Submission	
Submitter:	Mr David Hugh-Jones
Organisation Name:	Atlantic Shellfish Ltd.
Submission Title:	Fourth Submission re Dairygold P1103-01 discharge at Rathcoursey Point.
Submission Reference No.:	S005903
Submission Received:	18 December 2019
Application	
Applicant:	Dairygold Co-Operative Society Ltd and TINE Ireland Ltd
Reg. No.:	P1103-01
See below for Submission details. Attachments are displayed on the following page(s).	

FOURTH

Submission to the EPA by Atlantic Shellfish Ltd.

(David Hugh-Jones, MA, Dip. Agric. (Cantab.), MMBA, FRGS)

with reference to the

Application for an Industrial Emissions Licence

by

Dairygold Co-Operative Society Ltd. and TINE Ireland Ltd.

of Mogeely, Co. Cork

Relevant Inspector: Orla Harrington

Environmental Licensing Programme
Office of Environmental Sustainability

EPA Licence Application Reference No: P1103-01

Continuing the objection to the discharge of the treated wastewater from the enlarged cheese-making facility of Dairygold Co-Op and TINE Ireland Ltd. at Mogeely, Co. Cork, which is proposed to be made to the North Channel of Cork Harbour through the Midleton WWTP Primary Discharge at Rathcoursey Point in the North Channel of Cork Harbour.

With evidence as to water movements from the proposed outfall at Rathcoursey Point made over two spring/neap tidal cycles in October/ November 2019.

Contents

Necessity for more information on water movements to support or reject the Dairygold proposition that Rathcoursey Point is a suitable location for their discharge of creamery waste.

1. Background.

It was M.C. O'Sullivan who declared in the Cork Harbour Pollution Report of 1977, Vol. 1 p.102, with regard to the discharge of the domestic waste from the town of Midleton at Rathcoursey Point:

*"Because of the presence of oyster farming in the North Channel**, any outfall point should be such as to give very substantial dilution."***

In November 2016 Dairygold put forward their EIS and Natura Impact Statement (NIS) and also the study prepared for Irish Water by Irish Hydrodata Limited, "*Rathcoursey Outfall Investigation of the Impact of Treated Wastewater Discharges arising from the DairyGold Mogeely Plant to Cork Harbour",* dated 19th May 2017.

As the NIS incorporated the Irish Hydrodata Study, it was stated no less than 22 times with another 3 occasions in the EIS – 25 times in all, in this Dairygold first Submission, in words to the effect of:

"Discharging on an ebb tide only will allow the effluent to be flushed out of the receiving environment. Over the 6+ hour period between ebb tides, water will undergo an ~80% exchange so that the subsequent discharge event will occur on new water coming in rather than the column which has gone out on the preceding ebb tide. Thus, considering the water exchange within Cork harbour it is unlikely that significant cumulative water quality will arise. "

When requested by EPA Regulation 10 on 13.03.19 to update both the NIS and the Coastal Modelling study, Dairygold updated first the NIS in April 2019 and then supplied an updated Coastal Modelling by Irish Hydrodata, "Rathcoursey Outfall Investigation" on 11 July 2019.

This revised Irish Hydrodata Report now makes an entirely different statement to "*water undergoing an ~ 80% exchange*" on each tide. All 25 earlier references have now been removed and this new format suddenly appears, just once, in the penultimate paragraph of the final Chapter 5 of "Conclusions" on p.44 of the report:

"*Discharges from the outfall are carried by the ebb tide to the south and into the lower harbour. **A high proportion returns on the subsequent flood**. Based on dye tests (ref:17) this fraction is about 65%".*

Such a change of expert advice, from the discharge being made "*on new water coming in rather than the column which has gone out on the preceding tide*", to now being made into 65% of contaminated water returning from the Lower Harbour, cannot inspire confidence. Nor had any previous working been given to us, showing how this figure of 65% returning water has been arrived at as the new Conclusion of the Study.

Further, (*ref :17),* on which this revised advice is based, is given as:

"*17. M.C. O Sullivan Ltd, Cork Harbour Pollution Report 1988"*

Not only has the date been brought forward by 11 years, but this entirely new advice would not appear to have been based on any modelling, as had been specifically requested, but on the results of dye releases and subsequent measurements carried out 42 years earlier in the 1977 Study.

The EPA's Regulation 10 requirement was specific to modelling, with three specifics:

(1) Revise the model to reflect 2015-2017 data.
(2) The WFD requires the use of winter and summer medians rather than annual averages and the model requires re-running to reflect this.
(3) The model methods should be provided to enable the Agency to assess the merits of the model itself.

Measurements of dye remaining in the water, which went some way to providing an idea of water movements in 1977, can surely be improved upon now, with the enormous advances made in coastal modelling and in computer power and I have quoted the work of the Hydrographic Team in Galway University – and yet Irish Hydrodata can do no better than say of the returning, already contaminated water, "*Based on dye tests* (and the tidal prism method – see below) *this fraction is about 65%".*

When we come to look at the Irish Hydrodata response to requirement (3), they give details of their Model in Appendix B. It is divided into the two models that are used:

1. A two dimensional Flow Model – M2D (with 14 variables – there are now over 40 in the latest NUIG refinements).

2. An Integral Jet/Plume Model for dispersion from the diffuser itself

3. 3D Flow and Dispersion Model – M3D.

Why do they give this last one, when they advise us that they use the M2D model of Hunter (1997) - *"a general-purpose modelling package for simulating flow and transport in surface water systems"* (Para. 4.6 p. 26)?

This "general-purpose model" is 22 years old and is based on papers published from 1928 to 1990.

The Integral Jet/Plume Model, that they employ, is based on papers dating from 1960 to 1979.

As I have already said, with the huge advances made in coastal water modelling and the exponential growth of computer power since these models used by Irish Hydrodata were formulated, I feel we are all owed something a great deal better than this.

The EPA are well placed to decide whether the Dairygold assessment of water exchange, based on "*a simple tidal prism model*" (p.42 of the updated Rathcoursey Outfall Investigation) compares in any way to the modelling of Cork Harbour carried out by Prof. Hartnett's team in NUIG, now published in several papers, which I have sent with my first

submissions (needing opening on Internet Explorer to read the 21 References, which are attached).

The paragraph in the revised Irish Hydrodata Report of July 2019, which we have been considering at the start, continues:

"Estimates of flushing rates vary and are dependent on the method used and stage of the spring neap cycle. ***The tidal prism volumes*** *are large relative to the low water volumes. Estimates range from 3-8 days for the waters upstream of Rathcoursey Point".*

The tidal prism calculation method of M C O'Sullivan in 1977 is still being employed.

The estimate of flushing rates, that are arrived at, vary from 3 to 6 to 8 days. This is a colossal enough variation of 267%, but if the water remains for even a single day in the North Channel and Lower Owenacurra Estuary, this is more than enough time for its nutrient load to be removed by the toxic algal blooms that need to be minimized, or, indeed, for the oysters themselves to take up any other pollutants associated with the organic loads from Dairygold, or the Midleton WWTP overflows.

On p. 29 of my second Submission to the EPA, I copied the last 5 paragraphs of sec. 4.9 of the July 2019 Irish Hydrodata Revised Rathcoursey Outfall Study, which covered "Estuary Tidal Flushing", and I offered this vitally important section to the scrutiny of the EPA, without making any specific comment, explaining that my action was taken:

"....in the hope that the EPA will agree with me, that almost each succeeding statement is less worthy of our comment than the last, and that it is clear that Irish Hydrodata and M. O'Sullivan have not dared to properly revisit the illusion that they have built up together, that Rathcoursey was the suitable place to make the discharge from Midleton in 1988, 2000 and now still, in 2019, from Mogeely".

My Third Submission to the EPA covered in detail what I felt the EU Commission hoped to achieve from an Environmental Impact Assessment and how I felt the amendment of the EIA Directive 2011/92/EU by Directive 2014/52/EU, enlightened us towards what the Commission had in mind and I am grateful to the EPA for now requiring an EIA Screening Determination (15 November 2019).

If this has now been required of the Developer, then I feel that we, too, are more beholden:

(1) To put up our criticisms in detail of the relevance of the science behind the Irish Hydrodata "Estuary Tidal Flushing", using their tidal prism method, when we feel so much greater sophistication is now being achieved in computer modelling – and especially in the complex water body of Cork Harbour

and,

(2) As the water movements at this particular, long-disputed location of Rathcoursey Point, are crucial, to add what knowledge we have been able to obtain in the last two months with the use of a sophisticated GPS drogue and 2 ACDPs (Acoustic Dopler Current Profilers), all of which were kindly made available to us by BIM.

I explained on pp. 17-18 of my Second Submission that of all the preceding actual modelling work by Irish Hydrodata, leading to no less than 16 continuous or tidal discharges; from 4 different outfalls; on neap and spring tides - none lasted for more than HW-3; HW; HW+3; LW on a single day, **giving us no idea of the proportion of the discharge that returns after "mixing" in the Lower Harbour,** which would justify the second half of the Dairygold's Consultants' claim above:

"Thus, considering the water exchange within Cork harbour it is unlikely that significant cumulative water quality will arise,"

and casts doubt on the weight of both this statement and the latest version of 65% of already contaminated water returning after mixing in the Lower harbour, both based on the unsupported statement, ventured only in the very last paragraph of the Estuary Tidal Flushing section, before the Conclusions of Section 5:

"All of these prism calculations assume good mixing which is believed to be a reasonable assumption given the tidal volumes, shallow depths and expansive areas discussed previously."

We hope that we can now provide, in section 2, below, some rather more solid data than the pie in the sky, optimistic assumptions of this updated Coastal Modelling Study.

1.1 Criticism of Section 4.9 "Estuary Tidal Flushing" of the revised Rathcoursey Outfall Study. Irish Hydrodata Ltd., (July 2019).

This section is absolutely crucial to establishing whether Rathcoursey Point is a suitable outfall location to dispose of Dairygold's waste to the sea,

As I have said above and in my second submission, I believe there to be no comparison between the back-of-an-envelope Tidal Prism simplicity of $T= (P+V)/P$, put forward in this section of the Irish Hydrodata Report, to the highly sophisticated stage of hydrodynamic modelling that we are so fortunate to have for Cork Harbour, which can now give us a picture of the flushing that goes on in specific parts of the harbour.

The degree of flushing in the North Channel has a profound effect on the accumulation or dispersion of point source nutrients being discharged into it and also the build-up of the temperature of the water whilst resident in a very shallow cul-de-sac with large areas of mud-banks. Both these factors lead to the most favourable conditions for both phytoplankton growth and the retention and growth of oyster larvae for the 10+ days needed for their larval development before they settle on the sea-bed.

The hydrodynamic work of the Galway team proved their model, not only in comparing its results to the phytoplankton distribution assessed from the air, but in alerting me to look on the Ordnance Survey maps around the Harbour for other areas with high water residence times for signs of ancient oyster beds, which I then found at Carrigrennan in Lough Mahon and on both sides of Lough Beg in the Lower Harbour – all of which have ancient oyster middens recorded on their shores.

I have asked for an expert critical appraisal of the Irish Hydrodata/M. C. O'Sullivan Tidal Prism, approach in this section, in the light of alternative advances that are available today.

I have approached JBA Consulting, UK, who have visited the North Channel and are very conversant with our water. They have been working for the Environment Agency, UK, for over 15 years, working under its Water and Environment Management (WEM) and predecessor frameworks. They have also recently have been appointed to Lot 1 of the Collaborative Delivery Framework (CDF) within the Environment Agency's Next Generation Supplier Arrangements (NGSA) specifically dealing with the increasing risks of flooding in the UK.

I am hoping that we will have the benefit of their opinion in the next few days in a further submission to yourselves.

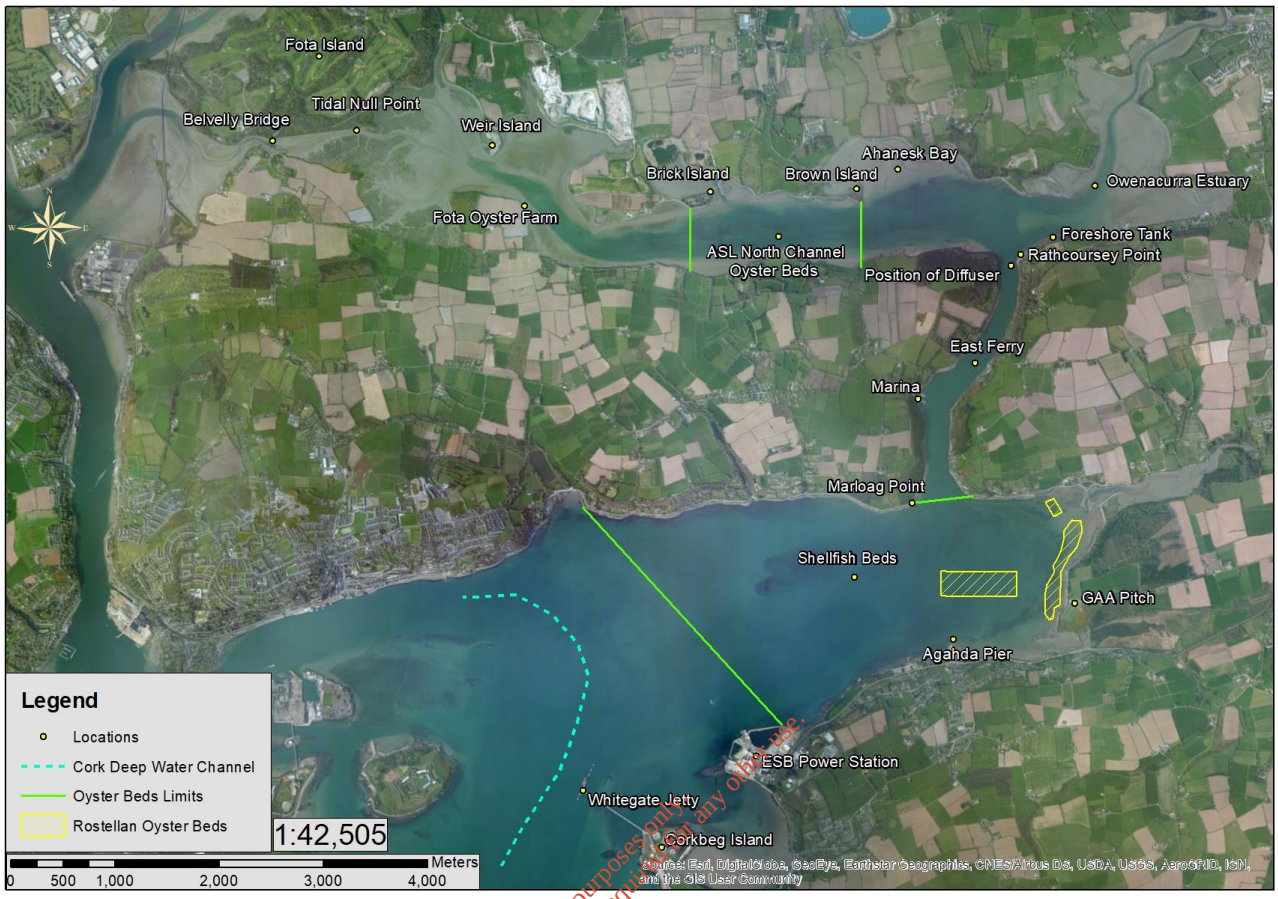
1.2 Drogue survey carried out in October and November 2019

BIM kindly made available their Pacific Gyre Microstar GPS Drifting Buoy, designed to track currents at 1 metre below the surface, for a period of a month, whilst they helped us to deploy two of their ADCPs - Acoustic Doppler Current Profilers in the North Channel in the same position close to Brick Island, as was used by Irish Hydrodata for their Midleton WWTP 1993 EIS and also at the north end of the East Ferry, close to the position of the diffuser for the Midleton WWTP outfall.

Note:

Drogue runs were carried out as follows (times on drogue are converted to BST in October; tide times and release times are in BST until November, when all are in GMT)

The drogue runs are shown on the satellite picture of the North Channel and NE corner of the Lower Harbour, below, on which BIM have kindly added the various landmarks that I have used in the text.



Satellite map of the North Channel and Lower Harbour of Cork, showing the position of Rathcoursey Point, with Midleton 5km to the NE; Cork City 12km WNW; and the open sea 4km S of Corkbeg Island.

2. To test the tidal excursion into the Lower Harbour from discharges from Rathcoursey Point.

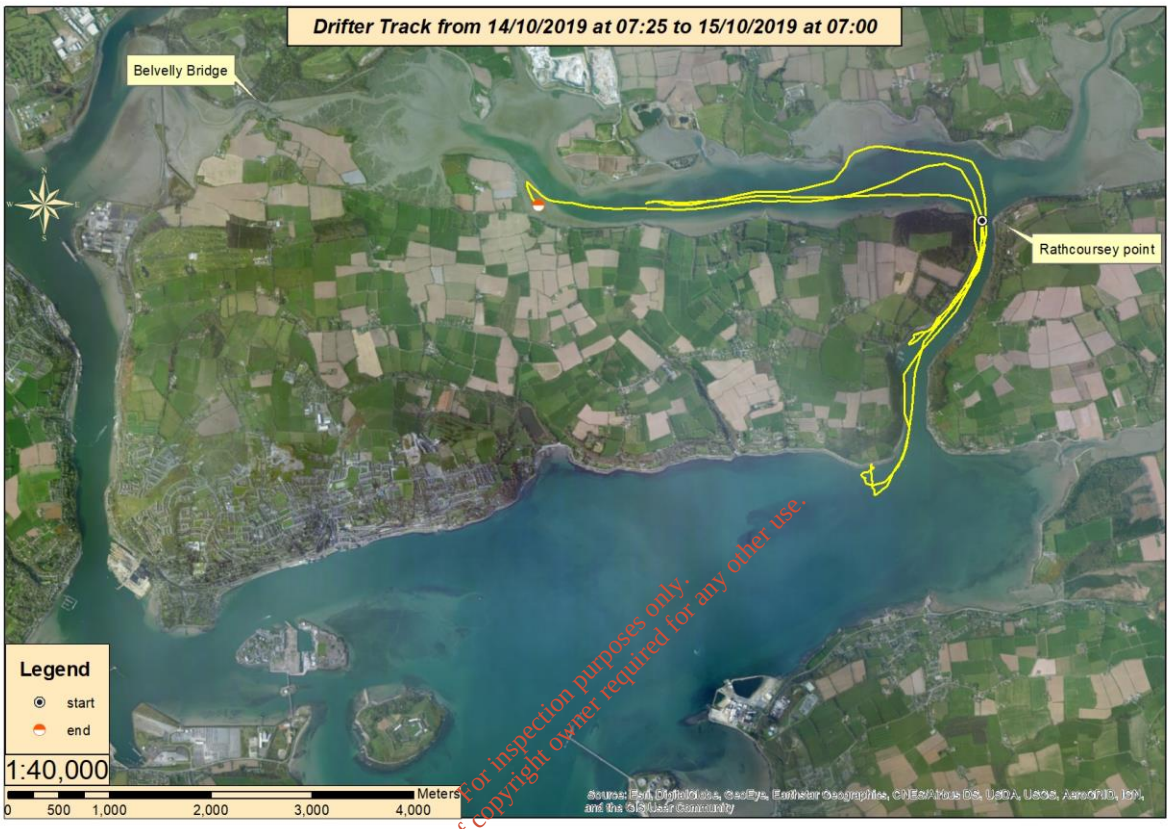
2.1 Spring tide runs.

2.1.1 <u>Spring tide on 14.10.19</u>

HW 06.27 & 18.44 BST (4.1m), LW12.52 (0.5m).
Released at the mid-point of the statutory 3hr discharge period i.e HW+2hrs at 08.25

08.25 Drogue released at Rathcoursey Point.
09.25 had taken **60 mins** to reach the mouth of East Ferry, but got caught in the clockwise gyre west of the mouth and carried to the shore.
14.05 Pulled to the edge of the East Channel, but did not catch the current properly till 14.30
15.35 top of East Ferry, continued N in a long loop up to Brown Island
16.47 Brown Island (east end of oyster beds)
17.56 Brick Island (west end of oyster beds) – **69 mins** to traverse beds on flood

18.50 stopped (HW 18.44) south of Home Pond
19.37 Brick Island
20.50 Brown Island – **73 mins** to return over beds on the ebb
21.30 entered East Ferry. Left to run, but caught in a gyre at the Marina.



(15.10.19)
02.15 started to flow back north LW 01.10 (i.e. LW+65mins)
03.35 out of East Ferry with a small sweep round the point
04.22 Brown Island
05.22 Brick Island – **60 mins** to traverse beds on flood
07.15 Reached Fota Oyster Farm. No slack water (HW at 06.59)
08.00 Drogue recovered.

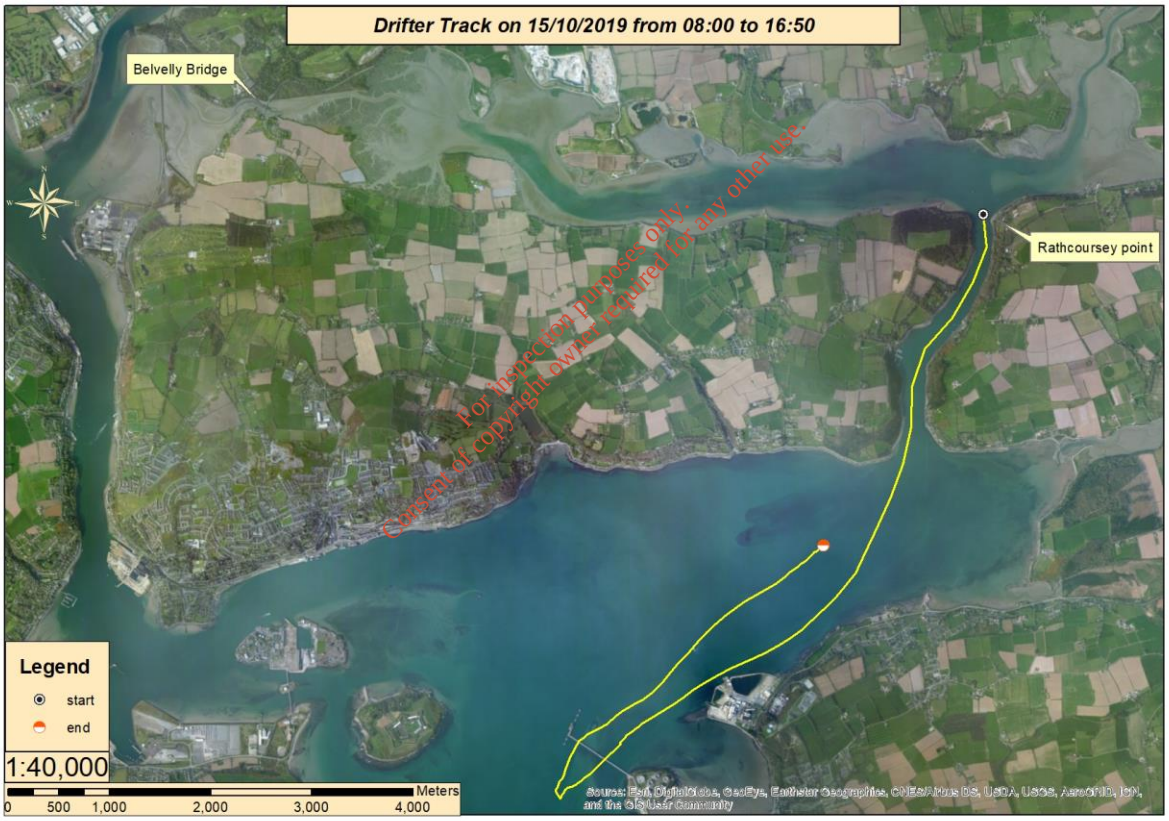
Information acquired.

With the drogue getting caught in the gyre at the mouth of East Ferry and on the continuing run in a gyre or obstruction in the Marina, halfway down East Ferry, this run gave us mainly times taken on flood and ebb tides to traverse the oyster beds. These are tabulated below.

However, it is clear from these runs that contaminated water, re-entering East Ferry with 3 hours of the flood tide remaining, will flow over all our oyster beds and up to those of Fota Oyster Farm another kilometre to the west.

2.1.2 <u>Spring tide on 15.10.19</u>
HW 06.59 & 19.15 BST (4.1m), LW13.24 (0.5m). Released again at the **mid-point of the 3hr discharge period** required of Cork CC **i.e HW+2hrs at 09.00.**

09.00 Released
09.35 reached mouth of East Ferry **(35 mins)**
10.20 reached Aghada power Station, keeping to S side of East Channel
12.35 passed under the Whitegate Jetty about a third out from shore
13.35 stopped level with Corkbeg Island and started drifting N (LW 13.24)
13.55 drifting NNE
14.35 back under Whitegate Jetty but still in water less than 2m deep; now going NW, but taking a course N of the main East Channel and progressing more and more slowly in consequence.
16.50 terminated.



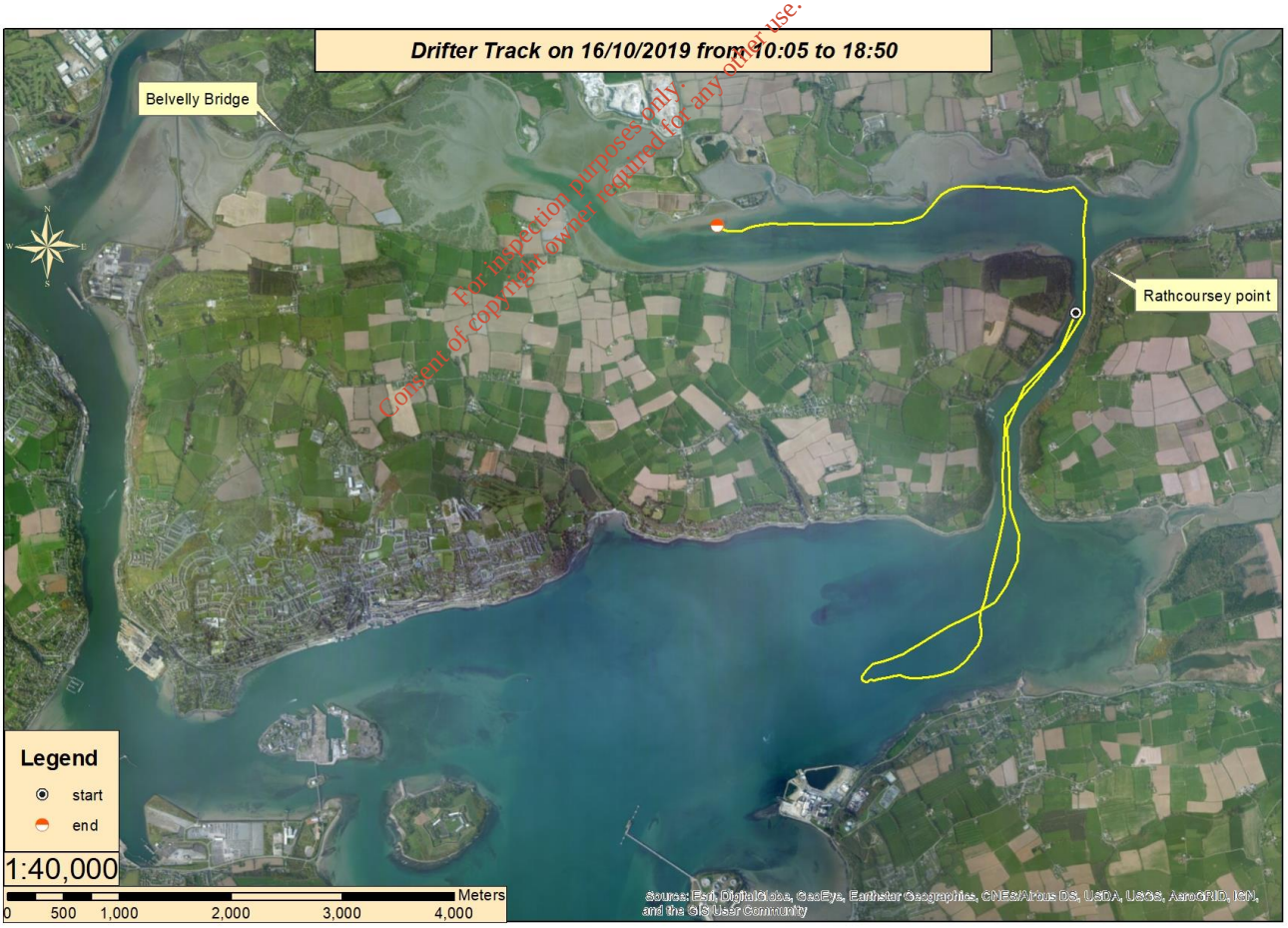
Information acquired.

We have shown how far the Rathcoursey discharge can travel on a big spring tide, with the important observation of the drogue **stopping short of reaching the outflow of the Cork Main Channel** to the open sea, 3.5km further south, at Roches Point.

2.1.3 <u>Spring tide on 16.10.19</u>

HW 07.30 & 19.47 BST (4.1m), LW13.56 (0.5m). Released at the **end of the 3hr discharge period** required of Cork CC **i.e HW+3½hrs at 11.00.**

11.00 Release at Rathcoursey Point
11.43 Reached mouth of East Ferry **(43 mins –** possibly slower due to more heavy rain down the Owenacurra yesterday)
12.25 Drogue probably affected by the anti-clockwise gyre to the east of the East Channel and as it drifted east out of the East Channel flow on to the Rostellan shallow shelf, we decided to try to bring it back to the Channel, with the aim of letting it maximise its tidal reach, to see how far it could possibly go.
13.30 Little further movement SW down the East Channel and it drifted westwards
14.50 Started moving towards East Ferry
16.30 Entering East Ferry
17.05 Top of East Ferry **(35 mins**) and looped up into Ahanesk Bay and turned W
18.05 Brown Island
19.14 Brick Island, but coming to end of run (HW 19.47) (**69 mins** to traverse beds on flood)
19.50 Drogue recovered.



Information acquired.

The drogue, released at the end of the discharge period and reaching the Lower Harbour at HW+4hrs, had missed half of the peak mid-tide flows and only got as far as half-way between Aghada Pier and the Power Station.

The returning discharge, re-entering the East Ferry at approx. mid-flood, continued to the North Channel and covered all the oyster beds including those of Fota Oyster Farm on the returning flood tide. **Thus all the water following the drogue would have been contaminated water, discharged that day at Rathcoursey. This returned over all of the oyster beds by HW.**

2.2 Neap tide runs

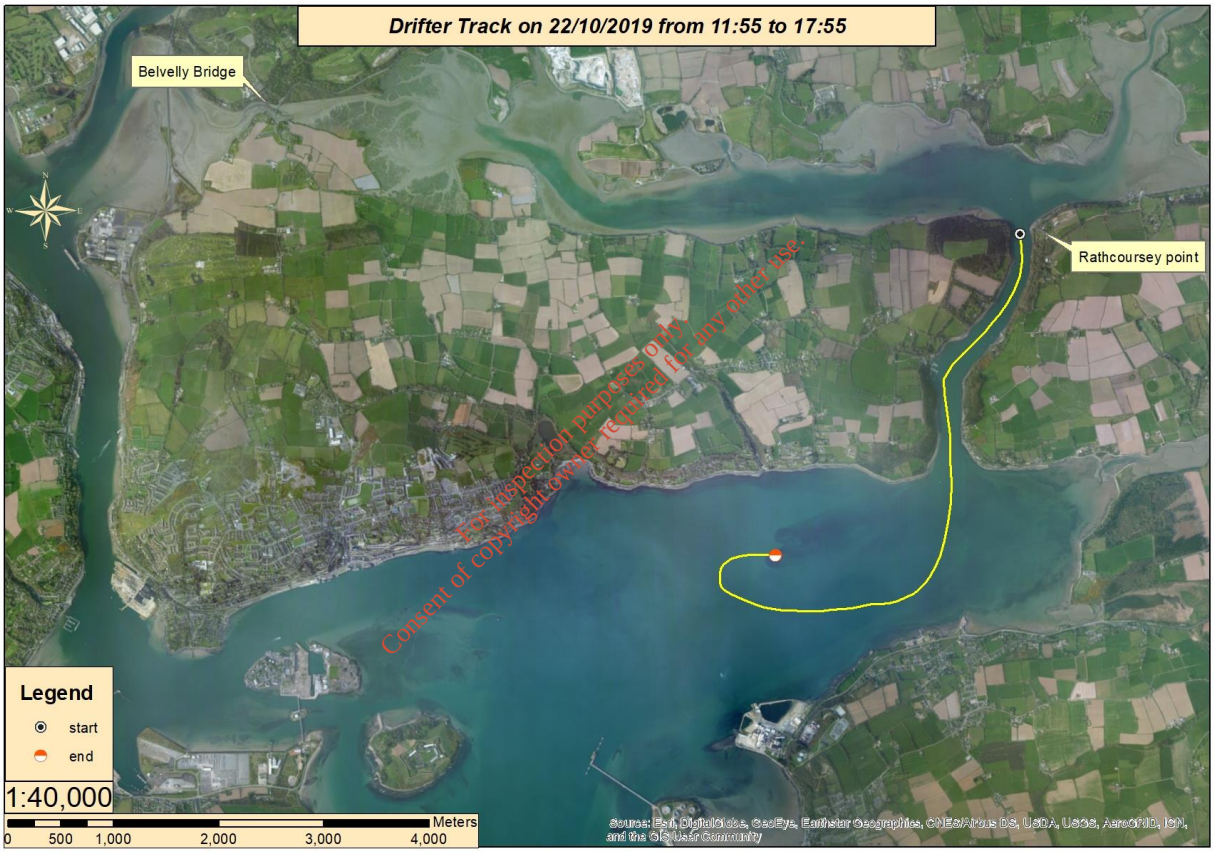
2.2.1 Neap tide on 21.10.19.

HW 11.04; LW17.33; HW 23.38 (3.4 and 3.3m tides)
Drogue released 3½hrs after HW at Rathcoursey - i.e. at the end of the official 3hr discharge period.

14.30 Drogue released
15.50 Reached Lower Harbour (**80 mins** travel time)
Kept to the East Channel until about
17.00 then started to drift westerly and out of the main East Channel steam.
18.35 reached the western limit of its flow, N of Aghada Power Station and drifted N
19.00 It was decided to try and pull it back into the East Channel.
19.50 Drogue left to its own devices and it drifted slowly NNE, outside of the main channel flow back to East Ferry.

2.2.2 Neap tide on 22.10.19
HW 12.21; LW 18.54; HW 01.02 next day (3.3m and 3.2m tides)
Drogue released at HW+ ½hr - i.e. at the START of the official 3hr discharge period

12.50 Drogue released at R. Pt.
14.15 reached Lower Harbour (**85 mins**)
15.00 had followed the main East Channel but started going westerly and kept west until
16.30 and then appeared to go into a clockwise gyre to the west of the mouth of East Ferry reaching no further west than the last run – i.e. N of the Power Station and further to the north.
17.35 drifting now to the north and then east in this gyre, making a full half-circle by
18.35 decided to end the run as unlikely to return up the main channel (LW – 20mins)



Information acquired.

These 2 neap runs at the start and end of the official 3hr discharge period both showed that discharges from Rathcoursey on neap tides do not get further west than a line running N from the Power Station and seemingly getting caught in a gentle clockwise gyre, which establishes to the west of the mouth of East Ferry.

There was evidence of a similar anti-clockwise gyre on the east side of the mouth of East Ferry with the spring tide run on 16.10.19 turning to the east from 12.15-12.30, when we decided to give it every chance to get further away by coaxing it back into the main flow.

Thus, on neap tides, the picture that has emerged was of travel down East Ferry at about half the speed of springs, opening into gyres retaining the discharge in the NE pocket of the Lower Harbour and up to 2 km away from the Cork Main Channel to the SW.

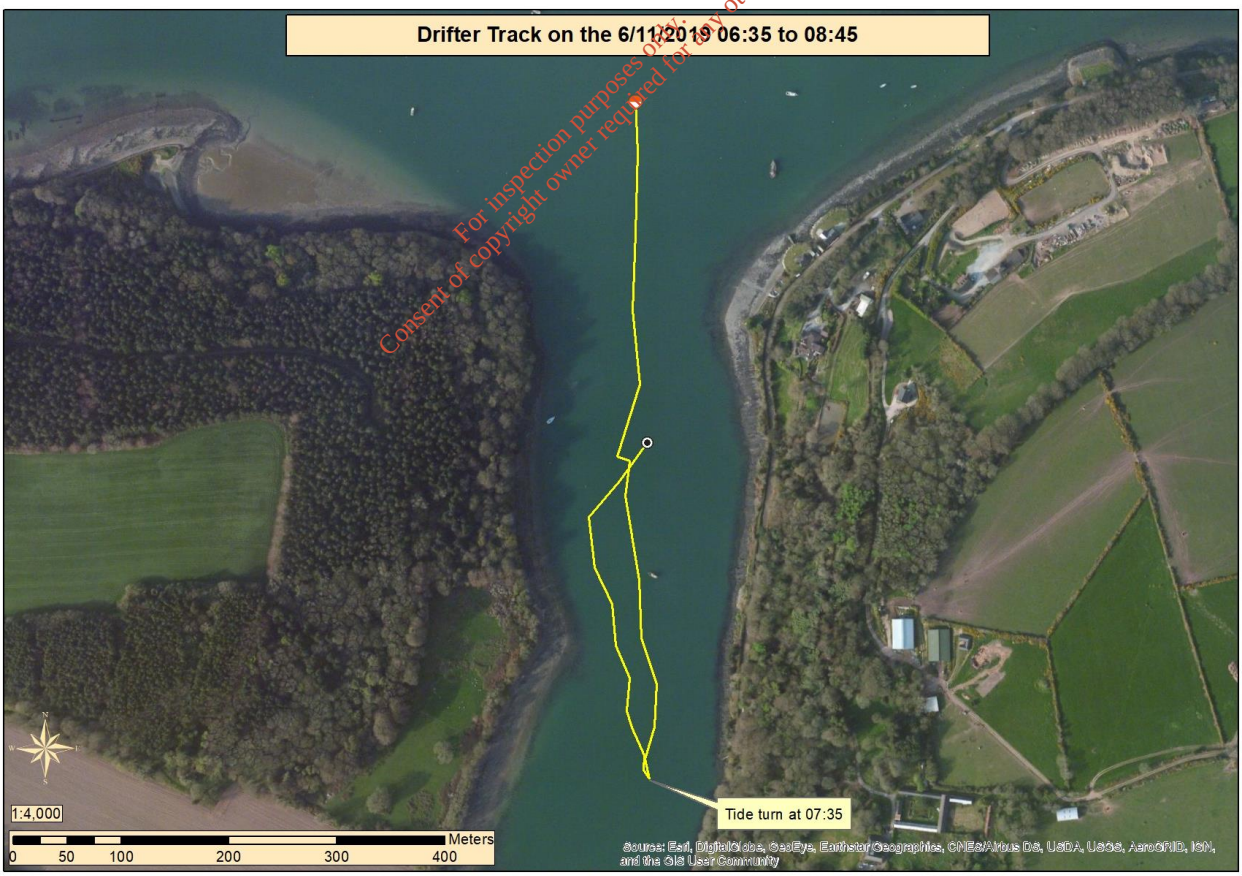
3. To test the reach into the North Channel from Rathcoursey Point on flood tides and see what evidence exists for any residual tide to the west.

3.1 Neap tide runs.

3.1.1 Neap tide on 06.11.19. Release at LW

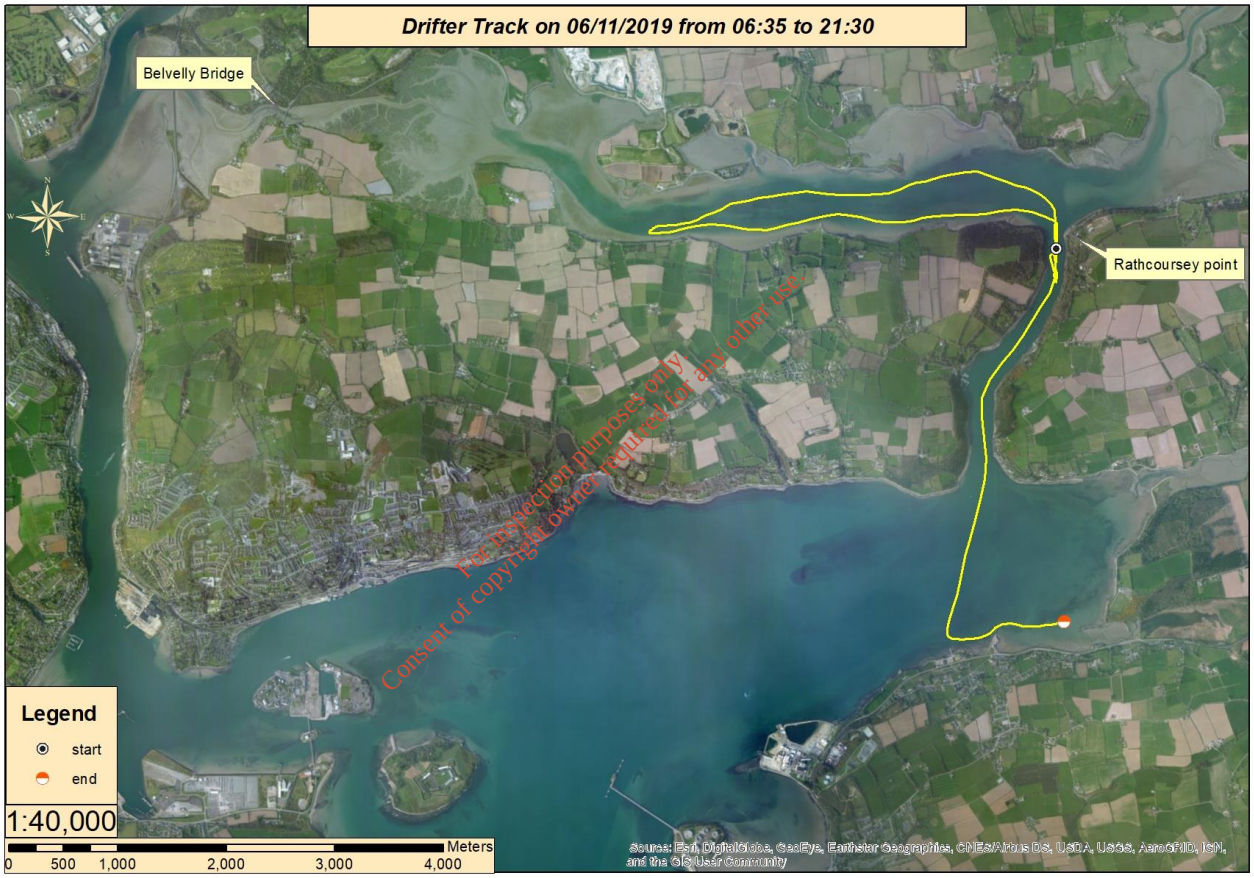
LW 06.34; HW 12.50; LW 19.17 (3.0m tide)

06.34 Release at R. Pt. at LW, with (surface) water still ebbing.
07.35 Start of (surface) flood tide (**66 mins after LW**) – see detail below:



08.20 back on top of the release point at the diffuser (**1hr 50 mins after Cobh LW**)
08.50 heading NNW and then north westerly
09.35 taking a course mid-way between spring flood tide tracks and level with Brown Island

10.14 Brown Island
11.33 Brick Island (**79 mins** to cross the beds on the flood)
12.40 hardly moving now.
13.15 tide has turned (25 mins after HW)
14.17 Brick Island
15.49 Brown Island (**92 mins**. to return over beds on the ebb)
16.55 at the top of East Ferry
18.10 exiting East Ferry (**75 mins** to come down the Ferry)
19.20 reached just west of Aghada pier (LW 19.17) and continued slowly due east to Rostellan along southern shore overnight.
22.30 beached south of GAA pitch at S end of Rostellan. Collected at 06.25 next morning.



Information acquired.

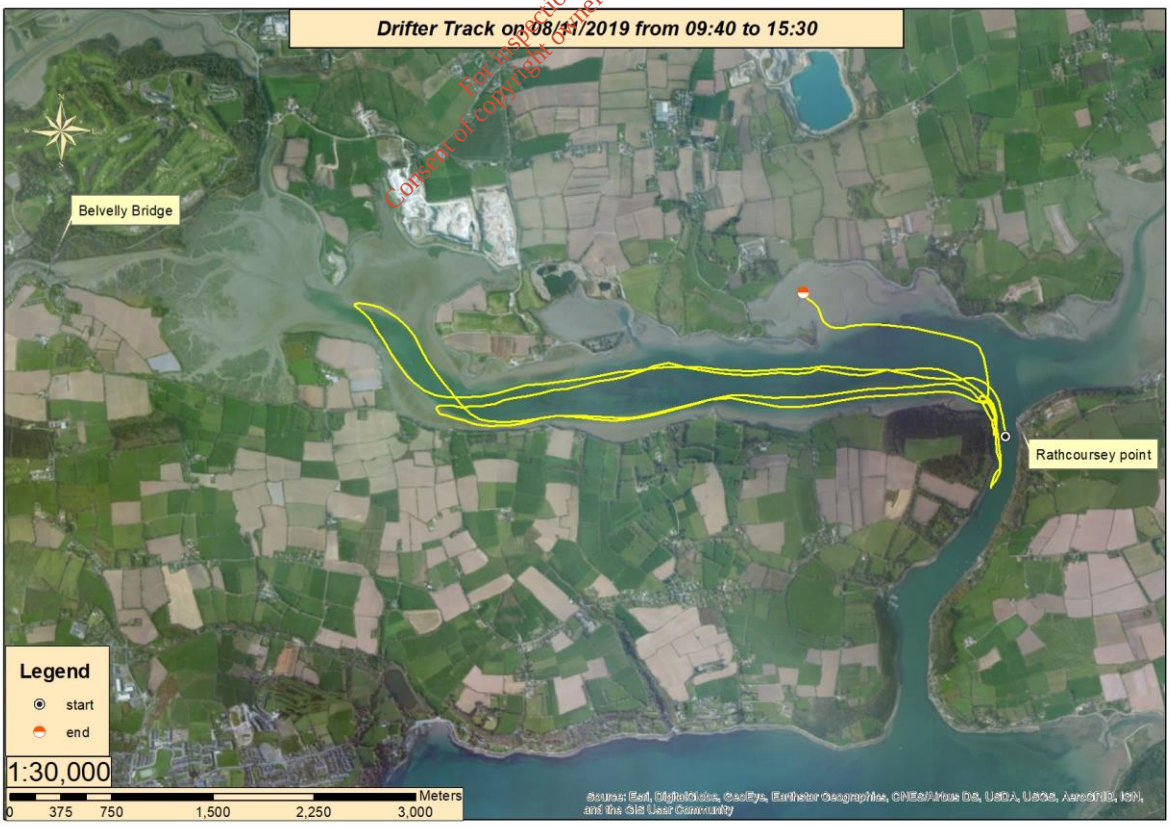
We hadn't realised that there was still a strong run of fresh water on the surface down East Ferry, which lasted for 66 minutes past Cobh LW and, by the time the drogue had returned to its initial release point at the top of the Ferry, it had lost 1hr 50mins after the planned LW release.

However, with this late release, if the discharge was made, as Dairygold plan, for all 6hrs of the ebb tide, this run tracked 100% contaminated water returning up East Ferry, with the MCOS-measured apportionment of 75% splitting to the North Channel, and 25% of it returning up the Owenacurra Estuary.

As can be seen, the water flowing up the North Channel covered all our oyster beds, though not yet those of Fota Oyster Farm, though as we will see, with the next two successive neap tide runs, that on the second tide of the pair, the drogue reached Brick Island with the potential to travel – and, indeed, did actually travel about some 900m further west, giving the proof we were searching for, of residual water movement up the North Channel to the west.

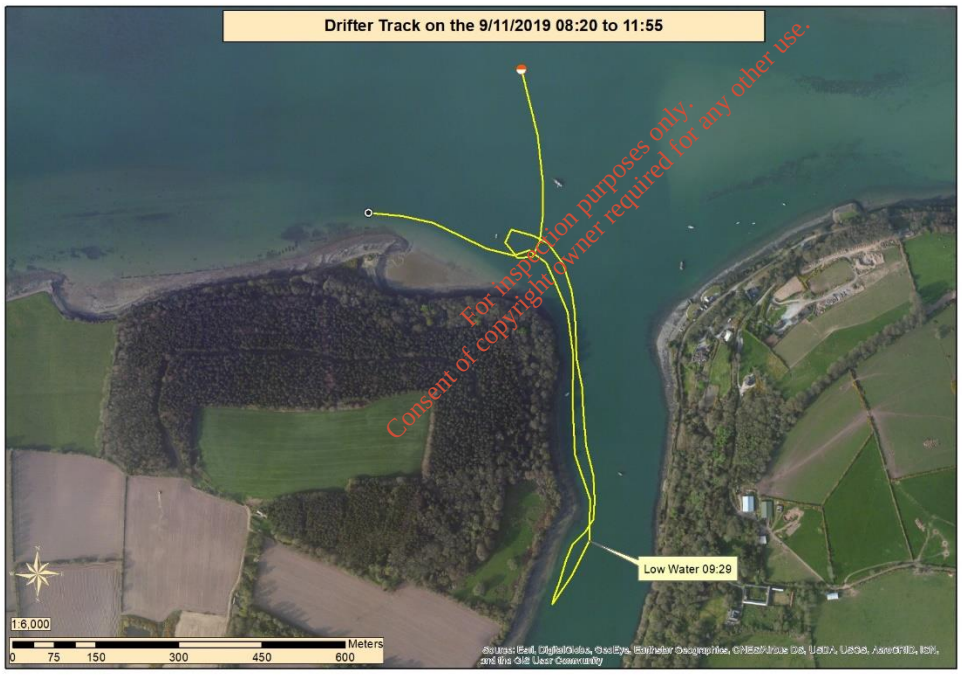
3.1.2 Neap tide run on 08.11.19 (continuing over to 09.11.19)
LW 08.43; HW 14.48; LW 21.11 (3.4m tide)
Release at <u>start of flood tide at HW+1hr</u>

09.53 Released on slow start of flood. Difficulty with the gyre and going slowly enough
12.03 Brown Island
13.26 Brick Island (**83 mins to cross beds on the flood** - same as on 06.11.19)
15.05 slowed - just beyond the pylon and over Fota Oyster's trestles. HW appears to have been about 17 mins later than predicted.
15.25 tide turned and drogue went to southern shore again - good progress
17.09 Brick Island
18.53 Brown Island (**104 minutes for the beds on the ebb**)
20.05 entering East Ferry very close to west shore
20.30 Followed shore a short distance (100m?) and now stopped and turning
21.00 bit of slow travel (NB LW not till 21.11hrs)
21.30 exiting Ferry back into N. Channel and taking an easy turn through gyre area, before it got going.



(continued on 09.11.19) LW 09.29; HW 15.30; LW 21.53 (3.6m tide)
00.03 Brown Island
01.13 Brick Island end of beds (**70 minutes to cover the beds on the flood tide)**
01.52 passing pylons
03.20 slowing right down close to tip of Weir Island
03.40 moving back eastwards
04.55 south of pylons moving close to southern side of N. Channel
05.34 Brick Island
07.17 Brown Island along southern shore (**103 minutes to cover beds on ebb tide**)
09.00 entering East Ferry and travelling slowly though, again, not very far perhaps some 300m
09.45 came to a stop and started returning to the North Channel (at LW+16 mins)
10.50 reached the top of East Ferry and curved NW
11.15 got sucked into the gyre and did a complete circle in 20 minutes (see fig. below)

Detail of LW (09.29hrs) portion of the drogue track.



Drogue forced close to west shore of Ferry by Owenacurra outflow from the east and getting into the early gyre off Bagwell's Hill.

11.35 came out of gyre
12.00 bending westwards
13.00 heading straight at Brown Island and very close, but took a sharp turn to the north and went up into Ahanesk Bay
14.20 ran into a stationary period (HW at 15.30)
16.30 picked up in Ahanesk Bay.

Information acquired.

A discharge at Rathcoursey, made at the start of the flood tide, covers the oyster beds and reaches very nearly as far as the spring flood tides – just short of Weir Island. Unfortunately the continuation run on 09.11.19 did not follow the usual run and ended up north of Brown Island.

However, times of passing Brown Island and Brick Island on both the flood and ebb tides are available for both days. HW in the middle of the day on 08.11.19 was 14.48hrs and in the middle of that night was 03.09hrs, i.e. 12hrs 21 minutes later. Thus allowing for this by adding 12hrs 21 minutes to the 08.11.19 times we can compare the times at which the drogue passed these marks and see if they were relatively earlier or later. What we find is:

3.1.2.1 Comparison of the times at which the drogue passed over the oyster beds on the succeeding NEAP tides of midday 08.11.19 and midnight 09.11.19

Date Times passing:	Flood tide		Ebb tide	
	Brown Is.	Brick Is.	Brick Is.	Brown Is.
08.11.19 : Times observed	12.03	13.26	17.09	18.53
Expected time next tide (add 12hrs 21 mins.)	`00.24	`01.47	`05.30	`07.14
09.11.19 : Times observed	`00.03	`01.03	`05.34	`07.17
Earlier than expected	**21mins.**	**44mins.**		
Later than expected			**4mins.**	**3mins.**

On these observations the same piece of water has reached Brick Island – the far west end of the oyster beds, 44 minutes earlier than would be expected for a perfect oscillation of the water. This means that the water has the time to be able to penetrate further to the west. Having gone further on the flood, it is a little later to pass Brown Island on the returning ebb.

If the average flood tide flows the length of the beds (c. 1,640m in 79 minutes = 0.346m/s) then in 44 minutes at Brick Island the flow would be about 900m further to the west and, it can be seen that this is what happened, with the drogue very nearly reaching Weir Island, more or less exactly that distance further up the estuary.

This would seem to be an observation of the residual tide to the west, which was to be expected from the considerably greater currents on the flooding tide than the ebb (c.60%), even though the ebb tide may last for about 10% longer (see the evidence of the ADCPs deployed at Brick Island and Rathcoursey Point later in sec. 4.)

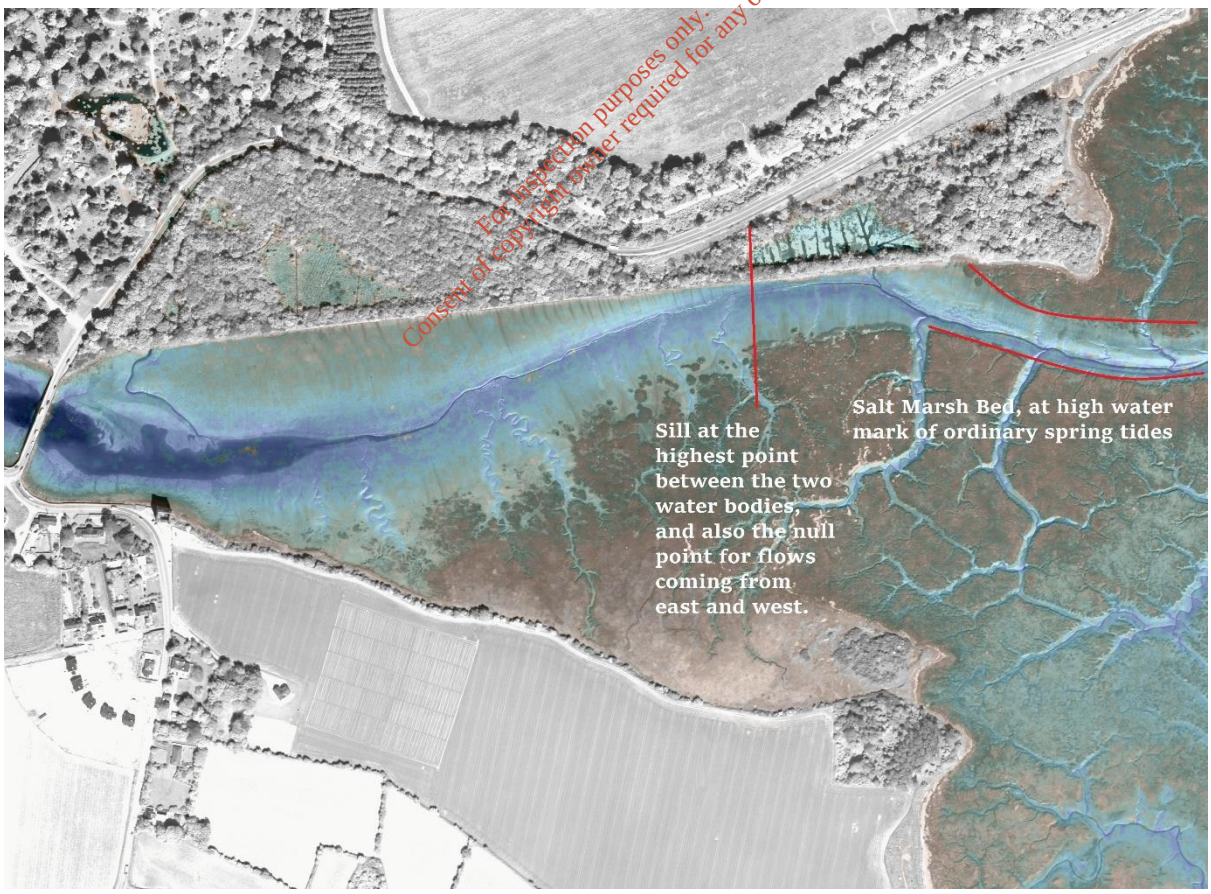
3.2 Spring tide runs (LW flood release at Rathcoursey Point)

3.2.1 Spring tide run on 12.11.19, continuing to 13.11.19

(LW 11.22; HW 17.14 (4.0m); LW 23.40 continuing to 13.11.19 (HW 05.31). **LW release at Rathcoursey Point.** Note: All times now in GMT

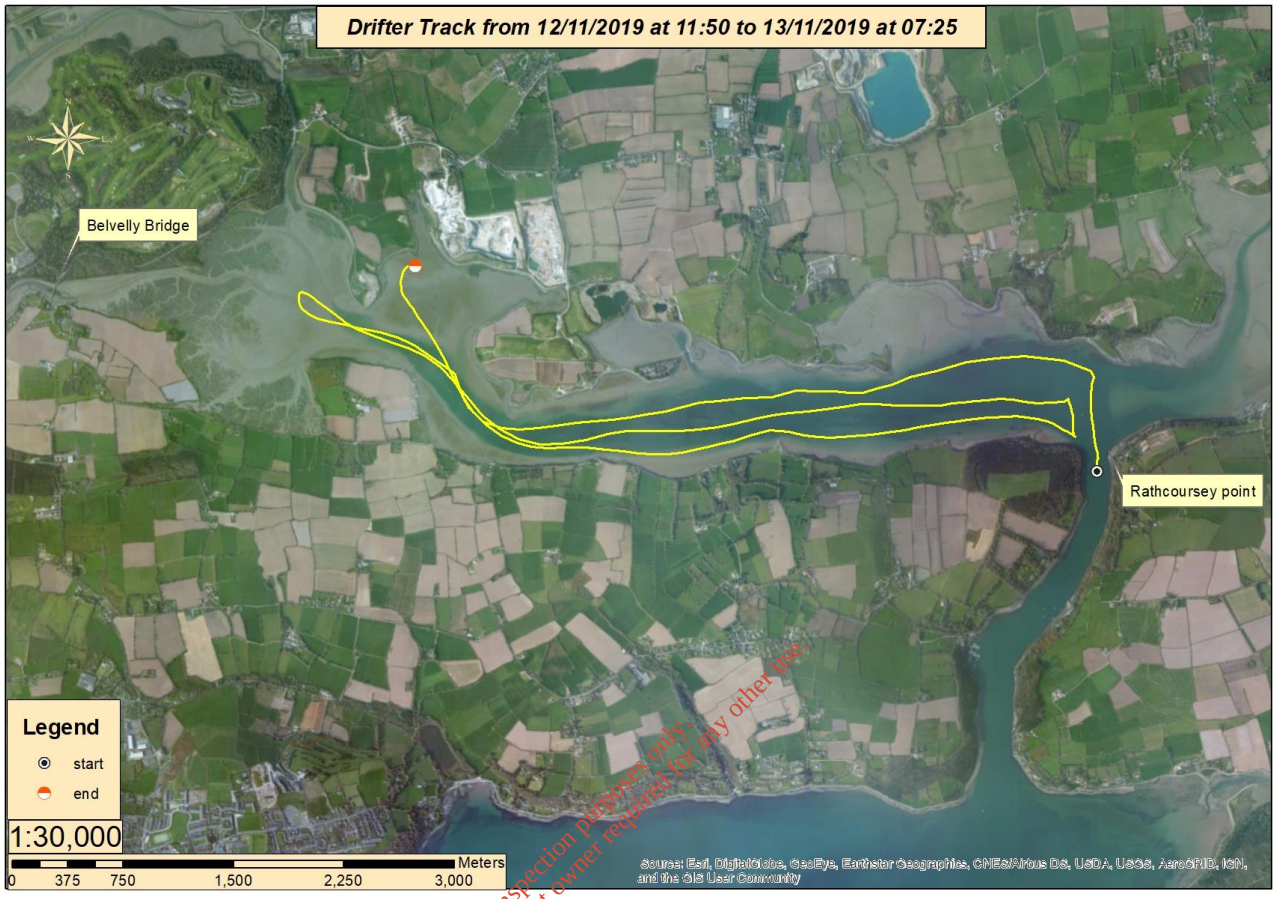
12.22 **Flood tide at surface commenced (LW+1hr)** and drogue travelled due N
13.40 turned westerly
14.11 Brown Island

15.15 Brick Island (**64 mins** to traverse beds on flood)
16.20 passed Fota Oyster Farm sheds
16.39 passed S tip of Weir Island
17.35 stopped moving west (HW 17.14)
18.15 started returning to east
20.12 Brick Island
21.18 Brown Island (**66 mins** over the beds on the ebb)
22.25 mid-channel and due N of west side of East Ferry
23.25 stopped just N of the top of the west side of East Ferry (LW 23.40)
23.30 and 23.45 already moving NW on the flood tide
(13.11.19)
00.45 drogue now moving west
01.52 crossing east end of beds following south side of beds for the first time - no loop up by Brown Island
03.23 Brick Island (**91 mins to traverse beds on the flood**) - on the south side of the North Channel
04.20 Fota Oyster Farm sheds
04.25 now flowing up <u>east</u> side of Weir Island
05.15 slowing down (LW 05.31). Stayed close to north end of Weir Island – drogue skirt caught on falling tide on the ***<u>Spartina</u>*** salt marsh (see satellite detail taken with Mars camera, below, of this salt marsh area to the west of Weir Island towards Belvelly):



08.25 Drogue picked up

Spring tide run on 12.11.19 to 13.11.19



Information acquired.

The drogue could hardly have travelled further west on each of these flood-tide runs – it would almost certainly have reached water shallower than its overall depth of 1.61m and have been prevented from going any further.

Comparing these 2 flood runs, despite a 30 minute slower run along the south side of the North Channel, the drogue was 10 minutes faster overall than the previous day to the passing of the Fota Oyster Farm sheds. It is possible that if the drogue had flowed on towards the Belvelly Channel, instead of to the east of Weir Island, and, indeed also found the narrow connecting channel through the Spartina grass meadow, it might have reached to the null point of the Lough Mahon/North Channel tides meeting, where the channel comes closest to the straight wall along the Fota Island shore – see the satellite photo at LW, above, showing this null-point where the two waters meet.

If we again look at the times the successive tides pass the ends of the oyster beds, as we did for the neap tides, we get:

3.2.1.1 Comparison of the times at which the drogue passed over the oyster beds on the succeeding SPRING tides of midday 12.11.19 and midnight 13.11.19

Date Times passing:	Flood tide		Ebb tide	
	Brown Is.	Brick Is.	Brick Is.	Brown Is.
	14.11	15.15	20.12	21.18
Expected time next tide (add 12hrs 21 mins.)	`02.32	`03.36		
13.11.19 : Times observed	`01.52	`03.23	na	na
Earlier than expected	**40 mins.**	**13 mins.**		
Later than expected				

If this section of water, marked by the drogue, is passing Brick Island relatively 13 minutes earlier than the preceding tide, then this might equate, as we estimated above for neap tides, but using an average of the two very varying times to traverse the beds on springs (a northern route of 64 minutes and a southern route of 91 minutes = 77.5 minutes for the 1,640m length) to a movement of the waterbody to the west over its position on the preceding tide of something like 13 x 60 x 0.35m/s = 273m.

Using the average of all the other spring tide flood runs (see the table below in sec. 4.1) with an average time over the beds of 66.5 minutes, the distance of the residual drift to the west becomes 13 x 60 x 0.41 m/s = 320m.

The data from both these pairs of successive tides supports what we believe to happen, that the greater current flow on the flood tide over the ebb tide, leads to a shift of the water body in the North Channel to the west on each successive tide.

We have suggested that Irish Hydrodata, with the figures for the entire neap/spring cycle in 1993, advise us what the situation is with their computer, rather than us saying that with the current speed on the flood appearing to be some 60% greater on the flood than on the ebb, and, from our observations above, that the ebb tide lasts no more than about 10% longer than the flood, there must be a residual water movement to the west via Belvelly and thus discharges from Rathcoursey are moving overall into the North Channel, rather than taking the more obvious route via Marloag to the Lower Harbour and to the open sea at Roches Point.

BIM suggested that we could obtain these figures now for ourselves, with the loan of their two ADCP current meters and we deployed one at Brick Island and one at the top of East Ferry, as Irish Hydrodata did in 1993 for two full neap/spring cycles from mid-October to mid-November 2019.

3.3 Evidence of the 1993 current meter records from the North Channel. Midleton WWTP EIS Technical Appendices. 1996. Hydrographic Survey Report by Irish Hydrodata (November 1993)

I have found, at last, a copy of Fig. 2.2a, which appears not to have been included in all the copies of the Midleton WWTP EIS supplied to me in 1993 and I reproduce it here:

3.3.1 Current speeds and directions at Brick Island. Midleton WWTP 1993. EIS 1996

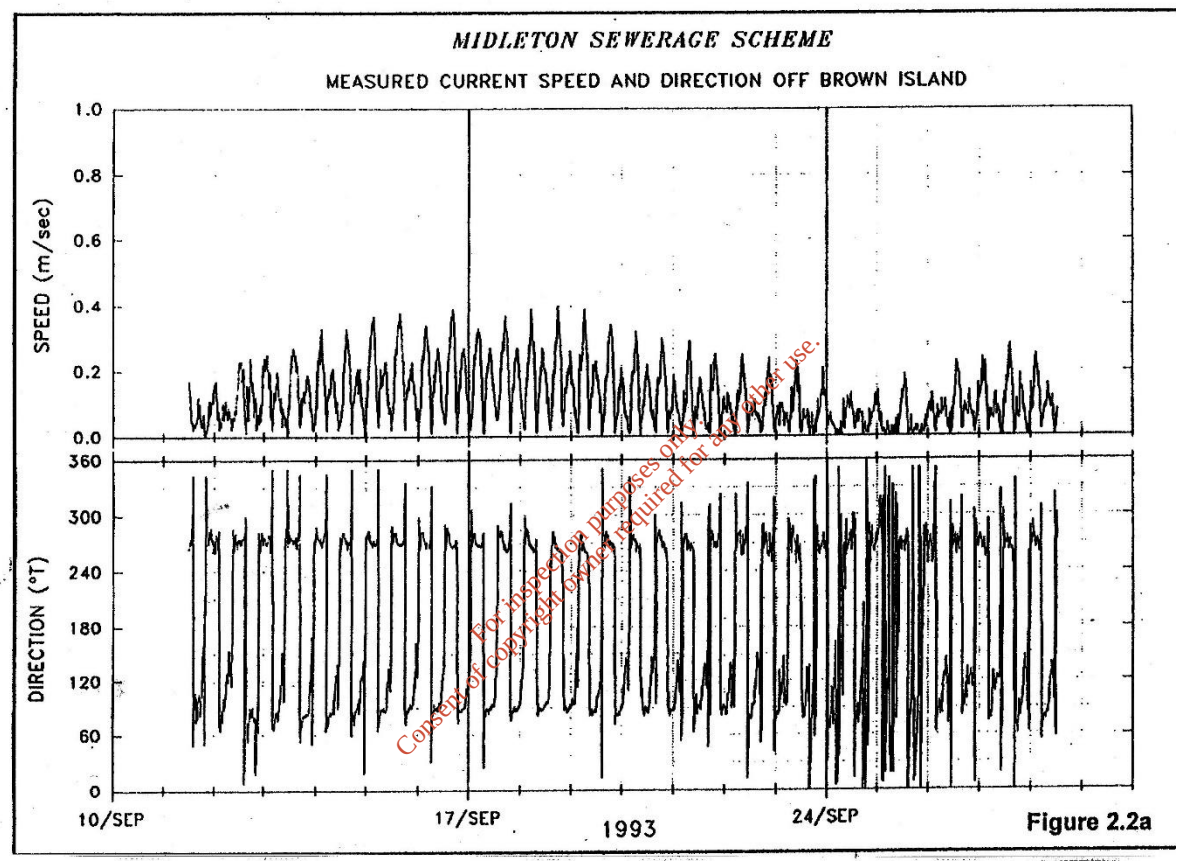


Figure 2.2a

As with the O'Kane presentation of the same current speed data in 3 pages of 4 day figures, which I included on pp. 44-46 of my first submission, it is necessary to correlate the current direction of the lower figure so that the flood tide is shown flowing due west at 270° and the ebb due east at 90°. It can be seen that the spikes of the flood tide are consistently hugely greater than the ebb on both springs and neaps.

The position of the current meter is shown as the westerly star close to Brick Island in Fig. 2.1, below, and is thus NOT "*Off Brown Island*" as stated in the heading. This is important as there may be something of a gyre at Brown Island creating the deep hole there of 10m at LW, whereas water should be flowing due east/west at the Brick Island site and give the truest picture of the flows up and down the North Channel. The other star marks the Bagwell's Hill gyre, which we have seen in the drogue study, develops as the flood tide increases in strength.

3.3.2 EIS Fig. 2.1, Position of the current meter close to the east end of Brick Island. This figure precedes the above current speed and direction data in the EIS. The position of the second meter in the Bagwell's Hill gyre is shown close to the top of East Ferry.

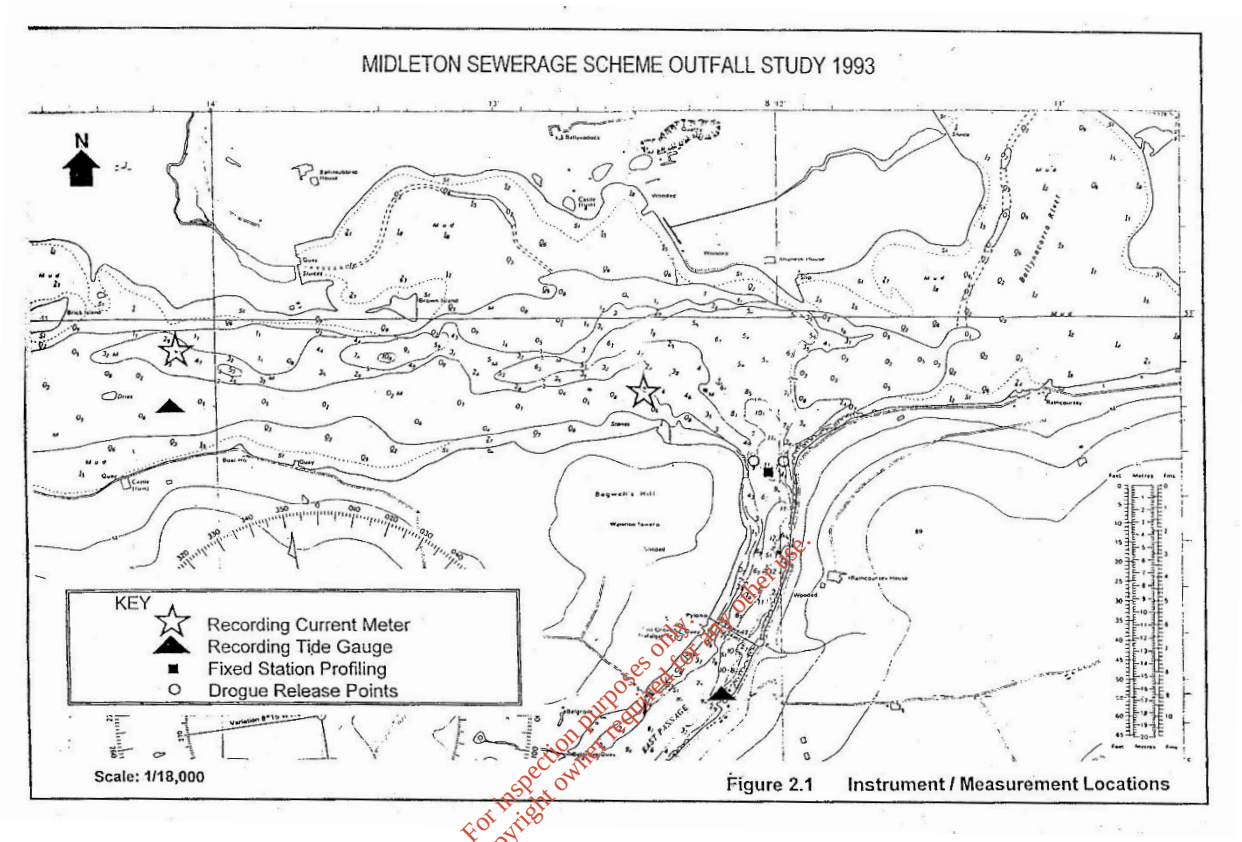


Figure 2.1 Instrument / Measurement Locations

Firstly, with the vagaries of individual tides, caused by winds and atmospheric pressure, we would prefer to look at the full spring and neap cycles as a whole to confirm the extent of these westward water movements.

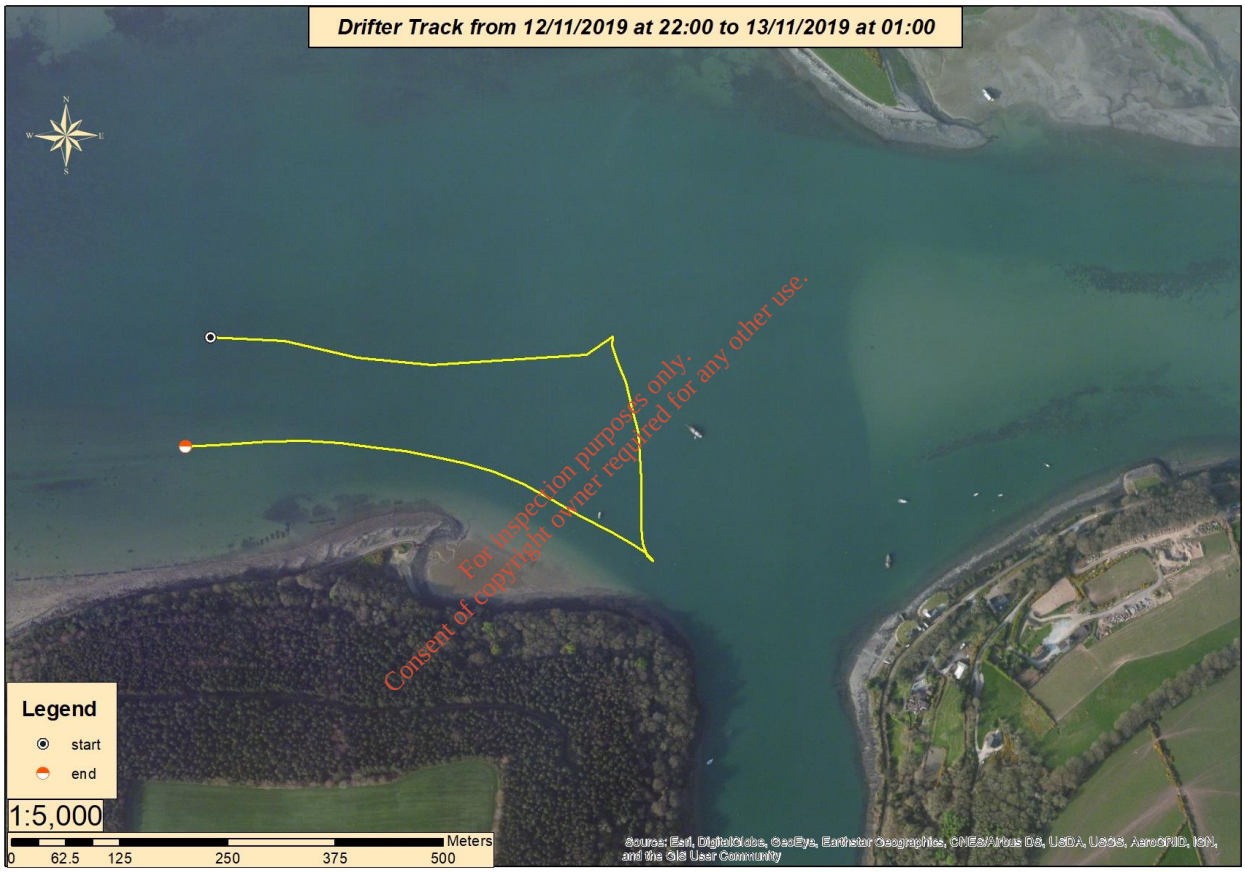
As stated already, we deployed 2 current meters (ADCPs) with BIM, leaving them down for 2 complete tidal cycles over a whole month, but unfortunately the setting of the timing intervals was in error and we only obtained two days of very precise 10 second-interval data, but from which we can glean a few useful facts, which I add below in sec.4. We hope to repeat the exercise as soon as we can in the New Year, so that we can come up with a definitive estimate of this residual water flow to the west up the North Channel from the Rathcoursey discharge.

Secondly, we should note also that it is abundantly clear that no water is coming in from Lough Mahon, or the drogues would not have got so far up the LW rivulets through the Spartina grass meadows at the far west and shallow end of the North Channel – indeed, as stated already, it is very probable that the drogue got caught in the grass to the side of the narrow channel, which shows on the satellite map, as the total depth of the drogue, at 1.61m, is considerable in these very shallow headwaters.

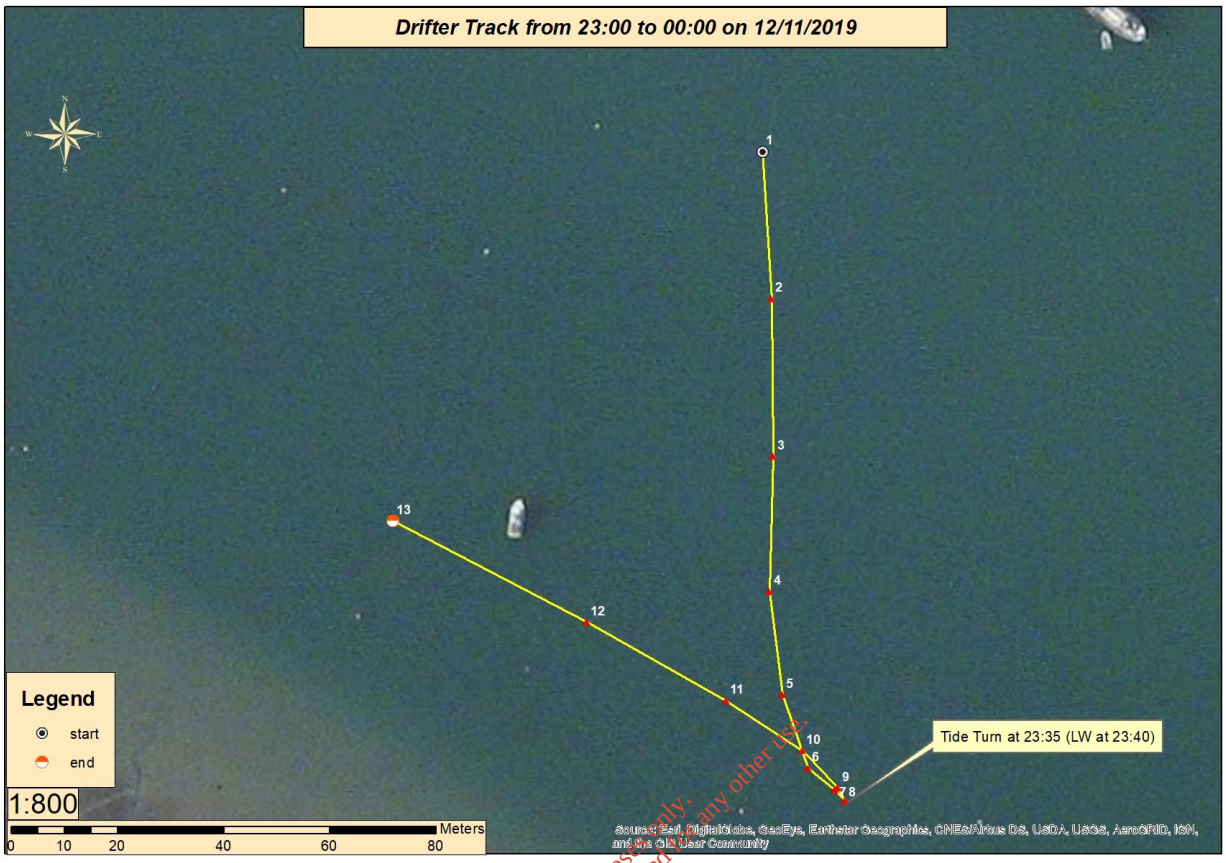
I have mentioned in earlier submissions that 27 temperature/salinity tows in the channel were also made on the far side of the *Spartina* grass to the west, for the NUIG Alexandrium bloom work, and this found that there was a null point where the North Channel and Lough Mahon waters met, down the straight Fota wall, which shows up quite clearly on the satellite map – and the position of this meeting point didn't vary on all these occasions by more than 17m.

Thirdly, we learn a great deal from the behaviour of the drogue at LW as it returns to the top of East Ferry. This is shown in the two detailed screenshots of:

12.11.19 22.00hrs to 13.11.19 01.00hrs (i.e. covering 3hrs around LW)



and, in greater detail **in 12.11.19 22.00hrs to 24.00hrs (i.e. covering just 1hr around LW),** below:



In the first of these two snapshots, we see the drogue meeting the outgoing flow from the Ballinacurra River (possibly swollen by the heavy November rainfall), which held the drogue back and even turned it northwards for a few minutes.

I have seen these two water bodies meeting at this point when they have had different coloured water, when the Owenacurra was in spate and thick with mud, meeting blue-grey water of the North Channel, which showed up their junction clearly and allowed us to observe and report what we saw to the Department of the Marine. I attach my report of this observation on 21.11.02 in the Appendix in s.8.

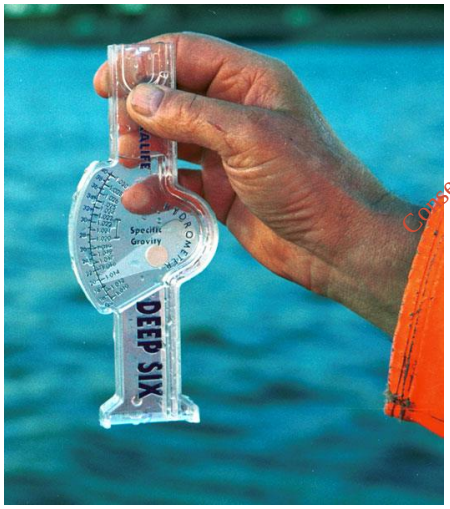
On this day the brown flow from the Owenacurra made a large semi-circle, right across the estuary, quite some way west of the line taken by the drogue here, even to the extent of throwing up a 6" wavelet where the two water bodies met. The brown water could be seen following the East Channel across the Lower Harbour at LW. The East Ferry, of course, was brown with the same water.

On the flood tide, we followed the body of brown water back from the top of East Ferry to the far west end of the oyster beds and managed to take this picture of the front as it approached Brick Island in a little under 2 hours:

Brown water front stretching right across the estuary at 14.03hrs (LW 12.13 4.0m tide)

I also recorded the salinity on each side of the front.

This shows up neatly the discrete nature of the different water bodies – in this case one contaminated visually by mud, as well as in specific gravity, but only behaving in exactly the same way as any discharges of urban waste from Midleton domestic overflows and the permitted diurnal discharge from the Rathcoursey outfall – driving into the residual water, left behind in the North Channel at the end of the previous ebb and forcing it back up the estuary towards Belvelly.



Low salinity spate water **Higher salinity North Channel water**

As seen in s.2.1.4, above, we have found in this drogue work, when releasing the drogue at LW on both neap and spring tides, the flood tide at the centre of East Ferry does not turn until a full hour after LW. This would seem to be the freshwater flow on the surface from the Owenacurra beating the weak current on the first hour of the flooding tide.

On this occasion, as the drogue was re-entering the top of East Ferry, it was held to the west of the East Ferry ebb, by the force of the flow from the Owenacurra side and it is illuminating

that, as can be seen in the detail of the turn in its direction of flow, it started to move back to the NW within 5 minutes of LW on the underlying flood tide.

This observation is important as it shows that the underlying water was indeed flooding according to the Cobh tide table, whilst the fresh water of the Owenacurra, which would have been on the surface, continued to beat the early overall flood, at least at drogue skirt depth, which is designed to track currents at 1m (Pacificgyre Microstar specification). This is shown up to a lesser extent in the 2 days of current meter data which we show below.

The other thing to note is that before the Bagwell's Hill gyre, off the NE corner of Great Island, can build up as the flood current increases in force, the drogue is not driven to the north side of the North Channel into Ahanesk Bay before turning to the west down the Channel, but can cut straight across the gyre area and follow a path along the southern shore.

From the first paragraph, above, it would seem that this first flow of water on the flood tide, reaches the west end of the North Channel some 30 minutes earlier than water looping up to the northern side around the gyre, where the greater volume and speed of the mid-tide current has cut the deep channel, though its speed across the actual beds is slower.

..

4. Analysis of measurements made from this work

4.1 Information from the drogue runs

4.1.1 Data on the time taken for the drogue to traverse the oyster beds and the length of East Ferry.

(Times in BST and GMT as for Tide Tables)

Date	Release time/place	Height of tide	Flood tide over the oyster beds			Ebb tide over the oyster beds			East Ferry		Timing of surface flood in minutes after LW at:	
			Start	Finish	Time taken (minutes)	Start	Finish	Time taken (minutes)	Time down (minutes)	Time up (minutes)	Top of E. Ferry	Lower Harbour
14.10.19	HW+2hrs at R.Pt.	4.1m	16.47	17.56	**69**	19.37	20.50 p.m.	**73**	60	48	c. 65	10
15.10.19	continuing run	4.1m	04.22 a.m.	05.22 a.m.	**60**							
15.10.19	HW+2hrs at R.Pt.	4.1m	(Drogue went past Whitegate jetty, but stopped short of Cork Main Channel.						35			10
			On return, drifted N. of the East Channel and by LW+ 4hrs 26min (i.e. fastest									
			tide) had slowed to negligible progress. Taken to mouth of E. Ferry							30		
16.10.19	HW+3½hrs at R.Pt.	4.1m	18.05	19.14	**69**				43	35		
21.10.19	HW+3½hrs at R.Pt.	3.4m	(Drogue went no further west than Long Point, but failed to return up E. Ferry)						80			5
22.10.19	HW+½hr at R.Pt.	3.3m	(Drogue went no further west than Long Point, but failed to return up E. Ferry)						85			in Marloag gyre
06.11.19	LW at R.Pt.	3.0m	10.14	11.33	**79**	14.17	15.49	**92**	75		66	5
08.11.19	LW+1hr	3.4m	12.03	13.26	**83**	17.09	18.53	**104**			60	not in L Harbour
09.11.19	continuing run	3.6m	00.03 a.m.	01.13am	**70**	05.34 a.m.	07.17 a.m.	**103**				not in L Harbour
12.11.19	LW +1hr	4.0m	14.11	15.15	**64**	20.12	21.18	**66**				not in L Harbour
13.11.19	continuing run	4.0m	01.52 a.m.	03.23 a.m.	91*	(Drogue stuck east of Wer Is.)					5*	not in L Harbour

* this flood run was made immediately after the turn of the tide, rather than c. 1 hour later on the stronger current of all other runs.

* flood started immediately as the drogue was to the west of the Owenacurra flow down East Ferry.

The spring tide flood run along the south side of the channel on 13.11.19 was quite slow across the beds, although, overall it arrived at the west end faster, as it did not loop up to Ahanesk Bay. However I excluded this time in the average speeds across the oyster beds calculated below.

4.1.2 Summaries of the observed times taken for the water to traverse the oyster beds from the above table, together with times to travel up and down East Ferry.

Average differences on spring and neap tides:

	Time to traverse oyster beds (Brick to Brown Is.)			Time to travel the length of East Ferry		
	Flood tides (minutes)	Ebb tides (minutes)	Difference %	Time down (minutes)	Time up (minutes)	Difference %
Spring tides	65.5	69.5	6.00%	46	37.7	22%
Neap tides	77.3	99.7	29%	80	n/a	

This seems to show clearly enough that the flood tide current flows faster than the ebb and this seems to be more pronounced on the neap tides where there is a difference of 29%, but we will get more accuracy by consideration of the full neap/spring tidal cycle.

As would be expected, the spring tide currents flow faster than the neaps and there appears to be a considerable difference in the time taken for a discharge from Rathcoursey to reach the Lower Harbour, with this passage on neap tides taking 74% longer. This is important as it reduces the benefit of utilizing the best part of the ebb currents at mid-tide to get the discharge as far away as possible.

4.2 Information from the Current meters (ADCPs) deployed at Rathcoursey Point and Brick Island 14-15th October 2019.

It was the greatest pity that these two meters were set incorrectly, so that they ran out of power in just two days, as we were lucky enough to have been allowed to deploy them for no less than two full spring/neap tide cycles over a month

The depth of water at Rathcoursey was also underestimated, so that the ADCP only measured up to about half the depth from the bottom (up to 6.357m).

BIM have offered to make these ADCPs available to us again for a full tidal cycle in the New Year, but, in the meantime, we can make some useful assessments of the information that was obtained.

Rathcoursey Point (in 10m water at LW)

Date	Direction of flow changing from:	HW or LW	Slack water taken as a current of <0.06m/s					
			Length of slack water	Meter on bottom	Cobh Tide Table		Length of flow	
					Time	Ht. of tide	Flood	Ebb
14.10.19	N to S	HW	20 mins	6.50 pm	18.44	4.1m		6hrs 20m
15.10.19	S to N	LW	40 mins	1.10 am	`01.10	0.5m	5hrs 50m	
"	N to S	HW	10 mins	7.00 am	`06.59	4.1		6hrs 30m
"	S to N	LW	5 mins	1.30 pm	13.24	0.4		
Average time of slack water:		HW	15 mins			av:	350min	385min
		LW	23 mins					

and at:

Brick Island (in c. 1.5m water at LW)

Date	Direction of flow changing from:	HW or LW	Length of slack water (mins)	Slack water taken as a current of <0.06m/s				
				Meter on bottom	Cobh Tide Table		Length of flow	
					Time	Ht. of tide	Flood	**Ebb
14.10.19	E to W	LW	5 mins	*12.20 pm*	*12.52*	0.5m	6hrs 40m	
"	W to E	HW	40 mins	7.00 pm	18.44	4.1m		6hrs 30m
15.10.19	E to W	LW	120 mins	*2.20 am*	`01.10	0.5m	5hrs 50m	
"	W to E	HW	20 mins	7.20 am	`06.59	4.1		5hrs 40m
	E to W	LW	30 mins	*13.00 pm*	13.24	0.4	6hrs 20m	
"	W to E	HW	20 mins	7.20 pm	19.15	4.1m		
Average time of slack water:		HW	30 mins					** see below
	*	LW	50 mins					

* These figures are difficult to gauge and far too liitle data, but they might show that periods of slack water are greater at Brick Island than at Rathcoursey Point.

** The LW change at Brick Island of tide was not clear and directions of flow were very variable (water depth 1.5m?) The HW changes of tide appeared to match the Cobh tide times very closely

From these observations we see that:

4.2.1. Tide times

The tides in the East Ferry and North Channel appear to follow closely those predicted for Cobh.

4.2.2 The length of slack water

We see that there appeared to be twice as long a slack water period at both HW and LW at Brick Island compared to the change of tide at the top of East Ferry, which, at depth especially, follows the Cobh tide times closely.

The length of the HW slack water at Brick Island was 30 minutes and at LW was 50 minutes, though it was not as clear-cut as at Rathcoursey. This may have been because the LW depth at Brick Island was only 1.5-2.0m and flows may have been disturbed by the nearby channel to the lagoon behind Brick Island.

4.2.3 The lengths of the flood v ebb tides

This was easiest to see from a sharp change in direction from N to S at Rathcoursey, where the flood tide appeared to last for 350 minutes compared to the ebb for 385 minutes.

This difference of an about 10% longer ebb tide, fits with my earlier estimate from the graphs of the 12 days of current data presented in the O'Kane Hydrodynamic Survey of Norovirus in the North Channel.

4.2.4 Evidence of freshwater ebb flow persisting down the East Ferry after Low Water (01.10hrs and height 0.4m on this day)

	Slack water current speed of less than 0.06m/s
	South flowing ebb water
	North flowing flood water (345° to 10°)

Height above the bottom

	Bottom		0.8m		1.4m		1.9m		2.4 m		2.9 m		3.4 m		3.9 m		4.4 m		5.9 m		6.4 m	
Date	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction	Speed m/s	Direction
10/15/2019 12:40:00 AM	0.08	164.65	0.10	158.53	0.12	152.81	0.16	147.49	0.15	146.72	0.15	152.36	0.17	151.42	0.17	148.06	0.18	157.24	0.16	162.85	0.15	175.63
10/15/2019 12:50:00 AM	0.03	163.36	0.01	211.53	0.03	175.96	0.08	165.76	0.13	139.02	0.15	142.57	0.09	143.85	0.19	144.18	0.20	159.49	0.21	167.63	0.20	170.77
10/15/2019 1:00:00 AM	0.01	82.62	0.03	101.42	0.07	138.93	0.07	134.52	0.10	132.49	0.12	138.67	0.13	143.38	0.16	147.72	0.16	158.71	0.17	163.61	0.17	165.71
10/15/2019 1:10:00 AM	0.01	54.08	0.01	287.69	0.02	143.73	0.02	138.93	0.02	113.22	0.04	133.34	0.03	135.05	0.04	139.16	0.05	140.89	0.06	138.79	0.06	149.90
10/15/2019 1:20:00 AM	0.06	9.30	0.04	319.63	0.04	336.12	0.06	353.72	0.06	11.51	0.04	1.94	0.01	62.71	0.02	43.33	0.01	47.38	0.04	72.36	0.03	66.71
10/15/2019 1:30:00 AM	0.13	346.46	0.15	334.65	0.13	334.71	0.14	336.97	0.11	334.31	0.09	322.69	0.08	326.20	0.05	356.98	0.03	24.08	0.02	89.21	0.03	78.22
10/15/2019 1:40:00 AM	0.13	5.67	0.16	4.20	0.14	5.23	0.14	359.72	0.14	353.93	0.12	343.97	0.12	337.77	0.09	331.28	0.07	343.41	0.07	0.15	0.01	19.26
10/15/2019 1:50:00 AM	0.14	1.93	0.16	3.40	0.18	5.42	0.16	12.18	0.17	8.94	0.16	18.95	0.13	356.05	0.11	334.65	0.09	332.57	0.08	346.23	0.08	352.29
10/15/2019 2:00:00 AM	0.16	2.68	0.18	357.14	0.18	2.34	0.19	2.39	0.19	1.09	0.19	3.59	0.19	5.40	0.19	2.25	0.16	352.26	0.13	342.87	0.14	343.35
10/15/2019 2:10:00 AM	0.23	6.80	0.25	1.58	0.26	3.30	0.28	0.33	0.28	0.91	0.29	353.69	0.28	354.20	0.29	357.89	0.28	354.43	0.28	358.99	0.29	3.90
10/15/2019 2:20:00 AM	0.27	356.85	0.31	356.14	0.34	357.19	0.36	356.33	0.37	354.75	0.38	351.17	0.38	350.90	0.36	351.36	0.36	351.73	0.36	352.20	0.36	354.86
10/15/2019 2:30:00 AM	0.32	346.12	0.34	345.78	0.38	346.49	0.39	348.22	0.42	348.40	0.44	352.27	0.46	355.60	0.49	355.91	0.49	358.71	0.49	357.21	0.44	353.82
10/15/2019 2:40:00 AM	0.38	346.00	0.41	348.90	0.45	349.90	0.48	350.97	0.50	351.98	0.52	356.30	0.55	358.31	0.59	357.95	0.61	358.97	0.60	358.84	0.57	356.27
10/15/2019 2:50:00 AM	0.42	347.94	0.44	348.39	0.47	351.60	0.54	354.05	0.55	352.18	0.59	353.86	0.61	353.13	0.63	355.41	0.62	356.27	0.65	358.19	0.69	359.03

The data here seems to show that the flood tide up East Ferry is close to that predicted in the Cobh tide tables, causing slack water on the bottom to occur at, or soon after, the predicted time of 01.10 hrs, with the first change in flow from S to N occurring at 01.20hrs, whilst, at 6m up, the change in direction of the current does not change till 01.50hrs, some 30 minutes later. We noted that the drogue at the surface was still flowing south for 60+ minutes after Cobh LW and resumably the more fresh water there is coming down the Owenacurra River, the longer the surface ebb will continue.

One can also see the effect of the flood tide being felt at the bottom at the top of East Ferry at Cobh LW, with the water above it still ebbing with the current speed increasing faster towards the mid-water depth we could measure on this occasion. This will presumably rise even further than this mid-depth speed recorded here, as the fresher water of the bulk of the flow from the Owenacurra River on the surface is reached:

Rathcoursey data

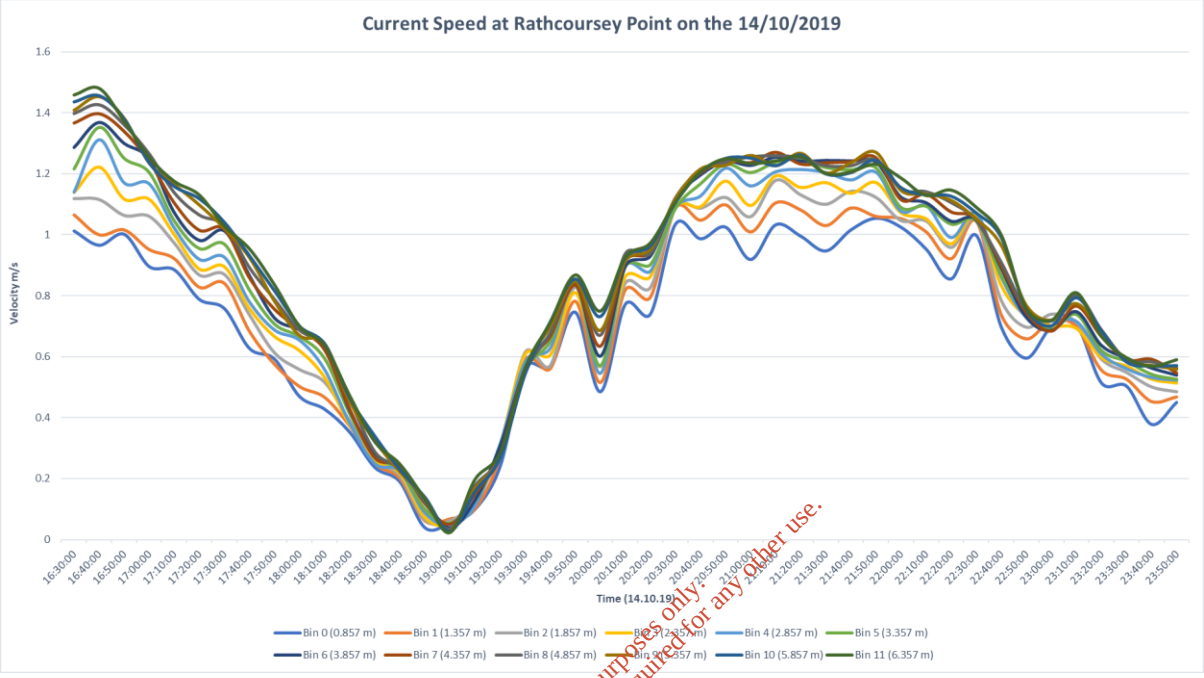
	HW	Cobh	Bottom		1.4m up from bottom		2. 4m up from bottom		3.4m up from bottom		4.4m up from bottom		5.4m up from bottom		6.4m from bottom	
DateTime	**LW**	**Tides**	**speed m/s**	**Direction °N**	**speed m/s**	**Direction °N**	**speed m/s**	**Direction °N**	**speed m/s**	**Direction °N**	**speed m/s**	**Direction °N**	**speed m/s**	**Direction °N**	**speed m/s**	**Direction °N**
10/15/2019 1:30:00 PM	LW	13.24	0.061	171.732	0.073	191.029	0.107	161.770	0.123	147.773	0.168	141.727	0.188	178.189	0.198	176.711
Current speed line increasing with height from bottom:					**20%**		**75%**		**102%**		**175%**		**208%**		**225%**	

1

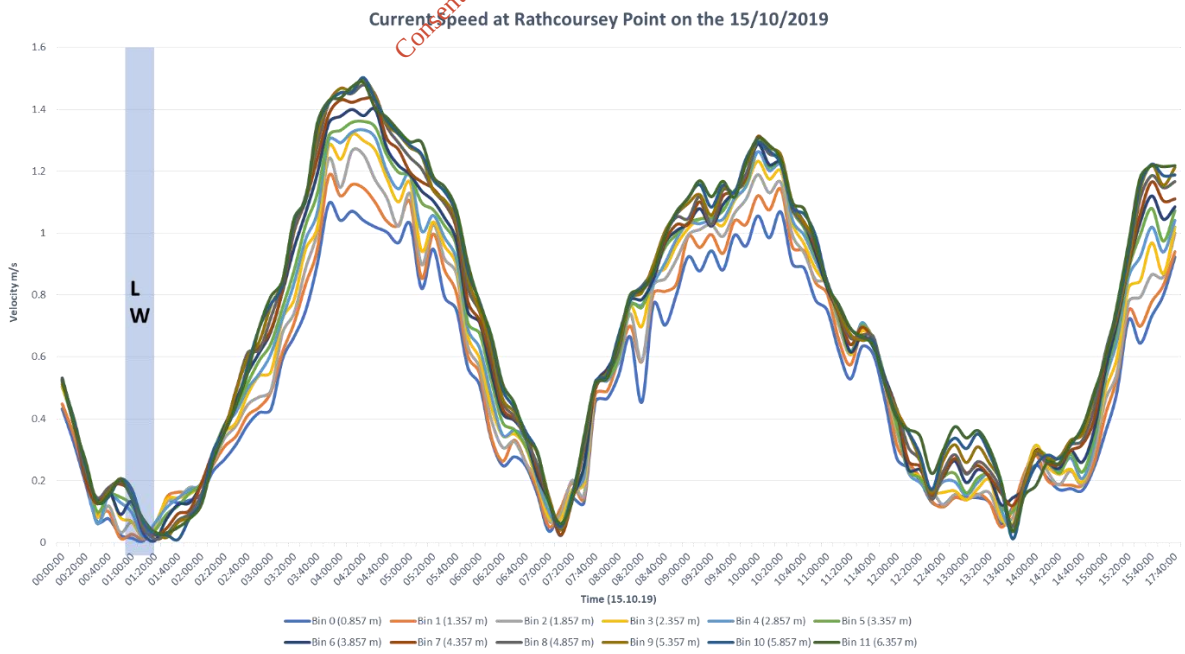
4.3 BIM analysis of the current meter data.

I am indebted to BIM for very kindly presenting the limited data that was obtained:

Rathcoursey Current Speeds measured at the top of East Ferry

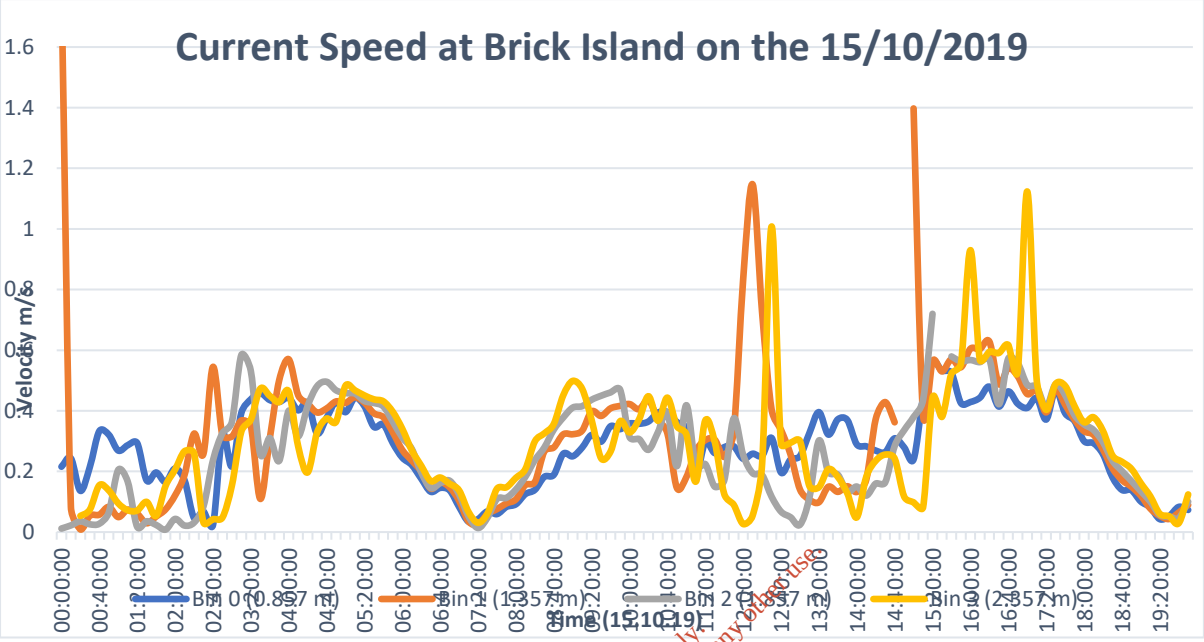


The flood current speed at Rathcoursey on the left, rising to Cobh HW at 18.44 (here at 19.00) is faster than the following ebb.

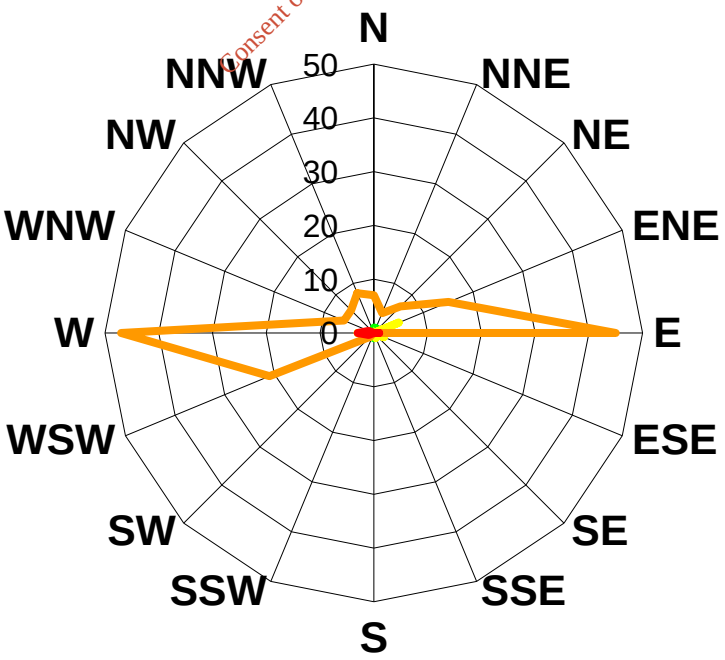


Again, the flood current after Cobh LW at 01.10 is flowing faster than the next ebb tide.

At Brick Island, there seems to be more noise in the record, possibly because the meter was in a much shallower channel, but the flood tide peaks are marginally higher than the ebb peak in the centre of the figure below, with Cobh LW at 01.10 and 13.24.



The Current Rose for Brick Island shows the more or less due east/west flow up and down the North Channel at speeds of between 0.1 and 0.5 m/s (vide my calculations above of the observed speed of the drogue at about 0.35m/s across the oyster beds).



5. Postscript on PSP

Seafood Poisoning. Vernon Ansdell in *Travel Medecine* (Fourth Edition), Elsevier 2019

I quote the following exerpts:

"*PSP is the most common and most serious form of shellfish poisoning and occurs after eating contaminated bivalve molluscs (clams, cockles, mussels, oysters, and scallops), crustaceans containing saxitoxin, and other potent neurotoxins produced by dinoflagellates (e.g. Alexandrium sp.).*

Saxitoxin, like CTX and tetrodotoxin, causes paralysis by blocking sodium channels in nerve cell membranes. It is 50 times more potent than curare. Saxitoxin and other toxins that cause PSP are heat stable and are not destroyed by normal cooking procedures, marinating, or freezing. Flaccid paralysis occurs in the most severe cases, with respiratory insufficiency as a result of paralysis of the diaphragm and chest wall muscles.

Deaths are typically caused by respiratory failure and tend to occur within 12 hours of eating toxic shellfish. For patients who survive past 12 hours, the prognosis is good. Recovery usually occurs within a week but may occasionally be prolonged for several weeks.

Case fatality rate averages 6% but may be as high as 44%. Mortality is higher in children, who seem to be particularly sensitive to the effects of the toxin.

There are no antidotes for PSP".

6. Resumé of recently acquired information on water movements.

1. The waters of East Ferry and the North Channel follow closely the predicted tide times for Cobh.

2. Whilst the flood tide reaches the top of East Ferry as the tide turns, the outgoing flow continues for up to an hour at the surface and 30 minutes at half-depth.

3. There is evidence from the drogue runs that this continuing outgoing flow is fuelled by water coming down from the Owenacurra Estuary from the east, which can actually hold back the North Channel surface water.

4. Water re-entering the south end of East Ferry (s.2.1.1) will flow over all the oyster beds and up to Fota Oyster Farm to the west on one tide – neap or spring.

5. A spring tide release at Rathcoursey in the middle of the 3hr accepted discharge period (HW+2hrs) (s.2.1.2), reached to the south of Whitegate jetty, to Corkbeg Island, but did not join the outgoing Cork Main Channel and was still some 3.5km from Roches Point.

6. A spring tide release at the end of the 3hr accepted discharge period (HW+3½hrs) (s.2.1.3) did not get further west than the Aghada Power Station and returned up East Ferry and

covered all our oyster beds . **This meant that that water contaminated that day had flowed back over the oyster beds within 9 hours.**

7. The above investigations assumed that the discharge stopped at HW+3½hrs, whereas Dairygold are seeking permission to discharge over the full 6-hour ebb tide and from the evidence of the above drogue runs, **this water will be back and covering all our beds in about 3+ hours** (1 hour up the Ferry, about an hour to the start of the beds at Brown Island and a few minutes over the hour to the far end of the beds at Brick Island).

8. The evidence of two neap tide releases (s.2.2.1 & 2.2.2) showed up the presence of gyres at the mouth of East Ferry, which tended to pull the drogue out of the main East Channel up on to the shallow banks. Neither of these neap ebbs (or the spring tide ebb at the end of the 3hr release period, got further west that the Aghada Power Station). Although the bulk of the returning flow to the North Channel and Midleton would come up the vastly deeper East Channel, the drogues themselves were not drawn into the flow on these occasions.

It should be noted, however, that the main East Channel, up which the drogues failed to be taken, is some 8-10m deep at LW and 500m wide, whereas the banks on the side of the channel are only about 1.5m deep at LW. Thus the major part of the water returning to the North Channel will be through the East Channel, whether the drogues stayed in it or not.

9. The evidence of the neap flood tide release at LW at Rathcoursey, which ran, without hitch, for two consecutive tides in the North Channel, summarized in Table 3.1.2.1 (s.3.1.2), shows the drogue on the second tide 44 minutes further ahead of its expected time to pass all the oyster beds.

This can be computed to be equivalent to a shift in the body of water westwards of 900m.

10. The drogue in these consecutive neap tide runs twice came back to the mouth of East Ferry, but stayed near its mouth, returning each time to the North Channel.

This demonstrated that there was no flushing at all of this remaining water.

11. On the spring tide (s.3.2.1) flood release at LW at Rathcoursey, this westwards shift past the west end of the beds at Brick Island of the second of two consecutive tides was 13 minutes ahead of the time computed from the previous run, **equivalent to a 320m shift of the water to the west.**

Again the water returning on the ebb had not gone down East Ferry, but remained in the North Channel. **There had been no flushing of this water on spring tides either.**

12. In these last few days, I have received the graphs for the current meters from BIM, which are shown above in s.4.3 above. There is no reason to believe that the full record of a neap and spring cycle, which we intend to carry out in the New Year, will show anything different to the graph of current speeds and directions

12. Evidence from 7 flood and 5 ebb traverses of the oyster beds (Table 4.1.1) showed the ebb tides taking 6% longer on spring tides and 29% longer on neap tides (Table 4.1.2)

13. The evidence of the very limited current meter data showed:

(1) The tides in the East Ferry (at the bottom at least) and North Channel appear to follow closely those predicted for Cobh. (s.4.2.1) – as we have observed over our 50 years.

(2) We see that there appeared to be twice as long a slack water period at both HW and LW at Brick Island compared to the (underlying) change of tide at the top of East Ferry (s.4.2.2).
.
(3) At Rathcoursey, which had the more obvious turns of tide, the flood tide appeared to last for 350 minutes compared to the ebb for 385 minutes. This difference of an about 10% longer ebb tide (s.4.2.3) bears out the measurements I made earlier on the O'Kane data of the 1993 Brick Island current meter record (s.5.6 of my First Submission).

7. Conclusions.

If, as M.C. O'Sullivan laid down for the discharge of Midleton waste at Rathcoursey Point in his specifically targeted 1977 study for a discharge at this particular location in his Cork Harbour Pollution Report (Vol. 1 p.102):

"(iii) Because of the presence of oyster farming in the North Channel, ***any outfall point should be such as to give very substantial dilution.****"*

and,

"(v) The existence of a commercial oyster fishery in the North Channel and the potential for shellfish development in Rostellan ***calls for special caution****."* (p.176)

acknowledging, on the same page, little flushing help from the Owenacurra in the summer toxic algal bloom season,

"(iii) The freshwater flushing of the Ballinacurra Estuary ***is well-nigh totally absent in summer and in winter is very small*** *in comparison with the Lough Mahon situation."*

Even with this top sewage expert for Cork County Council agreeing with our views above, all those years ago, in his more specific CHPR Volume XIV Physical Study – Dye Survey Analysis, p.16

"20. The hoped for benefit of an intermittent discharge over a continuous discharge would be that a large portion of the intermittent release would be carried towards the sea and not return. ***What is, in fact happening is that the intermittent release is not carried far enough by the outgoing tide to remove it permanently from the East Channel - it remains in the East Channel and is simply pushed inwards by the incoming tide****, thereby tending to build up in the Rostellan area.*

and finding that an intermittent discharge made no improvement to a continuous discharge:

"*22. In summary, therefore, the studies done to compare the effects of intermittent and continuous discharges* ***do not show the former method to be advantageous over the latter****. Study of the topographical, etc., shape of Cork Harbour shows that the results obtained for the Rathcoursey area can very reasonably be taken to occur within Cork Harbour.*

……it is quite extraordinary that, despite the 80+ page Submission by the Department of Fisheries and Forestry in 1984 and even letters from the Minister of Fisheries and Forestry to save the Oyster Fishery from potential contamination, that Rathcoursey Point was chosen as the place to outfall domestic waste in 1988, again in 2000, and now to bring in yet more waste from 14 km away.

With yet more direct observations with the GPS drogue and especially the evidence provided above of the westerly drift of water in the North Channel on successive tides, one must conclude that it would be very difficult to find a place less suitable than Rathcoursey Point if the provision of *"very substantial dilution"* is paramount.

This was also very much the opinion of the EPA studies in 2001 and 2002 (see a full account in s. 6.2.3 of my First Submission) with regard to sparking off more serious toxic algal blooms, copies of the relevant passages of which, I included with my First Submission, e.g.:

The summary of, "Measurement and Modelling of Nutrient Dynamics of Two Estuaries in Ireland – Wexford and Cork Harbours" by Costello et al (12 others) published in 2001 can be quoted here:

"The study found that point sources (outfalls) of nutrients are contributing to phytoplankton blooms in both estuaries. ***Measures to reduce waste inputs into the inner brackish-water part of the estuaries are thus required to reduce the occurrence of harmful algal blooms, especially in Cork Harbour where toxic blooms have occurred and are likely to continue to occur",***

and the authors made, as their first recommendation for "*Estuary Management*":

"Measures are required to reduce inputs of point source nutrients in both estuaries, because these are significantly contributing to the phytoplankton blooms. ***This action is especially important in inner Cork Harbour because potentially-toxic dinoflagellate phytoplankton develop blooms there during the summer."***

In the subsequent "Water Quality in Ireland 1998-2000", McGarrigle et al (10 others) 128pp. plus c.100 pp. of Appendices (2002), we have more detailed information on the underlying situation in our water in Cork Harbour:

p.78 "***Significant supersaturation*** (of oxygen) ***was only observed in the waters of the Ballinacurra Estuary and the North Channel above Great Island."***

"With the exception of the River Lee itself, ***very high oxidised nitrogen concentrations were typical of the tributary rivers which discharge to*** *the Upper Lee Estuary, Lough Mahon and* ***the Ballinacurra Estuary and North Channel (Owenacurra and Dungourney****)…..*

p.79 *"The Lee Estuary, Lough Mahon and* ***the Ballinacurra Estuary/North Channel were all strongly phosphorous-limited, but this was particularly pronounced in the Ballinacurra Estuary."***

These warnings were made a long time ago, but the current water quality is still very poor:

Trophic status of the North Channel and Owenacurra Estuary (EPA , Cork City AER, Indicators Report, Wilkes et al.)

	1995-1999	1999-2003	2001-2005	2007-2009	2010-2012	2014-2016
Owenacurra Estuary	Pot. Eutrophic	Eutrophic	Eutrophic	Intermediate	Pot. Eutrophic	Pot. Eutrophic
North Channnel	Eutrophic	Intermediate	Intermediate	Pot. Eutrophic	Intermediate	Intermediate

In fact in the latest piece of work, in the November 2018 EPA's "*Water Quality in 2017: An Indicators Report"* by Trodd W. and O'Boyle S., the Owenacurra Estuary is singled out as being one of the four water bodies in the country, which have the highest dissolved inorganic nitrogen concentrations. Not only does inner Cork Harbour (specifically the Owenacurra and Glashaboy Estuaries) have two of the highest DIN levels in the country, but they are the only two in in the country with a record of greater than 50% exceedances.

I hope that these water movement studies further reinforce all that we already know from the minimum 10-day (20 tide) larval retention period, essential for a historic oyster area; the inland drift of loose boats, flotsam and, unfortunately, bodies; together with the best hydrodynamic modelling that we have available today, that Rathcoursey Point, already 10km from the open sea, could not be a worse place to be considered for the disposal of waste.

1. There is very little dispersion available – something less than 5% per tide if all we know from oyster biology is applied.

2. The actual residual flow of water from Rathcoursey is inland, leading to the NUIG computed water-residence time of 50 days near Rathcoursey to 70 days at the west end of the North Channel leading to Belvelly

3. Thus there is an accumulation of nutrients in the North Channel rather than dispersion from any discharge made at Rathcoursey.

4. More importantly, no account has been taken in the Irish Hydrodata calculations of the existing situation of overflows from Midleton town, which continue to run at an average of about 1,000m3/day over the year, with constant spills recorded on more than every other day.

In this present case of the Dairygold discharge, what is being considered is a near-doubling of the volume of Midleton's treated waste disposed of at Rathcoursey, but this is on top of the worst unaccounted for domestic overflows that we have in the country, which have had no treatment whatsoever and have caused the Owenacurra/North Channel to continue to be eutrophic, or potentially eutrophic, every year since measurements first started in 1995.

The EPA is well aware of the problem of the overflows from the Midleton WWTP collection network as I spelt out in greater detail in s7.7 et seq. of my first submission, but in short:

1. In their Assessment of the first two years of AERs submitted by the Local Authorities (B. Kissane. Nov. 2012), out of 578 SWOs reporting, they reported that just 2 WWTLs accounted for 372 of them (64%). From the Midleton SWO records supplied to me monthly

under FOI, I can calculate that Midleton was responsible for at least 33% of the country's overflows in 2011 and 46.5% in 2012 of the national total of storm water overflows reported:

Storm overflows reported to the EPA in AER's for 2011 and 2012.

Year	Total SWOs in country	Total SWOs in Midleton	Midleton % national total
2011	864	281	**33%**
2012	578	269	**46.5%**

I also know that the storm overflow record at Midleton has not improved and in the last 12 months to the end of October this year, 336,517m3 was spilled on 140 days, giving an average spill size of over 2,400m3.

There were 2 large spills in June this year of 1,700 and 1,900m3 – i.e. in the bloom season for *Alexandrium.*

2. In 2013 the EPA placed the Midleton WWTP at the top of its Priority Enforcement List of 7 failing large urban WWTPs in Ireland.

3. In November 2013 Cork CC wrote to the EPA requesting that they be allowed to increase their CLV (Control Limit Value) from a frequency of 6 spills/annum to 10 spills/annum and a proposed increase in the 1.5% limit of total storm water collected in the relevant section of waste water works on the discharge volume for a storm overflow event, to 20%.

We were glad that the EPA refused both in April 2015 (all on EPA Midleton WWTP website)

4. In 2017 in their "*Urban Waste Water Treatment in 2016*", the EPA at last designated Midleton WWTP as failing to *"meet the EU's legally binding standards for the collection, treatment and discharge of urban waste water".*

5. An application to build 176 new dwellings at Ballinacurra, which was appealed to An Bord Pleanála (ABP-302780-18), was refused in February 2019

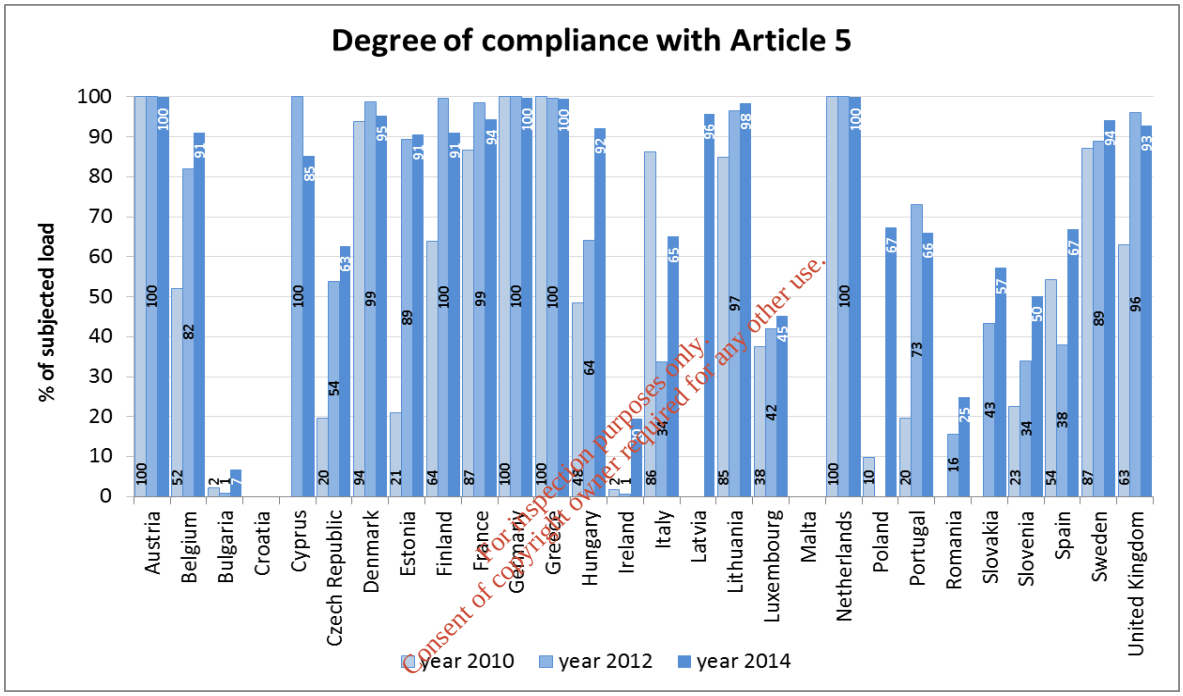
http://www.pleanala.ie/documents/orders/302/D302780.pdf

on the grounds that:

*"**There is a lack*** (of) ***wastewater treatment capacity at Midleton Wastewater Treatment Plant**. There is a lack of certainty around the delivery of a pump station and rising main to divert wastewater from Midleton Wastewater Treatment Plant to Carrigtohill Wastewater Treatment Plant and reduce the loading at Midleton Wastewater Treatment Plant. **Having regard to the existing deficiency in the provision of adequate sewerage treatment infrastructure serving the subject site, it is considered that the proposed development would be premature by reference to the existing deficiencies in the provision of sewerage treatment facilities and the period within which this constraint may reasonably be expected to cease and, in the absence of this improved wastewater treatment capacity, would be prejudicial to public health.** The proposed development would, therefore, be contrary to the proper planning and sustainable development of the area."*

6. On 28 March 2019 the European Court of Justice gave their ruling in Case C-427/17 on the implementation of the UWWTD in Ireland and found that Midleton WWTP had failed on all three Articles 3, 4 and 5 (collection; secondary treatment; and more stringent treatment and designating sensitive waters).

7. Viewing these standards of compliance with the norms now found in other Member States of the EU and, in particular for Article 5 of the UWWTD, which is what we are considering here for the quality of treatment on the receiving environment, i.e. "*more stringent or tertiary treatment and sensitive areas"*, shows that Ireland's compliance is really very poor, having been assessed as 2% compliance in 2010; 1% in 2012 and rising to only 20% in 2014 as shown in the latest report of 2017:



Progress in compliance rates for Art. 5 UWWTD in the last three Reports in % of the subjected load — data for 2010, 2012 and 2014 ***(Ninth Report on the implementation status and the programmes for implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment)***

The EPA's latest Urban Waste Water Treatment for 2018, published last month (November 2019) assesses Co. Cork's own contribution of 25 Priority Areas ("*where improvements are needed to resolve our environmental priorities"*) to the 120 in all 26 Counties, i.e. Co. Cork is accountable on its own for 21% of the failing plants in 4% of the total of the 26 Counties, and, of these failing plants, 6 of the 25 discharge into Cork Harbour, Midleton being one of these.

The EPA summarize the reasons for this list as:

"*Improvements are needed at these 120 areas to eliminate raw sewage, prevent water pollution, protect freshwater pearl mussels, bathing waters and* ***shellfish waters*** *and meet EU standards".*

In the EPA's discussion of the environmental priorities "*to target the right areas to bring improvements where they are most urgently needed"* - after the elimination of discharges of raw sewage, the protection of shellfish waters would appear to come next.

Midleton is also one of the 8 collection systems in Ireland that the Court of Justice of the European Union ruled were inadequate because it did not ensure that the collected waters were retained and conducted for treatment.

To put the Midleton overflows into a more international perspective, the volume of spills in the 3 worst years, have actually equalled in volume the spills from the 3 prosecuted WWTPs of Thames Water, for which Thames Water was fined £20.3 million in March 2017 (a fine since overtaken by the £126 million imposed on Southern Water in June this year by the water regulator Offwat).

In this latest report, the EPA laments that:

p.13, "*Irish Water is repeatedly extending the dates it expects to complete the important works needed at areas that are still releasing untreated waste water; for example:*

> *• In 2016 Irish Water reported that it would stop discharging untreated waste water from 30 of the 36 areas by the end of 2020. It is now only on target to provide treatment for two of these areas by the end of 2020",*

and,

"*Extending the time to eliminate discharges of untreated waste water prolongs the risks to the environment and public health. It is important to provide the outstanding infrastructure to end discharges of untreated waste water without any further delays".*

There is nothing more that the EPA can do to get more investment into urban waste water treatment, but, in areas where treatment is especially poor, they can, at least, ensure that matters are not made worse. Such a case must surely be this one, where an acknowledged sewage treatment fiasco, of which no account has been taken in the Irish Hydrodata calculations, must be compounded by an equally large discharge. Even if such a large discharge is treated adequately, it will introduce a twice-daily stream of additional nutrients to a water body, which our water-movement studies above show will not disperse, but accumulate it, and lead, in all likelihood to increased levels of our resident PSP blooms, and the potential for disaster for not only unfortunate consumers and our local oyster fishery, but for the whole shellfish industry in Ireland.

We trust that the EPA will see fit not to allow this discharge to be made into this most valuable part of inner Cork Harbour, and direct it to be taken to an open sea outfall in Ballycotton Bay or Ballycroneen.

8. Appendix. Observation of spate-water from Midleton impacting on the North Channel of Cork Harbour. 21.11.02

On my way to the Lower Harbour with Jim Mellis, we observed an amazing boundary between grey-blue water of good salinity (26 %o- we have been watching it daily for topping up the ponds) to the west and, in the space of 50cm, red-brown very fresh river spate-water that was almost drinkable, lying in an almost perfect semi-circle to the north and west of the mouth to East Ferry, about half-way between Brown Island and E.Ferry, just east of the Ahanesk Beds and circling around towards Ahanesk House. The grey-blue water could be seen very clearly right around this large circular area of brown, right to the other side along the shore by Ahanesk House. There was a very visible raising of the water, forming a "rim", where the two water bodies met, making the boundary even more striking. The time was 11.00 (LW was 12.13 – spring tide of 4.0m and very low atmospheric pressure)

The brown water was mixing in the Ferry and was not so fresh to the taste, but could again be seen very clearly exiting the mouth to the Lower Harbour on the western side of the Ferry, leaving clear grey-blue water for a third of the way across from the eastern side. Again there was a marked increase in salinity (by taste) in the grey-blue water. There was a demarcation with a lot of floating sea-weed and other detritus between the two waters, probably marking the position of the eastern edge of the deep channel. The time was about 11.15, an hour before LW.

We came back up the Ferry at about 13.15. The water was saltier but still very brown and this brown water now stretched all the way to ¾ up the Cunningham's Beds – some 1700m from where we left the front at LW-1 (by 13.30) with a very clear N/S demarcation, running right across the North Channel, with salty grey-blue water to the west.

I came back about 13.50 with David Doyle, who happened to be taking photos nearby and we went out to see if we could show up this clear boundary between the two different water bodies. It was very easy to see by eye (just beyond the boat at her mooring when we got to the island – i.e it had progressed another 400m to the west), but the sun went in as we went out in a small boat and, although there was scum along the boundary, the water colours were by now much more difficult to see and will probably not show up. David took photographs of the salinity meter showing 19%o in the brown water and 24%o (now) in the grey-blue.

By 14.00 the front passed the jetty on Brick Island (300m on); by 14.25 it was past the sheds (another 500m to the west)

There had been a great deal of rain last night (10mm only it appears, but that had followed 16mm the day before), but followed by a fine, still, sunny morning, with no wave etc. to break up this dramatic front, which could be seen from hundreds of metres away.

From the strength of the red-brown mud colour of the water coming from Midleton, the constant sort of rim or ripple thrown up by the force of the two water bodies meeting from opposite directions and its loss of colour and increasing saltiness as we went down the Ferry, the water could only have been the Owenacurra River water. **Storm overflows at Bailick would have been in this water and we could make the very easy observation that this water was transported right over all our beds by 14.15 (just 2 hours after the turn of the tide).**