Dublin Port Company

Dumping at Sea Permit S0024-01

Annual Environmental Report 2017

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1 INTRODUCTION

Dublin Port is situated on the lower reaches of the River Liffey which flows through the City of Dublin between the Great South Wall and North Bull Wall before entering Dublin Bay; see Figure 1.1, Dublin Port Estate. Dublin Port Company (DPC) has prepared a Masterplan to guide the development of Dublin Port in the period from 2012 to 2040. The first project brought through planning from this Masterplan is the Alexandra Basin Redevelopment (ABR) Project. Part of this project involves undertaking a capital dredging campaign, the aim of which is to deepen the ship navigation channel and fairway from -7.8m CD to -10m CD. This will permit ships of increasingly large draft to be able to safely navigate to and from Dublin Port.

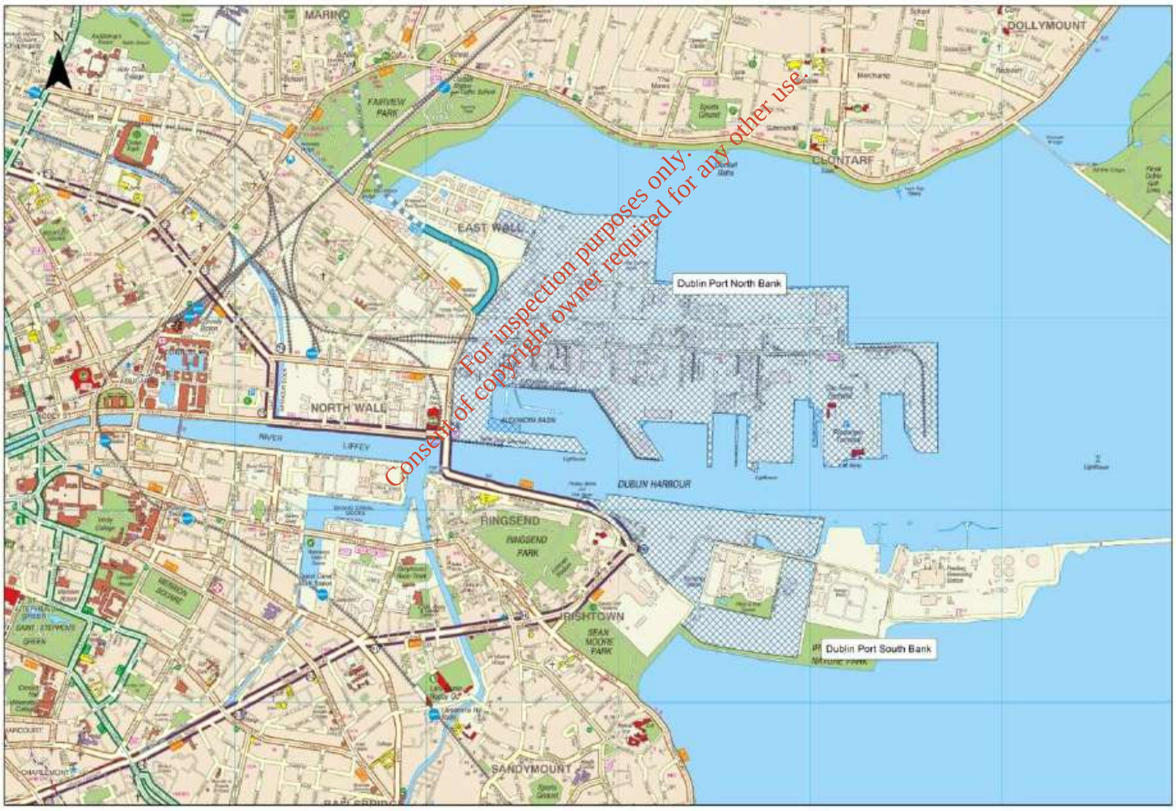
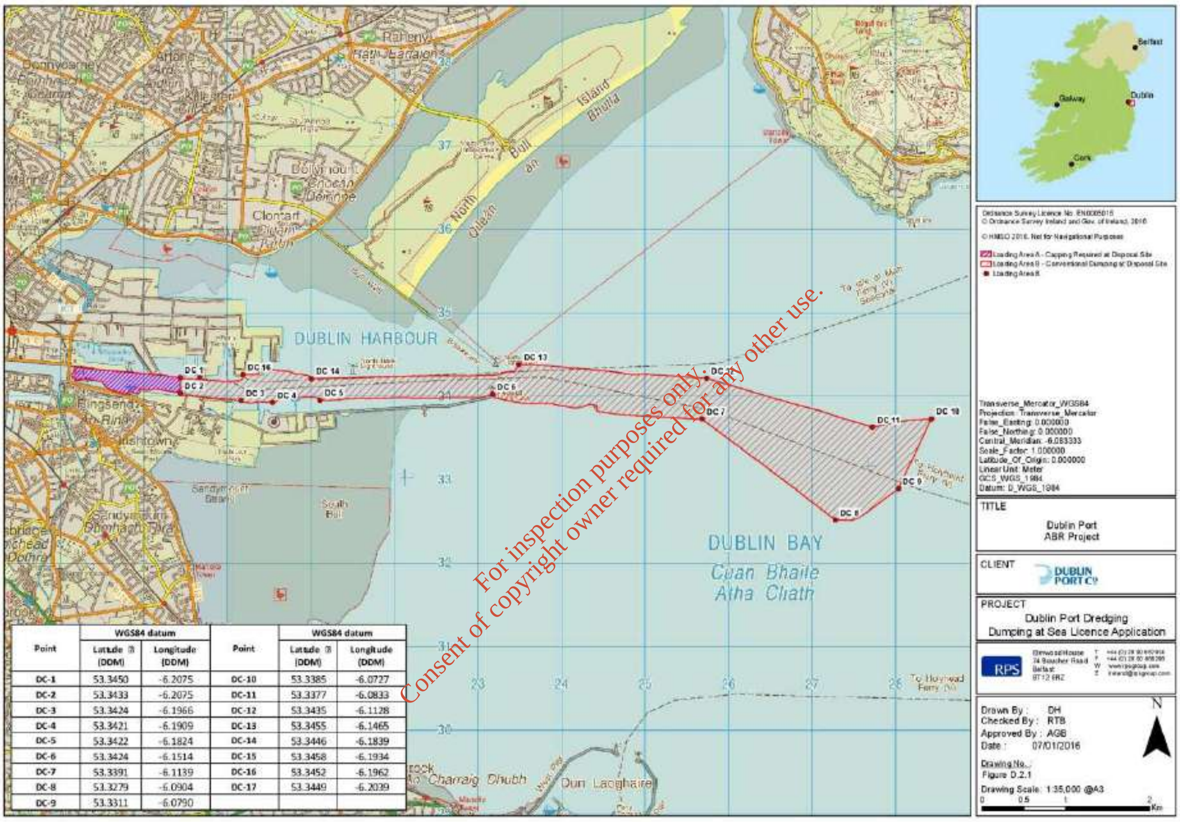


Figure 1.1 Dublin Port Estate

DPC applied for and were granted a Dumping at Sea permit from the EPA. The permit register number is S0024-01 and was granted on 13th September 2016. This allows DPC to load dredged material and to dump the dredge material from Dublin Port within the licensed dumpsite located to the west of the Burford Bank at the entrance to Dublin Bay. The area in which loading is permitted to take place is shown in Figure 1.2, denoted as Area B. Chemical sediment testing of the material to be dredged from Area B has been shown to be suitable for disposal at sea. The location of the licenced dump site is shown in Figure 1.3.



Point	WGS84 datum		Point	WGS84 datum	
	Latitude (DDM)	Longitude (DDM)		Latitude (DDM)	Longitude (DDM)
DC-1	53.3450	-6.2075	DC-10	53.3385	-6.0727
DC-2	53.3433	-6.2075	DC-11	53.3377	-6.0833
DC-3	53.3424	-6.1966	DC-12	53.3435	-6.1128
DC-4	53.3421	-6.1909	DC-13	53.3455	-6.1465
DC-5	53.3422	-6.1824	DC-14	53.3446	-6.1839
DC-6	53.3424	-6.1514	DC-15	53.3458	-6.1934
DC-7	53.3391	-6.1139	DC-16	53.3452	-6.1962
DC-8	53.3279	-6.0904	DC-17	53.3449	-6.2039
DC-9	53.3311	-6.0790			

Figure 1.2 Permitted Loading Area (Area B)

Note: Loading and Dumping is not permitted within Area A, denoted in Figure 1.2, under Dumping at Sea Permit S0024-01. Area A contains pockets of Class 2 sediments (slightly contaminated).

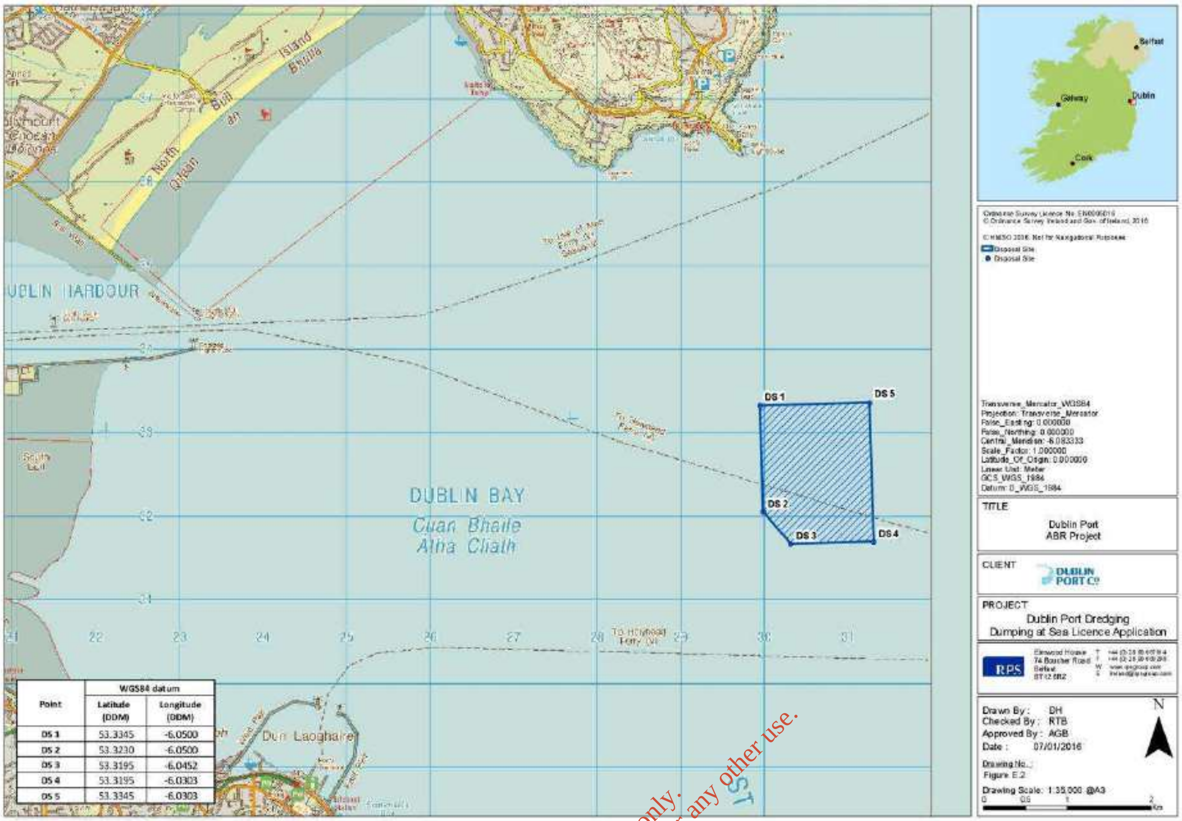


Figure 1.3 Dumpsite Location

The capital dredging campaigns under Dumping at Sea Permit S0024-01 will be confined to four winter seasons between the months of October to March.

- Season 1 October 2017 – March 2018
- Season 2 October 2018 – March 2019
- Season 3 October 2019 – March 2020
- Season 4 October 2020 – March 2021

Dumping at Sea Permit S0024-01 requires that all loading and dumping activities must be completed by 31st March 2021.

As part of the permit conditions, there is a requirement to submit an Annual Environmental Report (AER) every year (by 31st March) under condition 6.7 which states:

"*The permit holder shall submit electronically to the Agency, by the 31st March of each year an AER covering the previous calendar year. This report shall include as a minimum the information specified in Schedule C: Annual Environmental Report of this permit, and shall* *be prepared in accordance with any relevant guidelines issued by the Agency or as otherwise prescribed by the Agency*"

This document constitutes the AER for the period 1st January 2017 to 31st December 2017. Within this timeframe capital dredging was carried out during the three calendar months of October, November and December 2017.

The minimum reporting requirements are set out in Schedule C of the permit. These are:

- Register/log of loading and dumping activities
- OSPAR dumping report
- Marine positional log
- Reported incidents summary
- Complaints summary
- Monitoring summary
- Water Quality Monitoring Report
- Hydrographic Monitoring Report
- Sediment Plume Monitoring Report
- Marine Mammal Monitoring Report
- Accident Prevention Procedure
- Emergency Response Procedure
- Any other items specified by the Agency

The AER is set out in accordance with the headings as specified in Schedule C of the Dumping at Sea Permit S0024-01. An additional section has been added on Archaeological Monitoring.

2 REGISTER/LOG OF LOADING AND DUMPING ACTIVITIES

The first winter season capital dredging campaign being undertaken as part of the Alexandra Basin Redevelopment (ABR) Project commenced on 22nd October 2017 by dredging company NewWaves Solutions, a subsidiary of the International Dredging Company DEME using a Trailer Suction Hopper Dredger.

Loading and dumping took place over the following three periods:

- 22nd October 2017 – 31st October 2017
- 23rd November 2017 – 30th November 2017
- 1st December 2017 – 9th December 2017

The October 2017 dredging campaign was undertaken using NewWaves Solution's Trailer Suction Hopper Dredger (TSHD) *Minerva* which has a hopper capacity of 3,500 cubic metres. The Equipment sheet for the *Minerva* is presented in Appendix 2.1.

Figure 2.1 NewWaves Solution's Trailer Suction Hopper Dredger Minerva

The *Minerva* was replaced by the *Reynaert*, a larger Trailer Suction Hopper Dredger which has a hopper capacity of 5,580 cubic metres, for the November 2017 and December 2017 dredging campaigns. The Equipment sheet for the *Reynaert* is also presented in Appendix 2.1.

Figure 2.2 NewWaves Solution's Trailer Suction Hopper Dredger Reynaert

NewWaves Solution's Trailer Suction Hopper Dredgers' are equipped with a trailing suction head. When the ship reaches the location requiring dredging, it reduces speed and lowers the suction head to the seabed. The trailing suction head moves slowly over the bed, collecting the sediments in a similar way to a giant vacuum hoover. The water and material mix is then pumped up the arm of the suction head to the ship's hull (hopper). Once full, the dredger retracts its suction head and begins to sail slowly to the dump site.

When in position over the dump site, the ship slowly sails in the desired direction as doors in the underside of the vessel open up and the sediment is released from the hopper. This allows the operators to control accurately where the sediment is deposited.

Condition 3.10 of the Dumping at Sea permit requires DPC to ensure that the dredging contractor records the following information during each trip which its vessel carries out:

i. The name of the vessel;
ii. The Source of the material;
iii. The date, time, location and position at which the voyage, for the purpose of dumping began;
iv. The date, time, location and position at which dumping began;
v. The date, time, location and position at which dumping ended;
vi. The quantity , stated in metric tonnes, of the material dumped;
vii. The date, time and position at which the vessel completed the voyage for the purpose of dumping; and
viii. Logged vessel track record data.

The overall permitted loading area is presented in Figure 1.2. Loading for the period October 2017 – December 2017 was confined to a single block within Dublin Bay as shown on the following two drawings, presented in Appendix 2.2. A marine site investigation undertaken by Fugro in 2016 found the sediments within this block to be predominantly fine sand.

- Drawing M0697-RPS-00-XX-DR-C-2000 Site Location
- Drawing M0697-RPS-00-A-DR-C-2001 Dredging Layout

Dumping took place within the licenced dump site located to the west of the Burford Bank at the entrance to Dublin Bay. Maps showing the location of the dump site are presented in Figure 1.3 and Figure 2.1.

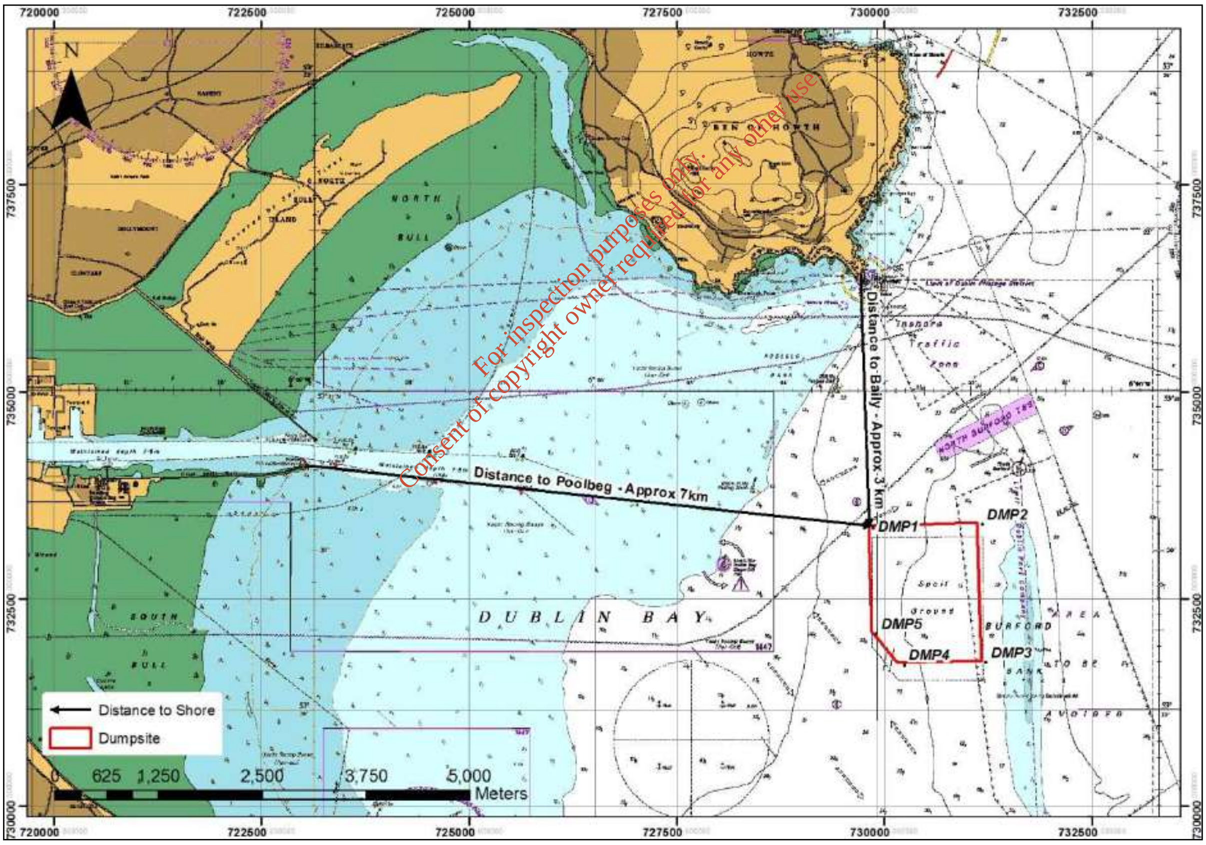


Figure 2.1 Dump Site Location

The locations of the loading and dumping activities are in full compliance with the locations specified under Schedule A: Limitations of the Dumping at Sea Permit.

Schedule A also specifies limits to the quantity of material which can be dumped at sea. The maximum quantity per calendar month is 292,000 tonnes, wet weight.

The October 2017 dredging campaign was completed by the TSHD *Minerva* with a hopper capacity of 3,500m³. A total of 130 loading and dumping trips were completed. 93% of the permitted maximum quantity of dredge material per month was achieved.

The November 2017 campaign was completed by the TSHD *Reynaert* with a hopper capacity of 5,600m³. A total of 91 loading and dumping trips were completed. 100% of the permitted maximum quantity of dredge material per month was achieved.

The TSHD *Reynaert* also carried out the December 2017 campaign. A total of 92 loading and dumping trips were completed. 100% of the permitted maximum quantity of dredge material per month was achieved.

Detailed loading and dumping at sea logs for each individual trip with information specified in Condition 3.10 were maintained during dredging campaigns. The complete log of loading and dumping activities is presented in Appendix 2.3. The records confirm that all loading was within designated loading Area B and all dumping was within the dumping site boundary.

To ensure all dumping took place within the confines of the dump site, DPC enforced a 100m buffer lying within the dump site boundary in which no dumping was permitted by the Trailer Suction Hopper Dredger.

Screen shots of each trip are held on file at Dublin Port. Example screen shots are presented in Section 4 of this AER (Marine Positional Logs).

3 OSPAR DUMPING REPORT

The OSPAR report for the 2017 capital dredging campaign in the required format is set out in Figures 3.1 and 3.2. The OSPAR dumping report has been sent separately to the Marine Institute (MI) as requested by the EPA.

S0024 - 01 OSPAR RETURN 2017		
Permit No.	S0024-01	
Date of issue	13th September 2016	
Location of dredging (Port)	Dublin Port	
Amount permitted (tonnes)	8,760,000 tonnes (max per month 292,000 tonnes)	
Capital or maintenance?	Capital	
Outline coordinates for dredging area (Dec deg WGS84)	53.3450° -6°.2075, 53.3433° -6°.2075, 53.3424° -6°.1966, 53.3421° -6°.1909, 53.3422° -6°.1824, 53.3424° -6°.1514, 53.3391° -6°.1139, 53.3279° -6°.0904, 53.3311° -6°.0790, 53.3385° -6°.0727, 53.3377° -6°.0833, 53.3435° -6°.1128, 53.3455° -6°.1465, 53.3446° -6°.1839, 53.3458° -6°.1934, 53.3452° -6°.1962, 53.3449° -6°.2039	
Date of dredging (from - to)	22 October to 31 October 2017, 23 November to 30 November 2017, 1 December to 9 December 201	
Method of dredging	Trailer Suction Hopper Dredger	
Dumpsite	Burford Bank Licenced Dump Site	
WASTES DUMPED		
If permit relates to dredge sediments please complete section A. Otherwise, complete section B		
A. DREDGED SEDIMENTS		
(a)	Specification of waste (e.g. mud, silt, sand etc.)	Predominantly Fine sand
(b)	Derived from harbour, estuary or open water?	Open water in Dublin Bay
(c)	Total quantity of wastes dumped (tonnes)?	861,000 tonnes
(d)	Details of any chemical, toxicity and/or other testing carried out on these sediments. (Reports to be attached as separate documents. Include report references, date of analysis, contractors.)	Section 3 and Appendix 3.1 of the S0024-01 AER 2017 presents sediment chemistry results for loading locations, sampled in May 2017.
(e)	Please provide a map of the area dredged with chemical analysis sampling stations indicated. Please include details of quantities dredged from specific areas.	These details are also presented in the AER 2017. Sampling location Map (Appendix 3.1), dredged quantities (Section 3), dredge location (Appendix2.2)
(g)	What monitoring has taken place and by whom? Please attach report.	Details of the extensive environmental monitoring carried out is provided in Sections 7 - 12 of the AER 2017
B. OTHER WASTES		
(a)	Specification of waste	n/a
(b)	Derived from harbour, estuary, open water or other (please specify)?	n/a
(c)	Total quantity of wastes dumped (tonnes)	n/a
(d)	Details of any chemical, toxicity and/or other testing carried out on this waste (reports to be attached as separate documents)	n/a
(e)	Please provide a map of the area dredged with chemical analysis sampling stations indicated. Please provide details of specific areas and quantities dredged.	n/a
(f)	What monitoring has taken place and by whom? Please attach report.	n/a
	Other relevant information	n/a

Figure 3.1 OSPAR Report (Sections A & B)

C. DUMPING AREA : **Note: EACH INDIVIDUAL DUMPSITE REQUIRES SEPARATE ENTRY**			
Dumpsite A			
(a)	Location	Burford Bank Licenced Dump Site	
	Co-ordinates (minimum of 4):		
	Lat (decimal degrees - WGS 84)	Long (decimal degrees-WGS 84)	
	-6.0500°	53.3345°	
	-6.0500°	53.3230°	
	-6.0452°	53.3195°	
	-6.0303°	53.3195°	
	-6.0303°	53.3345°	
(b)	Quantity of material dumped here	861,000 tonnes	
(c)	Origin of material (eg berths, fairway etc)	Loading area B covered by DAS Permit S0024-01 (open water in Dublin Bay).	
(d)	Depth (metres)	12.7m -24.3m	
(e)	Distance from coast (km)	Approx 7 km due East from entrance to Dublin Port (Bull Walls)	
(f)	Tidal flows		
	Direction (degrees)	20° N (flood tide) /200° N (ebb tide) at centre of dump site	
(g)	Maximum speed (m/s knots)	Max. speed: 0.86 m/s	
	Method of dumping (if more than one vessel involved, give the range of loads and discharge conditions)	Dumping through bottom doors of dredger	
(h)	Vessel(s) load (tonnes)	Average tonnage per trip circa 2,750 tonnes. Details of individual trips presented in Appendix 2.3 of the AER 2017	
(i)	Manner of discharge from vessel	Dumping through bottom doors of dredger	
(ii)	Rate of discharge (te/day)	Average: 31,900 tonnes/day	
(iii)	Speed of vessel while dumping (m/s or knots)	Between 1-3 Knots	
(iv)	Residual Water Movements	The residual current during spring tides is 0.54 m/s flowing 124° N at the centre of the dumpsite. The residual current during neap tides is 0.35 m/s flowing 118° N at the centre of the dumpsite.	

Figure 3.2 OSPAR Report (Section C)

Sediment Chemistry

Sediment Chemistry sampling and analysis was undertaken in advance of the capital dredging campaign in accordance with Condition 4.7 of the Dumping at Sea Permit.

DPC commissioned Hydrographic Surveys Ltd to undertake the sediment chemistry and grain size sampling and analysis programme. The analysis was undertaken by the appropriately accredited RPS Letchworth Laboratory.

The survey to collect the samples was undertaken on 31st May 2017.

DPC received Hydrographic Surveys Ltd Report on the sampling and analysis programme on 2nd August 2017.

Appendix 3.1 presents the following

- Hydrographic Surveys Ltd Report
- The results of the analyses transcribed into the standard Marine Institute format
- Location map of the sampling points

Table 3.1 shows a comparison of the sediment chemistry results with Marine Institute Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters.

The results show that samples at locations DC03A, DC05, DC06 and DC07 all fall below the lower MI guideline for disposal at sea.

The results for sample location DC04 however show a 'hot spot' of Mercury above the upper MI guideline.

The sediment chemistry result at location DC04 was not expected because elevated levels of Mercury at this location have not been detected by previous surveys. The source of the contaminant is not likely to be Port related. It is noted that the sample location lies downstream of a number of discharge points which may be potential sources. The source could also be from a current or legacy industrial discharge which has migrated downstream from Dublin City.

The area in the vicinity of sampling point DC04 is not scheduled to be dredged under Dumping at Sea Permit S0024-01 until the capital dredge winter season October 2019 – March 2020.

DPC will undertake an investigative sampling and analysis survey, in conjunction with the Marine Institute, to determine the extent of the contaminated 'hot spot' and make recommendations to the EPA of how to satisfactorily deal with this issue whilst safeguarding the environment.

Table 3.1 Results of sediment chemistry results against Marine Institute Guidelines

Parameter	Units (Dry Wt)	Results - 2017					Guideline Values	
		DC03A	DC04	DC05	DC06	DC07	Lower Level	Upper Level
		surface	surface	surface	surface	surface		
Arsenic	mg kg^{-1}	6.99	5.31	6.18	5.09	4.5	9	70
Cadmium	mg kg^{-1}	0.27	0.17	0.27	<0.1	<0.1	0.7	4.2
Chromium	mg kg^{-1}	41.5	38.2	21.7	21.5	17.7	120	370
Copper	mg kg^{-1}	15.9	9.12	4.12	3.19	2.34	40	110
Lead	mg kg^{-1}	27	18.5	10.5	9.97	9.34	60	218
Mercury	mg kg^{-1}	0.08	44.1	0.14	0.02	0.02	0.2	0.7
Nickel	mg kg^{-1}	15.9	13.5	10.1	7.32	6.35	21	60
Zinc	mg kg^{-1}	66.2	44.5	26	21.9	18.7	160	410
(TBT + DBT)	mg kg^{-1}	<0.007	<0.007	0.0269	<0.007	<0.007	0.1	0.5
g-HCH (Lindane)	ug kg^{-1}	<1.0	<1.0	<1.0	<1.0	<1.0	0.3	1
PCB 028	ug kg^{-1}	<0.1	1.15	<0.1	<0.1	<0.1	1	180
PCB 052	ug kg^{-1}	<0.1	5.67	<0.1	<0.1	<0.1	1	180
PCB 101	ug kg^{-1}	<0.1	2.88	<0.1	<0.1	<0.1	1	180
PCB 118	ug kg^{-1}	0.21	1.49	<0.1	<0.1	<0.1	1	180
PCB 138	ug kg^{-1}	<0.1	0.87	<0.1	<0.1	<0.1	1	180
PCB 153	ug kg^{-1}	0.32	0.64	<0.1	<0.1	<0.1	1	180
PCB 180	ug kg^{-1}	<0.1	<0.1	<0.1	<0.1	<0.1	1	180
Σ (7 PCBs)	ug kg^{-1}	1.03	12.8	0.7	0.7	0.7	7	1260
Hexachlorobenzine	ug kg^{-1}	<1.0	<1.0	<1.0	<1.0	<1.0	0.3	1
Acenaphthene	ug kg^{-1}	12.9	9.86	0.577	0.24	<0.1	-	-
Acenaphthylene	ug kg^{-1}	11.5	8.54	0.59	0.572	<0.1	-	-
Anthracene	ug kg^{-1}	31	23.3	2.31	<0.1	<0.1	-	-
Benzo (a) anthracene	ug kg^{-1}	104	76.4	2.45	3.44	<0.1	-	-
Benzo (a) pyrene	ug kg^{-1}	147	92.1	4.55	4.12	<0.1	-	-
Benzo (b) fluoranthene	ug kg^{-1}	104	80	3.37	8.93	0.393	-	-
Benzo (ghi) perylene	ug kg^{-1}	94.7	60.2	4.87	6.14	<0.1	-	-
Benzo (k) fluoranthene	ug kg^{-1}	43.5	31.4	5.18	2.88	0.223	-	-
Chrysene	ug kg^{-1}	64.3	59.4	1.6	3.64	<0.1	-	-
Dibenz (a,h) anthracene	ug kg^{-1}	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
Flourene	ug kg^{-1}	19.6	17.6	0.807	1.54	<0.1	-	-
Fluoranthene	ug kg^{-1}	162	147	5.4	6.33	<0.1	-	-
Indeno (1,2,3–cd)	ug kg^{-1}	82.7	51	3.22	6.45	0.76	-	-
Naphthalene	ug kg^{-1}	42.2	22	3.7	2.17	<0.1	-	-
Phenanthrene	ug kg^{-1}	109	95.3	6.1	5.49	<0.1	-	-
Pyrene	ug kg^{-1}	159	163	5.06	5.15	<0.1	-	-
Σ (16 PAH)	ug kg^{-1}	1187.5	937.2	49.88	57.29	2.676	4000	-
Total Extractable Hydrocarbons	g kg^{-1}	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	1	

In conclusion, the sediment chemistry survey shows that all sample results within the dredged footprint over Season 1 (October 2017 – March 2018) and Season 2 (October 2018 – March 2019) lie below the Marine Institute's lower guideline limit for disposal at sea. DPC will undertake investigative monitoring in the vicinity of sample location D04 and will not undertake dredging at this site until the results of the investigation are known and a solution agreed with the EPA.

Radionuclide Monitoring

The Office of Radiological Protection, EPA advised DPC that radiological analysis was carried out within the loading area in 2007 and 2009 and that the results were found to be *de minimis* indicating that the dumping of these materials at sea will not result in a radiological hazard. The EPA confirmed that no further radiological sampling and analysis was required (EPA letter of 17th May 2017 presented in Appendix 3.2).

Dredged Quantities

The quantities dredged between October 2017 and December 2017 are presented in Table 3.2.

Table 3.2 Dredged Quantities In 2017

Dredging Period	Quantity Dredged (tonnes, wet weight)
October 2017	277,000
November 2017	292,000
December 2017	292,000

The dredged quantities 2017 are also presented in the OSPAR reporting format in Figures 3.1 and 3.2.

4 MARINE POSITIONAL LOG

There were three calendar month dredging campaigns carried out in relation to Dumping at Sea Permit S0024-01 licence during 2017. These occurred from 21st October to 31st October; 23rd November to 30th November; and 1st December to 9th December.

A total of 313 loading and dumping trips were made during 2017; 130 trips in October; 91 trips in November; and 92 trips in December.

Marine Positional Logs with start and end times for each loading and dumping event were recorded on the dredging vessel. A complete record is provided in Appendix 2.3.

Screen shots illustrating the positional log are kept on file by DPC. Example screen shots are presented in Figure 4.1. The sample plots are for loading and dumping activities which took place during Trip 5 of the October 2017 dredging campaign. The log shows that loading for Trip 5 commenced at 15:35h on the 22nd October 2017 and was completed at 16:30h. Material was dredged from the southern side of the shipping channel as indicated by the vessel track shown in red. Dumping commenced at 16:50h in the south eastern section of the dumping site, also indicated by the vessel track in red. Dumping for Trip 5 was completed at 17:05h.

The marine positional logs for all dredging trips undertaken in 2017 show that all loading was within designated loading Area B and that all dumping was within the dump site boundary.

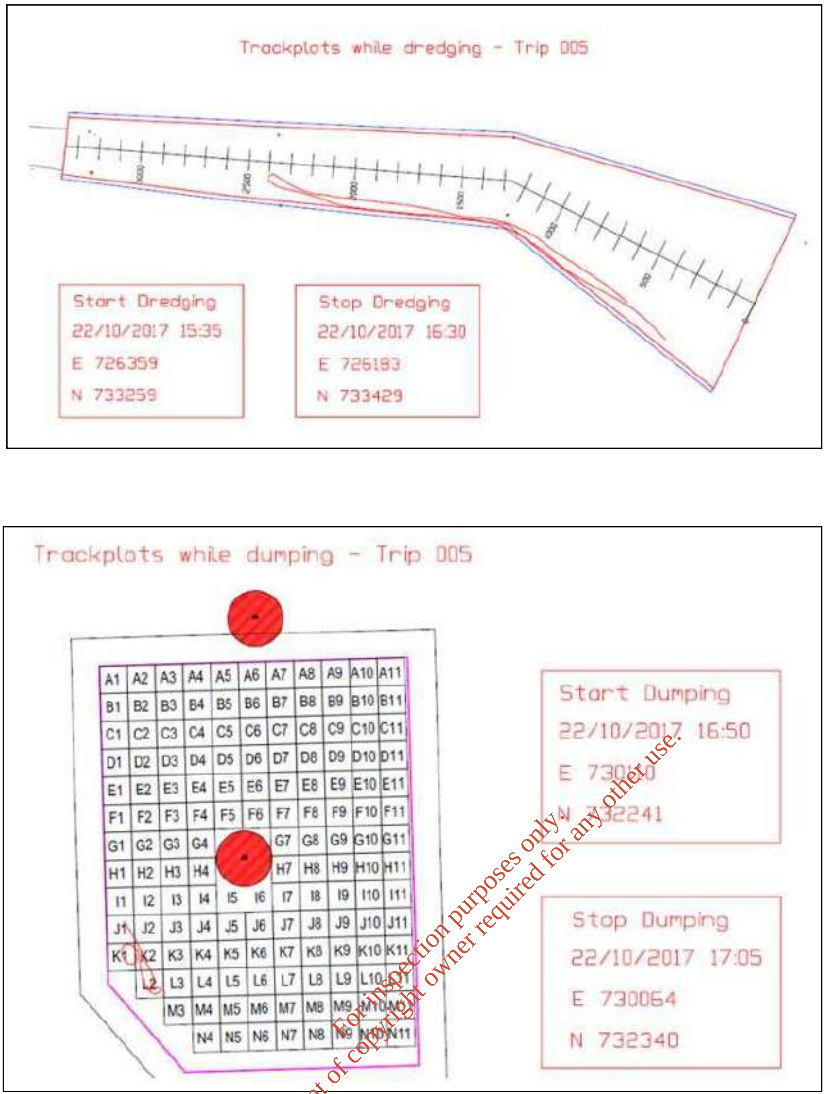


Figure 4.1 Example marine positional log for loading (top panel) and dumping (bottom panel) during Trip 5 on 22nd October 2017

5 REPORTED INCIDENTS SUMMARY

There were no incidents during the October 2017 – December 2017 capital dredging campaign.

DPC retains an “Incidents Register” on site. The summary register illustrating its format is presented below.

Summary of Incidents Register Dumping at Sea Permit S0024-01

Incident ID no.	Date of Incident	Time of Incident	Date of contacting OEE regarding incident	Nature of Incident	Corrective Action taken	Impact (if any) on marine environment resulting from Incident
2017 Dredging Campaign	No incidents occurred October 2017 – December 2017					
1						
2						

6 COMPLAINTS SUMMARY

Complaints received by DPC and the Office of Environmental Enforcement, EPA are recorded in a complaints register which is included in this section of the report.

There were no complaints received during the October 2017 – December 2017 capital dredging campaign.

DPC retains a "Complaints Register" on site. The summary complaints register illustrating its format is presented below.

Summary of Complaints Register Dumping at Sea Permit S0024-01

Table 1 Complaints received by Office of Environmental Enforcement, EPA relating to Permit S0024-01

Complaint ID no.	Date of Complaint	Time of Complaint	Method of contacting OEE, EPA	Name of Complainant	Nature of Complainant	Action Taken by DPC
2017 Dredging Campaign	No complaints were received October 2017 – December 2017					
COMxxxxxxx					-	
COMxxxxxxxx						

Table 2 Complaints received by Dublin Port Company relating to Permit S0024-01

Complaint ID no.	Date of Complaint	Time of Complaint	Method of contacting DPC	Name of Complainant	Nature of Complainant	Action Taken by DPC
2017 Dredging Campaign	No complaints were received October 2017 – December 2017					
1						
2						
3						

7 MONITORING SUMMARY

The Monitoring requirements for the Loading Areas and Dumping Site are set out in Schedule B of the Dumping at Sea Permit. The following monitoring took place in 2017 as required by the Permit.

7.1 MONITORING AT LOADING AREA

Bathymetry Monitoring (Schedule B.1.1)

A high resolution pre-loading bathymetric survey of the full extent of the loading area for winter season 1 dredging campaign (October 2017 – March 2018) is presented in Figure 7.1. The survey took into account tidal height variation over the course of the survey.

The post-loading bathymetric survey is scheduled to be undertaken within one week following completion of the winter season 1 dredging campaign in March 2018. The bathymetric survey results will be reported in the AER 2018 but will be made available to the EPA as soon as they are available.

Water Quality Monitoring (Schedule B.1.2)

Continuous monitoring of turbidity is required at four specified locations within the inner Liffey Channel. A programme of water quality sampling and analysis is to be undertaken to determine the relationship between turbidity measurements and suspended solids.

DPC has established four water quality monitoring stations within the inner Liffey Channel which have been operational for all of 2017. The four water quality monitoring stations are located as follows:

1. East Link Bridge – a water quality sonde is mounted on a mid-river dolphin structure immediately downstream of the East Link Bridge.

2. Poolbeg Jetty - a water quality sonde is mounted on the disused Poolbeg Jetty at the eastern end of the structure and on the southern side of the Liffey channel.

3. North Bank Light - a water quality sonde is mounted on the support structure of the marker light on the north side of the channel at the entrance to the Tolka Estuary.

4. Tolka Estuary - a water quality sonde is mounted on an Osil micro field buoy deployed approximately 500m from the men's bathing shelter at the end of the North Bull Wall. The buoy has a total length of 1.5m which allows it to be sited as far as possible within the Tolka Estuary insofar as the shallow water allows.

A1

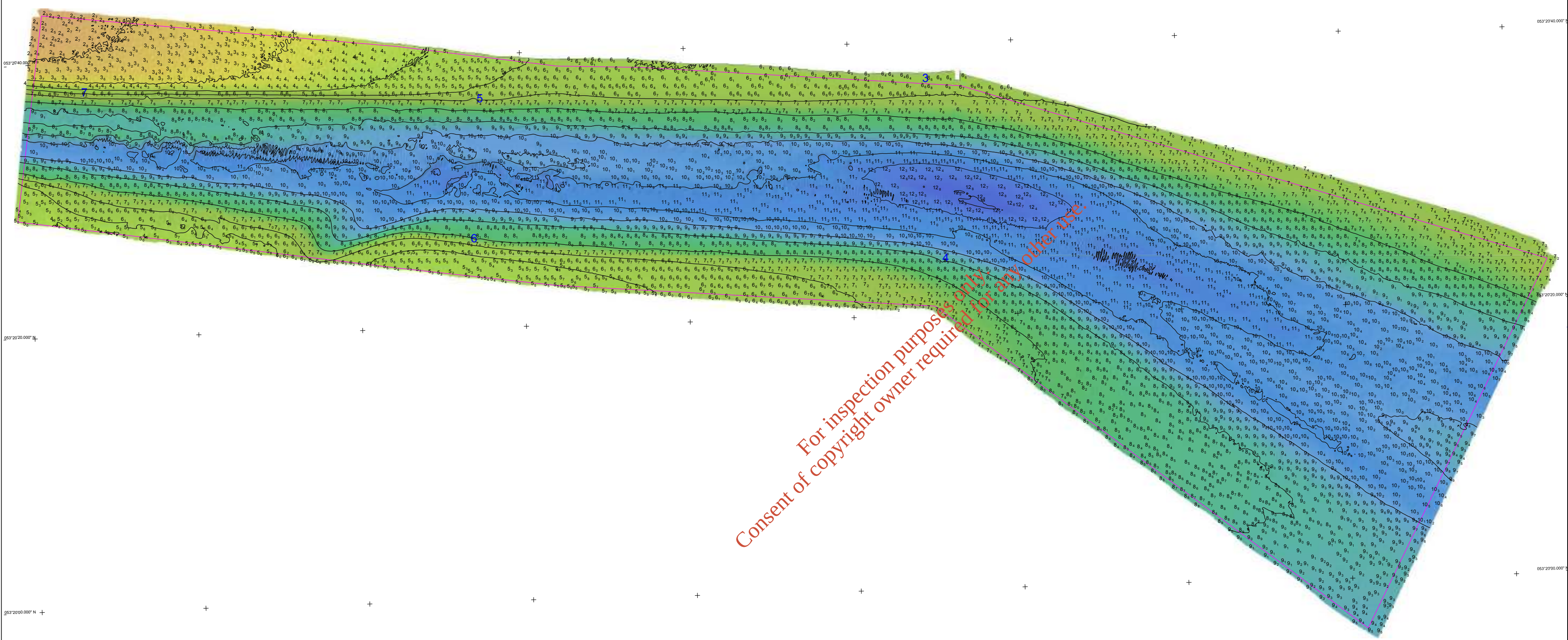
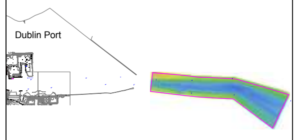


Figure 7.1 Pre-loading bathymetric survey of the loading area for winter season 1 dredging campaign (20th October 2017)



KEY PLAN - A

LEGEND

0 50.0 200.0 400.0 m

GENERAL NOTES

Soundings/Grid: Navigation Depths - Shoal Bias
Contours: Average Depths (every meter)

Datum: Chart Datum (OSGM02 + 2.51 m)
Projection: Geographic - WGS84

Survey Location: Dublin Port
Survey method: Multibeam
Survey Date: October 2017

CONTRACTOR:

HYDROMASTER LTD

Date:	Rev:	Description:	Drawn By:
20/10/17	0	Draft	MT

DUBLIN PORT Co

Client: Dublin Port Company

Project: Capital Dredge 2017

Drawing Title: PreCapital Dredge Chart 1	Scale: 1:5000
Drawing Status: Draft	

Job No: DP_1710_1	Dwg No: 001	Rev: 0
Date: 20/10/2017	Drawn By: MT	Checked By: BS

Osil Micro Buoy deployed at Tolka Estuary

The sensors used are Hydrolab multiparameter sondes which continuously monitor turbidity with the results transferred via telemetry link to the project's on-site Facilities Manager in real time.

Analysis of water samples for suspended solids content has been undertaken to determine the relationship between turbidity and suspended solids. Samples are taken at the turbidity monitoring locations.

The results of the water quality monitoring programme are presented in Section 8 of this AER.

Marine Mammal Monitoring (Schedule B.1.3)

Independent Marine Mammal Observers (MMOs) from the Irish Whale and Dolphin Group (IWDG) monitor a 500m zone around loading activities for the presence of marine mammals in accordance with the requirements of the National Parks and Wildlife Service. MMOs operate continuously on board the dredging vessel during the campaign.

The results of the marine mammal monitoring programme are presented in Section 9 of this AER.

Sediment Monitoring (Schedule B.1.4)

Sediment monitoring was undertaken within the loading area during the summer 2017. The results of the sediment monitoring are reported under Section 3 of this AER.

Marine Archaeology Monitoring (Schedule B.1.5)

A Marine Archaeology Management Plan has been agreed with the Department of Culture, Heritage and the Gaeltacht and Archaeological Licences have been obtained from the National Monuments Service to conduct the on-site archaeological works. Continuous archaeological monitoring of all dredging activities is undertaken by an experienced team of maritime archaeologists from ADCO Ltd and agreed protocols are in place to resolve fully any material of archaeological significance observed. The maritime archaeologists operate continuously on board the dredging vessel during the campaign.

The results of the marine archaeology monitoring programme are presented in Section 12 of this AER.

MONITORING AT DUMPING SITE

Bathymetry Monitoring (Schedule B.2.1)

A high resolution pre-loading bathymetric survey of the dump site is presented in Figure 7.2. The survey took into account tidal height variation over the course of the survey.

The post-loading bathymetric survey is scheduled to be undertaken within one week following completion of the winter season 1 dredging campaign in March 2018. The bathymetric survey results will be reported in the AER 2018 but will be made available to the EPA as soon as they are available.

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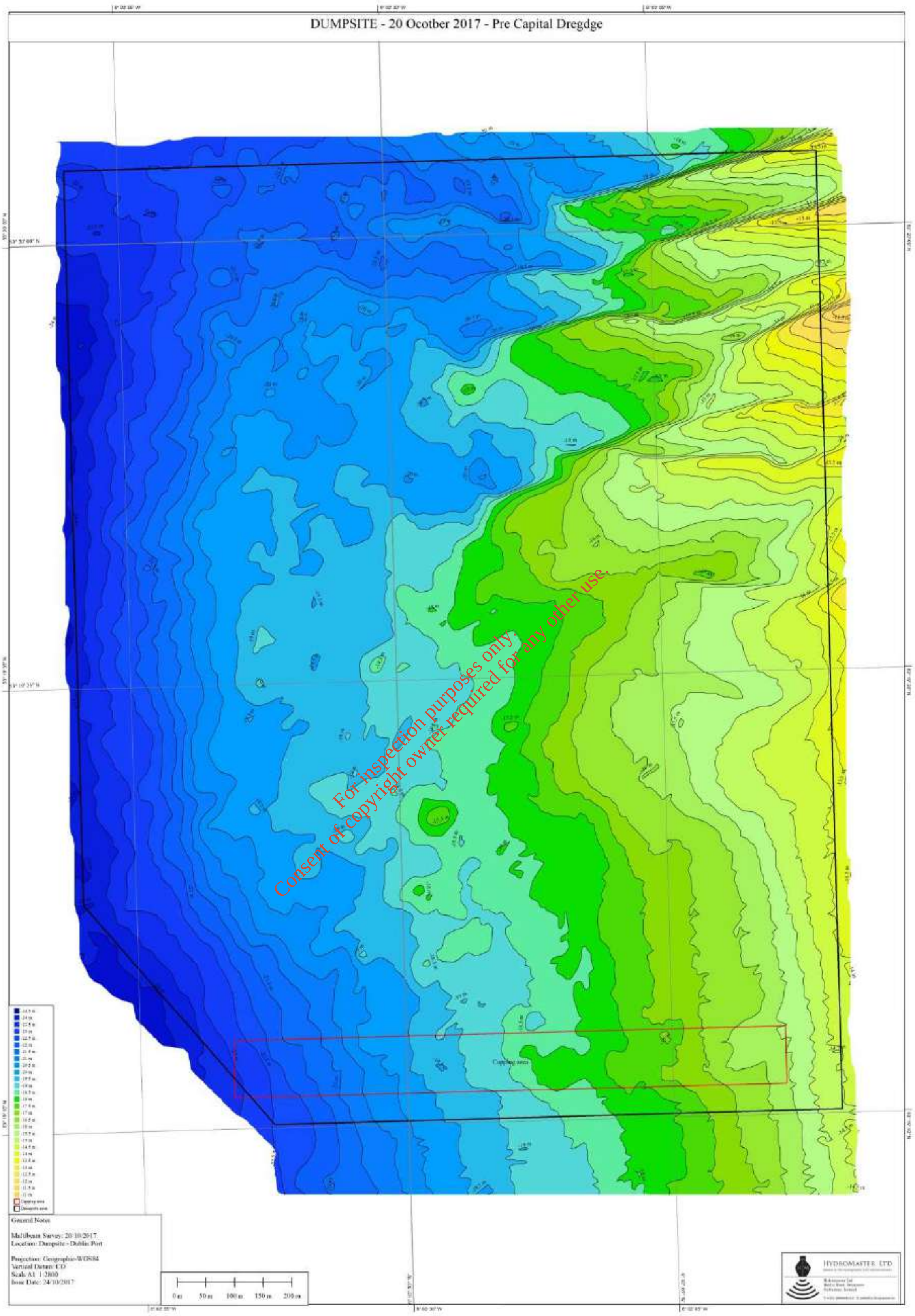

Figure 7.2 Pre-loading bathymetric survey of the dump site (20th October 2017)

Water Quality Monitoring (Schedule B.2.2)

Continuous monitoring of turbidity is required at four specified locations within Dublin Bay. A programme of water quality sampling and analysis is to be undertaken to determine the relationship between turbidity measurements and suspended solids.

DPC has established four water quality monitoring stations within Dublin Bay which have been operational from 18th September 2017 (providing one month's data prior to dumping activities). The four water quality monitoring stations are located as follows:

1. Immediately to the north of the dump site
2. Central monitoring station within the dump site
3. Immediately south of the dump site
4. Control site a suitable distance from the dump site to provide representative background information

Turbidity is to be measured continuously at four monitoring locations at various depths (near-bottom, mid-column and near surface). Mobilis buoy hulls have been used to provide platforms for monitoring equipment at the required locations. Two buoy sizes have been deployed. A DB2000 buoy hull has been deployed at two sites where instrument power demands are lower. However, at two sites with additional instrumentation (ADCP, Wave Sensor and PAM systems) greater power demands have required the use of DB8000 buoy hulls to support additional solar panels. The buoys have two point moorings. The moorings on the DB8000 hulls are specialised silent moorings to facilitate acoustic recording on these platforms. Each buoy continuously records turbidity using three Seapoint turbidity sensors deployed in-line from the centre of the buoy hull.

Monitoring Buoys on board the ILV Granuaile for deployment in Dublin Bay

Analysis of water samples for suspended solids content has been undertaken to determine the relationship between turbidity and suspended solids.

The results of the water quality monitoring programme are presented in Section 8 of this AER.

Hydrographic Monitoring (Schedule B.2.3)

Continuous monitoring of tidal current velocity, direction and water depth is being undertaken at the central monitoring station within the dumping site using a Nortek Acoustic Doppler Current Profiler (ADCP). Monitoring commenced over one month prior to the commencement of the first dumping campaign.

Continuous monitoring of wave climate is also being undertaken at the central monitoring station within the dumping site. Wave climate is being monitored continuously using a Seaview Wave Sensor.

Sediment Plume Monitoring (Schedule B.2.4)

Sediment plume monitoring has been undertaken during the first dumping campaign in the vicinity of the dumping activity. The monitoring programme has been designed to enable the horizontal and vertical extent of the sediment plume generated by the permitted dumping activity at different stages of the tide to be measured. High resolution real time data provided as part of Water Quality Monitoring and Hydrographic Monitoring above are being augmented by boat surveys during dumping operations to measure sediment plume extent and movement.

The results of the sediment plume monitoring programme are presented in Section 10 of this AER. The results of the sediment plume monitoring, together with the results of the hydrographic monitoring, have been used to validate the sediment transport model presented in *Appendix C: Coastal Process Modelling* to the Natura Impact Statement submitted as part of the Dumping at Sea Permit Application. The model verification exercise is also presented in Section 10 of this AER.

Marine Mammal Monitoring (Schedule B.2.5)

Independent Marine Mammal Observers (MMOs) from the Irish Whale and Dolphin Group (IWDG) monitor a 500m zone around loading activities for the presence of marine mammals in accordance with the requirements of the National Parks and Wildlife Service. MMOs operate continuously on board the dredging vessel during the campaign.

The results of the marine mammal monitoring programme are presented in Section 11 of this AER.

8 WATER QUALITY MONITORING SUMMARY

8.1 MONITORING AT LOADING AREA

Turbidity is being measured continuously at four monitoring locations within the inner Liffey channel. The monitoring locations are at East Link Bridge, Poolbeg Jetty, North Bank Light and Tolka Estuary as presented in Figure 8.1

Figure 8.1 Locations of monitoring stations in the inner Liffey channel, Dublin Port

Turbidity is measured continuously as Nephelometric Turbidity Units (NTU) during each loading campaign using Hydrolab DS5X Self-Cleaning turbidity sensors at all four locations. Sensors have a range of 0 - 3000 NTU, with a resolution of 0.1 NTU from 0 - 400 NTU and 1 NTU over 400 NTU. Accuracy is ±1% up to 100 NTU. Turbidity measurements are reported every 15 minutes. Routine cleaning and calibration of sondes is carried out at approximately monthly intervals. Calibration visits during 2017 are listed in Table 8.1.

Table 8.1 Dates of calibration and maintenance visits to monitoring stations

Month	Date		Month	Date
Jan	18 & 27		Jul	5
Feb	2		Aug	2 & 24
Mar	31		Sep	21
Apr	--		Oct	26
May	3		Nov	22
Jun	19		Dec	18

Hydrolab DS5X Self-Cleaning turbidity sonde

Turbidity is measured at each site at 15 minute intervals. Ambient physico-chemical conditions may vary significantly and rapidly in estuarine environments such as in Dublin Port and its approach channels. Amongst other factors, tidal and riverine currents, effluent discharges, surface water runoff and vessel movements exert large influences on the turbidity and suspended solids status of local waters.

A statistical summary of the turbidity monitoring results (January 2017 – December 2017) is presented in Table 8.2.

Table 8.2 Summary statistics for turbidity (NTU) measured at 15 min intervals from January 2017 to December 2017

	East Link	Poolbeg	Tolka Estuary*	North Bank
Mean	2.8	13.7	4.2	5.9
Max	185	2,719	690	617
Min	0	0	0	0
95%ile	10	36	18	12
Number of values	28,943	33,185	16,311	32,743

*The Tolka water quality sonde was deloyed in June of 2017

Mean daily turbidity data for all sites are plotted in Figure 8.2. It is apparent that average annual turbidity is low at all sites. Only the Poolbeg site average is above 10 NTU. This site has also shown the greatest variability in turbidity and values can be very high on some occasions cf. the maximum individual value reported of 2719 NTU. The site is situated where shallow marginal areas drop steeply to the shipping channel. It is also immediately downstream of the cooling race for the Synergen Power Station. Elevated turbidity is often associated with periods of spring tides when scouring of the shallow marginal flats may be occurring. It is important to note that incidences of elevated turbidity at this site occur when no dredging operations and no ABR Project related construction activities are taking place.

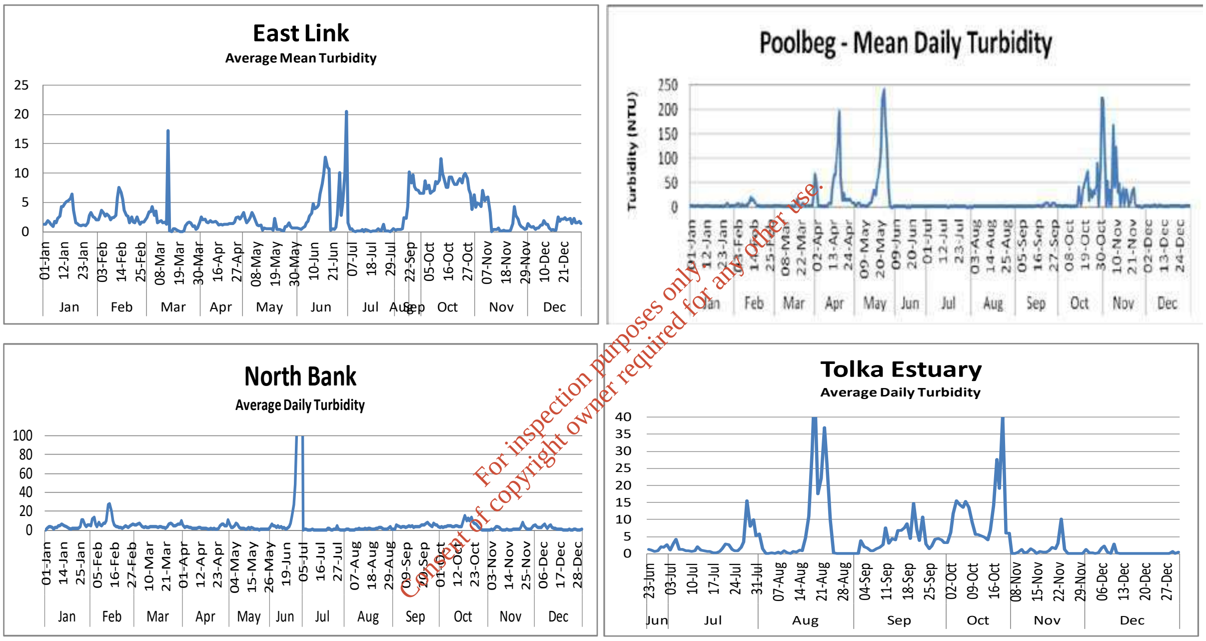

Figure 8.2 Mean daily turbidity (NTU) measured at each monitoring site during 2017

The period from September to December is examined in more detail below. Capital dredging took place in October (21st - 31st), November (23rd - 30th) and December (1st - 9th) and maintenance dredging occurred in September (14th - 30th). Table 8.3 shows the mean turbidity during periods of 'dredging' and 'no dredging' activity. There is little difference between absolute values and no apparent pattern i.e. no consistent increase in mean turbidity during dredging episodes. In fact mean turbidity is higher just as frequently during periods when no dredging was occurring.

Mean daily turbidity for this interval is also plotted in Figure 8.3. Periods when dredging was occurring are indicated by the horizontal red bars. A notable increase in turbidity is evident in three of the plots commencing on the 16th October 2017 (red arrows). This marks the onset of storm Ophelia and the beginning of a very stormy period, Ophelia being rapidly followed by storm Brian. The impact was most pronounced at the three more exposed sites and is not obvious at the more sheltered East Link site. The increase pre-dates the October campaign and is not associated with any dredging activity. The ensuing high and erratic turbidity at the Poolbeg site continued even after calibration of instruments on 26th October 2017. This may have resulted from storm impact on the measuring probe or reflect sediment disturbance and bed changes at this shallow site. The gap in records at Tolka Estuary resulted from damage to the buoy during Ophelia and subsequent loss of the sonde in storm Brian on 21st October 2017. A replacement unit was deployed at the earliest opportunity when a suitable weather window was available on 9th November 2017.

Table 8.3 Summary statistics for September 2017 to December 2017 and comparison of turbidity means (NTU) during dredging and no-dredging periods

Mean Turbidity	East Link	Poolbeg	Tolka Estuary	Noth Bank
Capital Dredge Ongoing	3.8	24.5	1.1	3.7
No Capital Dredge	4.2	15.1	4.5	3.1
Any Dredge Ongoing	4.5	17.0	3.4	4.2
No Dredge	3.9	17.4	4.3	2.7
Overall Mean	4.1	17.3	4	3.2

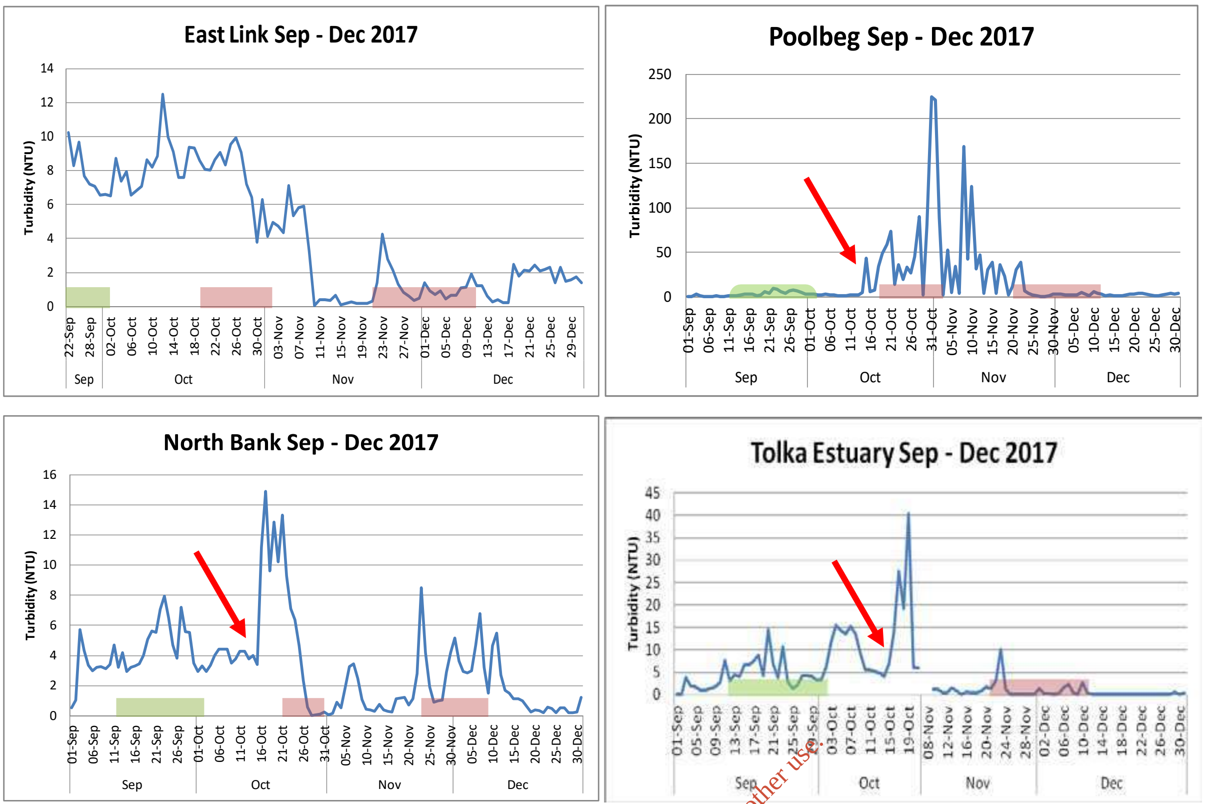

Figure 8.3 Mean daily turbidity (NTU) September to December 2017. Periods of dredging are indicated by horizontal bars (green for maintenance dredge and red for capital dredge campaigns). Onset of Hurricane Ophelia is shown by the red arrows

In conclusion, the measured turbidity results demonstrate that the capital dredging campaign (October – December 2017) did not cause any discernible increase in turbidity within the inner Liffey channel. This is not surprising given the capital dredging campaign was restricted to an area within Dublin Bay seaward of the North Bull Wall and Great South Wall. The data collected provides a very good base line for later years when the capital dredging campaigns advance towards the inner Liffy channel.

Interestingly, the measured turbidity results also demonstrate that the maintenance dredging campaign of September 2017 did not cause any discernible increase in turbidity within the inner Liffey channel above recorded background levels.

8.2 MONITORING AT DUMPING SITE

Turbidity is being measured continuously at four monitoring locations at various depths (near-bottom, mid-column and near surface). The monitoring locations are a central monitoring station within the dump site; sites immediately north and south of the dump site; and a representative background location (control point) a suitable distance from the dump site as presented in Figure 8.4.

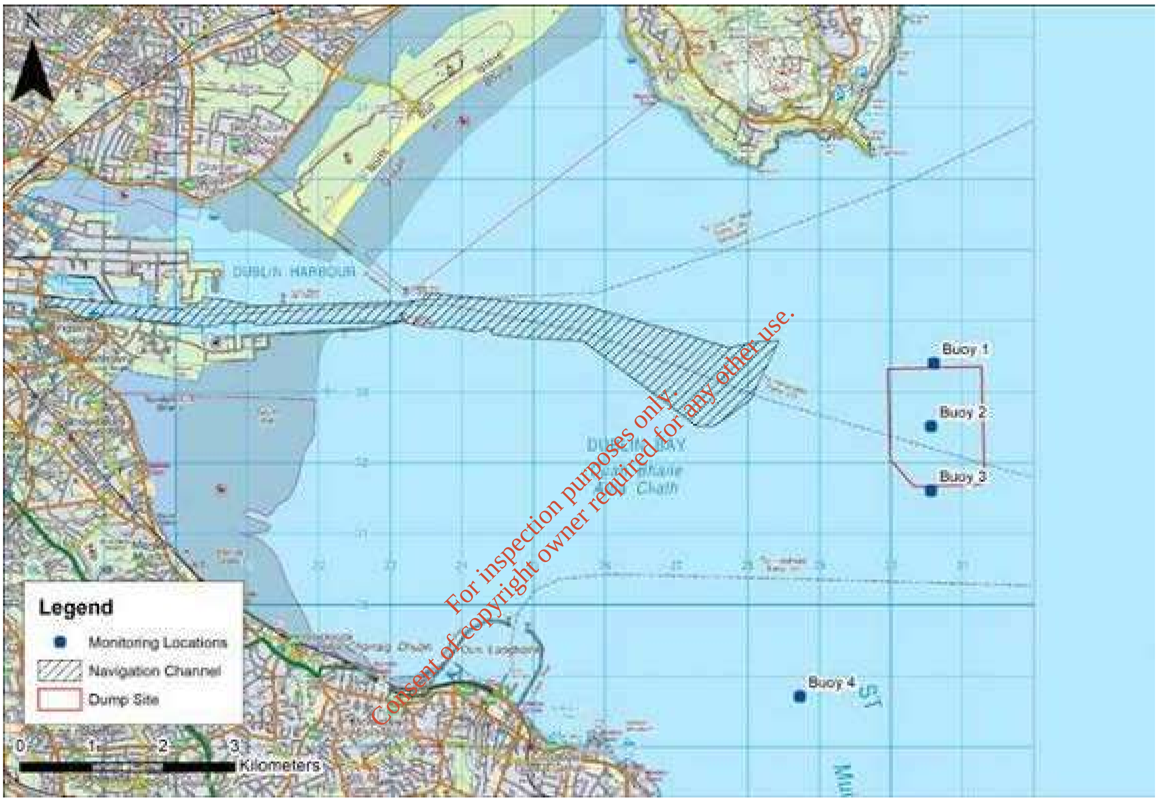

Figure 8.4 Location of the Coasteye buoys at the dump site (buoys 1 to 3) and background site (buoy 4)

Monitoring is to commence at least one month prior to the commencement of each dumping campaign and shall continue until at least one month following the completion of each dumping campaign. In compliance with this condition data recording at each buoy began on the 18th September 2017 in advance of the start of the first capital dredging campaign on the 22nd October 2017. The TSHD *Reynaert* is shown at the dumping site with a monitoring buoy in the foreground overleaf.

TSHD Reynaert at the Dublin Bay dump site with CoastEye monitoring buoy in the foreground

Turbidity is measured at 15 minute intervals at all buoys using 12 Seapoint Turbidity Sensors. Data is served out through the CoastEye marine data web portal. Examples of turbidity data at each dump site buoy compared to the background control buoy are illustrated in Figures 8.5 to 8.7. Note that some of the plots are annotated with details of calibrations or repairs and in some instances this may have resulted in recording of spurious data when sensors were raised from the water. Such data are ultimately removed from the datasets before analysis. Notwithstanding such anomalies, these plots of the complete raw data do illustrate the close general agreement between turbidity at all the dump site stations and at the control site throughout the monitoring interval when dredging and dumping was ongoing.

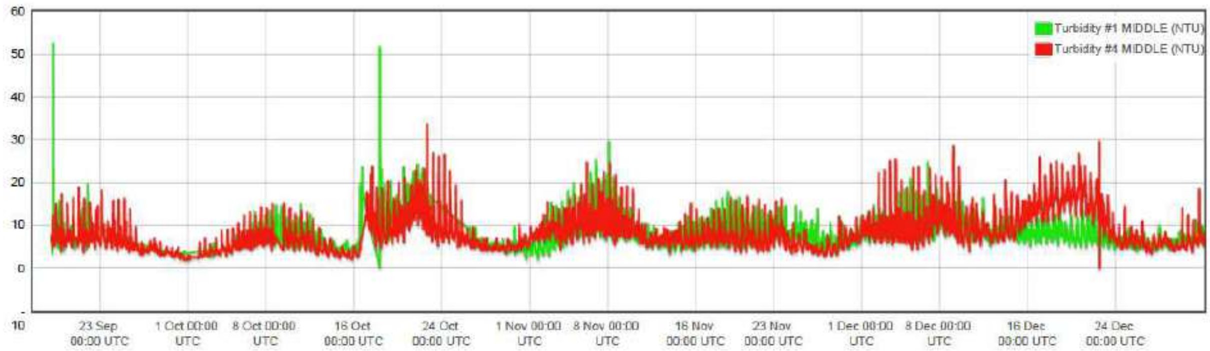

Figure 8.5 Comparison between turbidity recorded at Buoy 1 (mid depth sensor) and equivalent at Control Buoy 4 (raw data set)

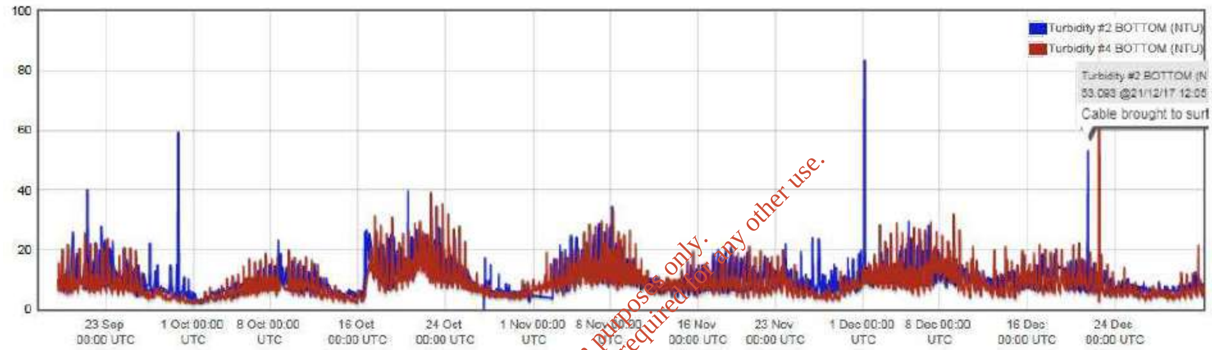

Figure 8.6 Comparison between turbidity recorded at Buoy 2 (bottom depth sensor) and equivalent at Control Buoy 4 (raw data set)

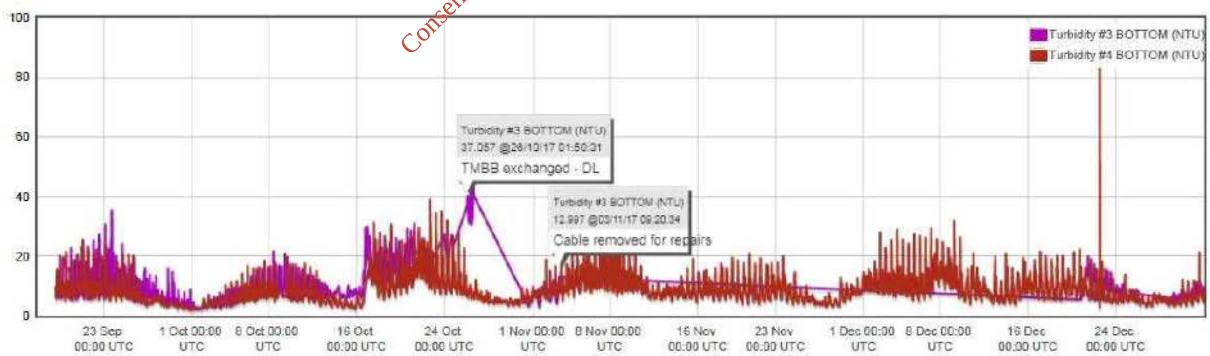

Figure 8.7 Comparison between turbidity recorded at Buoy 3 (bottom depth sensor) and equivalent at Control Buoy 4 (raw data set)

A statistical analysis of the turbidity monitoring results is presented in Table 8.4. The results show no marked difference between the results at the dump site (Buoys 1,2,3) and the control site (Buoy 4). The highest turbidity reading was in fact recorded at the control site.

Table 8.4 Statistical analysis of recorded turbidity values (NTU) September – December 2017. Top (T), middle (M) and bottom (B) turbidity is shown for each buoy. N is the number of measurements.

	Buoy 1			Buoy 2			Buoy 3			Buoy 4		
	T	M	B	T	M	B	T	M	B	T	M	B
Mean	7	8	10	7	9	10	7	8	10	7	8	9
Max	53	77	289	23	34	59	22	26	45	445	34	94
Min	1	2	3	2	1	0	2	2	2	2	0	2
95%ile	13	15	17	14	17	19	14	15	21	12	16	17
N	8041	8014	7656	3888	3403	3793	4001	3994	3752	9651	9651	9652

Mean daily turbidity levels recorded for September 2017 to December 2017 are shown in Figures 8.8 to 8.11. The periods in which dredging occurred (capital or maintenance dredging) are also indicated.

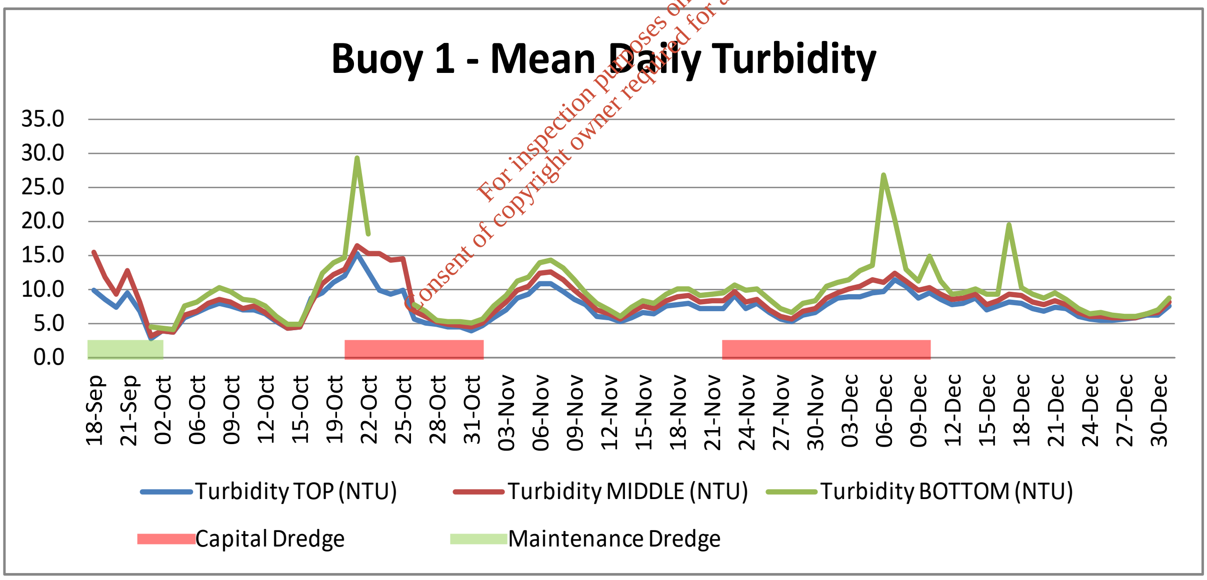

Figure 8.8 Mean daily turbidity recorded at Buoy 1 – north of dump site (September 2017 to December 2017)

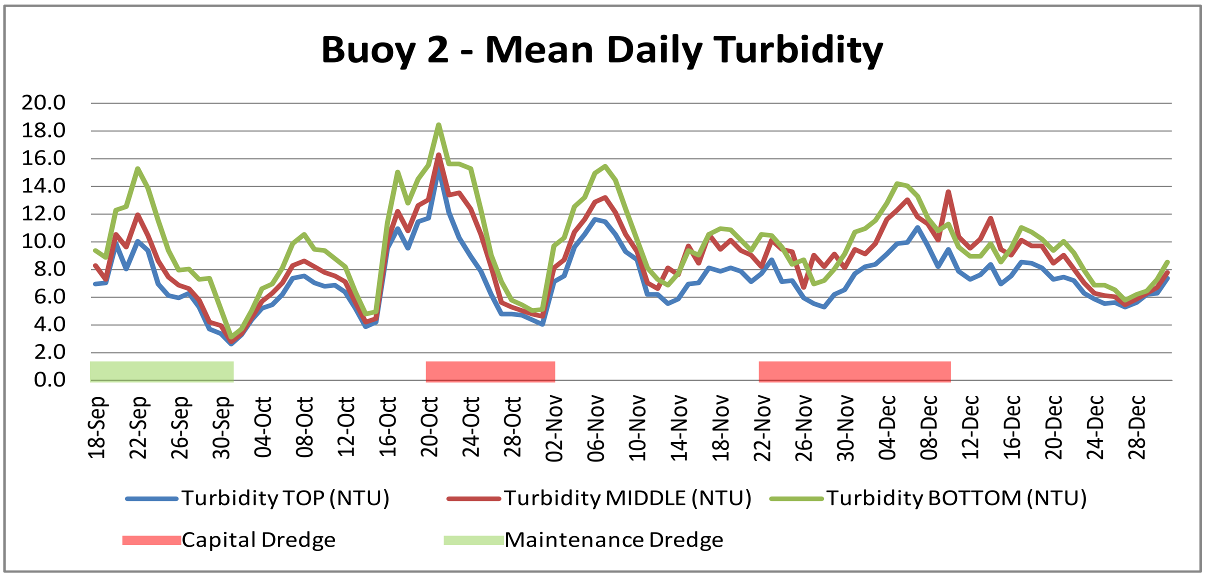

Figure 8.9 Mean daily turbidity recorded at Buoy 2 – centre of dump site (September 2017 to December 2017)

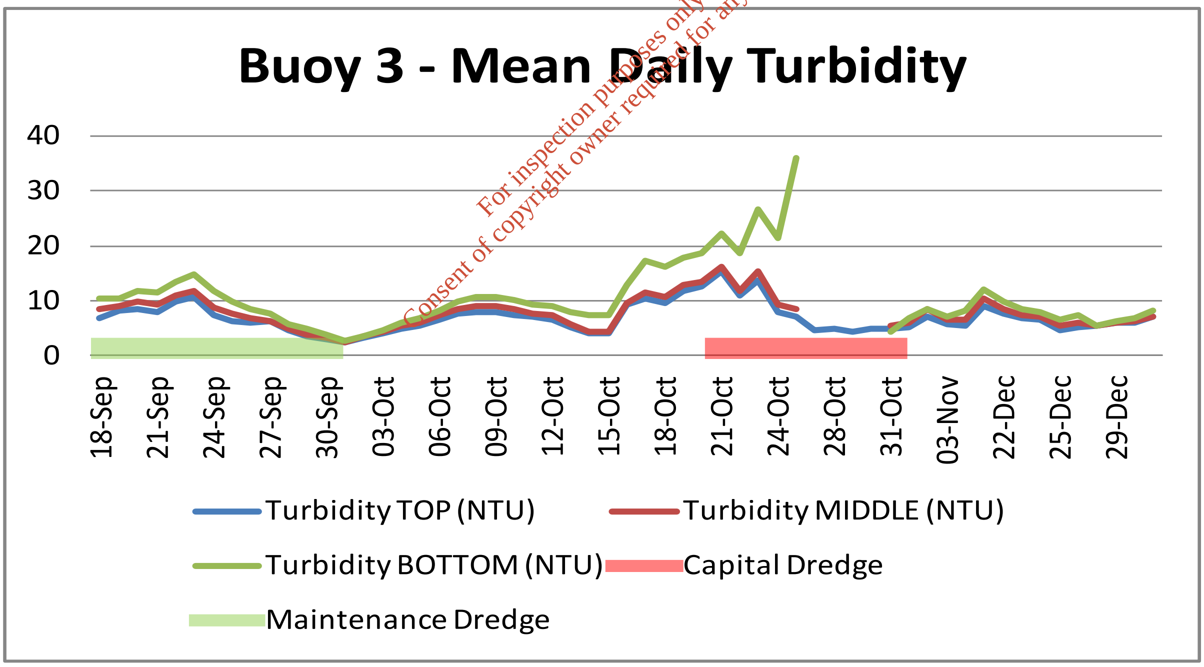

Figure 8.10 Mean daily turbidity recorded at Buoy 3 – south of dump site (September 2017 to December 2017)

Note: data was lost from two of the three sensors on buoy 3 from a limited period of time as a result of damage caused by storm Ophelia.

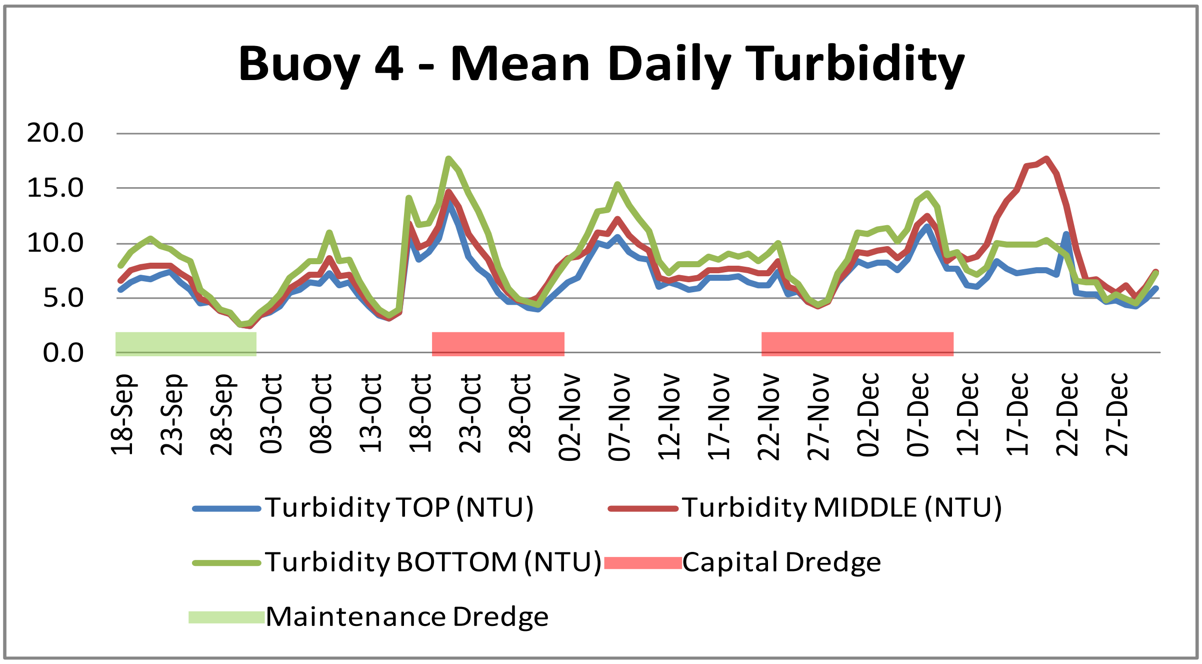

Figure 8.11 Mean daily turbidity recorded at Buoy 4 – Control Site (September 2017 to December 2017)

The plots show there is no discernible pattern of increased turbidity during either the maintenance dredging campaign (September 2017) or the capital dredging campaign (October/November/December 2017). This is confirmed by the similarity of plots from the dump site (Buoys 1, 2 and 3) and from the control site (Buoy 4). The results show that the dominant influence on turbidity levels is in fact the natural spring – neap – spring tidal cycles with the highest turbidity levels recorded close to the seabed.

A notable increase in turbidity is evident in the plots commencing on the 16th October 2017. This marks the onset of storm Ophelia and the beginning of a very stormy period, Ophelia being rapidly followed by storm Brian. A maximum wave height of 4.75m was recorded at the dump site during Ophelia. The impact of wave height on turbidity is illustrated in Figure 8.12 for Buoy 2 by way of example. It clearly shows that wave environment is also a significant driver of turbidity in Dublin Bay.

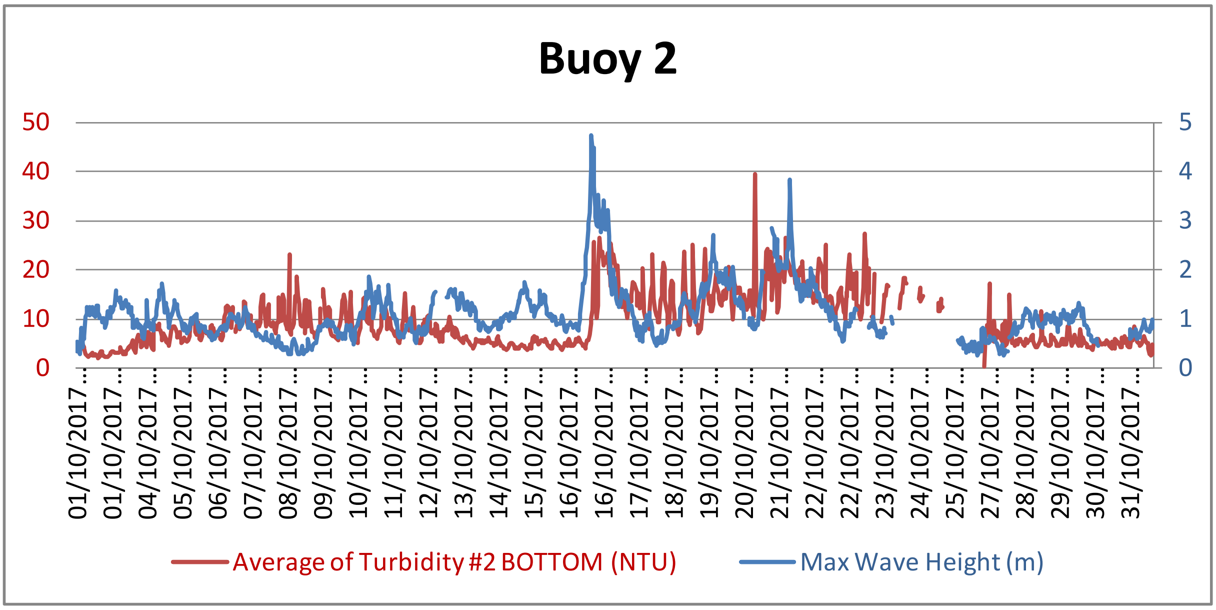

Figure 8.12 Maximum wave height and turbidity measured at Buoy 2 (October 2017)

Figure 8.13 shows individual turbidity values measured throughout the 22nd and 23rd October 2017 at Buoy 2 which is in the middle of the dump site. The first dumping of dredge spoil at the site commenced at 09.50h on the 22nd October 2017. Dumping episodes are indicated by the vertical grey bars. There is no apparent relationship between dumping events and peaks in turbidity at the dump site. Dumping may be associated with upward or downward trending turbidity.

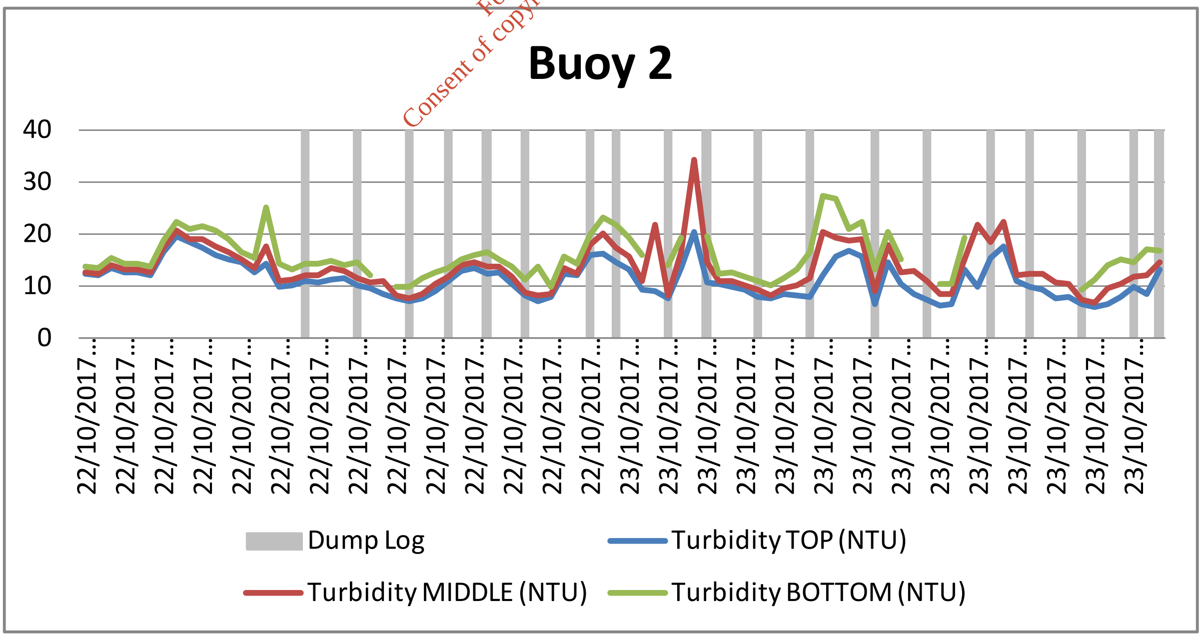

Figure 8.13 Turbidity recorded at Buoy 2 at the centre of the dump site and time of dumping events marked by grey vertical bars during 22nd and 23rd October 2017

Average turbidity at individual monitoring sites and depths are compared in Table 8.5 for periods when dumping occurred and when no dumping was taking place and plotted in Figure 8.14. The only substantial difference in turbidity at times of dredging activity is for the bottom sensor at Buoy 3 where mean turbidity during dredging campaigns was 21.4 NTU while in the absence of dredging activity it was 9.3 NTU. Storm Ophelia resulted in damage to monitoring apparatus at Buoy 3 which included hidden abrasion of a data cable. This resulted in data loss and a very limited number of observations (5#) for turbidity on the bottom sensor during dredging campaigns. The gap is apparent in Figure 8.8. The resulting mean is therefore not representative of overall conditions at B3 bottom during dredging and it is clearly at odds with results from all other monitoring sites.

Table 8.5 Mean turbidity values (NTU) for periods when dredging was ongoing compared to periods when no dredging was taking place. Mean top (T), middle (M) and bottom (B) turbidity is shown for each buoy and for all sites combined.

	Buoy 1			Buoy 2			Buoy 3			Buoy 4		
	T	M	B	T	M	B	T	M	B	T	M	B
Mean Dredge	7.3	8.7	8.8	7.3	9.1	10.0	7.0	10.1	21.4	6.8	7.9	9.2
Mean No Dredge	7.3	8.2	9.3	7.4	8.6	9.6	7.2	7.9	9.3	6.6	8.4	8.4
All Sites Dredge	7.1	9.0	9.2									
All Sites No Dredge	7.1	8.3	9.2									

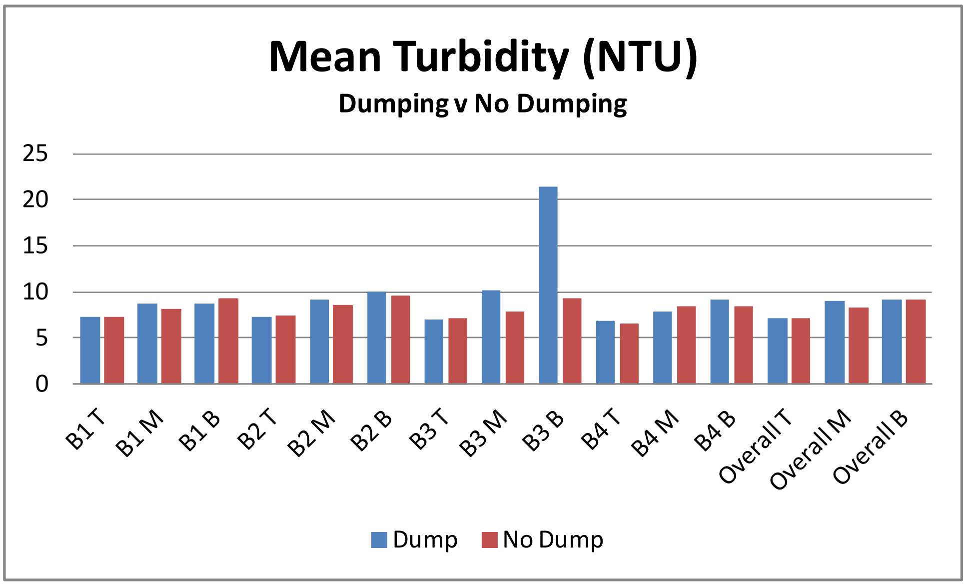

Figure 8.14 Average turbidity at individual monitoring sites and depths when dumping occurred and when no dumping was taking place

In conclusion, the measured turbidity results demonstrate that both the maintenance dredging campaign of September 2017 and the capital dredging campaign (October – December 2017) did not cause any discernible increase in turbidity above recorded background levels.

The results show the spring – neap – spring tidal cycles and wave action during storm events are the dominant causes of the natural variations in turbidity which exist in Dublin Bay. Further evidence is provided by satellite imagery (ESA Sentinel 2 & 3) for Dublin Bay as illustrated in Figures 8.15 and 8.16. These images, taken prior to any dredging activity, clearly show natural elevated suspended solids levels particularly off Howth Head and Dun Laoghaire Harbour. The satellite images are only available for cloud free days so do not illustrate the larger suspended solids variations expected during storm events.

Figure 8.15 Satellite image of Dublin Bay recorded by Sentinel 2, 8th April 2017 at 11:33am

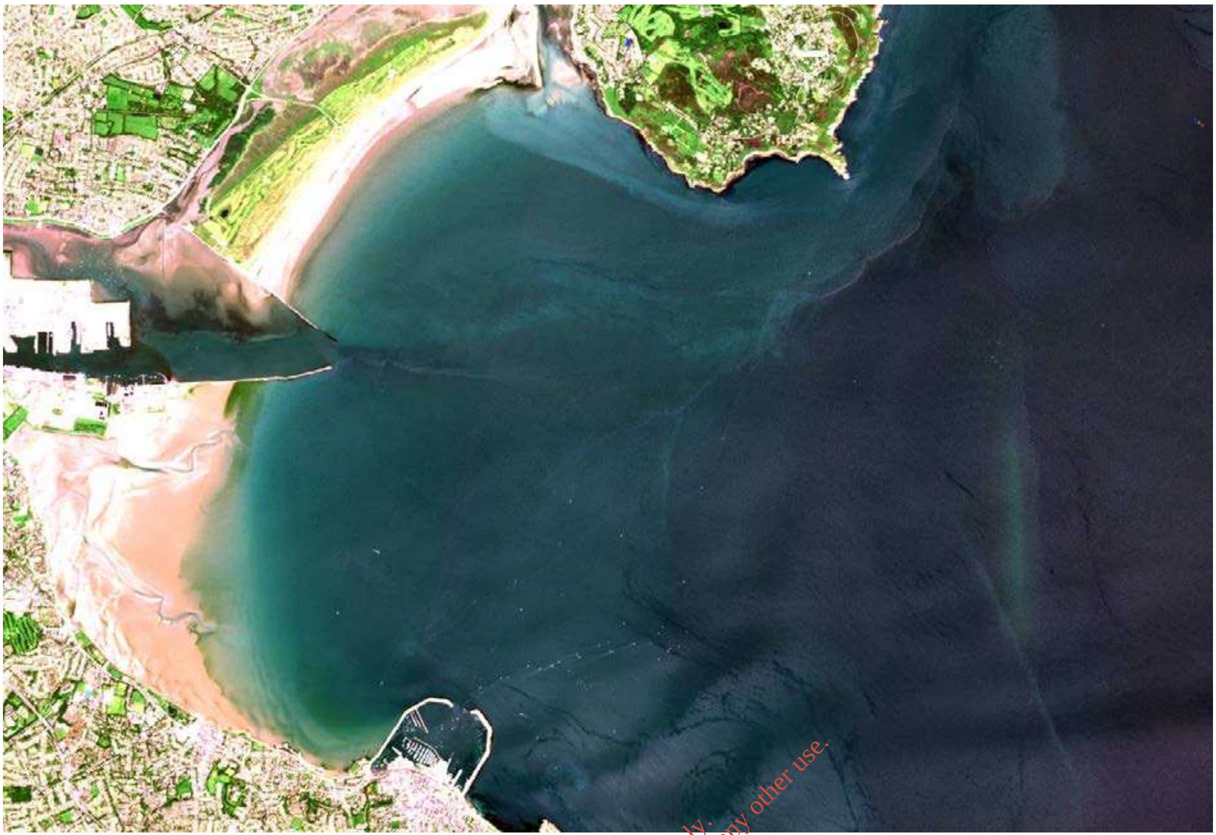

Figure 8.16 Satellite image of Dublin Bay recorded by Sentinel 2, 17th June 2017 @11:33

Furthermore, the recorded turbidity levels fall within the computer modelling simulation envelopes presented within the ABR Project EIS (see Section 10).

8.3 TURBIDITY AND TOTAL SUSPENDED SOLIDS

Analysis of water samples for total suspended solids (TSS) content is also required during the dredging campaign to determine the relationship between turbidity and suspended solids. Samples are taken at turbidity monitoring locations and submitted to an IAS testing laboratory (INAB Registration number: 275T) for simultaneous measurement of TSS and Turbidity.

In addition, sediments from the inner Port area and from the outer Bay area have been used to prepare a series of suspensions. The sediment samples taken within the inner Liffey channel consisted of a sandy silt and that from the approach channel was dominated by fine sand. These have been analysed to establish site specific relationship between TSS and turbidity. Fifty sediment suspensions were prepared from each of these samples to provide turbidity in the range 0 to 150 NTU. Twenty five of each set of samples were analysed in replicate. Turbidity (NTU) and TSS (mg/l) were measured for each suspension to allow construction of calibration curves.

The relationship derived between turbidity and total suspended solids is presented in Figure 8.17. The calibration curves are forced through the origin and TSS (mg/l) is estimated at 2.47 times the turbidity (NTU) for the inner Liffey channel sediments (silt) and 1.61 times the turbidity for the approach channel in Dublin Bay sediments (fine sand). The correlation coefficients squared show very good relationships in both calibration series ($r^2 > 0.90$). These relationships are site /sediment specific but allows an estimate of TSS based on recorded turbidity. They indicate that turbidity increases more rapidly with increasing amounts finer sediments (silt) in suspension than with coarser sediments (fine sand).

The turbidity and TSS measured in water samples are plotted (red series in Figure 8.17 for comparison with the calibration curves derived for the sediments (blue series in Figure 8.17). The relationship between turbidity and TSS is much weaker in these water samples (r^2 = 0.04). This is not unexpected since suspended sediment contributing to turbidity in these samples is derived from a disparate range of sources over an extended period. Many of the measured turbidity and TSS values are also at the very low end of the data range. However, it is noteworthy that the slope of both curves is similar at 2.1 and 2.5 for the water samples and the sediment suspensions respectively. The slope of the curve for the water samples is intermediary between calibration curves for silt and fine sand suspensions.

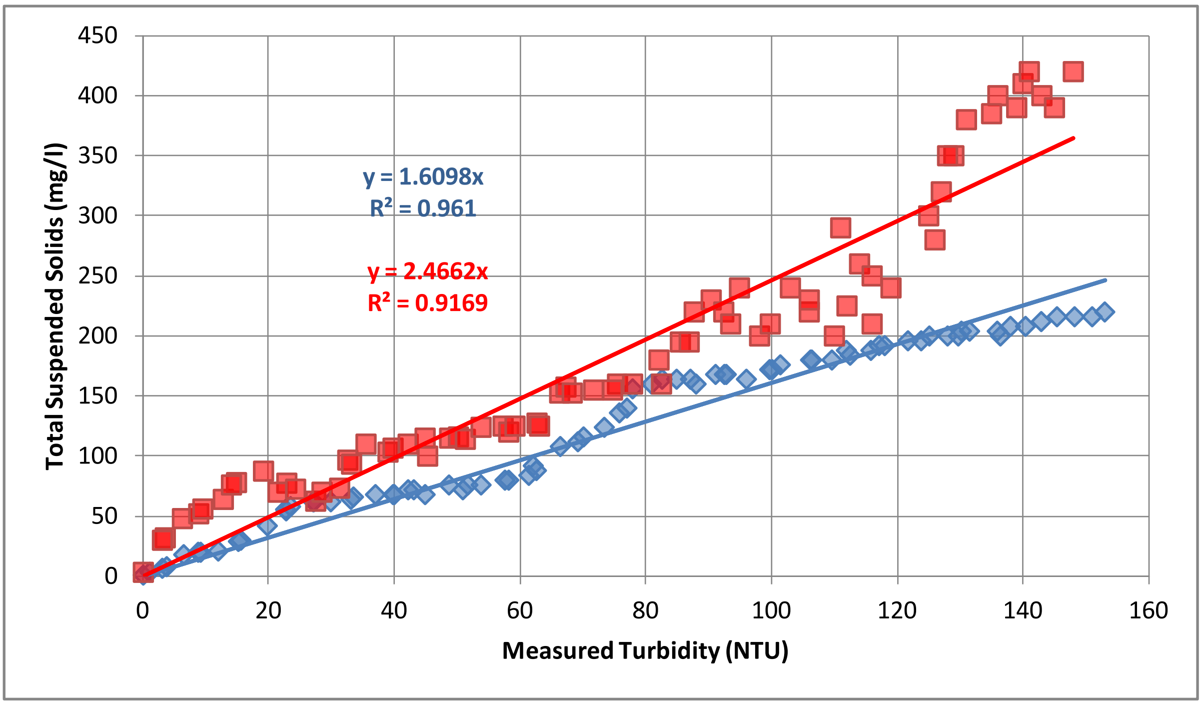

Figure 8.17 Plots of TSS versus Turbidity for suspensions of river bed silt sediment (red) and approach channel fine sand sediment (blue). Equations and r^2 values for each series are shown in corresponding colours.

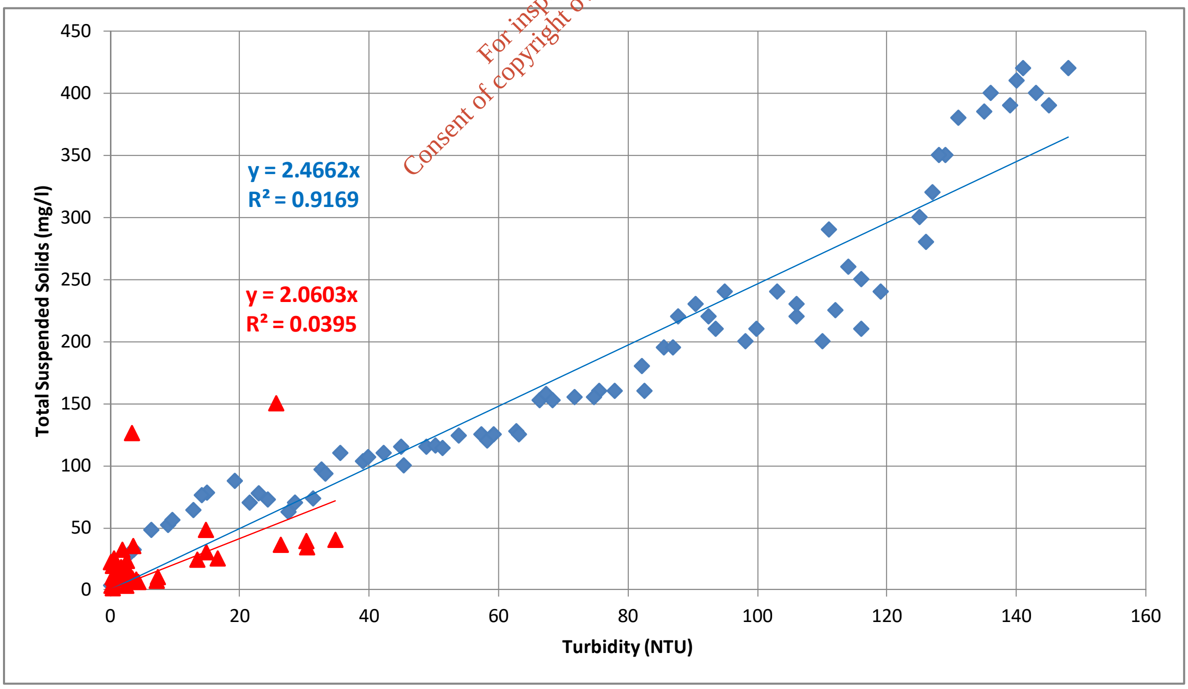

Figure 8.18 Plots of TSS versus Turbidity for suspensions of river bed sediment (blue) and water samples (red). Equations and r2 values for each series are shown in corresponding colours.

A statistical summary of the monitoring results (January 2017 – December 2017) recorded at the four monitoring locations within the inner Liffey channel presented previously in Table 8.2 in turbidity units (NTU) is repeated below in units of Total Suspended Solids (mg/l) using the derived relationships between turbidity and TSS.

Table 8.6 Inner Liffey channel monitoring sites - summary statistics for Total Suspended Solids (mg/l) January 2017 to December 2017

	East Link	Poolbeg	Tolka Estuary*	North Bank
Mean	7	34	10	15
Max	457	6,716	1,697	1,518
Min	0	0	0	0
95%ile	25	89	44	30
Number of values	28,943	33,185	16,311	32,743

*The Tolka water quality sonde was deloyed in June of 2017

A statistical summary of the monitoring results (September 2017 – December 2017) recorded at the four monitoring locations within Dublin Bay presented previously in Table 8.4 in turbidity units (NTU) is similarly repeated below in units of Total Suspended Solids (mg/l) using the derived relationships between turbidity and TSS.

Table 8.7 Statistical analysis of Total Suspended Solids (mg/l) September 2017 – December 2017. Top (T), middle (M) and bottom (B) TSS is shown for each buoy. N is the number of measurements.

	Buoy 1			Buoy 2			Buoy 3			Buoy 4		
	T	M	B	T	M	B	T	M	B	T	M	B
Mean	11	13	16	11	14	16	11	13	16	11	13	14
Max	85	123	462	37	54	94	35	42	72	712	54	150
Min	2	3	5	3	2	0	3	3	3	3	0	3
95%ile	21	24	27	22	27	30	22	24	34	19	26	27
N	8,041	8,014	7,656	3888	3403	3793	4001	3994	3752	9651	9651	9652

9 HYDROGRAPHIC MONITORING

Hydrographic Monitoring was carried out at the dump site in accordance with Schedule B.2.3 of Dumping at Sea Permit S0024-01 during 2017. Monitoring commenced on 18th September 2017 one month prior to loading and dumping and is scheduled to continue until at least one month following the completion of all dumping activity in April 2018. Hydrographic monitoring is being undertaken at the central monitoring station within the dump site.

The central monitoring station comprises a 3.0m diameter DB8000 buoy hull to support sufficient solar panels to meet the power demand from the turbidity, tidal current, water depth, wave climate and PAM systems including the real-time transfer of data to shore via a telemetry link. The moorings on the DB8000 hull are specialised silent moorings to facilitate acoustic recording on these platforms. The buoy arrangement is presented on Figure 9.1.

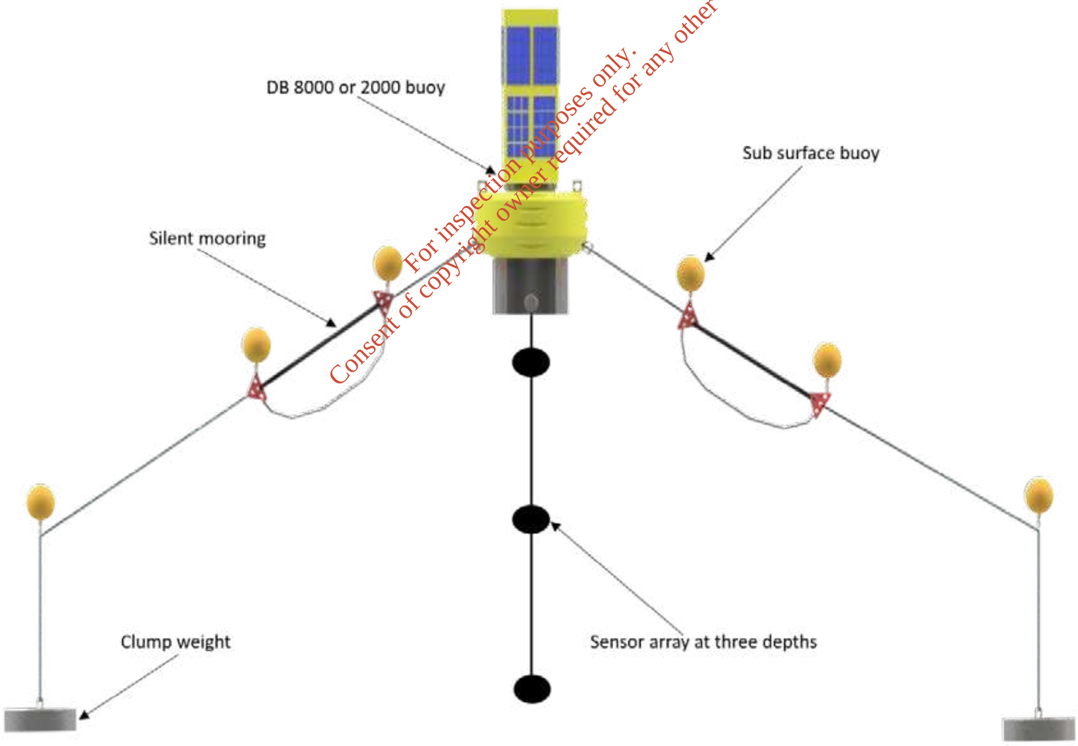

Figure 9.1 Arrangement of the monitoring station at the centre of the dump site

Details of Monitoring Equipment: Best in Class

TechWorks Marine – TMBB data logger, used Internationally (SMHI, Marine Institute, DAFM)
Seaview Wave Sensor (used by NOAA, CEFAS, Port of Cork)
Nortek ADCP, International leader (NOAA, CEFAS, NOCS)
Seapoint Turbidity Sensors, International leader (AFBNI, DAFM)

Wave Climate

The wave sensor is housed within the monitoring buoy. The wave sensor is specially adapted for data buoy platforms. The 9 Degrees of Freedom sensor compensates for 3-D motion, rotation and compass heading in all dimensions to cover the 9 degrees of freedom. The on-board electronics are able to provide near real-time wave statistics. The wave sensor provides results equivalent to a wave rider buoy. This is preferable from a navigational safety point of view because it minimises the requirement for offshore buoys in an area which is often used in winter for the transfer of personnel from pilot boat to shipping vessel.

The wave climate recorded between 18th September 2017 and 5th March 2018 contained three significant storm events

Storm Ophelia on 16th October 2017 (see Figure 9.2)

- Significant Wave Height Hmo = 3.03m
- Maximum Wave Height Hmax = 4.75m

Storm Brian on 21st October 2017 (see Figure 9.3)

- Significant Wave Height Hmo = 2.65m
- Maximum Wave Height Hmax = 3.83m

Storm Emma on 2nd March 2018 (see Figure 9.4)

- Significant Wave Height Hmo = 5.08m
- Maximum Wave Height Hmax = 7.86m

Peak wave periods were in the range 8.5 – 10.5 seconds.

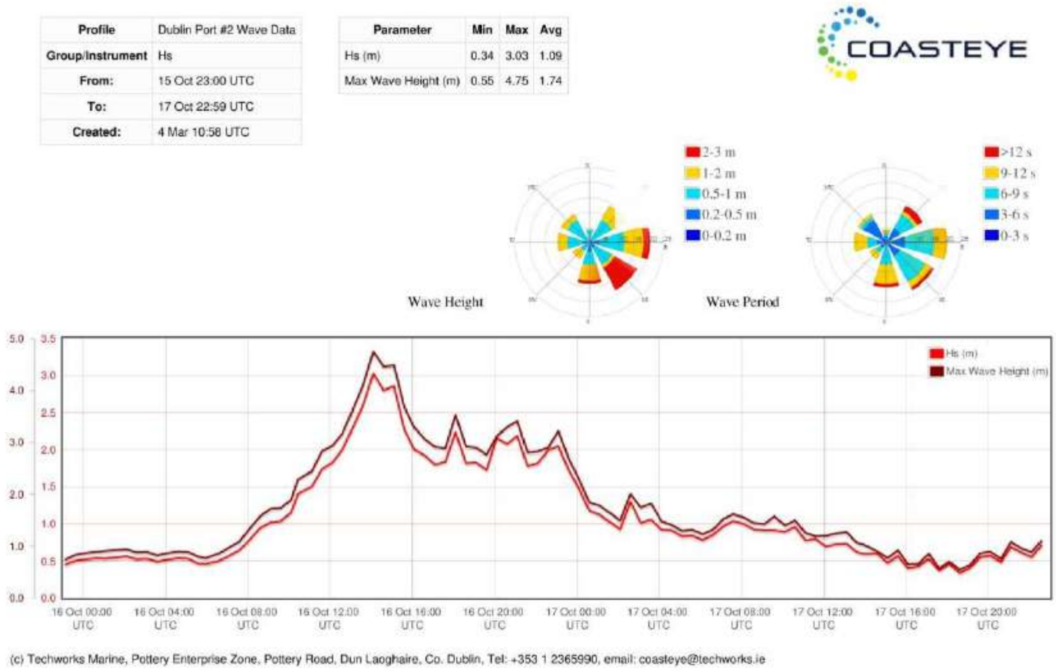

Figure 9.2 Wave conditions recorded during Storm Ophelia on 16th October 2017

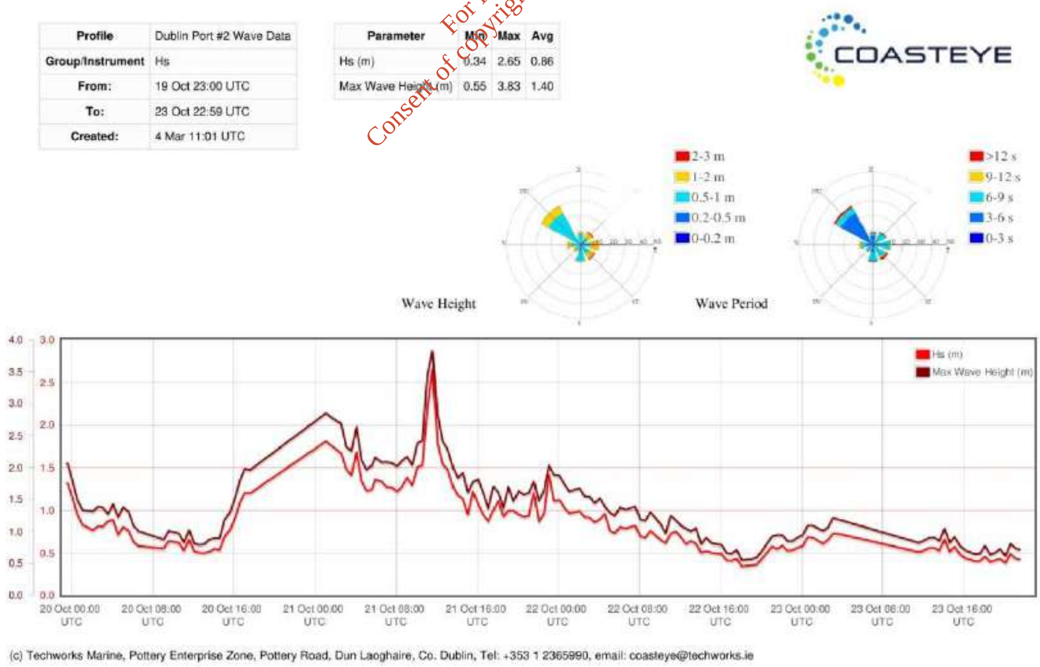

Figure 9.3 Wave conditions recorded during Storm Brian on 21st October 2017

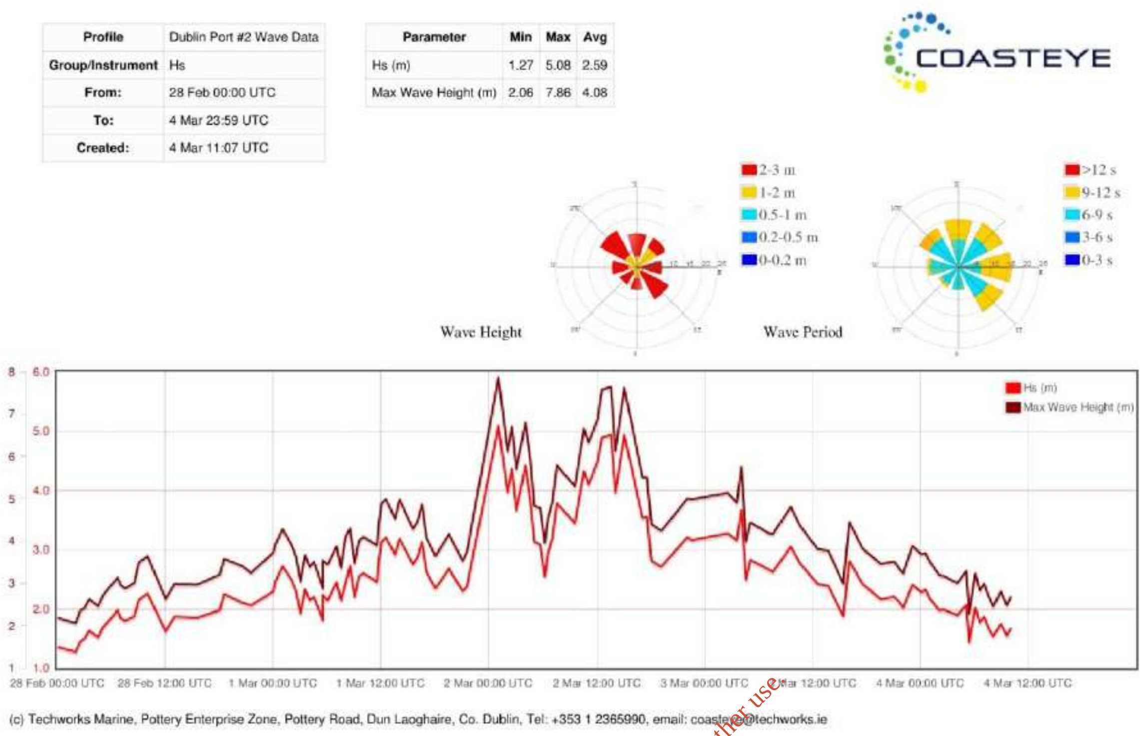

Figure 9.4 Wave conditions recorded during Storm Emma on 2nd March 2018

DPC has used the results of the wave climate monitoring to validate the hydrodynamic and wave climate model presented in Appendix C: Coastal Processes Modelling to the Natura Impact Statement (NIS) submitted as part of the Dumping at Sea Permit application.

The following extract is taken from Section 9.7 of Appendix 3 of the NIS

The hydrodynamic regime around Dublin Port and its approach channel can be influenced by waves generated within in the greater Dublin Bay area and the Irish Sea. An assessment was undertaken to determine the impact of the proposed capital dredging scheme on the wave climate.

For the modelling exercise, the inshore wave climate around the Port and the greater Dublin Bay area was established by transforming offshore waves into Dublin Port using the Mike 21 Spectral Wave (SW) modelling module. This is a spectral wave module that describes the propagation, growth and decay of waves in near-shore areas and takes account of the effects of refraction, shoaling, local wind generation and energy dissipation due to bottom friction and wave breaking.

The offshore wave data for points at 5.66oW, 55.50oN and 5.66oW, 55.25oN was taken from the UK Met Office European wave model for the period 1989-2004 and used as a source to select the largest event for each of the north east, east and south east directions. The 3 *hourly data included wind wave and swell wave components in the form of the significant wave height Hmo, mean wave period Tm and mean wave directions. The offshore wave climate data used in the wave transformation simulations are presented in Table 9.2.*

Table 9.1 Offshore wave climate data used to simulate the inshore wave climate

	Significant wave height (m)	*Peak wave period (s)*	*Mean wave direction (^{o}N)*
North Easterly event	*4.6*	*8.9*	*29*
Easterly event	*4.1*	*8.8*	*98*
South Easterly event	*5.4*	*10.4*	*148*

The model simulations presented within the NIS (Section 9.7 of Appendix 3) show that little wave attenuation is expected to occur as waves travel from offshore to the entrance of Dublin Bay (location of dump site). The wave climate recorded at the dump site should therefore be comparable to the offshore wave climate used in the environmental appraisals.

The largest significant wave height recorded between September 2017 and March 2018 was 5.08m during Storm Emma on 2nd March 2018. This storm approached Ireland from the south and combined with strong easterly winds from mainland Europe (the beast from the east) causing blizzard conditions in Dublin. The extreme wave climate recorded is similar both in significant wave height and wave period to that used in the environmental appraisals within the NIS (5.4m significant wave height, 10.4 second peak wave period).

Lessons learned – The relatively short wave periods associated with the extreme waves recorded at the central monitoring location within the dump site causes violent movements of the buoys making them prone to damage. Techworks Marine Ltd described the wave climate as a much harsher environment compared to sites off the west of Ireland where buoys can more easily ride over the longer period waves generated within the North Atlantic.

Tidal Currents

The ADCP sensor is also housed within the monitoring buoy and measures tidal current velocity, direction and water depth.

The typical spring-neap-spring tidal cycle recorded at the central monitoring station at the dump site is presented in Figure 9.5. There are three spikes in the data recorded on 2nd March 2018 which coincide with storm Emma. It is likely that these spikes have been caused by the expected violent movements of the monitoring buoy during the storm and have therefore been excluded from the analysis.

DPC has used the results of the tidal current monitoring to validate the hydrodynamic and wave climate model presented in Appendix C: Coastal Processes Modelling to the Natura Impact Statement (NIS) submitted as part of the Dumping at Sea Permit application.

A Mike 21 Hydro Dynamic (HD) model, developed by DHi was used to simulate the existing tidal regime in Dublin Bay, including the fairway, approach channel and berths of Dublin Port. A tidal Atlas of the model results are presented in Appendix 9. The model of the existing tidal regime was calibrated using tidal height data and current data from deployed ADCP current meters in Dublin Bay to ensure that the model results were representative of actual conditions.

The recorded tidal currents at the central monitoring station at the dump site were used as additional validation data.

The depth averaged tidal currents produced by the Mike 21 Hydro Dynamic (HD) model, coupled to RPS's storm surge forecast model, over the same period of time is presented in Figure 9.6. A comparison of the recorded tidal currents (Figure 9.5) and the model predicted tidal currents (Figure 9.6) show the predicted peak depth average tidal current is 0.58 m/s (or 58 cm/s) over the time period which lies comfortably within the range of tidal currents measured at the dump site.

In conclusion, the results of the hydrographic monitoring (waves and tidal currents) are consistent with the predicted results of the computer models and validate the hydrodynamic and wave climate model presented in Appendix C: Coastal Processes Modelling to the Natura Impact Statement (NIS) submitted as part of the Dumping at Sea Permit application.

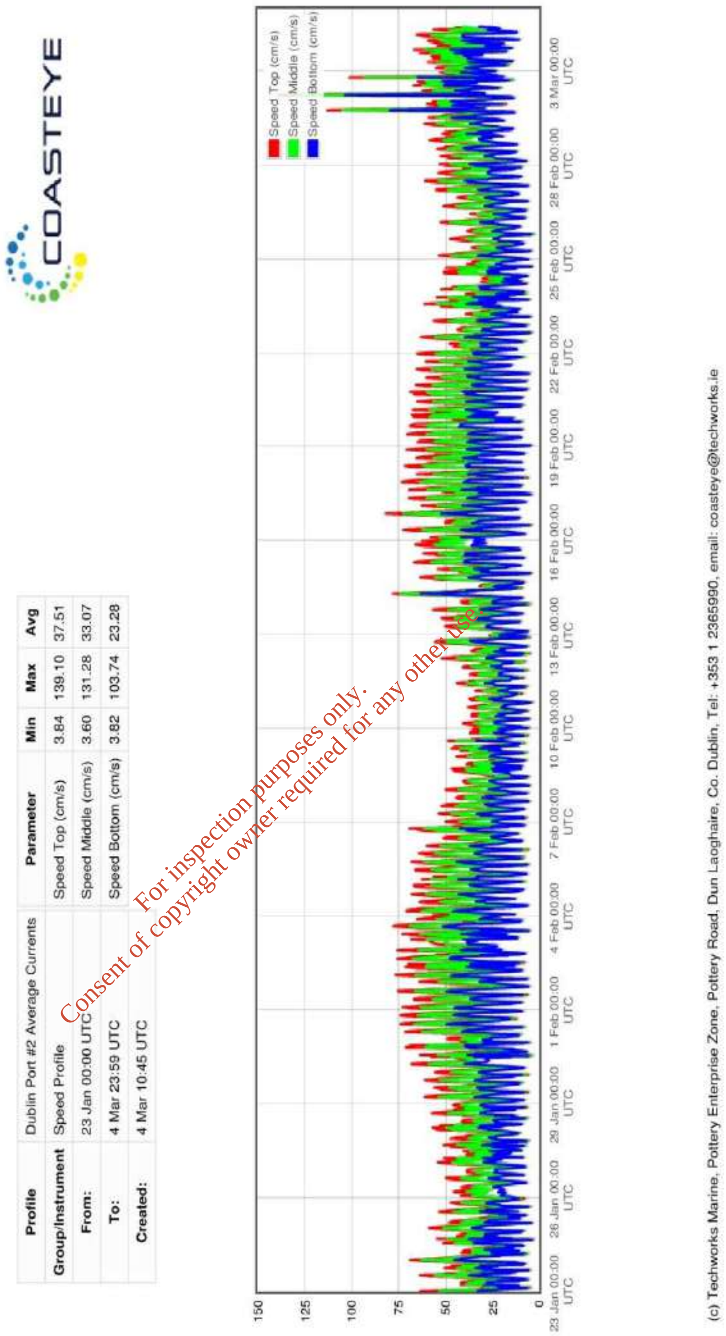

Figure 9.5 Example plot of Tidal currents recorded at the centre of the dump site (23rd January to 4th March 2018)

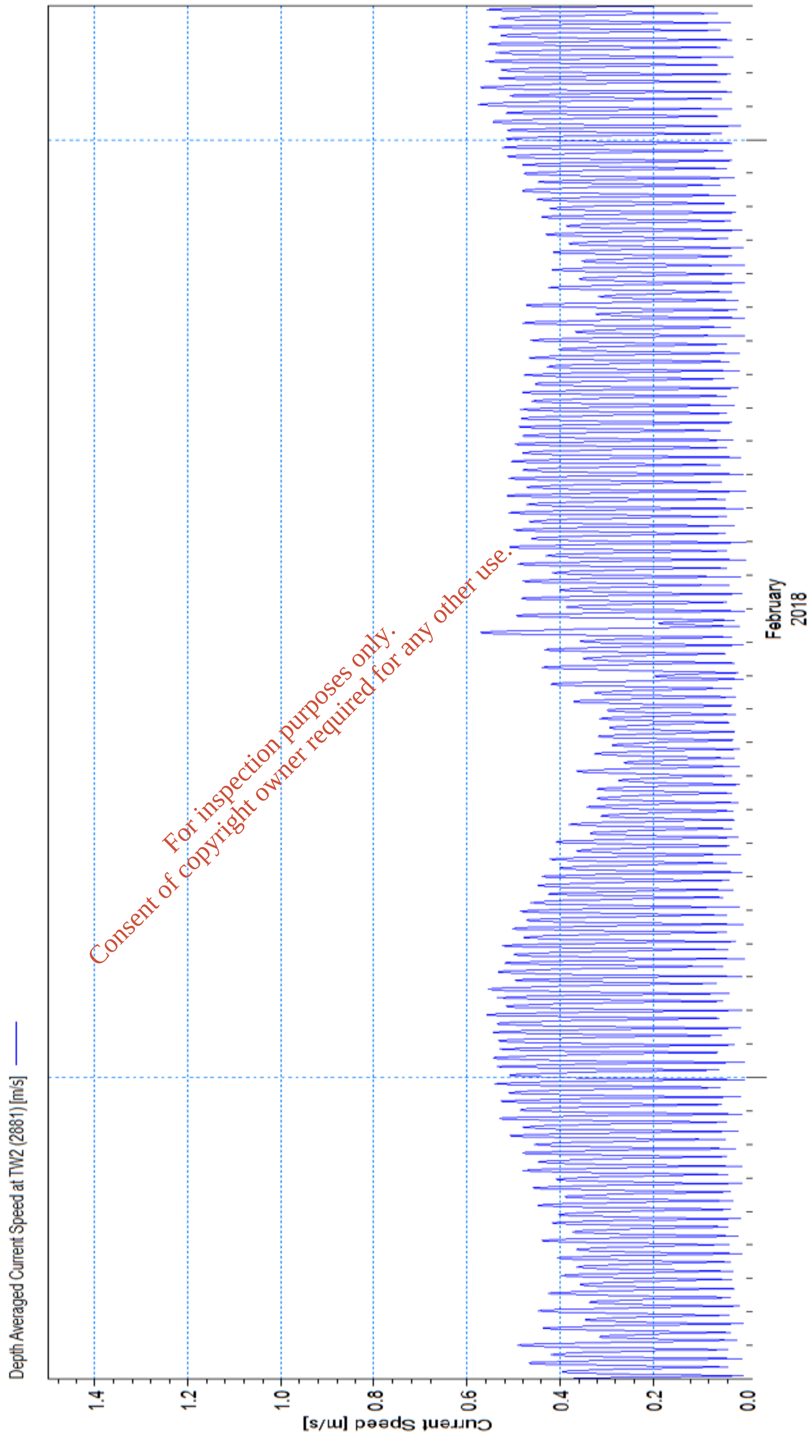

Figure 9.6 Depth averaged tidal currents predicted by the Mike 21 Hydro Dynamic (HD) model, coupled to RPS's storm surge forecast model (23rd January to 4th March 2018)