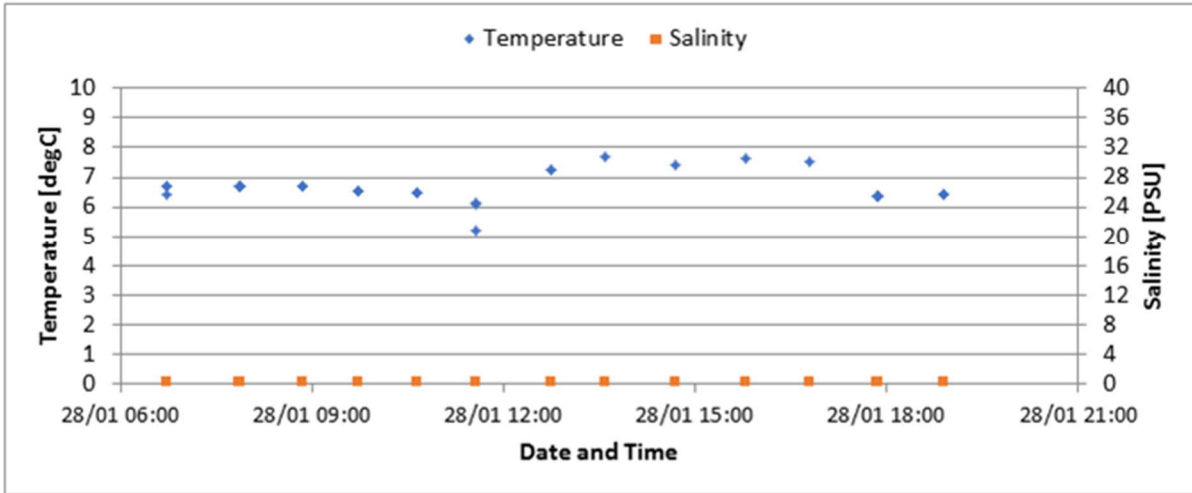


Location: **Dromana Bridge**  
 Date: **21 January 2020**



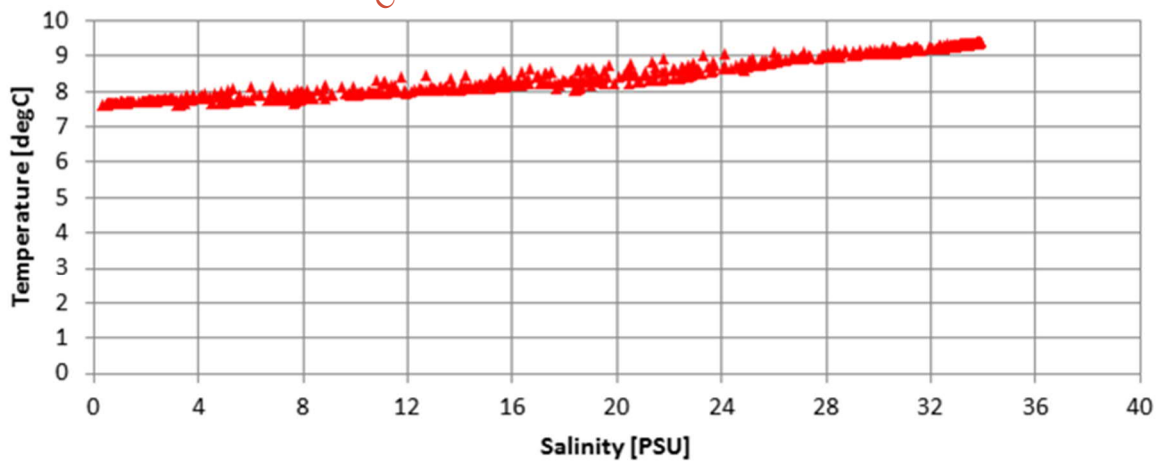
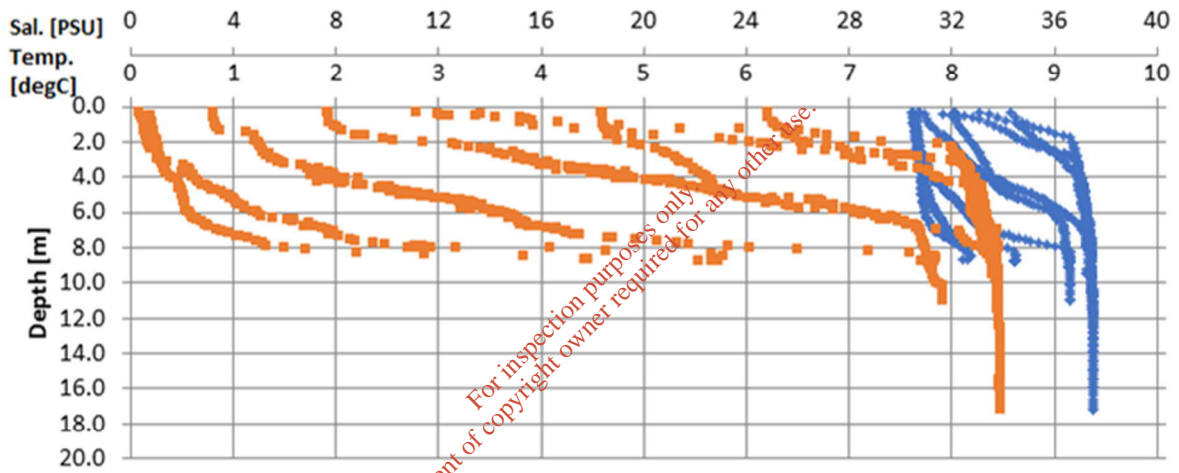
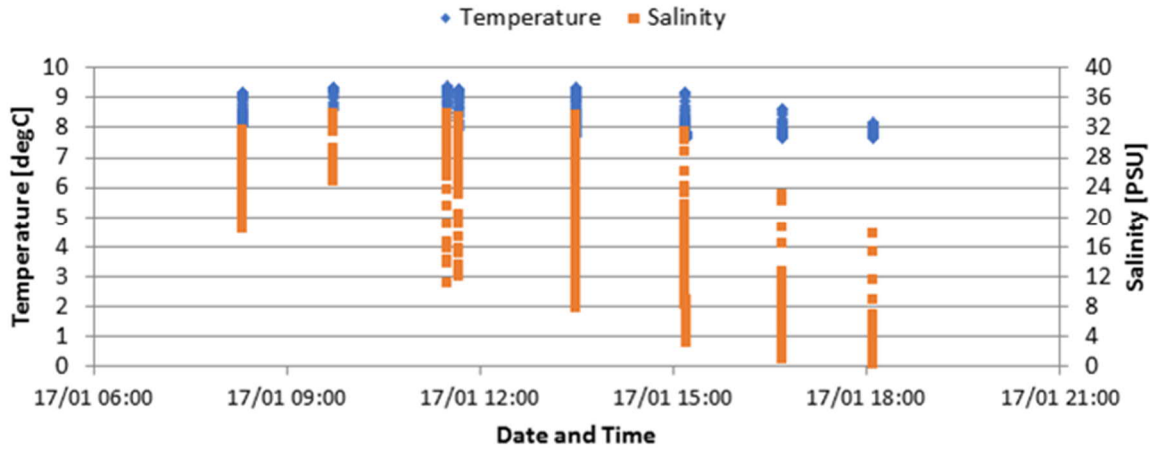
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Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
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Location: **Dromana Bridge**  
 Date: **28 January 2020**



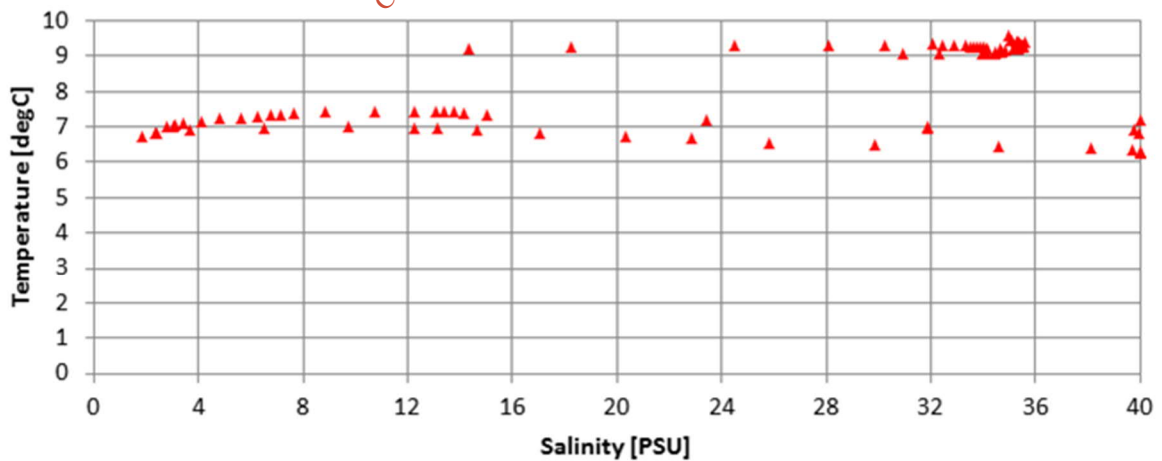
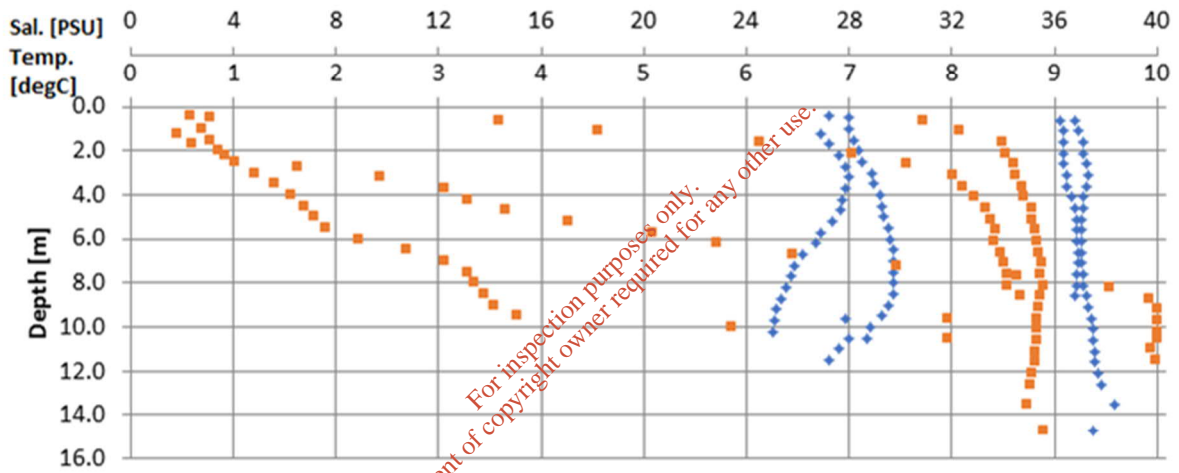
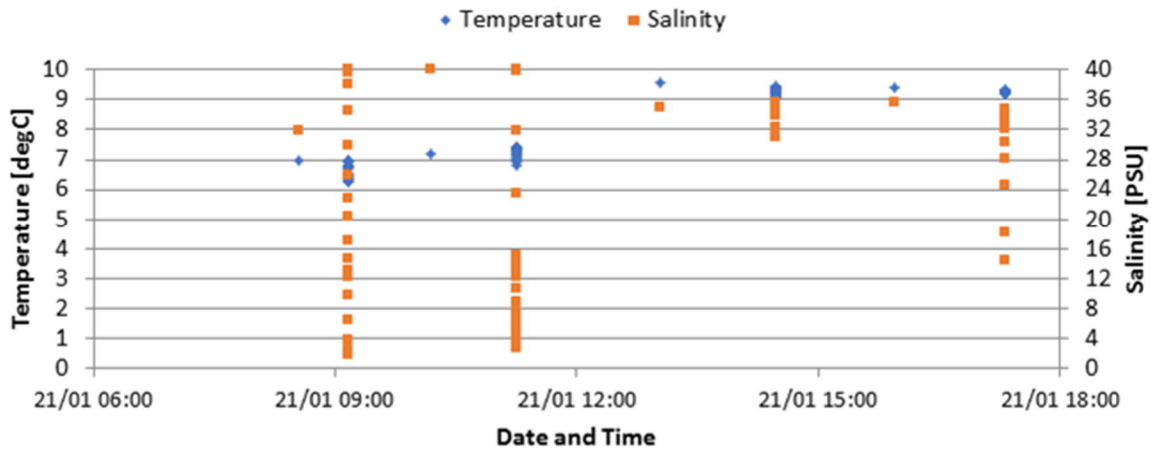
Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
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Location: **Youghal Bay1**  
 Date: **17 January 2020**



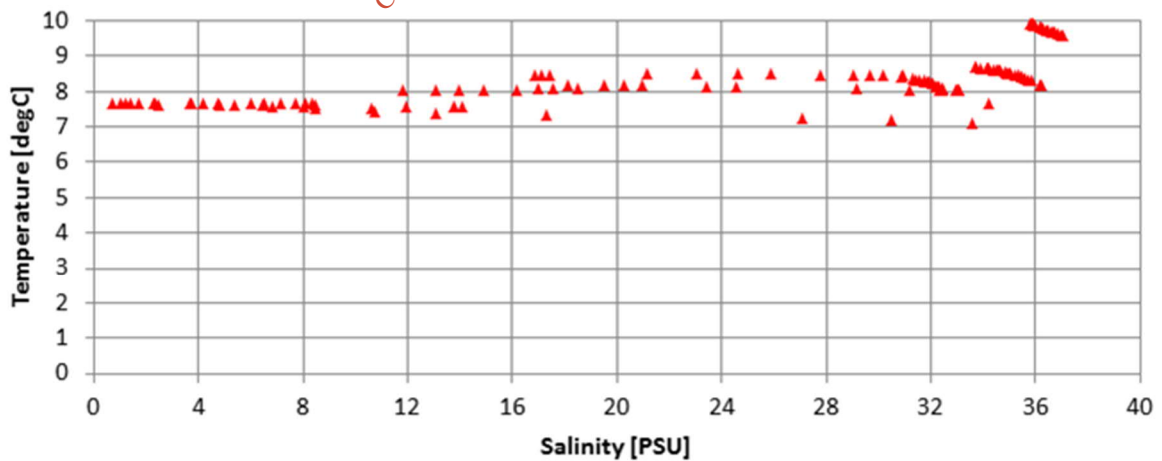
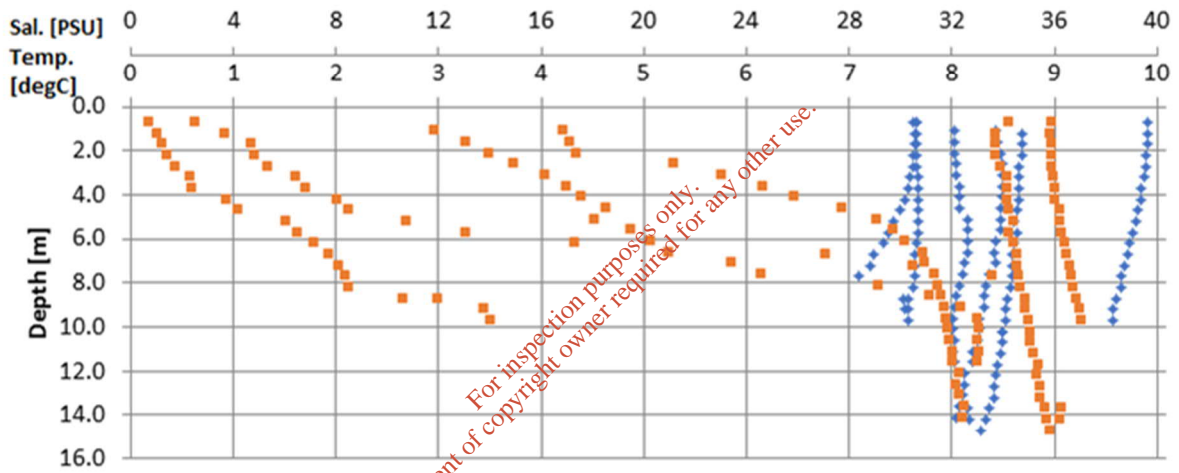
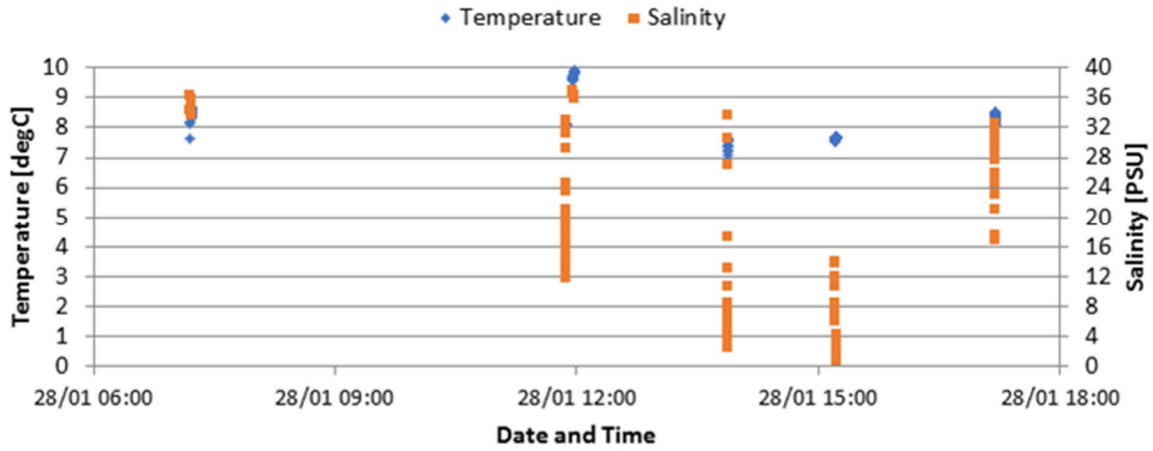
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Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
7.6	8.6	9.4	0.7	0.3	21.7	33.9	11.8

Location: **Youghal Bay1**  
 Date: **21 January 2020**



Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
6.3	8.1	9.6	1.2	1.8	25.1	40.0	12.8

Location: **Youghal Bay1**  
 Date: **28 January 2020**



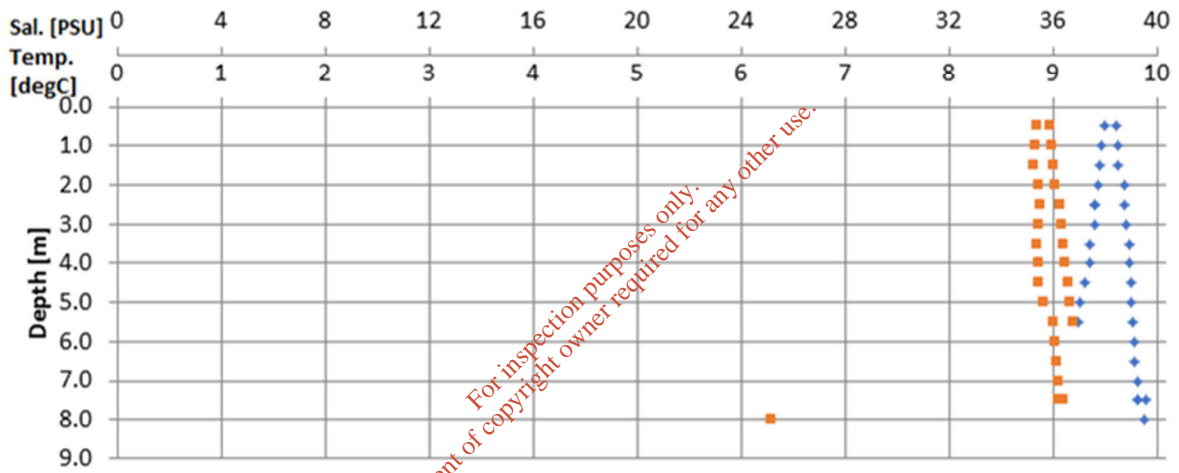
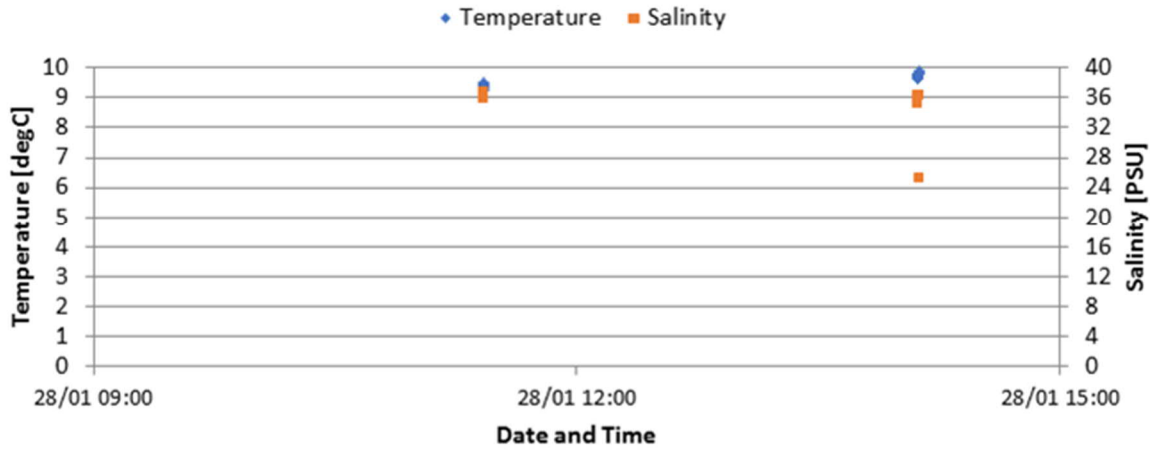
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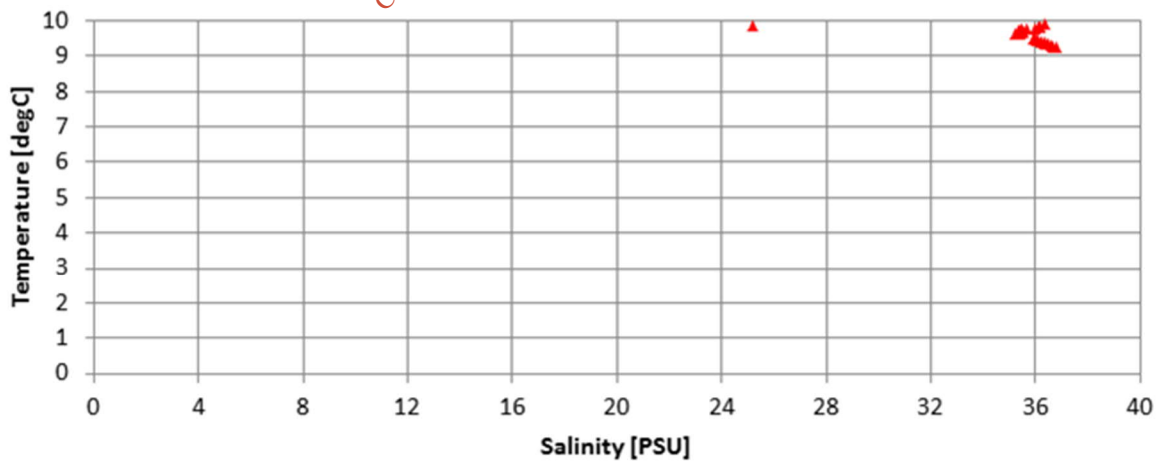
There are no profiles for Youghal Bay 2 17<sup>th</sup> January or 21<sup>st</sup> January 2020.

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Location: **Youghal Bay2**  
 Date: **28 January 2020**

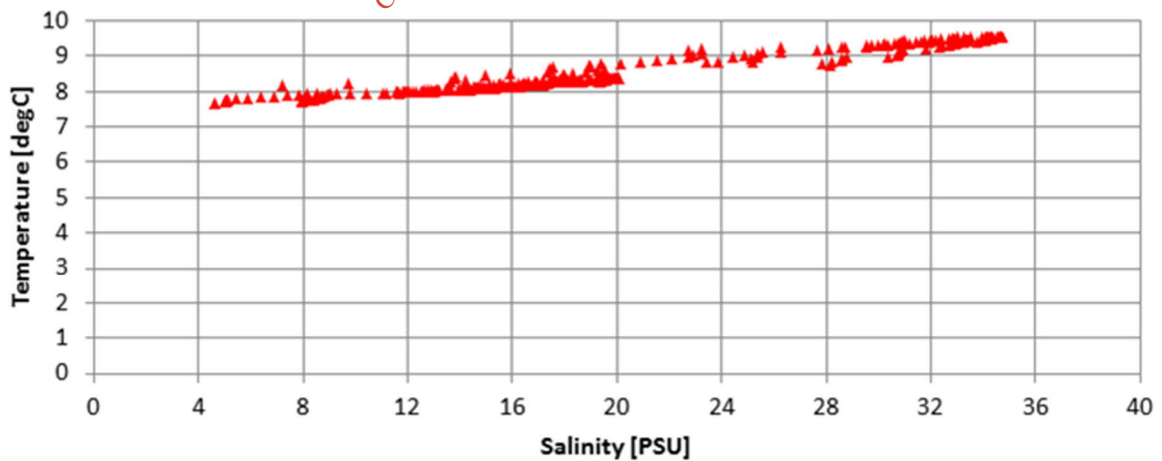
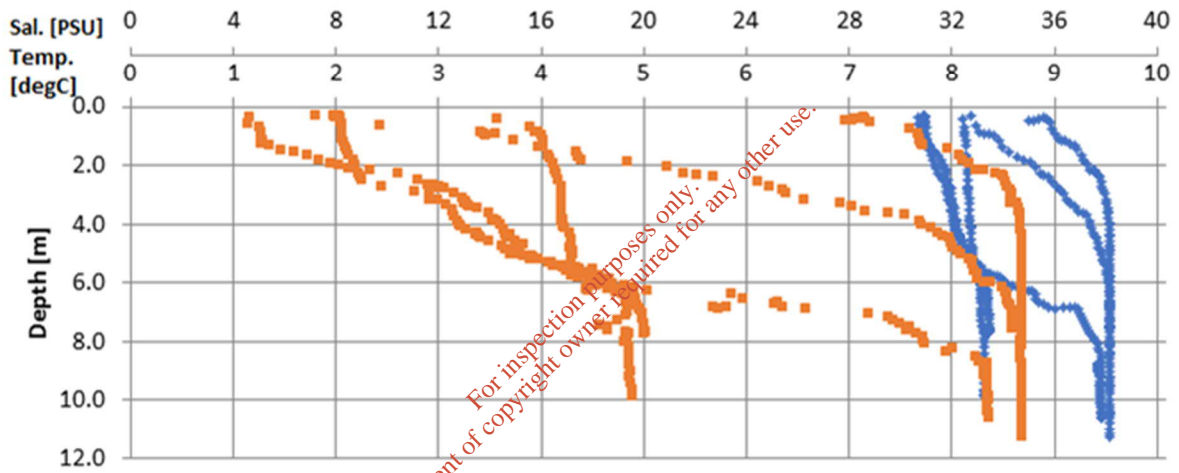
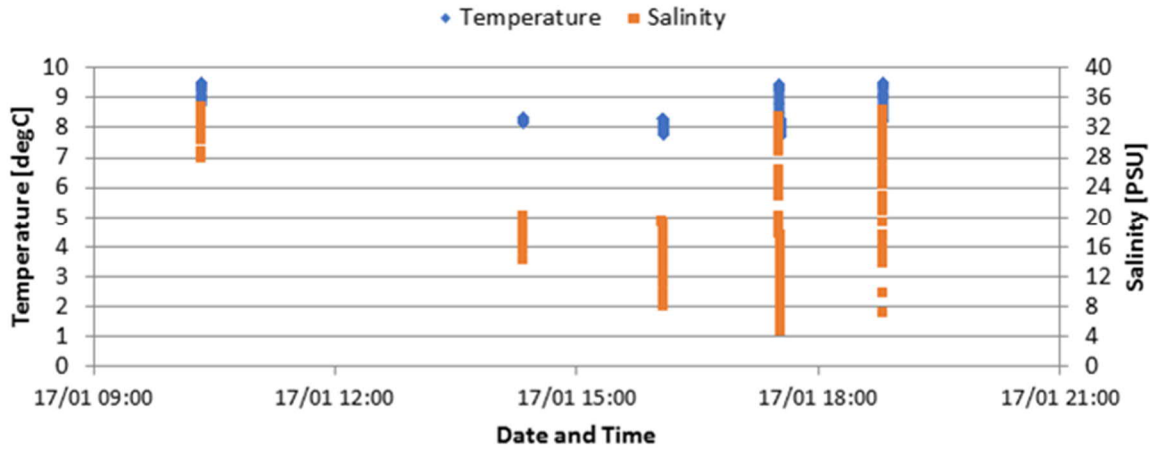


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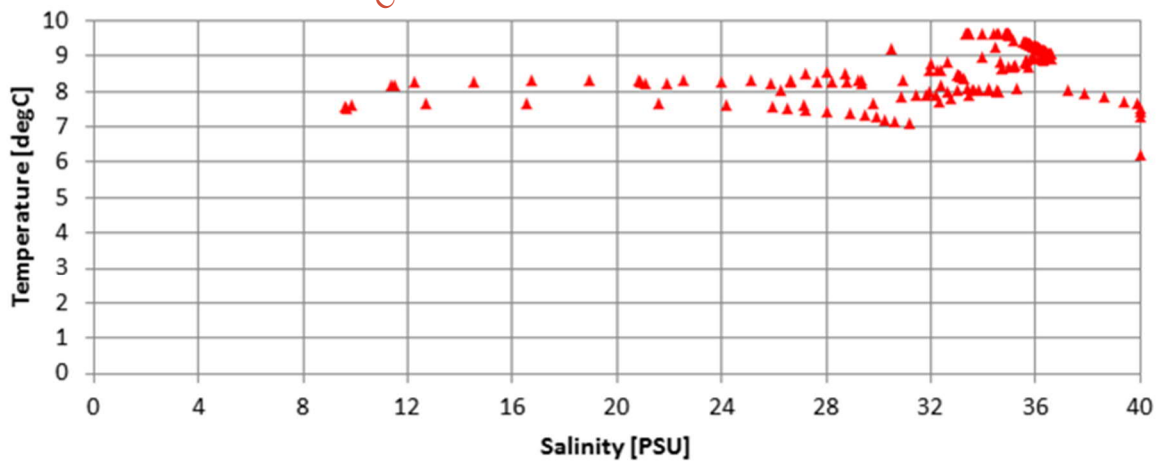
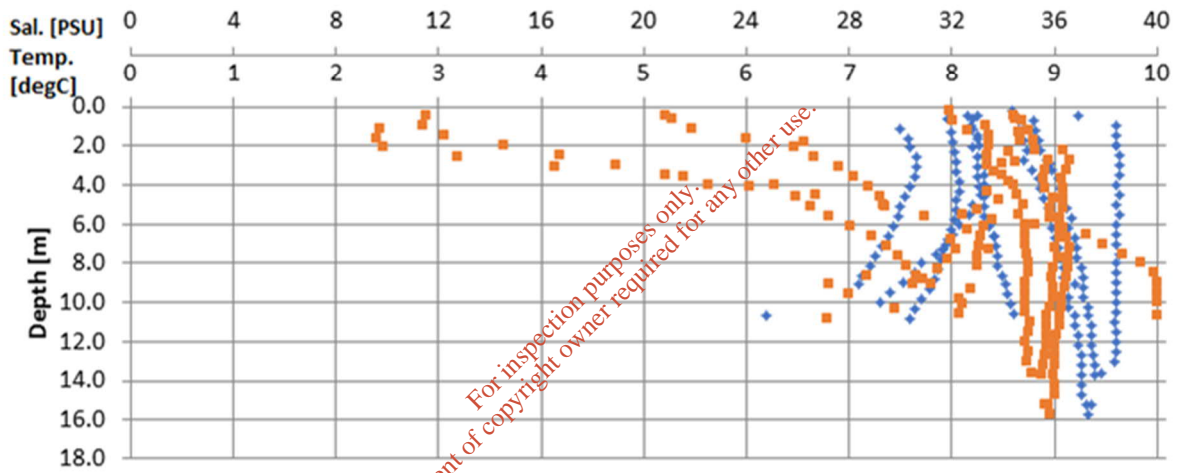
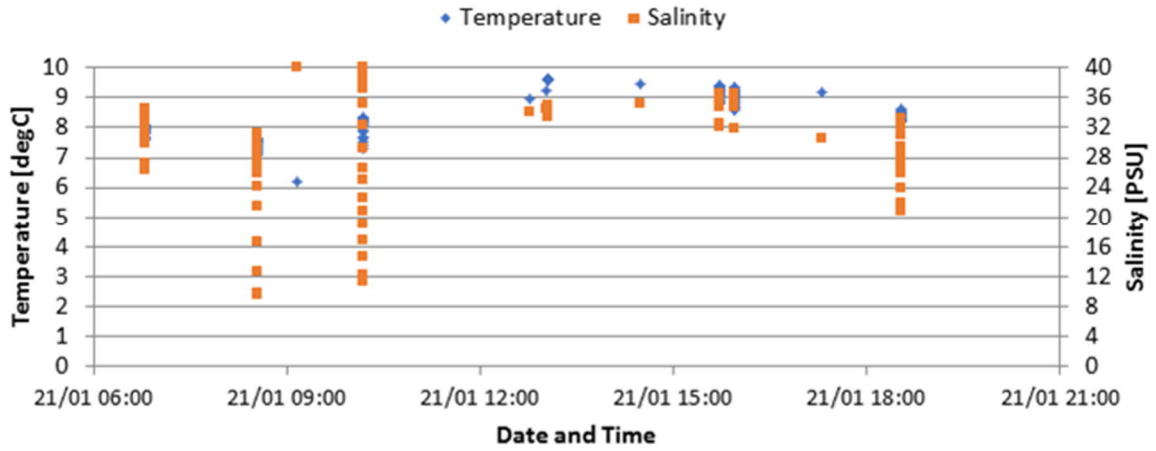
Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
9.2	9.6	9.9	0.2	25.2	35.6	36.8	2.0

Location: **Youghal Bay3**  
 Date: **17 January 2020**



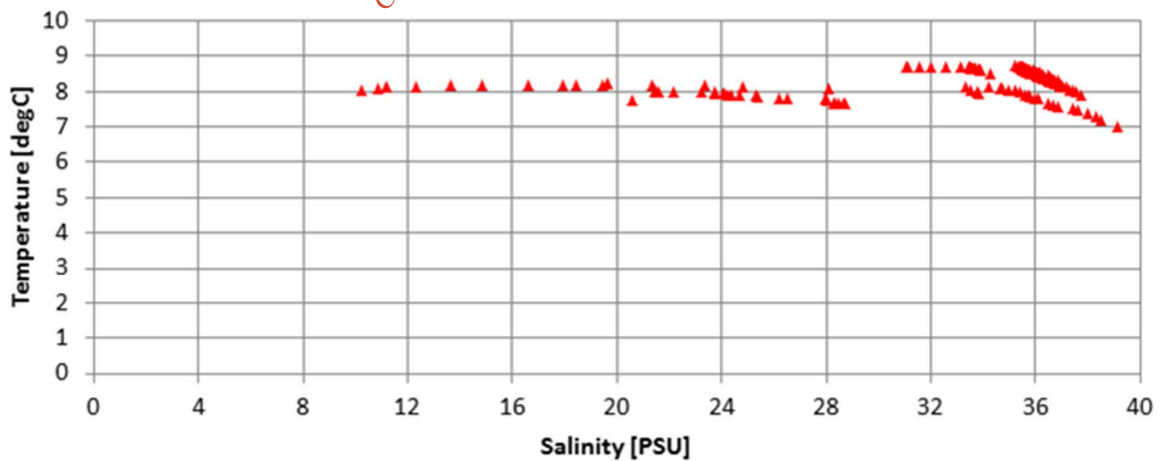
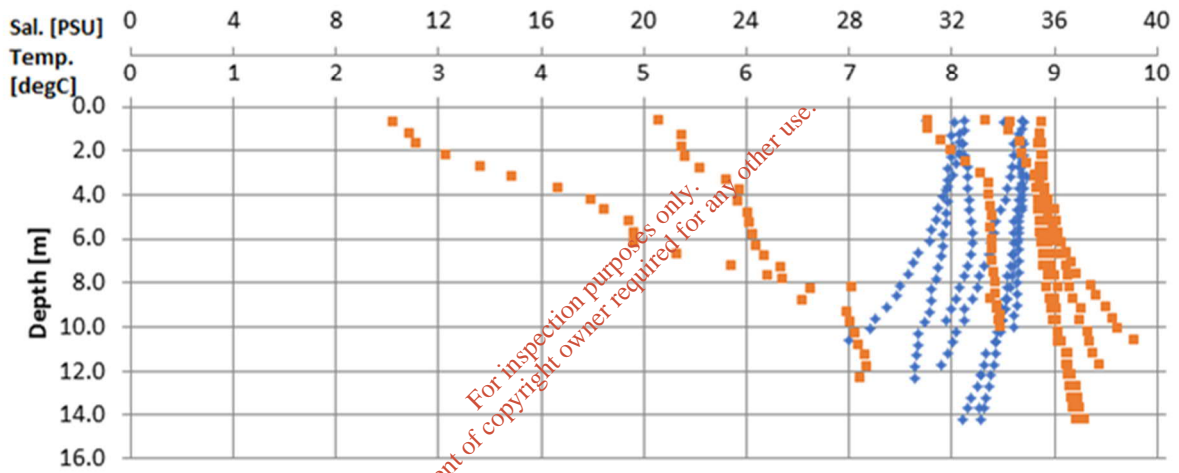
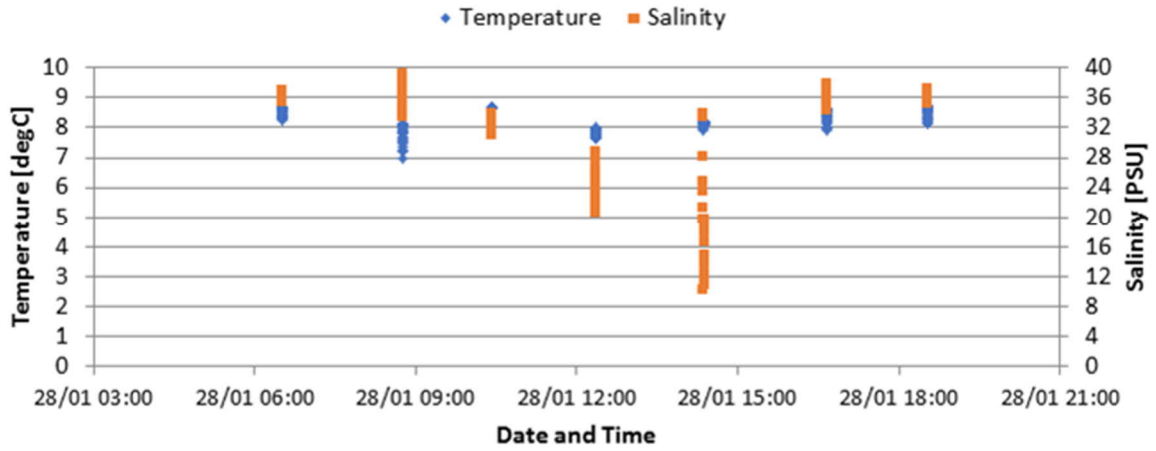
Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
7.7	8.7	9.5	0.7	4.6	23.0	34.7	9.4

Location: **Youghal Bay3**  
 Date: **21 January 2020**



Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
6.2	8.6	9.6	0.7	9.6	32.1	40.0	6.3

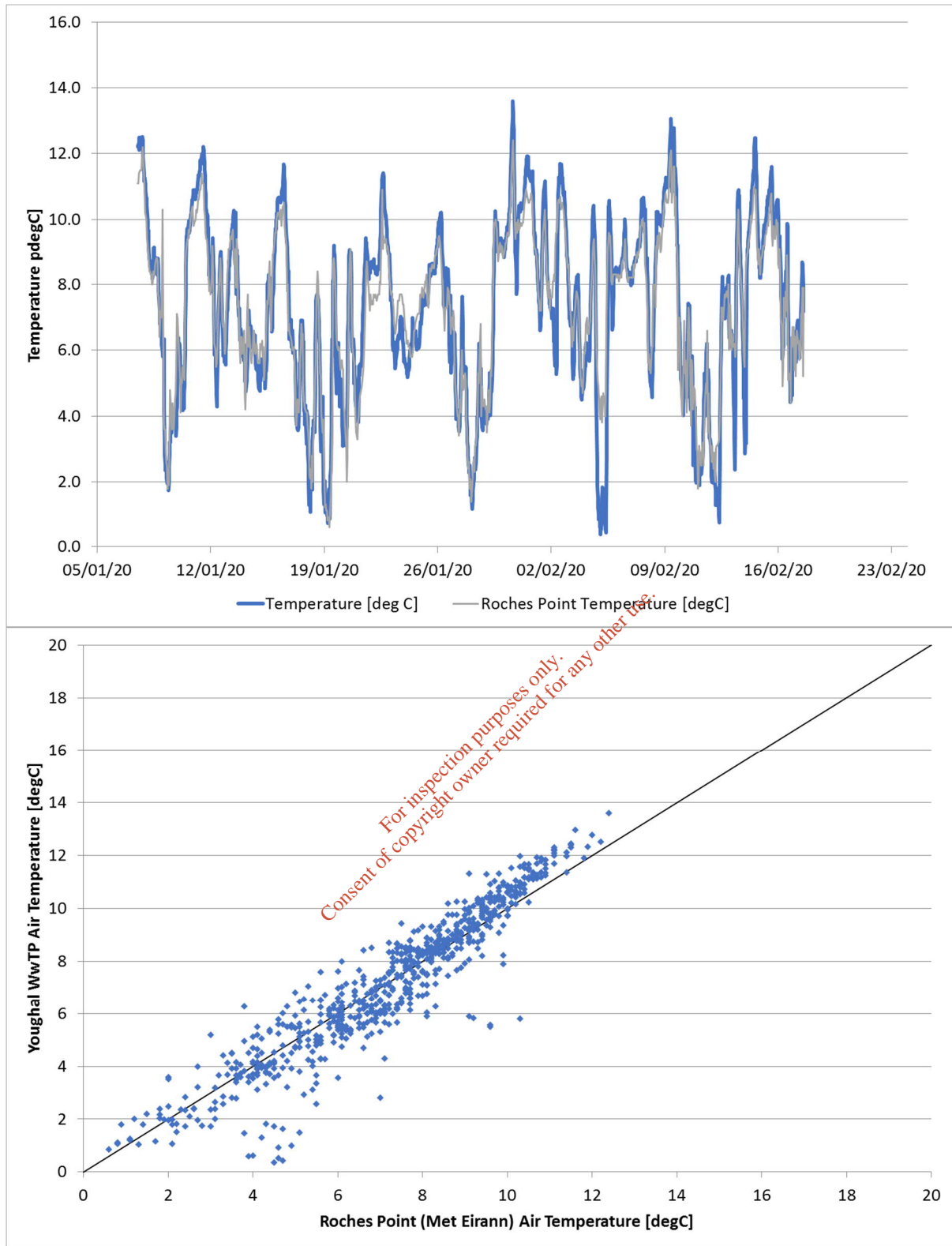
Location: **Youghal Bay3**  
 Date: **28 January 2020**



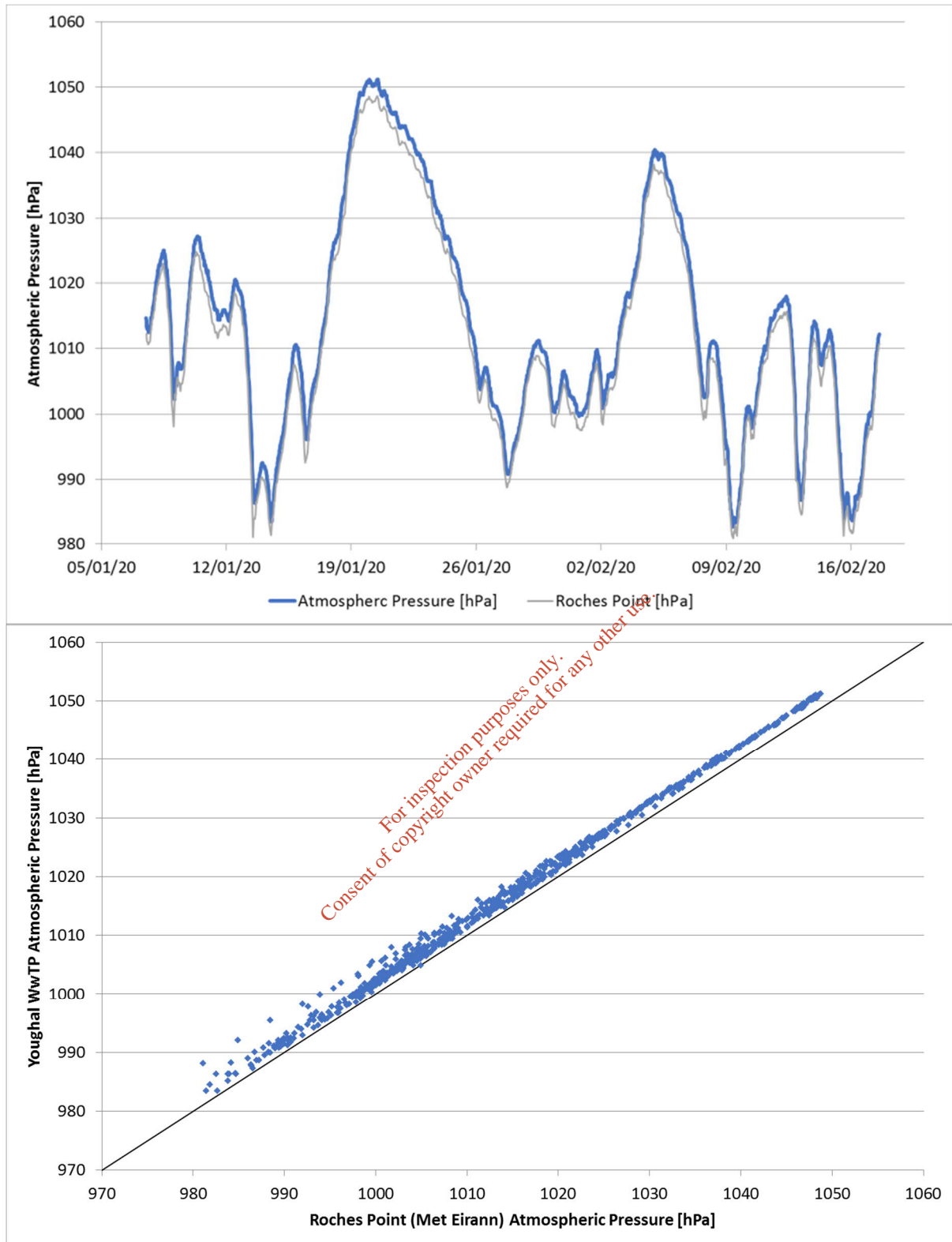
Temperature [degC]				Salinity [PSU]			
Min	Mean	Max	Stdev	Min	Mean	Max	Stdev
7.0	8.3	8.7	0.4	10.3	32.2	39.1	6.7

## Appendix E Comparison of Youghal Met Station Data with Met Éireann data for Roches Point

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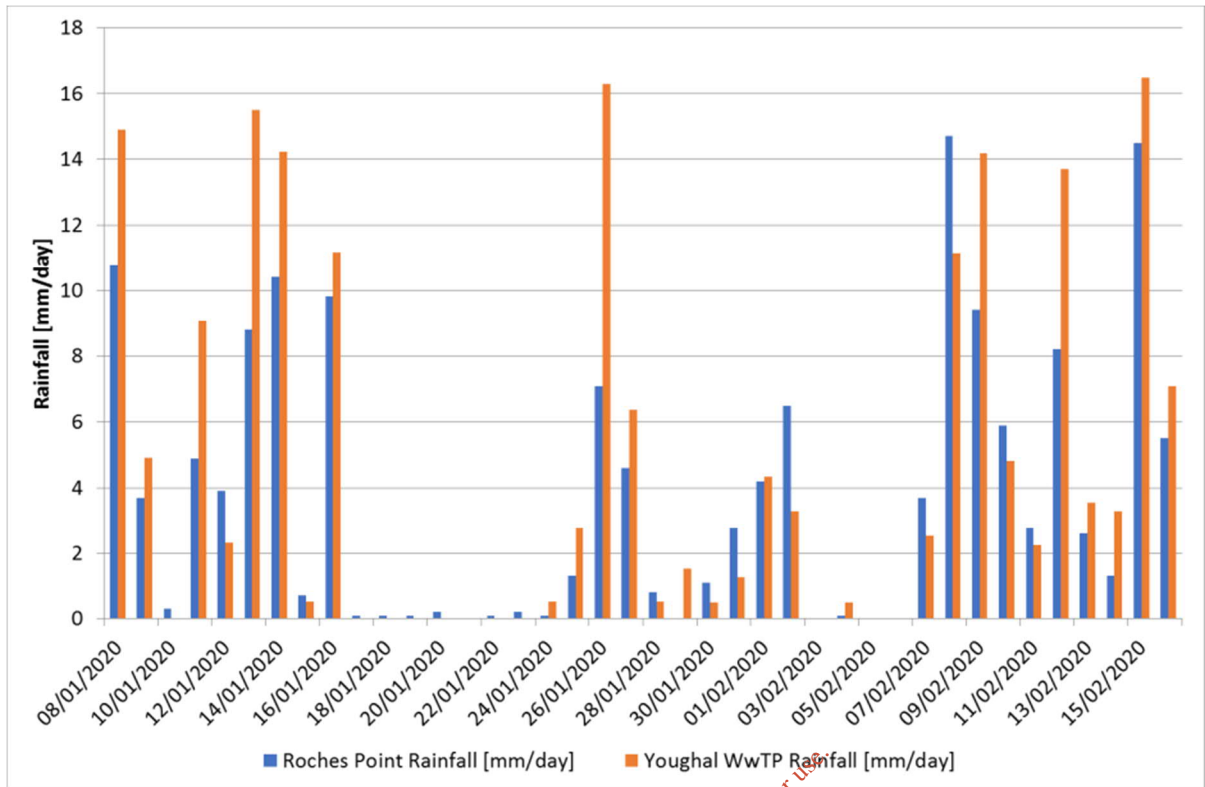


App Figure E-3. Comparison of the Air Temperature at Youghal WwTP with the Met Eirann station at Roches Point.



**App Figure Error! Use the Home tab to apply 0 to the text that you want to appear here.-4. Comparison of the Atmospheric Pressure at Youghal WwTP with the Met Éireann station at Roches Point.**

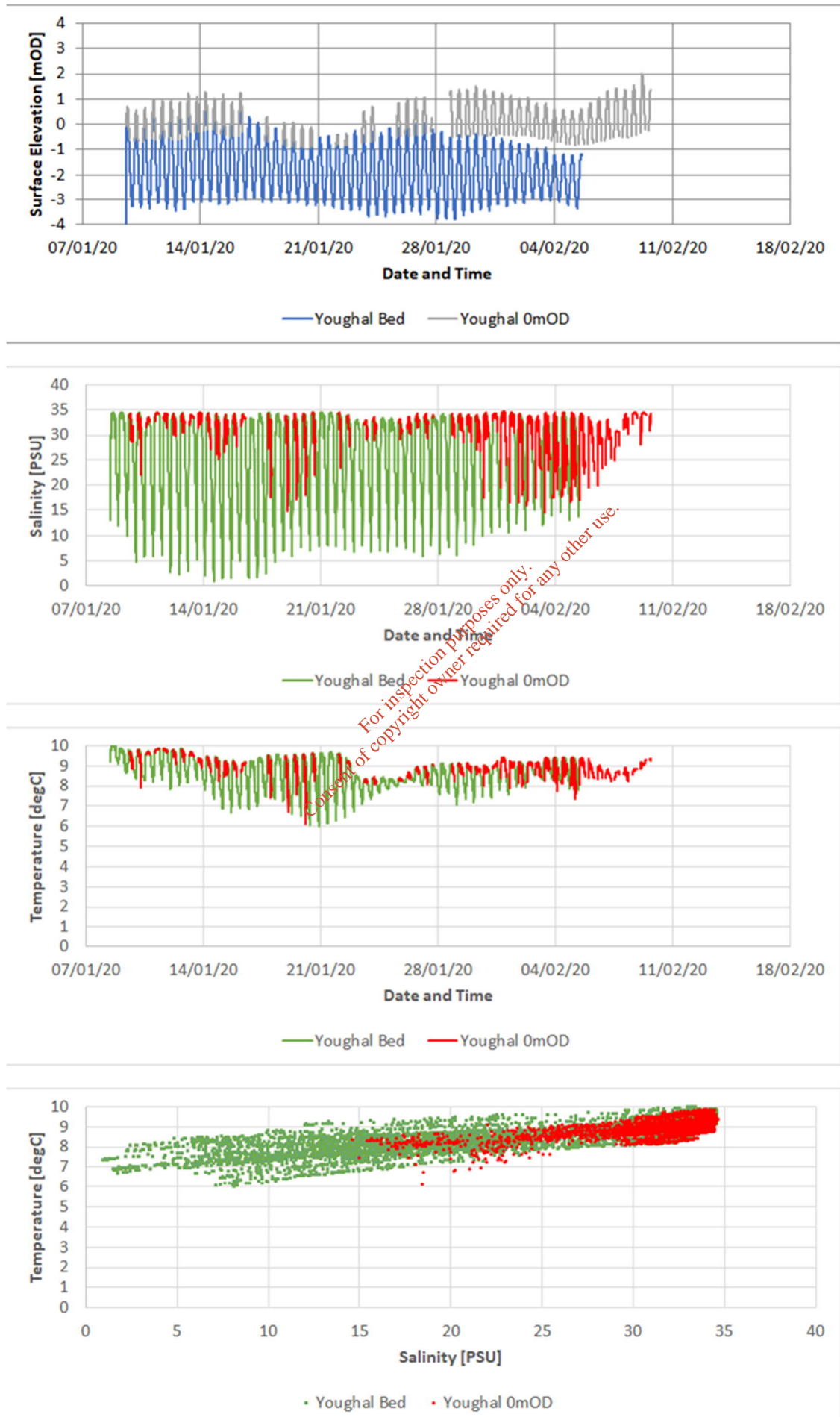




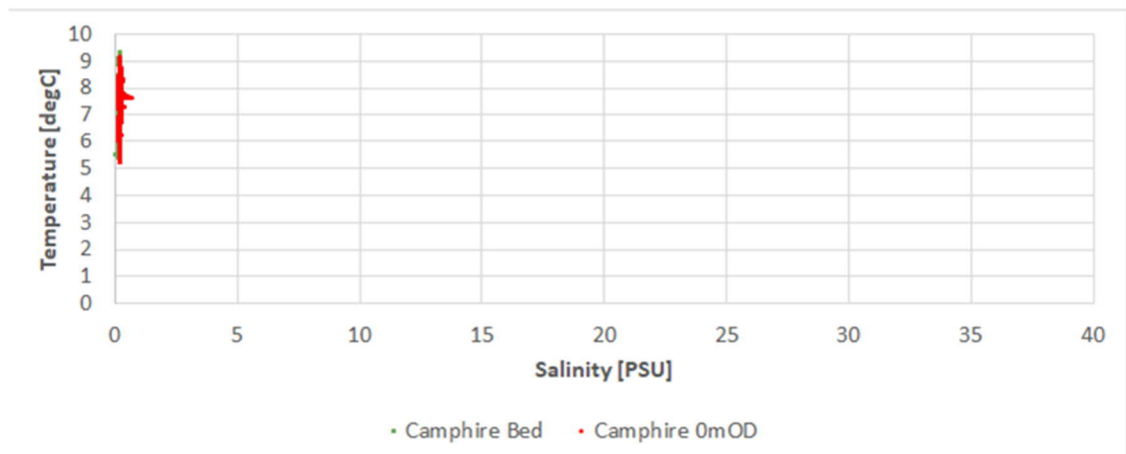
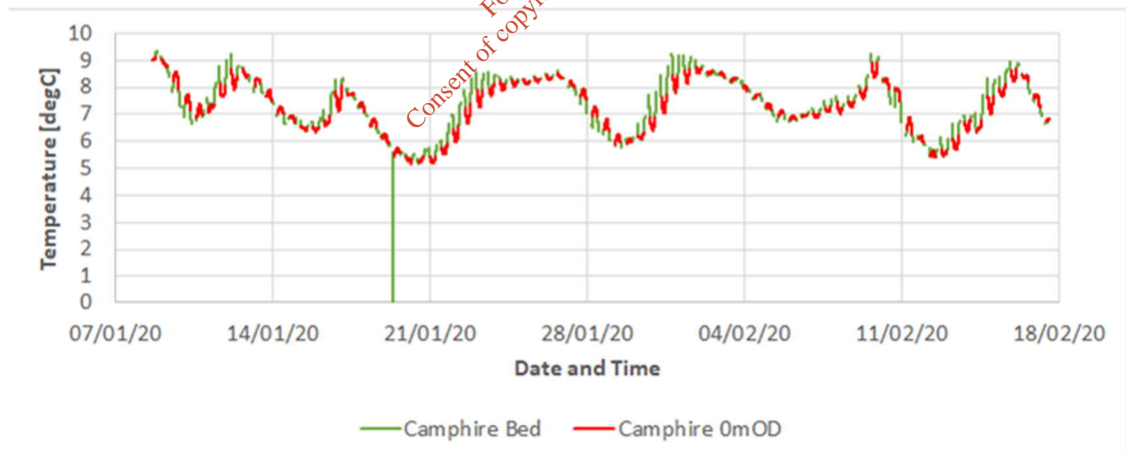
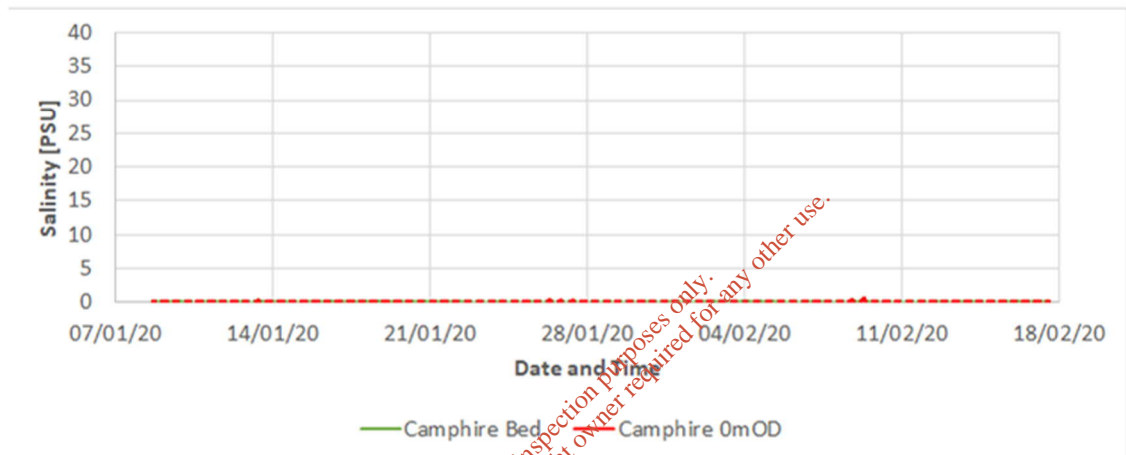
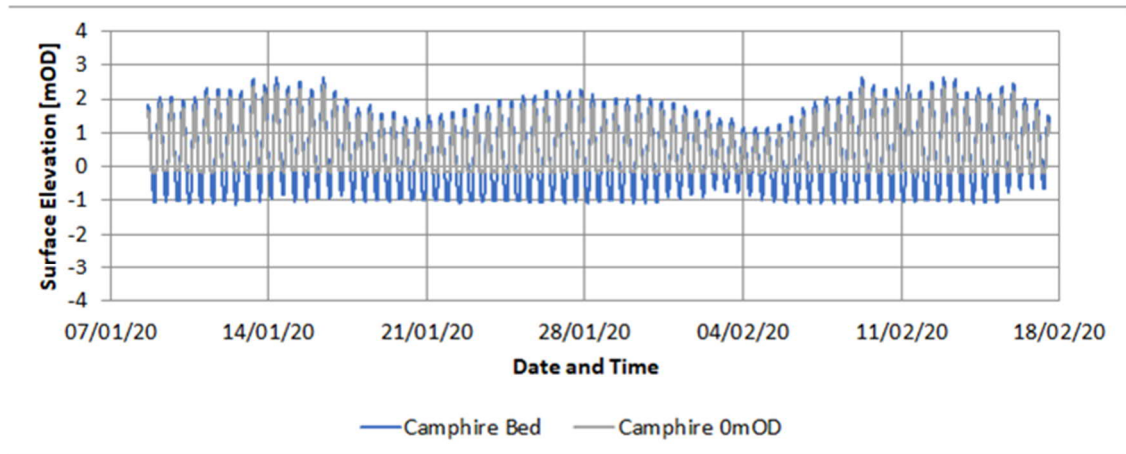
App Figure E-5. Comparison of the daily rainfall at Youghal WwTP with the Met Éireann station at Roches Point.

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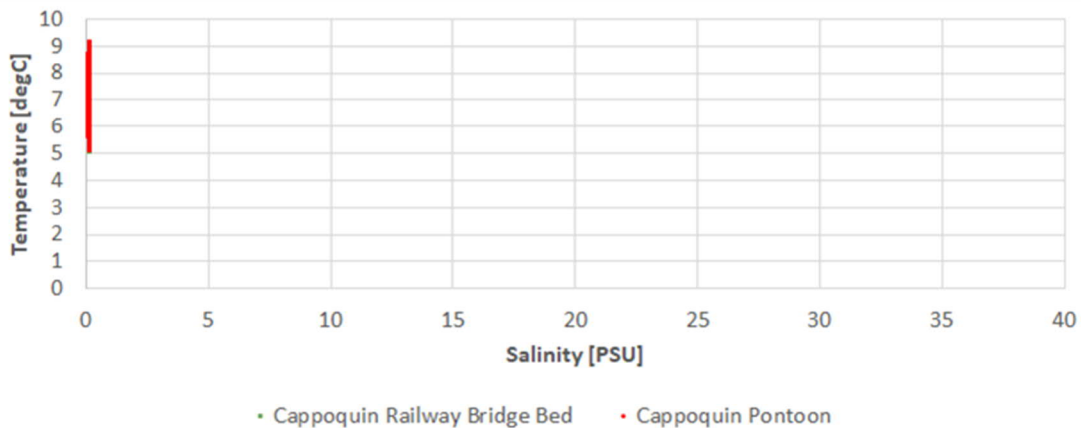
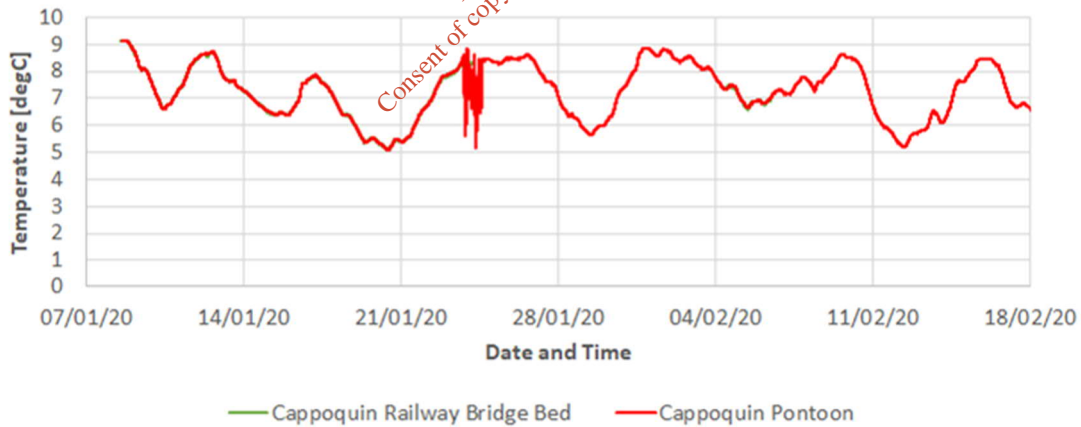
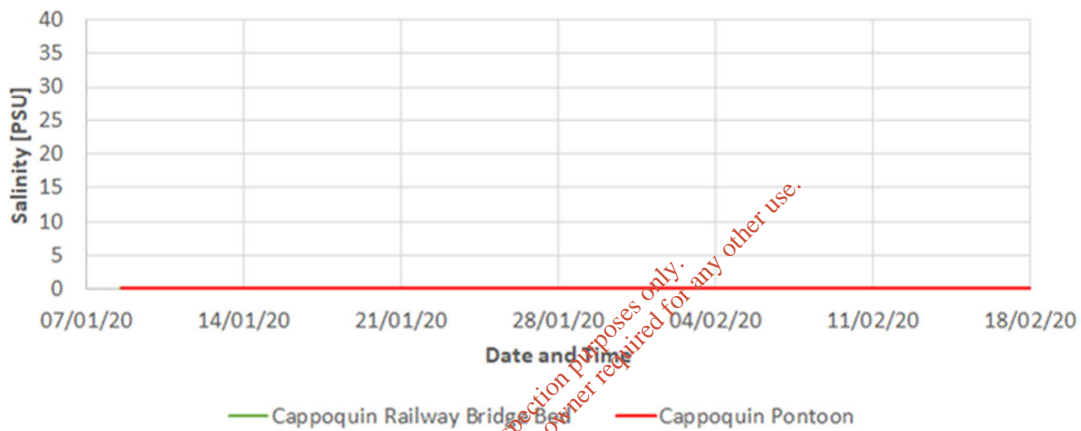
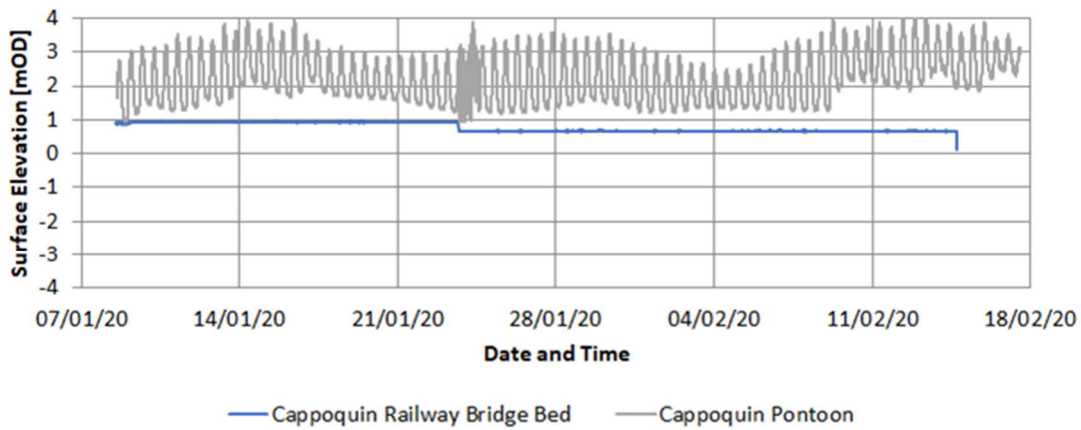
### Youghal Bed and Youghal 0mOD



### Camphire Bed and Camphire 0mOD



### Cappoquin Railway Bridge Bed and Cappoquin Pontoon



## Appendix F ADCP Current data

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